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The Emergence of New Industrial Activities: Fusing Services and Manufacture

TENIA

FINAL REPORT

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The Emergence of New Industrial Activities: Fusing Services and Manufacture

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Final report

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Coordinator of project:
Laboratory of Industrial and Energy Economics, National Technical University of Athens,
Department of Chemical Engineering, Division II
Athens, Greece
Yannis Caloghirou

Partners:
Laboratory of Industrial and Energy Economics, National Technical University of Athens, (LIEE/NTUA), GR
Centre of Research on Internationalization (CESPRI), Universita Commerciale Luigi Bocconi, Milan, IT
International KonkurrenceEvne (IKE), Department of Business Studies, Aalborg University, DK
Science, Technology Policy Research Unit (SPRU), Sussex University, UK
Fraunhofer Institute Systems and Innovation Research (ISI), Karlsruhe, DE

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Preface

Within the Fifth Community RTD Framework Programme of the European Union (1998–2002), the Key Action 'Improving the Socio-economic Knowledge Base' had broad and ambitious objectives, namely: to improve our understanding of the structural changes taking place in European society, to identify ways of managing these changes and to promote the active involvement of European citizens in shaping their own futures. A further important aim was to mobilise the research communities in the social sciences and humanities at the European level and to provide scientific support to policies at various levels, with particular attention to EU policy fields.

This Key Action had a total budget of EUR 155 million and was implemented through three Calls for proposals. As a result, 185 projects involving more than 1 600 research teams from 38 countries have been selected for funding and have started their research between 1999 and 2002.

Most of these projects are now finalised and results are systematically published in the form of a Final Report.

The calls have addressed different but interrelated research themes which have contributed to the objectives outlined above. These themes can be grouped under a certain number of areas of policy relevance, each of which are addressed by a significant number of projects from a variety of perspectives.

These areas are the following:

- ***Societal trends and structural change***

16 projects, total investment of EUR 14.6 million, 164 teams

- ***Quality of life of European citizens***

5 projects, total investment of EUR 6.4 million, 36 teams

- ***European socio-economic models and challenges***

9 projects, total investment of EUR 9.3 million, 91 teams

- ***Social cohesion, migration and welfare***

30 projects, total investment of EUR 28 million, 249 teams

- ***Employment and changes in work***

18 projects, total investment of EUR 17.5 million, 149 teams

- ***Gender, participation and quality of life***

13 projects, total investment of EUR 12.3 million, 97 teams

- ***Dynamics of knowledge, generation and use***

8 projects, total investment of EUR 6.1 million, 77 teams

- ***Education, training and new forms of learning***

14 projects, total investment of EUR 12.9 million, 105 teams

- ***Economic development and dynamics***

22 projects, total investment of EUR 15.3 million, 134 teams

- ***Governance, democracy and citizenship***

28 projects; total investment of EUR 25.5 million, 233 teams

- ***Challenges from European enlargement***

13 projects, total investment of EUR 12.8 million, 116 teams

- ***Infrastructures to build the European research area***

9 projects, total investment of EUR 15.4 million, 74 teams

This publication contains the final report of the project 'The Emergence of New Industrial Activities: Fusing Services and Manufacture', whose work has primarily contributed to the area 'Employment and Unemployment in Europe'.

The report contains information about the main scientific findings of 'TENIA' and their policy implications. The research was carried out by six teams over a period of 30 months, starting in September 2001.

The abstract and executive summary presented in this edition offer the reader an overview of the main scientific and policy conclusions, before the main body of the research provided in the other chapters of this report.

As the results of the projects financed under the Key Action become available to the scientific and policy communities, Priority 7 'Citizens and Governance in a knowledge based society' of the Sixth Framework Programme is building on the progress already made and aims at making a further contribution to the development of a European Research Area in the social sciences and the humanities.

I hope readers find the information in this publication both interesting and useful as well as clear evidence of the importance attached by the European Union to fostering research in the field of social sciences and the humanities.

J.-M. BAER,

Director

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Abstract

TENIA has examined structural change in European industry resulting from rapid innovation. Such innovation transforms extant sectoral systems by affecting their basic elements including products, agents, learning processes, interaction among agents, and selection processes. Six emerging hybrid activity areas have been studied in depth, chosen from three broader sectors: e-commerce, business data communications, and multimedia. They include:

- *M-Commerce.*
- *Mobile Data Communications.*
- *Dedicated Network Services Such as ASPs and Data Warehousing Service.s*
- *Electronic Book and Cross Media Production.*
- *Educational Software.*
- *Multimedia Services on Digital Television Platforms.*

The investigation emphasized the process of hybridization, considered to involve a variety of processes related to combining (fusing) distinct knowledge or competence to offer services or products. It was conceptualized as the construction of 'platforms' involving co-specialised assets constructed through processes of interactive learning and knowledge exchange within companies or between companies. Al six hybrid activity areas have been analyzed across five EU member countries: Denmark, Germany, Greece, Italy, and the United Kingdom.

The identified important issues and bottlenecks cutting across the six hybrid activity areas are not just related to technology. They also reflect regulation, payment systems, market fragmentation, consumer unfamiliarity with available technologies, standards, and the effective use of government procurement. Hence, the relevant, cross-cutting policy concerns are broader. We have isolated the following areas for policy consideration:

- **Networking** among economic agents with different business and technological concentrations and capabilities is key for innovation. Consequently, policies facilitating inter-organizational partnerships are clearly relevant as also are other policies that affect partnerships directly such as competition policy and intellectual property protection.

- **Power relations** among agents are often asymmetric. This may lead to situations where one agent type has too much power within the networks.

- **Technology standards**. The optimal timing for the imposition of standards and the best mechanism for doing so in early-stage, 'fluid' industrial activities are very important for competitiveness. Technology standards have become a potent strategy tool.

- **Public procurement**. Market fragmentation in the examined hybrid areas has often hindered the necessary investments in individual technologies. Industry looks at public procurement as a way of establishing de facto standards and of providing competitive advantage through scale economies and faster rides down the technology learning curves.

- **Technology diffusion – User familiarity** with available technology. Governments with sound innovation policy approaches try to balance the supply-side science and technology policies with demand-side policies to facilitate the uptake of advanced technologies by the general public (i.e., beyond public procurement).

- **Regulation**. All examined hybrid activity areas have benefited significantly from deregulation. Needless to say, the deregulation process can be driven to unnecessary extremes. The optimal level of regulation is activity-specific.

- **Technological bottlenecks**. A role for 'intelligent' governments would be to try to foresee emerging shortages of specialized resources in narrowly defined areas and try to alleviate those before they become binding for the system as a whole through the existing interdependencies. In other words, use selective intervention.

I. EXECUTIVE SUMMARY

TENIA has examined structural change in European industry resulting from rapid innovation. Such innovation transforms existing sectoral systems by affecting their basic elements including products, agents, learning processes, interaction among agents, and selection processes. The project concentrated on the emergence of new hybrid activities at the interface of technology-based, knowledge-intensive services and technology-intensive manufacturing. It purported to (a) advance our understanding of the processes underlying the emergence of such 'hybrid' activities, and (b) discuss relevant policy implications and suggest appropriate government action.

The consortium partners have studied six emerging hybrid activity areas in depth, chosen from three broader sectors: e-commerce, telecommunication networks for business data, and multimedia. The specific hybrid activity areas have been selected through a formal process also involving the input of external technology and industry experts. The six hybrid activity areas include:

- *M-Commerce – E-Commerce Applications Employing Existing Mobile Handsets or Those Under Development for UMTS Services.*
- *Mobile Data Communications.*
- *Dedicated Network Services Such as ASPs and Data Warehousing Services.*
- *Electronic Book and Cross Media Production.*
- *Educational Software.*
- *Multimedia Services on Digital Television Platforms.*

The selected hybrid activity areas were appraised in terms of products, agents, learning processes, technologies, inputs, demands, interaction mechanisms between actors, market selection processes, and institutions. Analytical emphasis was placed on the process of technology fusion and the factors affecting it. The same areas have been analyzed across all five EU member countries represented in the consortium.

The term technology fusion is used here to denote the process through which previously unrelated, but converging, technologies are put together to create new combinations. The expression "put together" masks several underlying processes/stages that can perhaps be described by the verbs combine, coordinate, integrate, transform. Transformation results in the creation of new technological domains which – when viewed

through the old lens (i.e., what existed before the fusion) – can be described as hybrids. These hybrids are occasionally important enough to demark the beginnings of new sectors. TENIA focused on the emergence of new sectors through a process of technology fusion at the interface of knowledge-based services and manufacturing in a set of information and communication technology sectors.

Fusion could be conceptualized as a process which stems from the convergence of similar or related technologies or even previously unrelated technologies that become part of a common technological paradigm. Fusion may, then, be perceived at different levels, since the technologies into question may simply be co-ordinated, or may be combined, or may even be integrated. Through such interaction, technology fusion drives a transformation of existing activities into hybrid activities, which span across different technological fields and even across different industries. In this sense, the notion of hybridisation aims at identifying a platform, i.e. an artifact, a set of standards, or a set of value chain relationships that emerge from integrating technologies traditionally belonging to different sectors. The following schematic illustrates the idea:

CONVERGENCE	→	FUSION	→	HYBRIDISATION
Technologies		*Co-ordination*		*Activities/Platforms*
(similar, related or unrelated)		*Combination*		
Integration				

The following working definitions were used in the research:

Knowledge-intensive service companies involve a substantially greater level of professional inputs (as measured by the employment of individuals with higher education qualifications) than the average of all service industries. A complementary definition relevant for some types of these companies is that they have organised innovation activities within which the elevated level of professional employment may be observed.

High-tech manufacturing companies are those where expenditures as a percentage of turn-over on organised innovation activities substantially exceeds the average for all manufacturing industry companies.

Fusion is the process of combining knowledge in the construction of complex integrated technological systems. It was hypothesised that fusion involves a higher degree of systemic integration than is required for combining 'components' from the service and manufacturing bodies of knowledge.

Hybridisation activities involve the combination of distinct competences or knowledge drawn from service and manufacturing-related activities. Firms within the three sectors chosen for examination of hybridisation – electronic commerce, multimedia, and business data communications – are engaged in a variety of different interactive relationships with hi-tech manufacturers.

Finally, the concept of a 'platform', which can be considered a co-specialised asset deriving from the combination of manufacturing and service sector knowledge assets, has provided a useful basis for proceeding in the definition of the case studies and field work. Platforms are particularly important in the selected hybrid activity areas and involve combinations of hardware, software, and specific knowledge of the service market involving end users. The respective roles of service and manufacturing companies needed to be carefully considered since the product definitions supporting service provision are usually co-produced by both the service company and the manufacturer or a third-party software company. One could envision the result of the fusion of manufacturing and service knowledge in ICT-related activities to the creation of platforms, representing combinations of hardware, software and specific knowledge of the service end user market.

In summary, hybridisation was considered to involve a variety of activities or processes related to combining distinct knowledge or competence to offer services or products. It was conceptualized as the construction of 'platforms' involving co-specialised assets constructed through processes of interactive learning and knowledge exchange within companies or between companies.

The core analysis in TENIA was based on *forty-four firm-level case studies* distributed among the six hybrid activity areas listed above across the five countries represented in the consortium. The case studies covered companies that engage in such hybrid activities and management companies that have developed relevant experience. The cases provided a set of important observations regarding technology development and business strategy with policy implications that will be discussed below. It is worth noting that the project also involved exploratory empirical analysis of patent data and research partnership data that has considered the possibilities for using such data to create "early-warning" indicators of hybridization.

The main conclusions of the case studies are summarized below, followed by policy suggestions. The results are presented on the basis of the three main sectors, signalling significant differences among them. Cross-cutting policy issues are discussed at the end of this Section.

M-Commerce

Mobile e-commerce has been touted as the next big frontier for European ICT companies for a number of years. Strategy and policy analysts have been in perfect harmony in their calls for concerted efforts to conquer the frontier. The factors justifying support to m-commerce in Europe are plenty. On the business front, both entrepreneurs and established companies sense a significant opportunity for profit, given the affinity of Europeans with their mobile phones. Phone penetration is reaching saturation levels in many parts of the continent implying that the mobile phone has become the most widespread medium of communication. Companies would very much want to reach all those millions of phones with their advertisements, thus bringing their products at the consumer's fingertips. Others see a great opportunity in facilitating such transactions. On the policy front, m-commerce is seen as the holy grail of mobile telephony. Even more, it is considered as the best shot of the European ICT industry for assuming global leadership in creating broad and potentially very profitable markets. European policy makers take it as a matter of pride to be able to extend the tremendous success of the European industry with the second generation of mobile phones (GSM) to the third generation and beyond and to the marvelous opportunities that those provide through features such as broadband, always on, fast transmission. M-commerce is seen as a natural extension of mobile telephony. Even better, the whole package agrees quite well with the Lisbon policy for the knowledge economy.

M-commerce necessitates the alignment of resources and capabilities residing in hitherto independent information-based sectors including telecommunications, computer hardware, software, entertainment, creative content, news distribution, and financial services. There is currently no consensus on how best to combine such resources and capabilities: bring them under common management or promote (complex) collaboration between independent owners. Regulatory hurdles such as those applying to antitrust and those delineating the boundaries of the banking sector also play a very important role in this milieu. For example, banks cannot turn into mobile operators in order to handle mobile payments, while operators cannot turn into banks in order to transfer money between users and let the user have an account. The operator can, however, collect money on the telephone bill. Unsurprisingly, m-payment has become one of the biggest barriers for successful m-commerce. The lack of a sound m-payment system hinders the formulation of sound business models.

The supply of m-commerce service requires the digitalization of products and service information in order to create and deliver value. It clearly requires the fusion of technologies residing in different industrial domains to create 'hybrid' activities, making

the 'hybridization' schematic presented above a fair representation of what is currently going on in m-commerce. The concept of technology fusion describes well the process of combining knowledge in the construction of the complex integrated technological systems necessary to support m-commerce. Firms in various sectors that combine into the fledgling m-commerce hybrid are already engaged in a variety of intense interactive relationships with each other. The case studies developed by the consortium members aimed at studying these interactions to identify processes involved in 'hybridization' and to examine progressive and dysfunctional elements in these processes.

The case studies conceptualized the m-commerce industry as formed by a service infrastructure supporting mobile transactions between different groups of actors and high technology providers that supply service providers and actors with technology that makes the mobile transactions possible. The high technology providers both provide hardware and software. The service infrastructure contains mobile operators, financial organisations and others. The actors can be consumers, users and retailers i.e. firms selling ring tones, logos, information services directly to the consumers.

Eighteen cases of hybrid activities in m-commerce were studied by the consortium partners: six in Denmark, two in Germany, five in Greece, one in Italy, and four in the United Kingdom. The cases focused primarily on interactions among actors and gathered information on three overarching issues:

- The objectives with which the actors establish interactions with technology providers, technology co-developers, and users.
- The strategies adopted by those actors.
- The problems faced during these interactions (bottlenecks, inefficiencies).

The interactions were, broadly speaking, classified on the basis of two qualitative variables, the "adopted role" of the partner and the "power balance" between the partners. The TENIA case study matrix summarized the possibilities for interaction among the three groups (Table 2).

Several important themes emerged from these cases. They are listed below in no particular order:

- The mobile telecom operators remain key to m-commerce and maintain very significant negotiating power, primarily because of size and because they 'control' contact with users. Their interaction with the other m-commerce partners is often about using the network to test applications. Mobile operators provide a critical link

that ties many of the pieces of the puzzle together, verifying the schematic of the m-commerce hybrid used in this document. They must thus occupy a central position in policies aiming at m-commerce.

- The price structure created by mobile telecom operators in Europe seems to be blocking market entry at the moment. In the least, the imposed price structure is making other partners quite unhappy.

- The financial system can block the m-commerce development process by not supporting the establishment of a viable m-payment system. The financial support system must also occupy a central position in policies aiming at m-commerce.

- The extent of interaction with technology users has been quite widespread, in line with best practice in technology management.

- Interaction with technology co-developers has also been fairly extensive. Relations with technology co-developers have attracted a lot of attention among m-commerce entrepreneurs in Europe. In our cases it appeared that m-commerce entrepreneurs (key actors) mostly fight an uphill battle as they are relatively less able than technology co-developers to determine technology characteristics.

- Regarding the interaction with technology providers, m-commerce entrepreneurs (key actors) from small countries seem to keep their ear close to the ground, position closer to the market, and make do with off-the-shelf equipment in order to decrease their dependency on technological advances that they cannot control.

- One of the utmost European successes in m-payment systems examined by a partner has maintained a neutral position between the fundamental columns of m-commerce – mobile network operators and banks. Given the strong pull that both operators and banks exert, this may be the right positioning for success. It is also a difficult position to maintain.

- Open platforms and consumer-centric focus seem to be the way to go for establishing a long-term winning proposition for m-payment. While many industry participants are professing standard openness, however, they still try to maintain at least partial control of the standard. One would like m-payment to be usable on every mobile phone, in every network, and with every bank account, at low and transparent cost.

- The four largest European mobile operators are currently cooperating to create the standards of m-payment. Their consortium is impressive but one wonders whether

a European payment system can be established without the active participation of the banking sector.

- The importance of institutional design and close communications for the success of joint innovative endeavors cannot be overemphasized.

- Close communications, whether formal, informal or both, are considered the best way to ascertain that information regarding needs, problems and possibilities is efficiently transmitted within the innovating network. Thus, even though network effects and the need for inter-operability between the different components of hybrid technological platforms appear as basic drivers for collaboration, mechanisms that guarantee a degree of alignment in the behaviors of those engaged in joint innovative efforts, close communication being one of them (other example would be financial incentives) should be put into place for successful technology development.

- In a context of evolvable business models and technological systems, which have to be constantly modified and re-adapted to the circumstances of a dynamic environment, there is a very important need to maintain sustained contacts and a uninterrupted information flow during all the stages of the innovation process (in which we include developmental stages).

- Communication between innovating partners in the development of hybrid technologies is not only used in order to transmit technical information for the coordination of innovative tasks, but also to negotiate and to carry out marketing activities: in what refers to the former function, actors use communication to transmit, explicitly or implicitly, their objectives and intentions to other partners in the innovative network. Communication is also used in order to build up reputation and trust.

Regarding **policy implications** specific to this hybrid activity area, the following emerge as the most prominent:

- The most pressing issue for the mobile commerce industry today – and, thus, an issue of utmost importance for policy – seems to be the lack of a credible m-payment system. The inability of setting up a viable form of m-payment, in turn, hinders the formulation of sound business models. Two major complications in the fledgling industry have been technology and incentive alignment across several players in different sectors.

- Mobile telecom operators must occupy a central position in policies aiming at m-commerce. Their relative size, direct contact with the consumer, and central position in the network of organizations linking forces to provide viable m-commerce solutions make mobile telecom operators indispensable targets of public policy.

The combination of the two points above with the fact that the financial health of several large mobile telecom operators has been weakened as a result of the 3G license auctions in a few European countries a few years ago makes for a potentially alarming situation. The pressure for 'results-now' can make the operators uncooperative for establishing long-term m-payment solutions with fair terms for other important partners with less powerful negotiating position such as content providers. Delay to take corrective action on the part of governments will negatively affect the whole m-commerce industry.

- Interaction between the different stakeholders in m-commerce becomes key in a context of fast evolving business models and technological systems. Maintaining sustained contacts and uninterrupted information flows across all stages of the innovation process becomes imperative. Policies that facilitate networking between the various economic agents while, at the same time, remain vigilant for anticompetitive behavior and continuing opportunities for entry of new players are of paramount importance.

Part of this role can be played by the European Framework Programmes for research and technological development that can create fora for such communication. Well-balanced competition policy will also be of key importance. Finally, mechanisms that guarantee a degree of alignment in the behaviors of those engaged in joint innovative efforts and financial intermediation must be in place.

Telecommunication Networks for Business Data

The emergence of hybrid activities within the area of telecommunication networks for business data concerns the development of fixed and mobile networks for the provision of value added services mostly directed to business users. Data communication services have traditionally been defined either within the framework of the tariff structure of ('wired') network operators, e.g. leased data lines or packet service subscriptions, or as value added services not subject to tariff regulation. The advent of deregulation and the growth of data communication capabilities in the wireless network, which often uses the wired network to connect different wireless receiving stations, have increased and made significantly more complex the range of service offerings in this market. Network operators have traditionally been very active in collaborating with manufacturing

suppliers in relation to the design of switching, transmission and terminal equipment. However, other important actors are now playing a role in the definition of the network features and in the implementation of different infrastructures for the provision of customised services. These actors can be identified in the users of these infrastructures, particularly big manufacturing and service firms and the government.

The project dealt with the two activities which best account for the technological development in the area of telecommunication networks for business data: dedicated backbone services and mobile links to the Internet. The analysis is based upon ten case studies carried out in Italy, Denmark, Greece and the UK by means of interviews with firms and other relevant actors. All the cases focused primarily on the interactions among actors and on the process of emergence of the above mentioned activities, by investigating the following issues:

- The objectives with which the actors establish interactions with technology providers, technology co-developers, and users.
- The factors that enabled the formation of the activities (incentives structure, role of key actors).
- The strategies adopted by those actors in the development of hybrid activities.
- The problems faced during these interactions.

The major findings can be summarised as follows:

- The market today is still experiencing a slowdown after the boom of 1998-2001. The existing operators do not foresee any other entry in the market, while they believe there will be a process of consolidation among the existing players, because some of them have not yet reached a critical customer base.
- Two factors can play a critical role in the process of fusion and development of the market for hybrid telecommunications/IT services: the role of demand in understanding the opportunities and the services offered by the new technology solutions; and the commitment of public administration to act as a key user in the development and in the diffusion of broadband services.
- In the mobile environment, the uncertainties emerging from the case studies are of a global character. Although the institutional set-ups differ between the main group of players in Europe, the US and Japan, there is a very open ended situation, where quite different outcomes all may have some degree of probability. Policy measures

and/or coordination between groups of actors may be of most relevance in the very uncertain phase between two technological life cycles.

The analysis also highlighted several **strategic considerations** and points of possible **policy intervention**:

- The diffusion of the new services is affected by factors that reside both in the demand side and in the supply side:

  1) Business users need to advance their grasp of the opportunities offered by the new technologies and link them better to their business strategies.

  2) Telecommunications providers should improve their commercial capabilities in terms of being better able to convey a clear message to the customer.

  3) Public policy can facilitate the interaction of the supply and demand sides by both assisted training efforts targeting SMEs and by providing financial incentives.

- In the past few years there has been an explicit commitment by European public institutions to foster the diffusion of broadband technologies and services. Different national ministries have announced the implementation of a number of initiatives, considering that advanced telecommunications/IT solutions represent the next technological advances to be exploited. The rationale for the public intervention is the consideration that the mere 'natural' reduction of prices might not represent a sufficient reason for the diffusion of technology.

- The presence of substantial public procurement could be effective by making available a large customer base for the introduction and deployment of new solutions. Broadband technologies could be adopted and applied to national and regional public institutions, public education and healthcare buildings and implementing projects that can exploit the potentiality of advanced digital and multimedia solutions as a stimulus for the diffusion of broadband solutions and for related technological advancements. The thorny issue here will, of course, be in the process of public demand allocation among telecommunications providers.

- The Nordic and European experience, so far at least, have fostered a common understanding of the significance of international coordination efforts ex ante. But the general crisis in the telecom service industry as well as among the equipment vendors starting in 2001 coupled with the huge rents that some of the major European governments have extracted from the service providers in the auctions

for 3G licences has determined a high degree of uncertainty in the shift from the 2G life cycle to 3G. The outer poles of the future scenarios may be represented by:

1) 3G systems may dominate the mobile telecommunications networks with WLAN solutions as a complementary service basically controlled by the incumbent mobile carriers.

2) 3G may prove to be a new 'Titanic' in Europe, if not Japan, because the US telecom industry may strike back by not adopting a 3G system at any large scale, but exploit the 2.5G options and combine them with the evolving opportunities offered by more decentralized WLAN experiments.

- Given such uncertainties it may prove relevant for a region involved in these technologies to put forward field experiments with the patterns of telecommunications services seen from a user perspective, including firms, government agencies at all levels as well as private consumers. To organise such efforts a key point is to involve various experiments with the telecom infrastructure. The aim can be to be prepared for different future trajectories, if not to influence these outright. Even small regions may eventually influence the future development abroad if they may use their potential institutional advantages in terms of organising field experiments that may be visible internationally. The interaction between suppliers, customers and knowledge institutions that such experiments require is a necessary condition for a successful innovation. Social experimentation with different solutions, however, assumes a general public that is prepared to take risks and accept that taxpayer's money may be lost, but not necessarily wasted, through such a process.

- National and regional policies cannot create competitive high tech clusters out of nowhere. Nevertheless, some of the components behind the emergence of such clusters have definitely been the outcome of deliberate policy efforts and long-term struggles. Examples discussed in this project related to Scandinavian regions, especially North Jutland in Denmark.

- In an effort to ensure easy and cheap public access to all stored digital information, the regulatory context determining the operation of transmission and reception stations in the 2.4 GHz zone could be revisited and readjusted. Issues here are, for example, the operation of wireless hotspots, and the extension of free transmission zones for public use in 5, 5.2 and 5.5 GHz.

Multimedia

Multimedia technologies were defined in TENIA as a number of diverse technologies that allow visual and audio media to be combined in new ways and using new platforms for the purpose of data storage, presentation or processing. Applications include information, communication as well as entertainment and education systems. Thus, multimedia technologies are characterised by media integration and aim at interactivity between producers and recipients. Special attention was drawn to three evolving hybrid business segments based upon multimedia technologies, including e-learning technologies, e-books, and digital TV and broadband services on the Internet platform. These three fields were selected as examples of the emergence of hybridisation within a so-called traditional sector and case studies have been carried out.

All business segments share basic characteristics, as the hybrid activities identified in the case studies are not confined to any individual organisation, but take place as the result of sustained interaction between diverse and changing inter-firm network along all the phases of technological development, from design through implementation to the provision of support services. The complexity of the whole industry, which was evident in the cases, is based on the mutual interdependencies of the actors. There are four main activity fields within the multimedia sector: technology providers, content producers and providers (including authors), service providers and consumers.

According to the case studies, the dynamics of technology (for hardware and software) can be characterised by three trends:

- the hardware segment shows continuous power enhancements, evolution and uncertainty in a context where network externalities and standards settings matter.
- The whole sector is capital-intensive, with high fixed costs of production coupled with low reproduction costs and DRM.
- Software development is affected by interconnection compatibility.

Close communications, whether formal, informal, or both, seem to be considered the best way to make sure that information about needs, problems and possibilities is efficiently transmitted within the innovating network. Communication is also used in order to build up reputation and trust. Trust which has grown through previous and existing interactions is useful in order to form relationships with new clients and partners. In many cases this is initiated by a recommendation from a third party.

The necessity for co-operation within hybrid activities is the main result of the study. All the cases show that co-operation is crucial and that often new intermediaries are needed within traditional sector structures to support new emerging co-operation needs. The role of intermediaries is either taken on by traditional, already established actors, who recognise the need for new activities, or by new actors entering the market due to emerging opportunities. A lack of sufficient communication with important lead users and thus a technology development which does not take user needs into account seems to be one reason for market failure.

To sum up, the case studies confirm that the processes of fusion and technological innovation have affected the traditional multimedia industry in many ways. Different key actors for the multimedia sector were identified. First of all, there are new actors like application developers who have taken on the role of intermediates between other, often traditional actors and are particularly important in providing the link to users and content providers/authors. Another group of key actors are traditional publishers and distributors, who are facing two problems in their fear of market loss: first, they have to make a relevant choice of content to provide, and, second, they have to achieve a scale of acceptance which is difficult because of the diversity of market expectations and needs. Additional groups of identified actors are publishers and distributors, consultants (providing expert knowledge and contacts for example regarding DRM), hardware producers of user devices and access technology as well as network providers and operators acting as intermediates for user access to the Internet.

- Analysing the interactions has revealed the importance of creating close, sustained relationships that do not depend on specific members of partner organisations, and in which future commitments, responsibilities and modifications in the technical infrastructure are clearly established from the start so as to reduce uncertainties for the success of new industrial activities.

- The technological situation for the multimedia sector in general is still unstable. A diversity of solutions exists causing incompatibility problems. This also hinders a widespread adoption and use of multimedia technologies and applications, especially in the digital TV and TV over the Internet markets.

- The high importance of communication activities and collaboration of actors for fusion processes is crucial for the success of new hybrid activities and results in a cultural change within the sector. The most important factor of success identified is a user-centric focus of technology and platform development.

- Public demand and public procurement are reportedly key drivers in the multimedia sector, especially when regarding educational content. In some of the analysed regions, market deregulation is still in progress and the commercialisation of the market is slow because of the protection of state-owned content providers.

- As users and co-developers are critical for developing and implementing the technology platform as well as for market success, all fusion processes need to have sustained contacts and an uninterrupted information flow during all stages of the innovation process. In any case, industry forums play an important role as a gateway to networks and co-operation. They are also helpful when developing standards and establishing reputation and trust between the collaboration partners.

- Educational products and services are not easy to sell as long as private and public educational systems co-exist. It will be interesting to observe the future developments, especially in regions where lifelong learning concepts are being introduced in educational systems. This may influence the complex co-evolution of technology, IT-literacy and lifelong learning culture, solutions for DRM, diffusion of complementary products and services and result in a higher market transparency.

We have reached the conclusion that the multimedia sector, as an example of incomplete fusion, has not yet found a solution to combining the knowledge of all the relevant actors. The findings summarized above suggest several items deserving **policy consideration**, including networking, technology standards, public procurement, market deregulation, and the nature of public and private educational systems.

- Networking among different actors is key. Governments may have a role to the extent that collaboration between stakeholders achieved through the market is considered insufficient or unsatisfactory.

- Uncertainty about technology standards creates instability. The question of standards, however, is not new and does not have a clear answer. Government involvement to facilitate technological compatibility may not be a good idea in a rapidly changing technological environment where solutions are changing fast. On the other hand, locking into some technology through public education procurement may have such an effect.

- Public demand and public procurement are reportedly key drivers in the multimedia sector, especially with regards to educational content. If used wisely, public procurement can then play an important role in determining technological trajectories and winning paths.

- Multimedia may take off in education as modern concepts of lifelong learning are being introduced in educational systems. The complex co-evolution of technology, new IT-literate generations and lifelong learning culture, solutions for DRM, and diffusion of complementary products and services is expected to create new dynamics. The government role here is more on the demand side, making sure that IT-literacy and lifelong learning are ingrained in society.

- Market deregulation is still in progress in some regions and the commercialisation of the market is slow because of the protection of state-owned content providers.

Cross-Cutting Policy Considerations

The examined six hybrid activity areas reflect some of the classic characteristics of early-stage, fluid technology sectors where large incumbent players with related specializations and strengths vie for dominance with nimble, small, technologically intensive companies and where extensive market and technological uncertainties overshadow the deployment of the necessary resources. As hybrid, however, they are also deeply influenced by the convergence of technologies into common technological paradigms. As such, they reflect extensive interaction among economic agents whose primary business span across different technological fields and even across different industries. They get together in order to achieve hybridization in the form of a technology platform, a set of standards, or a set of value chain relationships.

It must be emphasized that the identified important issues and bottlenecks cutting across the six hybrid activity areas are not just, or even mostly, related to technology. They rather reflect regulation, payment systems, market fragmentation, consumer unfamiliarity with available technologies, standards, and the effective use of government procurement. Hence, the relevant policy concerns are broader, akin to those that the economics, business and policy literature has proposed in relation to the social construction of competitive innovation systems. We have isolated the following areas for policy consideration in the examined hybrid activity areas:

- **Networking** among economic agents with different business and technological concentrations and capabilities proves to be key for innovation. Consequently, policies facilitating inter-organizational partnerships are clearly relevant. Such policies include the European Framework Programmes on RTD as well as national collaborative R&D programmes. They also include other policies that affect partnerships directly such as antitrust (competition policy) and intellectual property protection. Still, it is important that public authorities remain vigilant against the

possible dark side of inter-firm collaboration that may lock firms into unproductive relationships or inferior technologies.

- **Power relations** among agents are often asymmetric. This may lead to situations where one agent type has too much power within the networks. This was clearly identified in the case in m-commerce where a relatively small number of global mobile telecom operators have much more negotiating power than other agents. While in some situations this may work out as a catalyst for partnerships by forcing difficult agreements, it may prove counterproductive in situations where the powerful party is under stress for immediate business results (several large European operators currently carry a heavy burden due to debts incurred during the bidding for 3G licenses a few years ago). In such cases, the imposition of unfavourable conditions for other partners may actually hinder agreements for 'patient' solutions and long-term returns.

- **Technology standards**. Technological uncertainty creates confusion. It has long been known that early-stage, 'fluid' industries are characterized by the 'anarchic' search of dominant designs that we have observed in the examined areas. Still, the questions of the optimal timing for the imposition of standards and of the best mechanism for doing so have never before been so important for competitiveness. This is the result of the fast pace of innovation, intensive competition among players from many different parts of the world, very high stakes in terms of high investments-high payoffs, and progressively lesser opportunities to gain competitive advantage through other means of direct government intervention. Technology standards have, in other words, become a potent strategy tool as the case of the second generation mobile technology proved for Europe.

- **Public procurement**. Market fragmentation in the examined hybrid areas has often hindered the necessary investments in individual technologies. It was clear from our interviews that industry looks at public procurement as a way of establishing de facto standards and of providing competitive advantage through scale economies and faster rides down the technology learning curves. Exactly because public procurement has a role of standards by its mere size, all the considerations regarding the optimization of the timing and the appropriate vehicles for establishing standards apply here as well. In addition, governments will be under severe pressure and may make mistakes when the choice between technology quality and future prospects, on one hand, and cost and competitive national players, on the other, is not an easy one to make.

- **Technology diffusion – User familiarity** with available technology. It should not come as a surprise that governments with sound innovation policy approaches try to balance the supply-side science and technology policies with demand-side policies to facilitate the uptake of advanced technologies by the general public (i.e., beyond public procurement). This is typically achieved through broad campaigns to demonstrate the use and familiarize the population with new technologies. Regional 'field experiments' also partly play this role. Principal targets in such campaigns are small and medium-sized enterprises (SMEs) and individual consumers. The Lisbon policies of the European Community that aim at establishing in Europe the most advanced knowledge economy in the world have a strong flavour of such an approach.

- **Regulation**. Market deregulation has been important in speeding up innovation through competition in the past couple of decades. All examined hybrid activity areas have benefited significantly from deregulation. Needless to say, the deregulation process can be driven to unnecessary extremes: there is some optimal level of regulation necessary for markets to work properly. The optimal level of regulation is activity-specific.

- **Technological bottlenecks**. At a time of rapid technological advance, systemic complexity, and heavy private sector investments in new technologies, developed country governments cannot and should not try to foretell and heavily influence future technological developments. Such practice will more often than not lead to disasters through unproductive lock-ins in the wrong fields. A more appropriate role for 'intelligent' governments would be to try to foresee emerging shortages of specialized resources in narrowly defined areas and try to alleviate those before they become binding for the system as a whole through the existing interdependencies.

Such selective intervention reflects, of course, the general policy advise emerging from complexity theory: rather than firmly commanding the boat rushing downstream in a fast-flowing river, the boatman paddles strategically to avoid disastrous crashes on the rocks and dangerous dead-ends and to facilitate smooth, flexible, and fast riding downstream to the extent possible. The analogy is good as far as it goes, however: in this case it is limited to the extent that the river has a finite end whereas science and technology presents us with an 'endless frontier'.

We conclude with a comment on technology foresight. While TENIA did not involve a formal technology foresight exercise, it did explore the possibility of using extant data on

partnerships and patents for creating early pictures of emerging hybrid activities. Our resources were limited and the data available to us proved of somewhat limited value, primarily because it was relatively old for the examined hybrid activities that kept evolving as the project was unfolding but also because important detailed information on partnerships was missing. Nevertheless, we did obtain some encouraging results and remain convinced that foresight exercises based on quantitative techniques can provide the basis of 'early warning systems' that would be quite useful for 'smart' governance.

II. BACKGROUND AND OBJECTIVES OF THE PROJECT

This project has examined structural change in European industry resulting from rapid innovation. The change in question transforms existing sectoral systems by affecting their basic elements including products, agents, knowledge and learning processes, basic technologies, inputs, demand, mechanisms of interactions among agents, competition and selection processes, and institutions. We were especially interested in change that results from the fusion of interdependent service and manufacturing activities and convergence of previously separate sectors to exploit recently articulated market opportunities. The project focused on the emergence of new sectoral systems at the interface of technology-based, knowledge-intensive services and technology-intensive manufacturing.

The term technology fusion is used here to denote the process through which previously unrelated, but converging, technologies are put together to create new combinations. (The term will be elaborated in a subsequent section.) The expression "putting together" masks several underlying processes/stages that can perhaps be described by the verbs combine, coordinate, integrate, transform. Transformation results in the creation of new technological domains which – when viewed through the old lens (i.e., what existed before the fusion) – can be described as hybrids. These hybrids are occasionally important enough to demark the beginnings of new sectors. TENIA focused on the emergence of new sectors through a process of technology fusion at the interface of knowledge-based services and manufacturing in information and communication technologies (ICTs).

Figure 1 offers a graphical representation of the core concept of TENIA. Simply put, ICTs create a fusion of knowledge-intensive services and high tech manufacturing to create hybrid sectors. The consortium has studied a set of emerging hybrid activity areas in depth, chosen from three broader sectors: e-commerce, business data communications, and multimedia. These hybrid activity areas have been selected through a formal process involving technology and industry experts. The selected activities were appraised in terms of products, agents, knowledge and learning processes, technologies, inputs, demands, related links and complementarities, interaction mechanisms between actors, competition processes, and institutions. The same set of hybrid activities have been analyzed across all five EU member countries represented in the consortium.

TENIA had the following main objectives:

- Study the process of emergence of new industrial activities at the intersection of knowledge-intensive services and high-tech manufacturing, specifically in the sub-sectors of electronic commerce, business data communication, and multimedia.

- Analyze how firms enter, survive and grow in these sectors, their degree of technological and business diversification, and the strategic mechanisms that they use at the early stages of sector evolution (e.g., cooperative agreements).

- Examine differences in the pattern of new hybrid industry emergence across technological areas and across (European) countries; appraise the factors that are responsible for such differences.

- Consider methodologically sound sets of quantitative and qualitative indicators that can be used as "early warning systems" by governments – or other organizations – to capture the emergence of such activities and derive recommendations to guide future policy options towards emerging hybrid sectoral systems of innovation.

The socio-economic policy implications of emerging sectors at the manufacturing-service interface are several and very important. Improving our understanding of the process of new hybrid sector emergence and growth will allow methodological approaches to assist the delineation of sets of critical indicators and "early warning systems" in order to effectively follow an emerging sector since its very early evolutionary stages. That capability, in turn, makes possible a dramatically different approach to policy decision making, changing it from retrospective to prospective and anticipatory. Rather than a rigid technology policy with government trying to anticipate market outcomes, this suggests an ability to examine and adjust the institutional enabling conditions so that they are consistent with the successful emergence of such hybrid sectors.

The consortium kept as close as possible to the original objectives of the project. In particular, the conceptual analysis of hybridization and the empirical work of such processes on the basis of case studies were carried out quite successfully. One slight modification that became necessary along the way was the expansion of the range of research to include actors additional to innovation initiators including technology consultants, support service providers, developers of complementary products and services, and users. This has been done through the selection of some of these actors as case studies and the inclusion of questions regarding interactions with them for all the other firms we have analyzed. We believe this has strengthened the results.

Relative to the original objectives of the project, we've had lesser success with creating concrete quantitative indicators that can be readily used, in combination to qualitative

indicators, as an "early warning system" for governments interested in catching technological/industrial trends at very early stages of formation. The consortium studied this issue and we have some methodological suggestions based on our analysis, but we were not able to create final sets of quantitative indicators that can be used unequivocally for such a purpose. Two data-related factors accounted for this difficulty. First, a major industry survey that was part of our proposal was not accepted for funding, depriving us from a critical source of information. Second, the available data on research consortia proved much less fine-grained than necessary to create the desired indicators. Patent information proved much more useful for this purpose. Still, it would probably need to be supplemented with extensive science publication data (unavailable to us) and it would require significant additional work for a theoretically sound and empirically concrete set of quantitative indicators. More effort needs to be devoted to the identification of appropriate data and the development of such indicators.

III. SCIENTIFIC DESCRIPTION OF PROJECT RESULTS AND METHODOLOGY

TENIA has had a dual purpose:

1) Advance our understanding of the processes underlying the emergence of "hybrid" activities at the intersection of knowledge-based services and high tech manufacturing. It specifically focuses on three areas of strategic interest for Europe:

   - Electronic commerce.

   - Telecommunication networks for business data.

2) Multimedia.

Discuss policy issues related to the emergence and evolution of hybrid activities in the selected technology areas and government actions to facilitate them.

The inquiry was directed towards a long set of analytical questions through a combination of empirical analysis, extensive qualitative analysis through case studies of hybrid activities, and policy analysis. The questions, as initially posed to the consortium, can be described as follows:

- What are the underlying processes in the emergence and inter-temporal evolution of the selected hybrid activities?

- What regularities can be observed in each of the three selected hybrid activities in terms of:

  - Products.

  - Agents.

  - Knowledge and learning processes.

  - Technologies, inputs, demand, and related links and complementarities.

  - Company strategy.

  - Mechanisms of interactions, within and between firms, and outside firms.

  - Processes of competition and selection.

- Institutions.

- What regularities can be observed across the selected narrowly-defined hybrid activities?

- What regularities (if any) can be observed for each selected hybrid activity across the five represented countries? [Denmark, Germany, Greece, Italy, United Kingdom]

- What kinds of public policies would be useful to facilitating hybrid activities? Which of the current policies seem to be more effective in that respect?

- Is the divergence of national/regional markets within the EU an important factor that can be accountable for the differences in the update of hybrid activities observed among countries? How could such divergence be taken into account by policy-decision makers?

- What is the potential for developing quantitative and qualitative indicators to support "early warning systems" that can be used by policy makers to catch up early on with emerging hybrid activities?

- What are the lessons from the selected three hybrid areas for the sectoral innovation systems of the European Research Area?

The research methodology of TENIA was based on five basic analytical blocks:

- *Conceptualization – Literature search*: Develop the conceptual background of the study, especially with regards to correctly defining the concepts of "hybridization" and "fusion", and linking these concepts to the extant literature on services, sectoral studies, and industry evolution.

- *Selection of hybrid activities*: Develop a methodology with the assistance of technology and business experts to formally select the specific hybrid activities within:

  - Electronic commerce.

  - Telecommunication networks for business services.

  - Multimedia.

- *Exploratory empirical analysis*: Using the databases of EPO patent applications and the STEP TO RJVs databank on funded research cooperative agreements through

the Framework Programmes, this exploratory analysis has considered the possibilities for sing such data to create "early-warning" indicators of hybridization.

- *Field research – Case studies*: The core of this project became the conduct of a large number of firm-level case studies in the pre-specified hybridizing sectors and five countries represented in the consortium. The case studies covered companies that engage in such hybrid activities and management companies that have developed relevant experience.

- *Policy analysis and recom*mendations: Draw lessons for future science, technology and innovation policy options.

1. Literature Background

There has been mounting interest in the innovative activities of the service sector since the late 1980s. The historical "reputation" of the sector for not being innovative (Evangelista et al., 1998) has given way to a broad appreciation of both the sector's direct innovative importance and of its indirect impact on the innovation processes in other industries (Bilderbeek et al., 1998). This Section summarizes the contextual background that supported TENIA's approach to the study of the emergence of new, hybrid sectors at the intersection of services and manufacturing. Given the large volume of existing literature under each heading, our coverage is selective.

1.1. Service Industries in the Knowledge-Based Economy

The interest in the role of service sectors in innovation and the economy at large is not entirely new (e.g., Gershuny, 1978; Gershuny and Miles, 1983). In the late1980s, amidst serious concerns over the international competitiveness of US industry, the National Research Council published two volumes that purported to set the record straight concerning the extensive dependence of the American economy on service activities (Guile and Quinn, 1988a, 1988b). The main subjects and the tone of the discussion on the role of service industries in innovation (and innovation in services) were set therein.

Of direct relevance to TENIA, it was argued strongly that the effectiveness of service industries and manufacturing are mutually intertwined. Attempting to strengthen one without strengthening the other was said to be a misguided policy. It was clearly understood that effective services activities create new markets for manufactured goods, result in lower costs for manufacturers, and are central to increasing the value added by manufactured products. Similarly, manufacturers are important suppliers, customers, and innovators for services activities. The NRC volumes called for new regulatory philosophies and institutions across a wide spectrum to accommodate new realities.

These realities included the fact that technologies in the services sector were restructuring many manufacturing and services industries. The dynamics of technologies, combined with deregulation, were claimed to have broken down barriers among industries such as transportation, communications, finance, distribution, education, and health care, and to have resulted in a significant degree of cross-industry interaction and competition.

This was the time when the Internet was still unknown outside a small circle of US government and research laboratories (none of the popular browsers had been invented), when mobile telephony meant either a telephone fixed onto a car or a sizeable briefcase to be carried around and work in limited locations, no portable computers, and clumsy stand-alone personal computers that had just started entering private homes. A few years later, a vastly different economy is in full swing. Various terms have been invented to describe it, including information society, knowledge-based economy, and, more recently, globalizing learning economy (Lundvall and Borras, 1999). All these terms try to capture the tremendous impact information technology[1] has had on economic agents and their ability to scan, access, adapt, adopt, and distribute knowledge. A standard definition of a knowledge-based economy is "…one in which the generation and exploitation of knowledge play the predominant part in the creation of wealth" (DTI, 1998). A knowledge-based economy goes hand-in-hand with fast rates of change which, in turn, means that economic performance increasingly depends directly on the learning ability of individuals, firms, regions, and countries. Learning is important both in order to adapt to the rapidly changing economic environment (markets, technologies) and in order to contribute to innovation. A long stream of economic research has underlined the importance of scientific and technological knowledge, in particular, crediting it with the lion's share of long-term growth.

In the era of knowledge, knowledge-intensive services acquire an even more important role. In addition to the multiple value added functions mentioned above, and empowered with networked and mobile information technologies, they now significantly affect the learning capacity of the whole system (particularly knowledge-intensive business services, KIBS). "Through their function as intermediaries between companies' idiosyncratic, and often tacit, knowledge bases, these services play an increasingly complementary role to more traditional public 'technology transfer' instruments. Similarly, … [they] are crucial instruments for inducing organizational change in different institutions (not only firms)." (Lundvall and Borras, 1999, p. 118)..

[1] More broadly, these terms try to describe the increasing application of scientific knowledge to productive activities (as Galbraith, Kuznets, and Schumpeter had predicted several decades ago).

One of the factors that have increased and strengthened the relationship between independent service producers and manufacturers during the past couple of decades is the trend in manufacturing for concentration on core activities. Concentration implies relinquishing of the rest, complementary, and still very useful activities (Teece, 1987) to be outsourced or to be otherwise accessed through cooperative agreements. Many of these complementary activities are knowledge-intensive business services such as design, R&D, information systems, consulting, finance. This process has been further facilitated by the relentless push for codification of knowledge through information and communication technologies that has increased the tradability of knowledge-intensive services (Petit and Soete, 2001).

A number of extensive studies in the last few years have started opening the "black box" of technology in services, (the role of) services in technology, and the related economics, all areas needing extensive research. They have included, for example, several TSER-funded projects in Europe such as SI4S (Hauknes, 1998) and US-based studies such as Leech et al. (1998). The following (selective) list of findings seems to apply across regions and knowledge-intensive service industries:

1) The service sector of large variety, including very traditional, low technology activities and some of the most dynamic, knowledge-intensive industries such as knowledge-intensive business services (KIBS). Aggregating across leaves much to be desired.

2) The multifaceted, important role of knowledge-based services in innovation has been known – or, better perhaps, strongly suspected – for some time but hardly ever "proven". This role is arguably being enhanced by the widespread use of information technology.

3) By and large, the service sector is still a consumer of technology rather than a developer of technology. While the internal R&D expenditures in service industries have grown steadily, there is significant evidence that the bulk of it is concentrated in few areas, particularly communications and computer service industries whereas the typical service industry is far less active in R&D.

4) Far and away the dominant technology in services is information technology, accounting by some calculations for 80 percent or more of the technology purchased by service sector firms.

5) It appears more appropriate to speak of the RDT&E function (research, development, test, and evaluation) than simply the R&D function of service sector firms. The typical focus of the RDT&E staff is on information technology.

6) What genuine R&D effort is performed in service sector firms often involves co-development efforts with hardware and software suppliers. IT is increasingly being applied to service delivery and content, in addition to traditional "back office" and "front office" operations. This appears to be stimulating more co-development efforts and has contributed to a more dynamic model of technology development and use.

7) A targeted technology policy that aims to support the development and implementation of IT in the service sector must address three overarching technology issues: industry and technology convergence, service sector-customer interface, system interoperability and security. Concerning the first issue, the convergence that is taking place as a result of the IT revolution raises uncertainty among service providers and users. Technology "roadmaps" is an essential public policy tool for mitigating the intense technological uncertainty that pervades the service sector. Concerning the second and the third issues, a significant role of the government in infrastructure technologies, (de)regulation, and standard creation process is important.

In other words, the service-manufacturing interface, largely as defined and influenced by information technology, is where the action currently is and is expected to continue for the foreseeable future. There is an important role for public policy in creating technology "roadmaps", infrastructure, regulation, and standards creation processes. The empirical work in this project will focus primarily on the first ("roadmaps").

Lastly, three quite influential observations must be mentioned. First, it is said that the relationship of manufacturing and services is intimate because manufacturing products often replace services (e.g., washing machines, dryers). They also create the need for new services. Interestingly, manufacturing products will tend to replace simpler services, which are more easily codifiable and create needs for new more knowledge-intensive services. The cycle from services to manufacturing to services seems to increase the knowledge-intensity of both service and manufacturing products.

Second, ICTs have increasingly allowed knowledge-intensive services to take on characteristics of commodities and vice versa. In other words, it has been argued that technology is transforming the nature of the products of both sectors (OECD, 2000). On the one hand, manufacturing is becoming more like services: customer service is

becoming more important and products are increasingly being tailored to the needs of the individual customers. It is estimated that over three quarters of the value of a typical manufactured product is already contributed by service activities such as design, sales, advertising. On the other hand, technology is also changing the production and consumption patterns in some of the most valuable and fastest growing service sectors (e.g., business services). Codification of knowledge makes the direct contact between producer and consumer unnecessary allowing such services to be held as inventories and to be traded internationally (e.g., expert computer systems). The introduction of ICTs is making services more capital intensive and more productive. It will also make them more susceptible to competition and to the economic cycle, like manufacturing goods.

Third, innovation processes are said to differ between manufacturing and services. Innovation-related learning processes are said to differ due to the rather different impacts of codification that characterize the paths of cumulative growth in the two sectors (Petit and Soete, 2001). In the case of goods, the learning process is centered upon the product itself. Producers learn how to adapt the new product to tastes and how to take advantage of expanding markets. In a Vernon-like typical product cycle, later stages bring in standardization and imitation and a rush to achieve higher productivity through economies of scale. By contrast, it has been argued that the dynamics in services go the other way around, in a "reverse product cycle" model (Barras, 1986). Improved manufactured goods first increase the tradability and market for an existing product. It may lead to service product innovation at a later stage.[2]

1.2. Sector Studies, Industry Evolution, Technology Fusion

1.2.1. Sector Characteristics and Evolution

The fundamental question of TENIA is about the emergence of new sectors at the intersection of services and manufacturing. That naturally leads to an interest in concepts of industry evolution, a field of study with a long tradition of work by economists, business analysts, economic historians, and policy makers. Two strands of literature can be distinguished here. One is rooted in the formal industrial organization tradition and has concentrated on sectoral structure in terms of concentration, vertical integration, diversification; the dynamics of sectors in terms of technical progress, entry, firm growth, etc.; and strategic behavior (e.g., Scherer and Ross, 1990; Sutton, 1998).[3] These analyses have paid less attention to knowledge and learning processes, the role of

[2] The extent of differences is debatable. See Sirilli and Evangelista (1998).
[3] Caves (1998) has summarized a large part of the theoretical and empirical aspects of this literature.

non-profit organizations, the wide range of interactions among agents, and the transformation of sectors in terms of their boundaries, agents, and products. The second strand of literature provides rich empirical evidence on the characteristics of sectors, on their technologies, production features, innovation, demand, and on the type and degree of change. Unfortunately, the possibility for an integrated and consistent analytical approach across this group is still fairly limited.

During the past few years, however, Malerba and colleagues have undertaken a significant effort to provide a multidimensional, integrated and dynamic view of sectors, combining important elements from both analytical traditions above to advance the concept of sectoral system of innovation and production (Malerba, 2000). The theoretical and analytical approach underlying this work is the evolutionary theory (Dosi, 1988; Nelson, 1995) and the system (of innovation) approach (Edquist, 1997). Importantly, this work is also informed by an important strand of theoretical and empirical literature on industry evolution, initiated in the late 1960s by Mueller and Tilton (1969) and Abernathy and Utterback (1975) (see Utterback, 1994, for a synthesis). Work in industry evolution has also benefited from important contributions by Carlsson (1995), Gort and Klepper (1982) and Klepper (1996).

The important aspect of this work is its concern about all the stages of industry evolution, from the very early stages to maturity. The approach is both quantitative (based on indicators such as patents or firms' variables), formal (with the development of history friendly models of industry evolution) as well as qualitative and "appreciative", by focusing on several aspects such as learning, knowledge base, competences, and relationships among agents. In general the basic elements of a sectoral system could be identified in the following:

- Products.
- Agents (including both firms and other organizations such as universities, financial institutions, etc.).
- Knowledge and learning processes.
- Basic technologies, inputs, demand, and the related links and complementarities.
- Mechanisms of interactions both within and between firms and outside firms (including market and non market interactions).
- Processes of competition and selection.

- Institutions (rules, norms, etc.).

This analytical approach enables rich conceptualizations of sector birth, death, and turbulence while linking these directly to different market structures and different patterns of innovation. An important role is played by the learning environment in terms of different technological regimes characterized by various degrees of technological opportunity, appropriability, cumulativeness, and properties of the knowledge base and learning processes (Malerba and Orsenigo, 1996; Gambardella and Malerba, 1999). Importantly for TENIA, the approach allows to examine the processes of transformation of sectors and the dynamics of firms, addressing questions such as "[H]ow many of the new technological entrants in any technology are really new innovators, and how many have already innovated in a technology and have then diversified in a different one? How many of these new innovators are occasional innovators, and how many have become persistent innovators? Are there significant differences in the rate of technological entry and exit across technologies? Across countries?" (Malerba and Orsenigo, 1999, p. 42). As such, this particular approach to sector evolution deserves particular attention for the project at hand.

New technologies are presumed to come about within or against existing technological regimes and social contexts which are themselves the results of the linkages between different agents – firms, users, universities, research organizations - and institutions. These regimes enable some kinds of technological developments while constraining others, and they change over time as the result of the appearance of new technologies (among other things). Agent behavior and new technology emergence have deep roots in the previously existing regime, but they help transform the strategies, research agenda, engineering expectations and practices of users working with the prior technologies (Van Den Ende and Kemp, 1999). Thus, when analyzing the emergence of a new technology, there is a need for adopting a "contextual" view, considering the innovation as a part of an evolutionary process of technical, institutional and social change, which occurs simultaneously at three levels: the level of individual firms or research laboratories, the level of technological regime, the level of social and institutional context. Innovations do not arise at random, but they are generated in organisations and social systems on the basis of capabilities that are available. Their value, potential development and eventual success depend upon the presence of a system, the existence of a market need for the new product, the presence of active strategies of firms and the existence of a supporting web of organisations and institutions. This idea is close to the concept of co-evolution of knowledge, technical competencies, firms and non-firm organisations and institutions as the engine of industrial dynamics. Technical change is not simply situated and shaped by the ensemble of technological economic, social and political factors: new technologies

can indeed radically modify the context in which they emerge. Co-evolution exists both among different technologies (Pistorious and Utterback, 1997) and between the technology and the surrounding actors (firms and non firm organisations and institutions), demand, social and cultural environment (Nelson, 1994; Metcalfe, 1998; Malerba, 2000).

1.2.2. Technology Fusion

Sectors differ in their basic technologies and these technologies affect the nature, boundaries and organisations of sectors (Rosenberg, 1976; Grandstand, 1994). Technological activity is industry-specific. The rapid advancement and proliferation of three types of "infrastructural" technologies (ICTs, biotech, advanced materials) during the past few decades, however, have created important opportunities for cross-fertilization of knowledge across a wide range of technological fields. A typical contemporary industry is active in several technological fields that do not traditionally identify its core activities. Companies must draw upon an ever broader range of technologies and capabilities to be competitive (Granstrand et al., 1997; Fai and Von Tunzelmann, 2001; Rycroft and Kash, 1999; Kodama, 1992). This has led to new levels of technological complexity. It has also increased the stakes regarding opportunities for technology fusion and hybridization (Kodama, 1992; Miyazaki, 1994; Koumpis and Pavitt, 1999; Fujimoto et al., 2000).

As a first approximation, one could conceptualize fusion as a process which stems from the convergence of similar or related technologies or even previously unrelated technologies that become part of a common technological paradigm. Fusion then may be perceived at different levels, since the technologies into question may simply be co-ordinated, or may be combined, or may even be integrated. Through such interaction, technology fusion drives a transformation of the existing activities into hybrid activities, which span across different technological fields and even across different industries. In this sense, the notion of hybridisation aims at identifying a platform, i.e. an artifact, a set of standards or a set of value chain relationships that emerge from the fusion of technologies traditionally belonging to different sectors. The following schematic illustrates the idea:

CONVERGENCE	→	FUSION	→	HYBRIDISATION
Technologies		*Co-ordination*		*Activities/Platforms*
(similar, related or unrelated)		*Combination*		
Integration				

One of the main features of technology fusion is that it often stems from long-term R&D collaborations both between firms and between firms and other organisations - mostly universities - across many different industries and research disciplines, so that, within each technological area, there is an increasing orientation towards R&D investments in non-core technologies. Technological fusion depends also upon the existence of a growing breath of knowledge. This implies that research capabilities and technological competencies outside a specific sector could become a threat for that sector's firms, if they are harnessed for the development of new markets. As an example, the cable TV operators may threaten the telecommunications operators for the provision of high-speed Internet access and services, as they possess competencies in broadband transmission, which have become increasingly important following the development of advanced fibre-optic infrastructure and the growing requirements for value-added services. Similarly, the producers of small form-factor disk drives face a potential threat from the distributors of storage devices that rely upon flash memory semiconductors, solid state components that offer comparable storage capacity, but are smaller and consume less power.

As technologies become more and more pervasive and knowledge acquires an increasing importance within different sectors, a relevant issue appears to be how to make the best possible use of the existing technologies in order to respond to the need of the market. The capacity of articulating the demand requires some competencies of technology fusion: this process is particularly important in industries that are very competitive and technically sophisticated and need to put particular attention on customers' needs. This happens quite often in the information- and knowledge-intensive sectors, where the service component of innovation and production is very important and the absorption rate of technologies from other industries is high. Indeed, in such innovative activities, the specification of demand involves processes of user-producer interaction and collective learning, which may occur either in the pre-competitive stages of development of innovations or in the phases that follow their commercialization. It is worth mentioning that the nature of technology fusion varies quite remarkably across different technological areas: for example, the process-related fusion captured by the emergence of mechatronics is very different from the science related fusion exemplified by optoelectronics or by computational chemistry (Mahdi and Pavitt, 1997; Koumpis and Pavitt, 1999; Fujimoto et al., 2000). And that would, in turn, seem to be very different from the service-manufacturing fusion that provides the focus of TENIA.

A parallel phase of technology fusion goes beyond the manufacturing sectors and occurs more frequently among sectors. An example of this trend is the fusion of the materials sector (drawing on both biology and chemistry) with manufacturing, which created "fourth-generation" materials, custom-designed by engineers by manipulating atoms and

electrons. However, even more than fusion between manufacturing and materials, this phase is characterised by fusion between manufacturing and services: there is a strong interaction between separate bodies of competencies and knowledge in the development of innovative products and services, which cross boundaries between organisations and institutions. This means that the production of innovations involves processes of collective learning. Such opportunities appear to be particularly high in the knowledge-intensive services (business services, telecommunications and Internet services, financial services) and high-tech manufacturing, especially those related to the employment of ICT. The process of fusion between these industries generates hybrid activities, whereby the services providers exchange knowledge and competencies on a continuous basis with manufacturers of high-tech products.

There is a close and symbiotic relationship between services and manufacturing, so that the distinction between the two, particularly in the information-intensive and high-tech sectors has become blurring and sometimes arbitrary. Without the demand for information and entertainment, for example, there would be no need for media distribution channels; similarly, the interrelationship between computers and software provides a case for the dynamic interplay between manufacturing and service activities, as software advancements are pushing the development of more powerful computers and vice versa. Even going beyond the technological perspective, computers and software are totally dependent on each other also from a "market" point of view, in that neither would have commercial value without the other.

The fusion between manufacturing and services occurs not only in the forms of interaction, but also in the form of an increasing embodiment of the services in manufactured products. This is reflected in the innovative efforts and expertise that is captured in the final value of the products, as well as design, technical assistance and other "intangible" aspects. In some cases, the rising demand for products with a high service-oriented content has an impact on the characteristics of the firms themselves (OECD, 2000). In this respect, it is reasonable to argue that, in providing more services activities, some manufacturing firms have become service-oriented companies, implementing non-technological types of innovation and increasingly looking at customers' needs. However, the process is also going the other way round, since, in delivering to end users, service providers consider more and more the manufactured products that may be supplied as part of their service package or involved in supporting the service provision (Hauknes, 1999; Howells, 2000). As an example, some telecommunications and Internet service providers are now offering telecommunications and computer equipment to subscribers at low cost, reflecting the growing intrinsic value

of the service rendered. In this way, services (and service providers) are becoming knowledgeable facilitators and supporters within the technological and industrial process.

One could potentially envisage the result of the fusion of manufacturing and service knowledge in ICT-related activities to the creation of *platforms*, representing combinations of hardware, software and specific knowledge of the service end user market. The examples of telemedicine and multimedia illustrate this trend (Mansell and Steinmueller, 2000; Howells, 2000).

1.2.3. Technology and Business Diversification

A stream of literature with direct relevance to TENIA has developed during the past couple of decades on the nature and the determinants of firms' productive and technological diversification.[4] The determinants of diversification in economic literature have been categorized by Montgomery (1994) into three groups focusing on:

i) Expectations for additional profit via increased market power. Market power for the diversifying firm is the expected outcome of cross-subsidization between markets, mutual forbearance (less competition) due to the recognition of multi-market contact with competitors, and collusion to foreclose markets to new entrants.

ii) Better use of resources. The resource-based view of the firm (Penrose, 1959) has stressed that the firm, characterized by its sticky and unique (i.e., difficult to imitate) collection of resources and capabilities, diversifies in order to employ more profitably its underutilized resources;

iii) Agent "misbehavior." Agency theory points out that the managers of a public firm (agents) may act self-servingly and try to build larger conglomerates, not in the interests of shareholders (profit maximization) but in an attempt to promote their own status as heads of empires (empire building).

The focus of the 1st and the 3rd streams of literature is on business, rather than technological, diversification. The 1st group employs the tools of traditional industrial organization economics in order to explain diversification as an attempt by firms to take advantage of the market structure that is thus created (Caves, 1998). In this context, the major incentive for diversification is market power. The 3rd stream of literature takes

[4] See, e.g., Breschi et al. (2003), Gambardella and Torrisi (1998), Grandstrand and Oskarsson (1994), Grandstrand and Sjoelander (1994), and Patel and Pavitt (1997). Vonortas (1997, 1999) reviews part of this literature.

its lead from Berle and Means (1932) and the separation of ownership from control thesis. However, modern agency theory sets out, almost unanimously, to reject this thesis by theorizing the principal agent relationship as an optimal contractual arrangement through which the principals (the owners of the firm) are able to curb the opportunism of the agents (the managers) *ex ant.* (Fama, 1980; Fama and Jensen, 1983). In this context, business diversification is thought of as always driven by the motive of profit maximization and as ensuring the efficient allocation of the firm's resources. The major requirement for the mechanism to work is efficient capital markets. Indeed, capital markets inefficiencies are singled out as the major factor explaining the rise of the conglomerate in the 1960s, while the market's enhanced efficiency in the 1980s is thought of as the factor that may explain the decline of the conglomerate in that period (Klein, 2001).

In contrast to industrial organization and agency theory, the 2nd group puts both business and technological diversification at center stage. Although firms have been shown to diversify non-randomly (Teece et al., 1994), there has been significant uncertainty in explaining the direction of diversification. Some apparent relationships have been established empirically. For example, there has been some evidence pointing to a relation between the resource base of firms –particularly in R&D and marketing– and their choices of diversified expansion (Lemelin, 1982; MacDonald, 1985; Montgomery and Hariharan, 1991). This is reminiscent of the proposition founded in the resource-based view of the firm according to which successful diversification should be anticipated to occur "close to home," i.e., in industries related to the core competencies of the expanding firm (Leech, 1993; Streitwieser, 1991). Recent work has substantiated these earlier findings by providing strong evidence that knowledge plays a major role in affecting the technological diversification of firms and has to be accounted for in any analysis of firms' entry in emerging sectors. In fact "…firms extend their innovative activities across knowledge-related fields as a consequence of learning processes (either unintended in terms of spillovers or intended in terms of local learning) and of knowledge features and links (due to scope, complementarity or the generic nature of knowledge). Even the most technologically diversified firms patent in closely related fields." (Breschi et al., 2003).

While in principle the above is a straight-forward proposition, substantiating the implied causality from capabilities to patterns of diversification, the actual process of diversification is not. Consider, for example, Kodama (1995) who takes issue with the typical conceptualization of diversification as a spin-off process – essentially postulating that a technology is first developed for a high-end process and is subsequently extended to less technologically demanding, low-end goods. In environments where the co-

development of product and process technologies is the norm, he argues, business diversification follows the opposite trajectory: technical knowledge is first developed and applied to low-end markets. Instead of a "trickle-down" process, the accumulated technology and production experiences in the low-end markets direct development toward high-end markets in a "trickle-up" process.

The relation between the development of the firm's technological competencies and the diversification of its product range –i.e. business diversification- has been the focus of much work. Patel and Pavitt (1997) point out that firms tend to have a much broader range of technologies –measured by the technological areas of their patents- than products. They maintain that, while the forces of competition tend to restrict the scope of products which the firm may produce competitively, there are two causes that explain the need to spread its technological resources: a) the *technological interdependence* between the firm's products and processes and those of its suppliers and b) the *emerging technological opportunities* that the firm must familiarize with in order to identify potential contributions to future business opportunities. Lei (1997) focuses on this last issue and labels the processes through which the firm attempts to combine older, current and emerging technologies and the relative competencies as "technological fusion".

More complex explanations of the scope (direction) of firm diversification have been offered by evolutionary economics where establishing the boundaries of the firm has been a priority. Teece et al. (1994), for example, have proposed that learning, path dependencies, technological opportunities, the selection (competitive) environment, and the complementary assets of the firm determine the firm's boundaries – i.e., they determine the incentives to expand (contract) and the direction of expansion (contraction). Though attractive because they are based on multi-directional effects, such explanations have depended largely on primarily anecdotal evidence. What's more, they have dealt almost exclusively with diversification in manufacturing industries.

2. Hybridization and Emerging Technologies: Sector Definition[5]

The following working definitions were used in the research:

Knowledge-intensive service companies involve a substantially greater level of professional inputs (as measured by the employment of individuals with higher education qualifications) than the average of all service industries. A complementary definition

[5] This section is based on the TENIA paper "Hybridization and Emerging Technologies: Sector Definition for Empirical Work" by Ed Steinmueller.

relevant for some types of these companies is that they have organised innovation activities within which the elevated level of professional employment may be observed.

High-tech manufacturing companies are those where expenditures as a percentage of turn-over on organised innovation activities substantially exceeds the average for all manufacturing industry companies.

Fusion is the process of combining knowledge in the construction of complex integrated technological systems. It was hypothesised that fusion involves a higher degree of systemic integration than is required for combining 'components' from the service and manufacturing bodies of knowledge.

The above three points and the main research objectives of TENIA resulted in the following specific operational definition of the 'hybridisation' activities:

Hybridisation activities involve the combination of distinct competences or knowledge drawn from service and manufacturing-related activities. Firms within the three sectors chosen for examination of hybridisation – electronic commerce, multimedia, and business data communications – are engaged in a variety of different interactive relationships with hi-tech manufacturers.

Finally, the idea of a 'platform' (K. Imai), which can be thought of as a co-specialised asset (Teece) deriving from the combination of manufacturing and service sector knowledge assets, provided a useful basis for proceeding in the definition of the case studies and field work. Platforms are particularly important in the three selected sectors and involve combinations of hardware, software, and specific knowledge of the service market involving end users. The respective roles of service and manufacturing companies needed to be carefully considered since the product definitions supporting service provision are usually co-produced by both the service company and the manufacturer or a third-party software company.

A competence/knowledge results from either specialised experience or organised innovation activities, and it is rendered distinguishable when it becomes a 'resource' for the production of specific goods and services. The consortium took an agnostic viewpoint with regard to whether distinct competence or knowledge provides the basis for sustainable competitive advantage since many of the activities that we chose to investigate were not fully market tested. In this respect, our ambitions to judge the performance of particular arrangements were moderate. We were in a position to document perceived barriers and bottlenecks, but we were *not* in a position to definitely compare the performance of alternative arrangements. This was consistent with the aim

of examining the *processes* involved in hybridization. It, however, raises some problems in developing policy relevant conclusions from the investigation.

Following long deliberations, the TENIA consortium members decided that the specificity of involvement between manufacturing and services would need to be relaxed in cases where the 'platforms' involve incremental improvements that facilitate the extension of service offerings (e.g. new uses of telecommunication networks) rather than the production of an entirely distinct manufactured good (e.g. wireless personal digital assistants). It was also important to make distinctions between companies involved in a vertical relationship in which one is providing 'capabilities' that the other may exploit through the offering of complementary products. Examples of this include the possibility of dividing software companies according to those that produce 'primary' products that provide a basis (or platform) for other, 'secondary,' producers to offer complementary products. It remained, nonetheless, important to consider the reciprocal interaction between the 'platform' producer and service providers involved in 'interface specifications.'

Interface specifications can be pursued unilaterally in cases where the technological capabilities of the supplier or the supplying industry are well known. In innovative activities, however, requirements specification often involves additional processes of knowledge exchange (user-producer interactions) and collective learning (joint research or strategic research alliances). These processes can occur at different stages in the innovation process of either the service sector 'user' or the manufacturing 'supplier' and are likely to differ in nature in the 'pre-competitive' stage of development from those that emerge once the innovation (either from services or manufacturing) becomes fully commercialised. In addition to the interface specification process, there are a) the processes involved in taking account of feedback from the ultimate users of services, b) the process of financing 'platform' development, and c) the processes of interacting with regulatory authorities in producing 'platforms.'

In summary, hybridisation was considered to involve a variety of activities or processes related to combining distinct knowledge or competence to offer services or products. Hybridisation can be conceptualized as the construction of 'platforms' involving co-specialised assets constructed through processes of interactive learning and knowledge exchange within companies or between companies.

Three Chosen 'Sectors' and Candidate Hybrid Activities

Three 'sectors' were chosen for studying hybridisation activities:

- ***Electronic commerce***. The provision of business or personal services using electronic communication networks including (but not limited to) the Internet. Electronic commerce spans a very wide range of activities although it is often conceived of in terms of the 'dis-intermediation' of wholesalers, retailers, and other economic agents to provide direct marketing of goods or services to final customers.[6] Although electronic commerce has traditionally not been a widely recognised source of interactive relationships between manufacturers and service companies, changes may be underway, particularly in the area of mobile e-commerce applications.

- ***Telecommunication networks for business data***. The telecommunication delivery of business data is achieved through the use of some type of communication infrastructure extending beyond the boundaries of the firm (and therefore excluding traditional implementations of local area networks). Wireless and 'wired' telecommunication methods offer alternative infrastructures for these purposes. Data communication services have traditionally been defined either within the framework of the tariff structure of ('wired') network operators, e.g. leased data lines or packet service subscriptions or as 'value added' services not subject to tariff regulation. The advent of deregulation and the growth of data communication capabilities in the wireless network (which often utilises the 'wired' network to connect wireless receiving stations) has greatly complicated the range of service offerings in this market. Network operators have traditionally been very active in collaborating with manufacturing supplier companies in relation to the design of switching, transmission and terminal equipment. In recent years they have partially withdrawn from terminal equipment markets.

- ***Multimedia***. Multimedia is usually defined in terms of the encoding, transmission, and display of audiovisual information with a capacity for user interaction. This definition is usually not strictly observed and has therefore been applied to everything from television broadcasting to illustrated electronic books. Retaining the idea of user interaction, at a minimum in selecting from diverse content, is a

[6] All economic commodities that might generate commercial transactions through use of electronic communication networks are either intangible (as in the direct delivery of software or counseling services) or involve other services (delivery services in the case of books or groceries).

useful distinction to preserve. The bandwidth limitations of the Internet constrain the quality of multimedia offerings that can be made using this medium and Eurostat emphasises the significance of the CD-ROM medium as an alternative. It is also true that the television platform, often accompanied by a conditional access device (or 'set top box') provides another possible infrastructure for the distribution of interactive multimedia content. Although it is generally true that multimedia content production is a highly fragmented industry with little influence over the hardware produced, there are some segments where service provision is tightly coupled with content production and involves a greater degree of concentration and influence of the service/content producer.

An important aspect of 'hybrid' activities is the relative capacities of each of the potential partners in the exchange to influence the others. While each of the sectors does involve a mutual interdependence between 'platform' and 'complementary product or service' companies, the nature of these companies and their size are likely to have a significant influence on the knowledge exchange and collective learning processes involved in hybridisation.

Table 1 below briefly summarises these issues through stylized facts early this decade.

Table 1. Industry Structure in Chosen Hybrid Activities: Observations

	Electronic Commerce	Telecommunication of Business Data	Multimedia
Size of companies producing services	All sizes	Bifurcated: Large for network operators and medium or small for others	Generally small. Where service/content offerings are linked (e.g. digital TV service) larger companies may be involved.
Size of companies producing manufactures for use in hybrid activities	Large	Bifurcated: Mostly large in the case of telecom equipment, but some specialised terminal companies can be medium sized	Large
Resulting capacities for hybrid activities	Mixed: however, standard 'platforms' with little specific input from service companies dominate	Bifurcated: Highly negotiated outcomes between major players with smaller players either dependent on standard platforms or actively involved in hybridisation activities	Hybrid activities likely to involve co-ordination problems or 'user dominance' in the case of concentra-ted service/content markets

2.1. Candidate Activities in Electronic Commerce

There is little doubt that electronic commerce will eventually stimulate a variety of hybrid activities as specialised applications provide the basis for hardware implementation. At present, however, most electronic commerce services are based upon a series of 'platforms,' some of which may be regarded as 'legacy' systems from the pre-Internet era when a substantial number of business-to-business applications were developed using electronic data interchange (EDI). The maintenance of EDI systems remains a significant economic activity but is not likely to be an active locus of new development activities.

Most new developments in electronic commerce involve the Internet as a platform, either employing the Internet Protocol (IP) as a means of transporting data between applications or the WWW as a platform for application development. A promising application for study appeared to be the use of IP for data transport ranging from wireless applications and related standards such as WAP and WML to more traditional 'terminal session' type applications. After consideration in two meetings including extensive consultation with industrial experts, the TENIA consortium decided to focus on the area of mobile e-commerce applications (other candidates but excluded activities are noted in Annex 1).

- *M-Commerce: E-Commerce Applications Employing Existing Mobile Handsets or Those Under Development for UMTS Services*

Unfulfilled expectations about the rate of WAP handset deployment, as well as the oft-proclaimed shortcomings of WAP applications have created a fertile, if controversial, area for research. The roll-out of new (at the time of this research) services such as O2 and the transition to UMTS provided a further fertile area for investigation which elicited considerable partner interest.

2.2. Candidate Activities in Telecommunication Networks for Business Data

Of the three 'sectors' selected for study, the telecommunication of business data represents the most difficult area for the selection of candidate hybrid activities. While it is not difficult to map a vast array of service activities that involve the telecommunication of business data, it is more difficult to identify areas where these services specifically impinge upon the design of hardware or, correspondingly, where service innovation reflects the combination of knowledge from service providers and hardware manufacturers. This is primarily due to the ubiquity of data communication networks as a

basic infrastructure upon which both legacy and innovative services are defined for the telecommunication of business data.

In practice, the upgrading of the public switched telecommunication network is meant to provide *generic* capabilities for service definition so that specific service providers are neither advantaged nor disadvantaged. Moreover, it is one of the roles of telecommunication regulators to attempt to ensure that new entrants are not disadvantaged by specific developments in the public switched telecommunication network. While it is true that the generic capabilities of the telecommunication network reflect 'hybrid' activities, the scope and complexity of these activities is enormous, reflects a long historical development, and entails highly proprietary interactions between telecommunication equipment producers and network operators. A larger scale project than TENIA would be necessary to properly examine this single hybrid activity for any of the bigger European countries. Thus, more completely developed examples of hybrid activities in the telecommunication of business data should involve activities that occur at the periphery of the public switched telecommunication network. In some cases these activities involve more distant communication than others.

With these reservations in mind, two activities were selected:

- *Mobile Data Communications*

The very rapid diffusion of 2G mobile communications technology created 'overheated' expectations about the business potential of 3G technologies at the end of the 1990s, not least in the field of wireless data communications for business applications, as well as for consumers. Huge sums of money have been invested by telecom operators in 3G licenses (more than $100bn) and the telecom hardware companies have invested large sums as well. A gap has however emerged between expectations created and the actual possibilities in the medium term. 3G will probably at best be capable of transmission rates about 330 Kb/s if the 3G infrastructure can be diffused within the next 2-4 years. On the other hand, alternative technologies are emerging that may facilitate very high transmission speeds over short distances. Wireless Local Area Network solutions (WLAN) offer possibilities for short distance high speed wireless connections to the Internet, for those who are willing to move to the 'hot spots' with wireless access. The winning standard appears to be the IEEE 802.11 family of solutions, of which 802.11b is already on the market with up to 10 Gb/s with 100-150 m distance and the 802.11a (so-called WiFi) offering up to 50 Gb/s follows closely. These technologies can be implemeted in PDAs, laptop PC, etc. and can potentially be considered as competitors to the 3G system itself. One may talk of 'premature' 4G solutions emerging at present representing a

significant step towards integrating wired and wireless data communications systems. The WLAN technologies are in general considered more as potential complementary technologies to the existing 2G and 2.5G technologies. In this part, TENIA was decided to focus on the fusion between the wired and wireless world.

- *Dedicated Network Services Such as ASPs and Data Warehousing Services*

The improving Internet infrastructure is providing support for increasingly complex services and the storage of growing volumes of information. These services and data are being combined with or replacing earlier generations of technology created to deliver application services to users and the data collected by a vast array of more specialised data collection techniques. Application service providers (ASP) are actively supporting the re-engineering of legacy systems for both application delivery and data analysis as well as engineering new applications. Some of these activities will involve a fusion between new hardware and services offerings; in others the element of fusion involves the interaction between legacy and newer systems.

2.3. Candidate Activities in Multimedia

The multimedia 'sector' involves both Internet and alternative content distribution channels. While producers of multimedia content are clearly 'service' firms in formal definitions of the industrial sectors, such as those underlying the NACE codes, this is because they produce 'intangible' or informational goods. In practice, the mass reproduction of CD-ROMs involves manufacturing processes and the distribution of tangible artefacts even though these artefacts are only the repositories of information content. The basic problem with examining 'hybrid' activities in the case of multimedia is the relative dominance of a specific platform, the multimedia-enabled personal computer (personal computers with CD-ROMs are usually also equipped with the capacity for Internet connection). There have been other important European multimedia platforms, but these have largely been eclipsed by the growth of the share of Japanese games consoles. European firms do continue to command a major position in DVD equipment, but these are only nominal multimedia products. Despite these limitations, there remain important instances of European producers of multimedia related hardware, such as Guillemot, which, under the Hercules label, produces high performance graphic adapter cards for multimedia personal computers.

- *Electronic Book and Cross Media Production*

The development of various types of e-book platforms for the electronic distribution of text (often supplemented by illustrations or other capacities) and other material

(sometime called cross-media content) represents the effort to create a new 'platform' for the electronic distribution of multimedia content. E-books have not yet achieved a significant market position and the reasons for this are worthy of investigation as well as the potentials for European firms to have an active role in development of this market. More generally, the relation between e-book software, hardware, and content production was considered an area for investigation.

- *Educational Software*

It is well recognised that educational software is needed for European schools and that such software will have specific content relevant to particular national curricula. This need has provoked a number of specific development efforts. Of particular interest is the development of Internet-based educational services for higher and life-long learning. Case studies in this area would need to refine the issue of platform to service provision interaction, i.e. generic Internet tools *per se* are not sufficiently novel to qualify as emerging technologies for these purposes.

- *Multimedia Services on Digital Television Platforms*

The provision of digital television services over cable and satellite as well as the problems encountered in developing terrestrial digital television services provides an important area for examination. The principal focus of case studies in this area would be the provision of interactive services employing the conditional access device (set-top box).

All six candidate areas listed above, distributed in the three pre-selected 'sectors', were selected on the basis of criteria of potential economic impact, intuition about the possibility of gaining access for in-depth interviews, and likelihood of interaction between hardware and service providers. In addition to extensive internal deliberation, the consortium partners solicited the opinions of a large and diverse group of experts in the different countries from the private sector and academia. The list of activities was finalized through an iterative and consultative process.

3. Exploratory Empirical Analysis

In early stages of the project two consortium partners engaged in exploratory work into possible usage of publicly available data towards the creation of quantitative indicators of hybridization. For that purpose, one team used patent application data from the European Patent Office (EPO) and the other used data of research partnerships funded through the Framework Programmes.

3.1. Analyzing the Emergence of New Industrial Activities through Patents[7]

This study draws its theoretical background from the existing literature on keywords and co-word analysis (Courtial, Callon and Sigogneau, 1993; Van Raan and Tijssen, 1993; Noyons and van Raan, 1998; Ding et al., 2000) and proposes an innovative empirical approach to the emergence of new technologies and new industries through patent data. The basic idea is to identify new and hybrid technologies by selecting relevant couples and triplets of words (keywords) from patent abstracts and to perform a co-occurrence analysis on these keywords in order to understand which are the technologies (or products and applications) that most frequently appear together. This allows to detect hybrid technologies in the ICT area as well as to identify the emerging ones by looking at the growth rate of their occurrence.

3.1.1. Preliminaries

The analysis follows a bottom-up approach. It starts by selecting a set of technological classes that we identified as related to the ICT areas of interest. The outcome of this process is the identification of 22 technological sub-classes belonging to H01, H03 and H04 macro-classes of the International Patent Classification, version 7 (Annex Table 13). This process allows us to compute the number of patents and patenting firms by technological class and country, and to analyse the evolution of patent activity in selected classes over time. Annex Table 14 shows descriptive statistics regarding the number of patents and patenting firms by country and by technological class.

Attempting to match the pre-selected 'sectors' with patent technological classes, this approach can be criticized for not permitting to identify emerging technologies nor hybrid technologies. Knowledge domains are *a priori* determined, therefore excluding the possibility of capturing emerging technological fields: computing the number of patents in pre-determined technological classes does not allow to identify hybrid activities that may result from the fusion of different technologies. Another shortcoming refers to the consideration that the selected technological classes may not cover all the innovations developed within the ICT-related areas of interest and may instead capture innovations that are not strictly linked to those activities.

The emergence of new technologies and industrial activities related to ICT is examined by adopting a two-fold approach, based on the identification of keywords and the

[7] This section is based on the TENIA paper "Analyzing the Emergence of New Industrial Activities: Some Methodological Issues" by Nicoletta Corrocher and Fabio Montobbio.

performance of co-word analysis. These are two available ways to extract words from publications. The first consists of extracting words from keyword lists, title, and sometimes even classification codes. Coulter et al. (1998) select descriptors chosen by professional indexers, considering that professional indexers' experiences assure standard application of that taxonomy. Noyons and van Raan (1998) utilise the co-occurrence of classification codes. This methodology has a main shortcoming: indexing might reflect the prejudices and points of view developed by indexers during the course of their training and the probable inconsistencies in keyword selection by professional indexers working for different databases. The second way of finding words involves extracting words directly from full-text documents by using some software or by developing specific algorithms. The words or sets of words with a certain frequency are chosen as the subject of co-word analysis to represent the core topics of the specific field.

This analysis took patent abstracts as the unit of analysis. In order to identify patents that refer to ICT, we selected eight technological classes belonging to the sections of *Physics (G)* and *Electricity (H)* of the International Patent Classification v.7: G01 (measuring; testing); G06 (computing; calculating; counting); G09 (educating; cryptography; display; advertising; seals); G11 (information storage); H01 (basic electric elements); H03 (basic electronic circuitry); H04 (electric communication technique); H05 (electric techniques not otherwise provided for). A time period of six years was considered (1995-2001). It is worth mentioning that there is a lag of 18 months between the priority date of a specific patent at the European Patent Office and the appearance of that patent in our database, which means that some data from 2001 are missing. The final sample consisted of 108,000 patents' abstracts.

3.1.2. Keyword Analysis: An Example

In order to provide a preliminary analysis of ICT-related technologies, relevant keywords are identified from books, reports, papers, articles and other sources of information. The final list includes 58 keywords (Annex Table 15).

It is possible to examine the occurrence of these keywords in patent abstracts by technological class over time. This allows us to account for the emergence of new technologies and for the process of hybridisation of existing and new knowledge bases. As far as the emergence is concerned, it is possible to detect it by counting the number of patents in which a specific keyword appears and by examining the rate of growth of its occurrence over time. In this respect, the analysis considered following years: 1995-1996 and 1998-1999. Regarding hybridisation, it is possible to approach it by examining the

simultaneous occurrence of a specific keyword in patents belonging to different technological classes, as well as the shift of that keyword across different technological classes over time. When analysing the degree of hybridisation of a specific technology, two issues appear to be relevant: the number of technological classes in which the keyword appears and the degree of concentration of the keyword in different technological classes - as measured by the Herfindal index. Annex Table 16 illustrates the results of the analysis.

The analysis provides interesting results. When looking at the total number of patents, the most common keywords are the following: Multimedia, Internet Protocol, Asynchronous Transfer Mode, Local Area Network, Mobile Phone, Code Division Multiple Access, Wireless Network, Compact Disc, Ethernet, Time Division Multiple Access. This ranking is consistent with the importance of different technologies in the ICT area, particularly with the leading role of multimedia and the Internet, mobile phones and associated technological standards. However, relevant information also derives from the analysis of the rate of growth of technologies and products, since the picture is different. Table 2 ranks technologies by growth rate over time.

Table 2. Growth Rate of the Occurrence of Keywords

Keyword	Growth rate	Keyword	Growth rate
Digital Versatile Disc	1000,0%	Global System for Mobile Communication	50,0%
Fast Ethernet	800,0%	Broadband Access	33,3%
Internet Protocol	555,0%	iMode	18,2%
Wireless Internet	500,0%	High Definition Television	16,7%
General Packet Radio Service	300,0%	Multimedia	1,6%
Electronic Data Interchange	200,0%	Cell Relay	0,0%
Wireless Application Protocol	200,0%	Compact Disc	-4,3%
Universal Mobile Telecommunication System	200,0%	Cable Television	-7,4%
Synchronous Optical Network	200,0%	Local Area Network	-7,9%
Mobile Phone	197,2%	Token Ring	-20,0%
Code Division Multiple Access	172,2%	Hypertext Markup Language	-22,2%
Digital Subscriber Line	163,6%	Wide Area Network	-22,7%
Virtual Private Networks	150,0%	Asynchronous Transfer Mode	-27,2%
Metropolitan Area Network	133,3%	Advanced Intelligent Network	-28,6%
Wireless Network	125,7%	Time Division Multiple Access	-36,1%
Closed Circuit Television	100,0%	Direct Broadcast Satellite	-50,0%
Interactive Television	93,8%	System Network Architecture	-50,0%
Network Interface Card	83,3%	Asynchronous Time Division Multiplexing	-50,0%
Digital Video Broadcast	83,3%	Internetwork Packet Exchange	-50,0%
Digital Audio Broadcasting	72,7%	Video-on-Demand	-73,7%
Ethernet	57,6%	Integrated Service Digital Network	-75,0%

The analysis of the growth of keywords in patent abstracts reflects the characteristics of technological change within specific fields and provides interesting insights concerning the emergence and evolution of technologies. The first example is given by the evolution of mobile technologies and mobile phone standards over time. If we look at the Table, Global System for Mobile Communication (GSM- 2nd generation) grows less than General Packet Radio Service (GPRS - 2,5 generation) and less than Universal Mobile

Telecommunication System (UMTS - 3rd generation). However, UMTS grows less than GPRS, meaning that patents related to this technology are still few. Similarly iMode, Wireless Internet and Wireless Application Protocol (WAP) have been growing considerably, but the first technology is still under examination and it is currently successful mostly in Japan: therefore its occurrence within patents' abstracts is increasing at a lower rate as compared to Wireless Internet and WAP, which constitute more established advancements in mobile technologies all over the world.

Another relevant example is given by the evolution of the transmission protocols used in local area networks (LAN). Indeed LAN developments are marked by the emergence of competing technological standards for developing the infrastructure: the first standard was Token Ring, followed by Ethernet and Fast Ethernet. The growth rates of the occurrence of these three keywords within patents' abstracts reflect the subsequent appearance of different standards in the area, with Fast Ethernet growing at a 800% rate between the two sub-periods, Ethernet growing at 57.6% rate and Token Ring recording a negative growth rate (-20%).

Third, if we look at the technologies which improve access speeds, it is possible to draw some important corresponding to the development and diffusion of multiple networks for the delivery of multimedia content - fixed, mobile and satellite. One of the most relevant technologies (or family of technologies) for fixed networks is Digital Subscriber Line (DSL), which allows the local loop of telecommunication carriers to carry a much greater volume of digital information and has the effect of widening the bottleneck of local access speed to the Internet: this technology shows a growth rate of 163.6%. If we compare DSL with Integrated Service Digital Network (ISDN), the first example of a network with a high digital bandwidth for business and consumer applications, we see that ISDN displays a negative growth rate (-75%), indicating the obsolescence of this technology. Direct broadcast satellite also shows a negative growth rate (-50%), despite the number of innovative applications that are possible using this network infrastructure. This may be due to the fact that some of the advanced functionality of planned new-generation set-top-boxes is in an area where the development of standards, or the implementation and deployment of standards, is immature (Steinmueller and Mansell, 2001). Finally, Wireless Network exhibits a high growth rate (125.7%): this is consistent with the idea that the mobile telephony network is one of the most promising infrastructure for the delivery of multimedia services, at least across European countries.

Another area of development related to ICT concerns the optical discs: the evolution of technological standards is indeed well depicted by the growth rate of relevant keywords in patents' abstracts. Several important improvements have characterised the optical disc

market in recent years, and the CD format has reached a maturity stage of its life-cycle. At the same time, a new life cycle has emerged with the introduction of Digital Versatile Disc (DVD) in the market-place. Looking at the occurrence of these two devices in patents' abstracts, DVD records the highest growth rate (1000%), while CD shows a negative growth rate (-4.3%). Similarly in the field of broadcast TV it is possible to observe the good performance in terms of growth rate of interactive television (+93,8%) and digital video broadcasting (+83,3%) with respect to high definition TV (+16,7%) and cable TV (-7,4%), which is in line with the most recent developments in the area.

One last example refers to the competition between different packet-switching technologies, in particular Internet Protocol (IP) and Asynchronous Transfer Method (ATM). The technological evolution in this area has been characterised by the existence of network externalities, so that the dynamism of IP expansion has disrupted plans for the upgrading packet-switching within the core of the networks maintained by telecommunication operators, which were started, at the European level, with the development of ATM. The evidence from patents' abstracts on these technologies suggest that IP is growing fast (555%), while ATM is decreasing in importance (-27.2%).

Following the emergence of different technologies, the degree of technology hybridization was also analyzed. We can consider two indicators: (a) the number of technological classes in which each keyword appears and (b) the Herfindal index which measures the concentration across technological classes of the patents in which the keywords occur (Table 3).

Table 3. Technology Hybridisation

Keyword	Number of classes	Herfindal
iMode	7	0,295
Multimedia	7	0,466
Local Area Network	6	0,679
Mobile Phone	6	0,678
Cable Television	5	0,710
Code Division Multiple Access	5	0,894
Compact Disc	5	0,622
Wireless Network	5	0,801
Asynchronous Transfer Mode	4	0,948
Ethernet	4	0,736
Synchronous Optical Network	4	1
Digital Audio Broadcasting	3	0,840
Digital Subscriber Line	3	0,888
Fast Ethernet	3	0,594
Time Division Multiple Access	3	0,862
Wide Area Network	3	0,576
Advanced Intelligent Network	2	0,905
Digital Video Broadcast	2	0,889
Direct Broadcast Satellite	2	0,680
Electronic Data Interchange	2	0,556
Global System for Mobile Communication	2	1
Interactive Television	2	0,841
Internet Protocol	2	0,911
Metropolitan Area Network	2	0,654
Network Interface Card	2	0,500
Universal Mobile Telecommunication System	2	1
Wireless Internet	2	0,680
Asynchronous Time Division Multiplexing	1	1

Broadband Access	1	1
Cell Relay	1	1
Closed Circuit Television	1	1
Digital Versatile Disc	1	1
General Packet Radio Service	1	1
High Definition Television	1	0,583
Hypertext Markup Language	1	0,599
Integrated Service Digital Network	1	1
Internetwork Packet Exchange	1	1
System Network Architecture	1	1
Token Ring	1	1
Transport Control Protocol	1	1
Video-on-Demand	1	1
Virtual Private Networks	1	0,722
Wireless Application Protocol	1	1

Multimedia and iMode are the technologies that appear in the highest number of technological classes. However, there is a significant difference between the two in term of Herfindal index: Multimedia shows a relatively high value of this index, implying that the occurrence of this technology is concentrated within specific classes (in particular 300 patents in H04 and 139 patents in G06), while iMode exhibits a low index, meaning that this keyword occurs more evenly across different technological classes. Local Area Network, Mobile Phone, Code Division Multiple Access, Wireless Network, Compact Disc and Cable Television also appear in a considerable number of the selected technological classes.

As mentioned earlier, the approach in this Section has a limitation in that it utilizes pre-conceived keywords, which identify already existing technologies, products, and platforms. While the results are interesting, the analysis does not help generically to identify emerging new technologies. Nevertheless, the approach allows us to detect which are the most frequent and fastest growing technologies and which of them cut across different technological classes. In order to make a further step, it was decided to couple the keyword approach described above with a bottom-up methodology in order to identify relevant technologies without imposing any pre-determined keyword when examining the content of patents' abstracts. This bottom-up methodology requires a two-

step process: first, the generation of couples and triples of words within patents' abstracts; second, the performance of co-word analysis.

3.1.3. Co-word Analysis: Methodological Steps in Identifying New Technologies and Knowledge Domains

Co-word analysis counts and analyses the co-occurrence of keywords in the publications of a given subject and has the potential to map the relationship between concepts and ideas in sciences and social sciences. It reduces and projects the data into a specific visual representation with the maintenance of essential information contained in the data (Ding et al., 2000). It is based on the nature of words, which are the important carrier of scientific concepts, idea and knowledge (van Raan and Tijssen, 1993). Relevant applications of this methodology can be found in different fields such as software engineering (Coulter et al, 1998); scientometrics (Courtial, 1994); neural network research (Noyons and van Raan, 1998; Van Raan and Tijssen, 1993); patents (Courtial et al. 1993); medicine (Rikken et al., 1995).

This type of analysis relies upon the assumption that a text's keywords constitute an adequate description of its content or the links the paper establishes between problems. Two keywords co-occurring within the same paper are an indication of a link between the topics to which they refer. The existence of many co-occurrences around the same word or couples/triples of words identifies a strategic alliance within texts that may correspond to a specific research topic. Co-words analysis reveals patterns and trends in a specific discipline or technological field by measuring association strengths of terms that are representative of relevant publications produced in this area. The main advantage of this methodology is that it visualises the intellectual structure of a specific scientific or technological field into knowledge maps of this field and that a the evolution of these maps over time.

Our analysis, which is performed on patents' abstracts instead of patents' titles as done elsewhere (Courtial et al., 1993), involves as a preliminary step the extraction of couples of words, in order to identify the most relevant and the emerging technologies, products and applications that cut across different ICT-related technological classes. The extraction of couples of words leave us with 3,000,000 couples, out of which we select the most frequent ones (frequency $\geq$100). Looking at the list of couples, some problems emerge. First, it is quite difficult to identify relevant technologies, since some couples have a very generic meaning. Related to this, there are many useless couples that are made of articles, prepositions, adverbs and so on: in order to solve this problem and to eliminate useless couples, an *a priori* "cleaning" of patents' abstracts is required. In doing

so, one has to remember that, by deleting some elements in the abstracts, words that were previously separated now become very close to each other. Finally, because of punctuation, couples of words that indicate the same technology appear as two different couples (i.e. "Communication network," "Communication network."). As a consequence, there is an overestimation of the number of couples, but an underestimation of the frequency of occurrence of relevant technologies within patents' abstracts.

Once a research subject is selected, a matrix based on the word co-occurrence is built. The value of the cell of two words is decided by the times these two words appear in the same document. The higher the co-occurrence frequency of the two words means the closer relationship between them. The matrix is then transformed into a correlation matrix by using specific correlation coefficients. In order to map the data, the most commonly used methods are multidimensional scaling and clustering techniques; other methods include the use of specific software. For example, following Ding et al. (2000), a useful methodology is to adopt hierarchical clustering techniques with Ward's method to divide the available keywords (couples and triples of words) into different clusters. Subsequently keywords with the highest frequency in each cluster are chosen to represent the cluster, so that the coarse general overview map is achieved by using multidimensional scaling techniques to represent the overall positions of the clusters in the field.

The extraction of couples and triples of words leads us to interesting results, which can be exploited in order to build a knowledge and technology map in the ICT areas. Annex Table 17. illustrates the triples that appear with a frequency >150.

Useless sets of keywords must be eliminated, referring to terms that could be used in the description of any modern electronic system and that therefore do not distinguish any relevant element of a given system from another. An example of such a term is *power supply voltage*: all electronic devices have a power supply and all of these power supplies have voltages; whether the power supply voltage is mentioned or not is inconsequential for our purposes. Within the provided list, there are still some generic terms that are very likely to be used in description of any modern electronic system and that only provide limited distinguishing information. For example, the printed and wiring circuit boards tell us that this is a multi-component system, and the central or data processing unit and memory tell us that the device has some intelligence. Since virtually all systems of interest are multi-component and have some degree of processing capacity, the terms do not add much. Among the generic keywords, there are some whose relevance is difficult to detect. A good example in this respect is *light emitting diode*: while virtually any modern electronic system may incorporate a light emitting diode (e.g. a power on

indicator), the inclusion of this detail in a patent may indicate an essential element of the system (e.g. an infra-red controller or an emitter that is meant to couple with a receiver).

Once all the couples and triples that appear in patents with a certain frequency have been extracted and compared, the research of the new technologies can proceed with the co-word analysis of a selected set of keywords. The implicit assumption is that the frequent co-occurrence of two or three keywords likely identifies a relevant hybrid technology or application. Such analysis allows proceeding along several lines of research:

- First, one can examine the emergence and evolution of new technologies, by computing the growth rate of these technologies in patents' abstracts and the shift of technologies across technological classes.

- Second, one can analyse the network underpinning the development of innovative activities in terms of knowledge links (citations), technological collaborations and communities of inventors.

- Third, one can investigate the role of firm-specific technological diversification, by looking at the specialisation of firms in different technological classes.

- Fourth, one can depict the patterns of innovative activities in the relevant technological classes, in terms of firms characteristics, concentration, entry and exit.

- Finally, one can identify the technological proximity in terms of properties and nature of different knowledge basis.

3.2. European Research Partnerships[8]

A further possible source of useful information for devising quantitative indicators of emerging hybrid activities can be alliance databases. Several such databases exist, including the SDC database of Thompson Financial, the CATI database maintained at Maastricht University, and other sectoral databases such as BIOSCAN for biotechnology. In this project we used the EU-RJV database developed by NTUA which focuses on research partnerships funded through the European Framework programmes. Six years of data were used for this exploratory search of traces of hybrid activity, including

[8] This section draws on the TENIA paper "A Preliminary Descriptive Analysis of the TENIA Database of Research Joint Ventures" by Aimilia Protogerou and Stavros Ioannides.

consortia funded through FWPs during 1995-2001. The programs that funded these consortia were ESPTIT 4, TELEMATICS, 2C, and ACTS from the 4th Framework and IST from the 5th Framework. These programmes were considered the most relevant to the technology areas studied in TENIA.

Keyword analysis was used to isolate the research partnerships that dealt with the hybrid activities technologies. A long list of keywords were identified through an iterative process with technical experts (Annex Table 18.).They were applied on individual cooperative R&D project objectives. All in all, 234 research partnerships were found to include one or more of these keywords in their description. They are distributed across the hybrid activities as in Table 4.

Table 4. Research Partnerships by Hybrid Activity

Hybrid Activities	RJVs	RJVs (%)
Dedicated networks	9	3,9
M-commerce	33	14,1
Mobile links to the internet	40	17,1
Digital TV	50	21,4
Educational software, e-book/cross media	102	43,6
Total	234	100,0

Given that the object of TENIA was to study emerging hybrid activities, the question of how the number of RJVs in each such activity changes between the 4th and the 5th FWPs is of great significance (Table 5). It should be emphasized that the data for FWP5 is incomplete as coverage stops in 2001; we do not have projects initiated during the last year of the programme (2002). The important finding here is the spectacular rise in the number of RJVs in three hybrid activities (dedicated networks, m-commerce and mobile links to the internet), bearing in mind that the total number of RJVs in our database remains roughly the same between the 4th and the 5th FWPs. This might be considered as tentative indication as to the overall significance of the hybrid activities that the TENIA consortium has chosen to investigate. It is reinforced by Table 6 showing rapidly growing numbers of participants between FWP4 and FWP5 in these activities.

Table 5. Partnership Change by Hybrid Activity Between 4th and 5th FWPs

Hybrid Activities	4th FWP	5th FWP	% Change
Dedicated networks	2	7	250,0
M-commerce	8	25	212,5
Mobile links to the internet	9	31	244,4
Digital TV	28	22	-21,4
Educational software, e-book/cross media	67	35	-47,8
Total	114	120	5,3

Table 6. Participating Entities in 4th and 5th FWPs

Hybrid Activities	Participating Entities	
	4th FWP	5th FWP
Dedicated networks	16	54
M-commerce	60	218
Mobile links to the internet	72	172
Digital TV	157	140
Educational software, e-book/cross media	376	234
Total	681	818

'Entities' are firms (F), universities (U), and other research institutes (R). Annex Table 19 shows the frequency of participation by entity type. Less than 5% of them have participated in more than four cooperative R&D ventures during the examined seven years. Companies represent the majority of entities across all hybrid activities (Annex Table 20.). Linkages that involve all three kinds of entities dominate the cooperative research partnerships funded by the Framework programmes (Annex Table 21.). In addition, TENIA partnerships tend, on average, to be of larger size than the consortia in the rest of the 4th and 5th FWP projects (Annex Figure 16).

The important point here is that such information could potentially be utilized for obtaining information about the ways actors combine to tackle new opportunities. The limitation is the extent of information available about the activities of the individual ventures. To the extent that such an obstacle is removed (e.g., through the provision of supplementary information on venture activities through the regular annual surveys of the Commission), the partnership data could provide a powerful analytical tool. With

sufficiently long time series – say, ten to fifteen years – network analysis on the base of this enhanced data could point out the technology areas where networks are thickening and others where networks are thinning. In parallel to the type of patent analysis described in the previous Section, such an investigation would point out more directly and accurately the areas where detailed concurrent information need to be obtained through surveys and case studies in order to provide timely and valuable input to the policy process of government agencies planning ahead.

4. Case Studies of Hybrid Activities

4.1. General Framework

A case study could potentially take any of the three approaches shown below:

1. Sectoral study	2. Project management	3. Technology management
Define: Market Actors Interactions (dynamic evolution) Barriers and accelerators	Who gets involved (actors)? How the actors get involved? What are the objectives of their collaboration? Barriers and accelerators	Manage, exchange, recombine knowledge processes

TENIA case studies concentrated on project management, with important elements from the sectoral approach. They were formed around the following basic elements:

1) **Activity description:** Activity is a product/process that has a first market application or has reached the stage of a concrete plan for commercial launch by the firm or another organization during the past 2-3 years (it is not necessary that the product is already a success). The focus is on activities that represent a fusion between separately evolved knowledge bases.

2) **Market description:** Market is the collection of potential users (in the eyes of the studied company) of this application. The concept of market includes the identification of rivals and competitors.

3) **Actors:** Market participants, controllers/regulators of the market, producers of knowledge relevant to the activity, and financial institutions.

4) **Key actors: A**ctors who can move or block the process of fusion or its commercial application.

5) **Documentation:** Basic background documentation on key actors including such elements as ownership, employees, sectors, technologies and products.

6) **Interaction:** Fusion/technology hybridisation typically involves interaction between key actors. Such interaction can be characterized as a process with a beginning, middle and an end:

The beginning:

- Starting the interaction. Key actors start developing a product/process which is to be eventually commercially offered.

The middle:

- Partner identification. How, why, when did the responding organization involve one or more partners.

- Organization. How did the responding organization organize to search and design the new product or process.

- Network coordination.

- Barriers to the process and how they were overcome.

- Most "important" developments during the lifetime of the project.

- Light at the end of the tunnel. The responding organization becomes confident that the process will come to an end.

The end:

- Actual commercial offering, concrete plan for commercial launch.

- Subsequent actions. What was done next. Feedback. Moving into other activities.

4.2. Case Study Methodology[9]

The case studies focused primarily on interactions among key actors and gathered information on three overarching issues:

- The objectives with which the actors establish interactions with technology providers, technology co-developers, and users. These objectives are in great part determined by the competencies of the actors and their location in the industry being considered, that is, by the characteristics of the inputs they need in order to coordinate and integrate their output into the broader innovative processes taking place in the industry.

- The strategies adopted by those actors with the objective of establishing interactions with other entities that collaborate in the development of those hybrid technologies.

- The problems faced during these interactions: for example bottlenecks and inefficiencies observed during the transmission and reception of information, which might be caused by intellectual property, competitive and epistemological issues.

The interactions were, broadly speaking, classified on the basis of two qualitative variables, the role of the partner and the power balance between the partners. Potential partners include users and co-developers as well as providers of technology that is an input to the actor's activities. The shape of interactions is also bound to be strongly influenced by the relative power of the participants. The intersection of these two variables will indicate a certain cell configuration for interaction (i.e. "interaction of agent x with a more powerful technology provider") that implies a greater possibility of interactions adopting a certain shape (e.g., "having to buy an 'off-the-shelf' technology that has been developed with no specific feedback from the actor"). Each configuration can be associated with a set of issues and potential problems for the actor (e.g., "a strong possibility of a lack of adaptation of the technology to actor's needs", "a necessity of hiring intermediate actors for the implementation of the technology" etc). The result of this approach is the **TENIA case study matrix** which contains a series of configurations for interactions between technological partners. The TENIA case study matrix is shown in Table 7.

From the matrix in Table 7 we can extract five different shapes of interactions:

[9] This section draws extensively on the TENIA paper "Methodology and Implementation of TENIA Case Studies: E-Books and M-Commerce" by Juan Mateos Garcia.

- Feature request/feature implementation

This refers to a relationship between a powerful technology user and a less powerful technology provider(s). In economic terminology, this is a monopsony in which the user party can carry out its transactions in advantageous conditions, basically by defining a "space" of required specifications with which the technologies supplied by (competitive) providers and assigning a contract to the supplier who fulfils these specifications more efficiently. This type of interaction is depicted in Figure 2.

The interactions between users and developers will be recursive, stretching far beyond the actions of defining and implementing requested features. During the uncertain process of feature request and implementation, demands of users may have to be reduced or modified in order to adapt to the uncertainties and shortfalls of the technology development process as well as to changes in the economic or technical environment. Technology providers may need additional information about user needs as the technology development process advances, both before and after the selection of the party that will be in charge of the provision of the technology. The cyclic nature of the process of redefinition, reinterpretation and implementation of features was taken into account during the interviews.

- Interface specification/interface compliance

This configuration is similar to the feature request/feature specification described above: in this case, a powerful party in charge of the development of a component of the technological platform defines a set of rules (an interface) with which components ("complementors") created by other developers should comply in order to be accepted inside the platform. This interface is the expression of the technological capabilities and objectives of a party that, because of its power, can force others to adapt the components they are developing to its demands (embodied in the interface specification). Amongst the incentives the weaker developers might have to comply is that of making their product compatible with a winning platform, this making it possible for them to benefit from its popularity/network effects. This type of interaction is depicted in Figure 3.

The issues, strategies and complications in this configuration appear and unfold in a dynamic way as milestones of technological development are successfully (or not so successfully) reached. Again, the modification of interface specification and complementors taking place as the innovative process unfolds was given special attention in the interviews. The presence of events such as a need for a redefinition of specifications or a reassessment of compliance, their causes and the way they are

perceived, handled, communicated and interpreted by the actors taking part in these interactions were determined and analysed.

- Independent design/"off the shelf" purchase of a technology

In this configuration there is a technology developer that is powerful enough as to develop a generic "off the shelf" technology without the need to implement or adapt it to the specific organisational setting of individual, differentiated users. If the cost that this lack of adaptation represents for the latter is high we may observe the emergence of third parties specialising in the provision of technology "customisation" and "troubleshooting" services (we will define these third parties as "implementers"). This case represents a reversal in the power balance present in the feature request/feature implementation configuration. This type of interaction is depicted in Figure 4.

The interaction between parties engaged in the "independent design/off the shelf purchase" configuration is recursive, and the shapes and channels through which it takes place adapt and develop as new events such as a need for redesign in the product, the discovery of not addressed user needs etc. emerge, are perceived and dealt with. As in the previous cases, special attention was given to these dynamic aspects of the interactions.

- Shared definition of requirements

In this case we find users and technology developers of a similar power engaging in a negotiated, bi-directional process aiming at feature determination and the shaping of a certain technology. This case shares similarities with configuration I above, but here, given the greater bargaining power of technology developers, features are negotiated instead of simply requested and implemented. This redefinition of the power balance present in this configuration brings forward new issues for the parties involved. This type of interaction is depicted in Figure 5.

The interaction taking place between the participants in this configuration was also analysed from a dynamic perspective, taking into account how unpredicted events in technology design and development affect established channels for communication, prompt the creation of new ones, etc.

- Joint development of technology

In this configuration there is a group of technology developers of similar power engaged in the collective development of a technological platform, probably through the definition of some interface specification that makes it possible for components that have been

independently developed to interact efficiently with each other. The issues present here are parallel to those described for configuration II above, but with the additional considerations stemming from the fact that imposition of standards, interfaces and capabilities by a more powerful party is replaced by negotiation between equally powerful parties. Again, we find specific forums and institutional channels (such as standard-setting organisations or partnerships) where the dialogue that constitutes collective technological development takes place. This type of interaction is depicted in Figure 6.

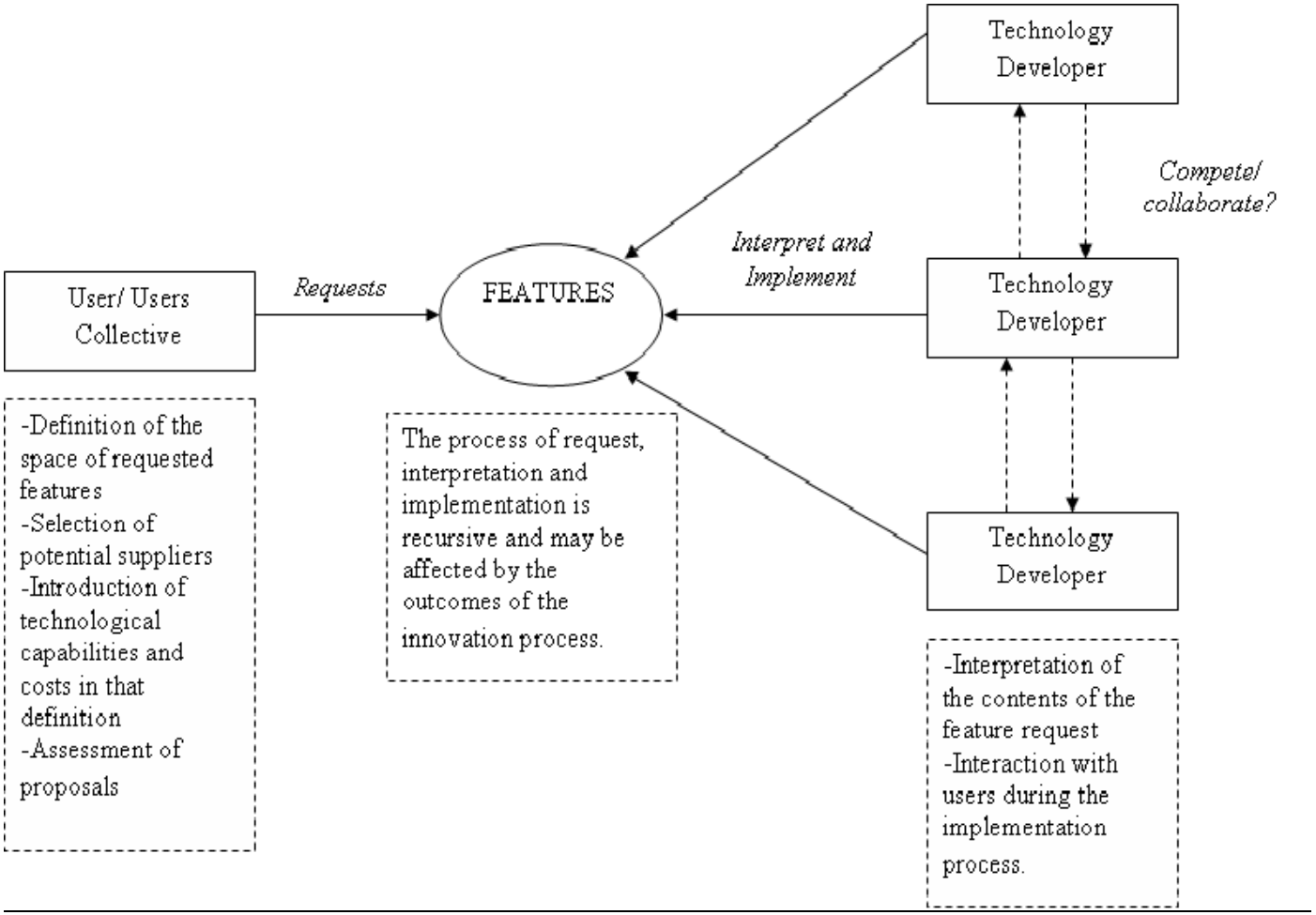
The recurring nature of innovative processes taking place inside a joint development effort make it necessary to adopt a dynamic perspective when analysing the channels of communication, forums established, strategies adopted and problems faced by its constituents.

Table 7. TENIA Case Study Matrix: Type of Interactions

	Interaction with technology providers	**Interaction with technology users**	**Interaction with technology co-developers**
Larger size/power than the other party	**Feature Request** (I.e. a supply contract)	**Independent design of the technology** (taking into account feedback from selected users, or including as many features as possible)	**Definition of interface specifications** (with which other developers of other components of the platform have to comply)
Equal size/power as the other party	**Joint definition of features** (provision of feedback for technological design),	**Joint Definition of features** (maybe through a partnership or inside a standard setting forum)	**Joint development of the technology** (possibly inside a standard setting organisation)
Smaller size/power than the other party	**"Off-the-shelf" purchase of the technology**	Feature Implementation	**Compliance with interface specifications** (defined by other co-developers)

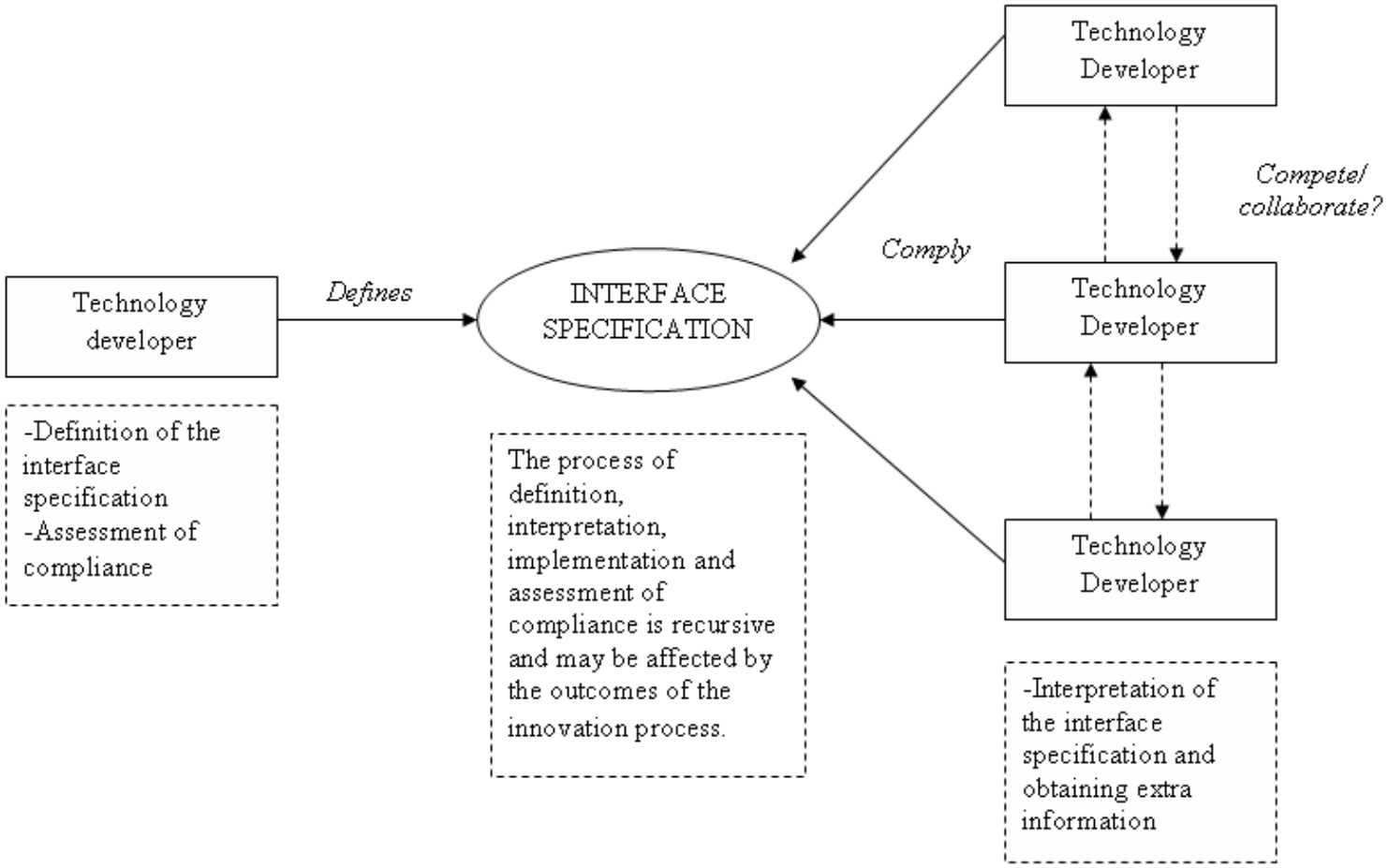
Source: Mateos-Garcia (2003)

Figure 2. Issues Present in the 'Feature Request/Feature Implementation' Interaction Configuration



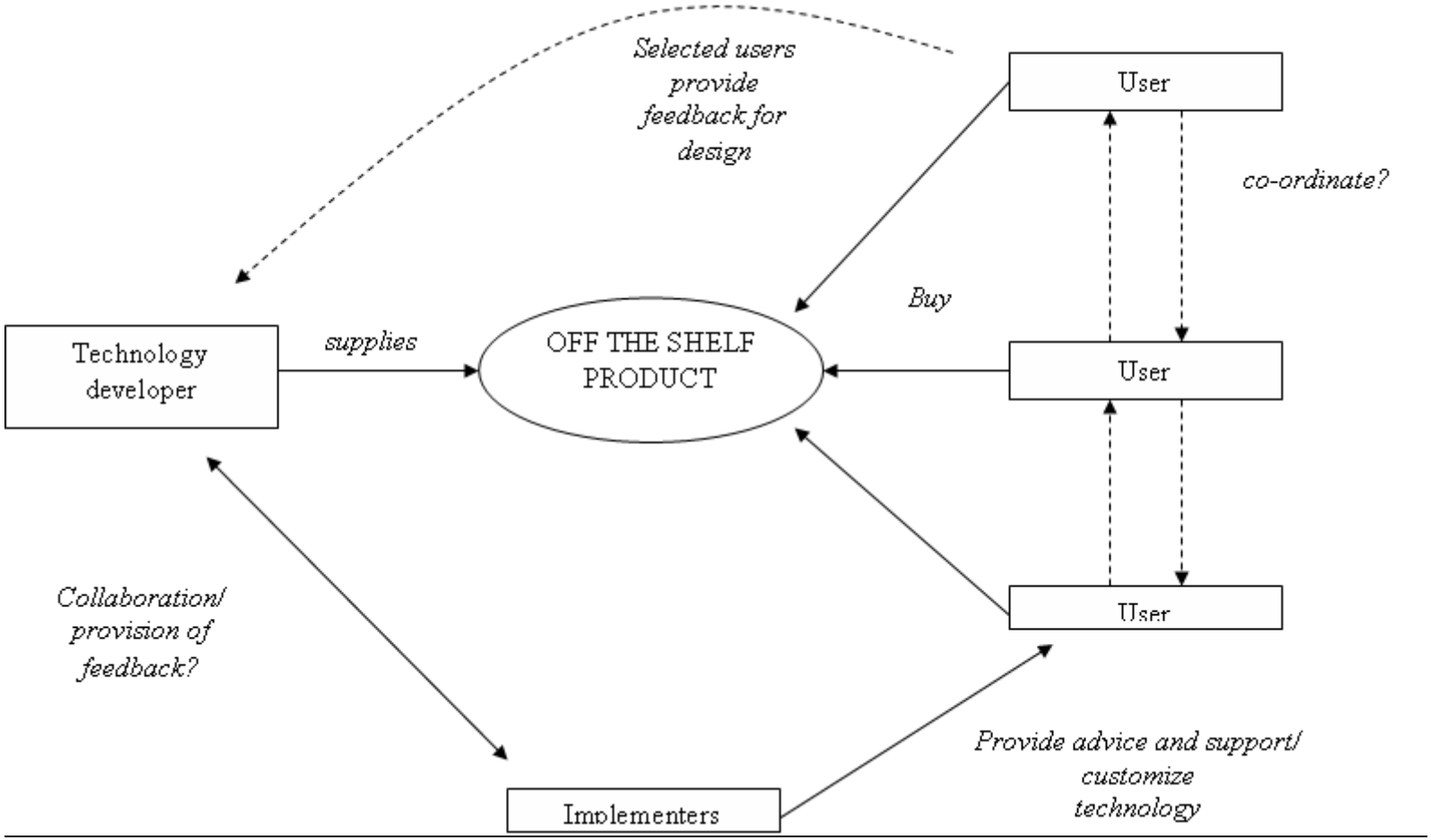
Source: Mateos-Garcia (2003)

Figure 3. Issues Present in the 'Interface Specification/Interface Compliance' Interaction Configuration



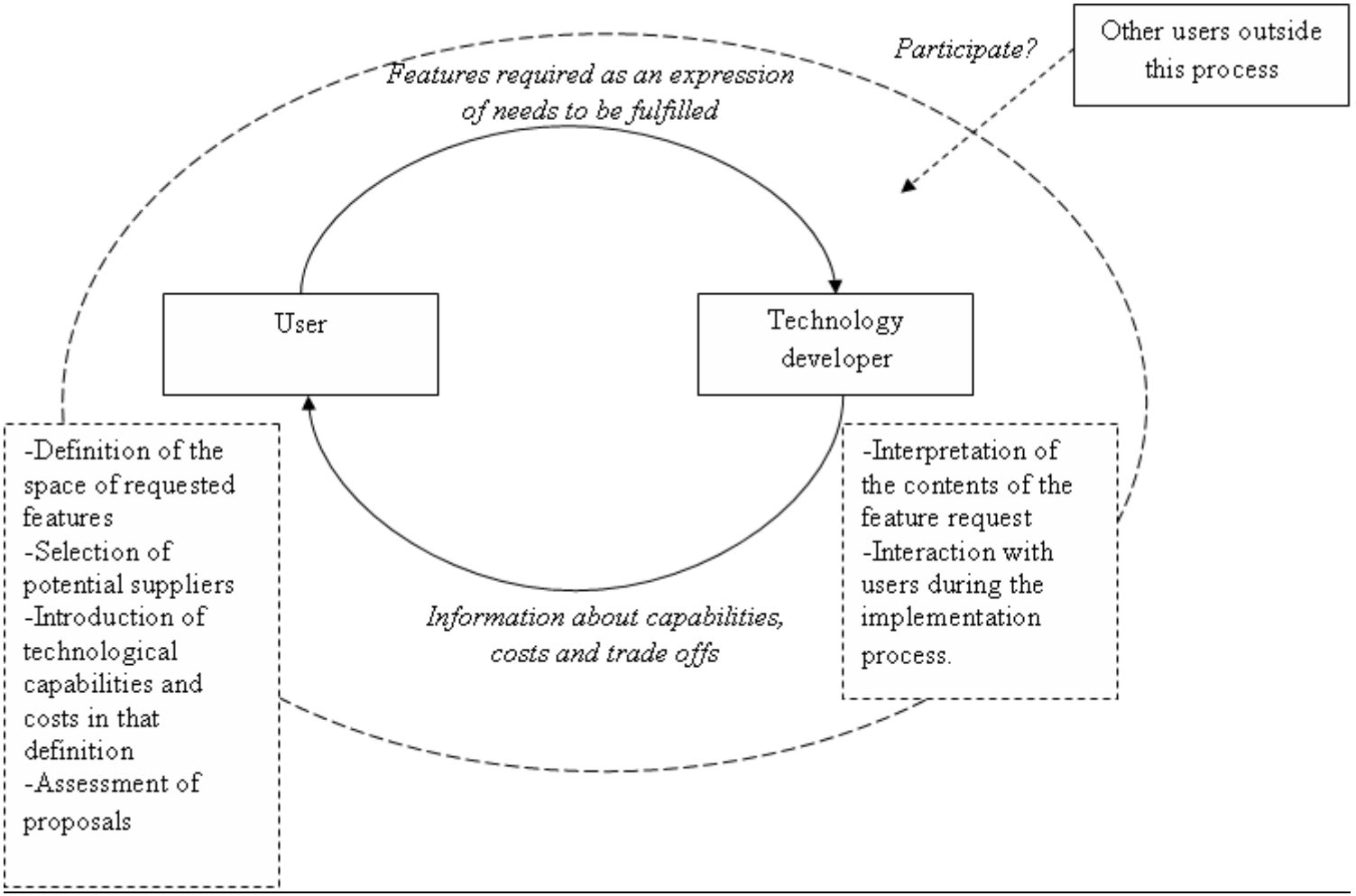
Source: Mateos-Garcia (2003)

Figure 4. Issues Present in the 'Independent Design/Off-the-Shelf Purchase of Technology' Interaction Configuration



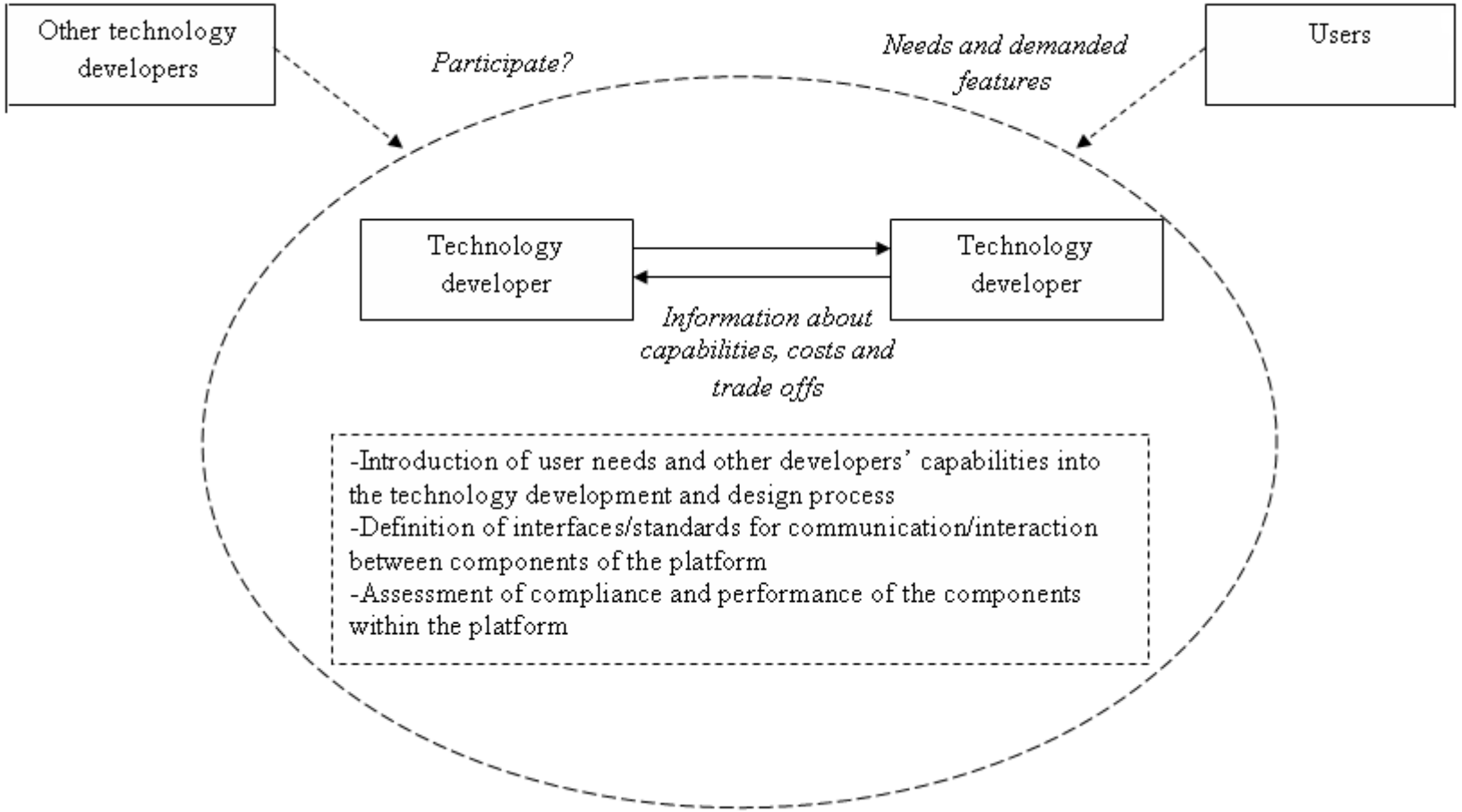
Source: Mateos-Garcia (2003)

Figure 5. Issues Present in the 'Shared Definition of Requirements' Interaction Configuration



Source: Mateos-Garcia (2003)

Figure 6. Issues Present in the 'Joint Development of Technology' Interaction Configuration



Source: Mateos-Garcia (2003)

4.3. M-Commerce[10]

The actors in m-commerce are the operators, non-network operators and manufactures of mobile phones, financial organisations, content- and platform providers (including diversifiers of the mobile platform), retailers, users (consumers) and regulatory bodies. These are connected in a wide variety of ways in order to create a successful mobile Internet focusing on value added for the user.

In TENIA the m-commerce industry is described as being formed by a service infrastructure supporting mobile transactions between different groups of actors and high technology providers, which supply service providers and actors with technology that makes the mobile transactions possible. The high technology providers both provide hardware and software (García and Steinmueller, 2003). The service infrastructure contains mobile operators, financial organisations and others. The actors can be consumers, users and retailers i.e. firms selling ring tones, logos, information services directly to the consumers. The consortium adopted the schematic of the m-commerce offered in Mateos-Garcia (2003). It is reproduced in Annex Figure 17.

Confronted with the realities of an industrial activity in its early evolutionary stages, the partners in this consortium embarked on a series of Europe-based case studies in order to study the processes leading to the development of "hybrid" technological platforms in m-commerce,. Multiple case studies across a number of countries carried out under a single methodology seemed the most appropriate way to approach a fluid industrial field. Regularities, as well as differences, were anticipated to arise across several case studies. Table 8 lists the case studies in m-commerce.

Table 8. Case Studies in M-Commerce

<u>Denmark</u>
The Digital Mall
Mobital and Mobile Gatekeeper
Personalized Mobile Broadband Services
MobileContent
The Mobile Employee
Remote Monitoring of Cardiac Patients

<u>Germany</u>
Mobile Payment *(Paybox.net AG)*
eHealth *(Vitaphone GmbH)*

[10] This Section draws on the TENIA report "M-Commerce" by Nicholas Vonortas which presents the cases in much greater detail. The report reflects the collective research activity of all five consortium members that contributed annual reports on this area of hybrid activity.

Greece
Mobile Force (*American Computers and Engineers SA*)
A Fleet tracking and Management System (*Spacenet SA*)
GroupSMS (*FORTHnet SA*)
Mobile content platform (*Eurocom Expertise SA*)
M-payment/M- vending platform (*Asyrma Ltd*)

Italy
Bankpass Mobile

United Kingdom
Simpay *(Vodafone, T-Mobile and Telefónica)*
Source O2 Revolution *(O2)*
RedRock Software *(Netstore PLC)*
Consult Hyperion

Case Summary

Using the illustration of the main components of the m-commerce industry in Annex Figure 17, the m-commerce cases in Table 8 can be spread out to obtain a visual representation of their qualitative distribution across the industry landscape. Figures 7-10 do that for the cases investigated in Denmark, Greece, Germany, and the United Kingdom respectively.

The impression one gets is of Danish cases spreading all over the map, British cases concentrating more on the mobile telecom operators part of the graph, German cases one step lower at the intersection of operators and high tech service providers, and Greek cases resembling those of Germany and keeping close to the market. Not unexpectedly, perhaps, the case studies have covered the 'supply' side of m-commerce (telecom operators, high tech providers, service providers) more extensively than the 'demand' side of (retailing and individual consumers) with a couple of exceptions from Denmark.

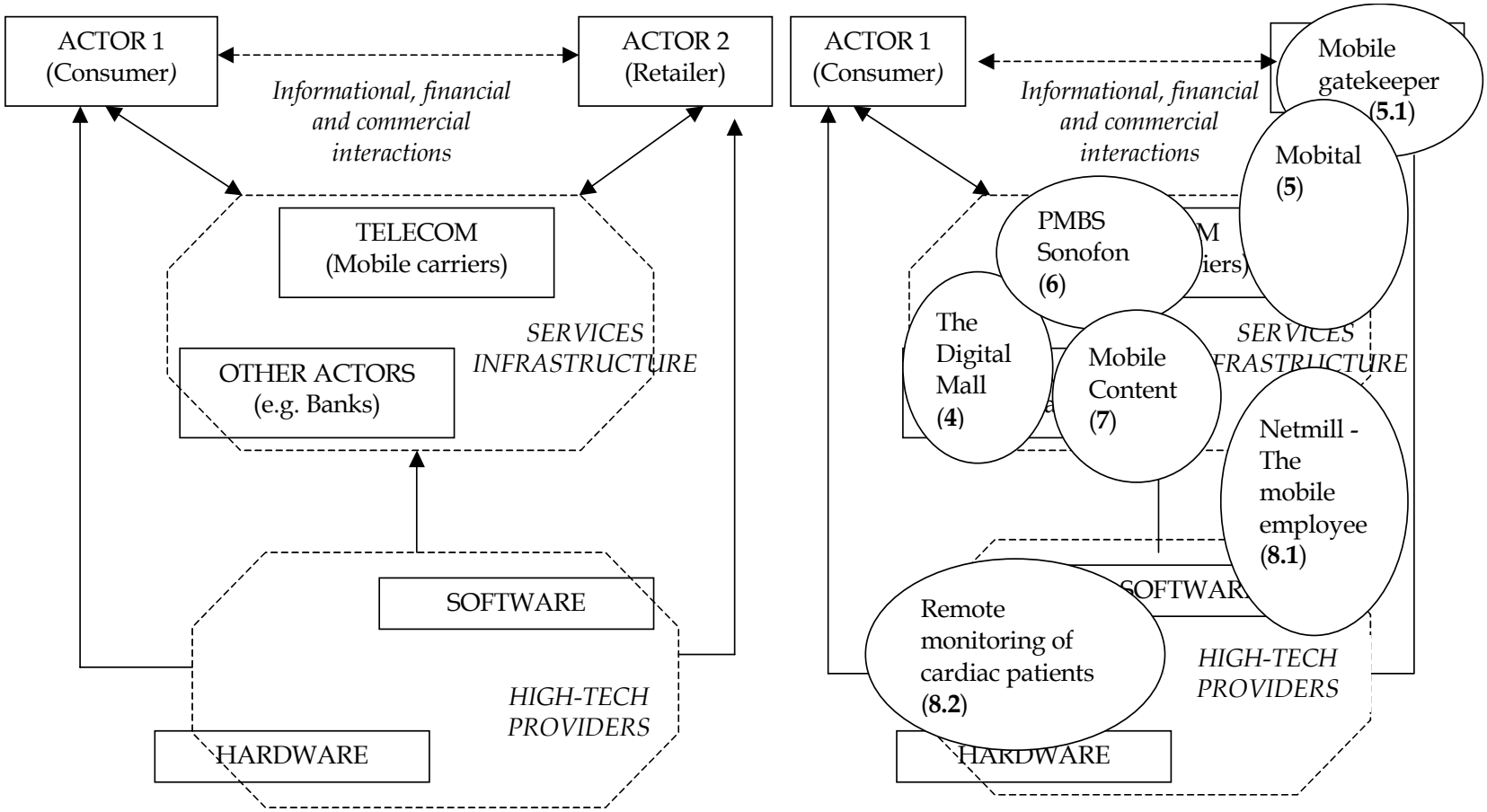
Given the objective of TENIA to analyze the collaborative processes that take place between service and manufacturing companies engaged in the development of 'hybrid' technological platforms, the TENIA case study matrix (Table 7) was used to summarize the results. Annex Tables 22-25, then, allocate the main interactions of the key actors in the investigated cases across this matrix for Denmark, Germany, Greece, and the United Kingdom. Table 9 below summarizes the results across all five countries represented in the consortium.

A caveat is warranted at this point. It must be stressed that the allocations on Table 9 – and, thus, Annex Tables 22-25 – are not based on a rigorous appraisal but rather on the qualitative judgement of the team members conducting the case studies. Moreover, it should be emphasized that an activity may receive multiple allocations, which is quite in

accordance with the intent of the matrix: the relationship of the key actor with technology users may well be of a different nature that her relationship with technology providers and technology co-developers. The relationship may even vary with different partners in each of these three categories. The subsequent discussion is based on the assumption that the value judgements of the case study analysts are correct. We are aware that the lack of analytical rigor makes many of the arguments below speculative rather than conclusive.

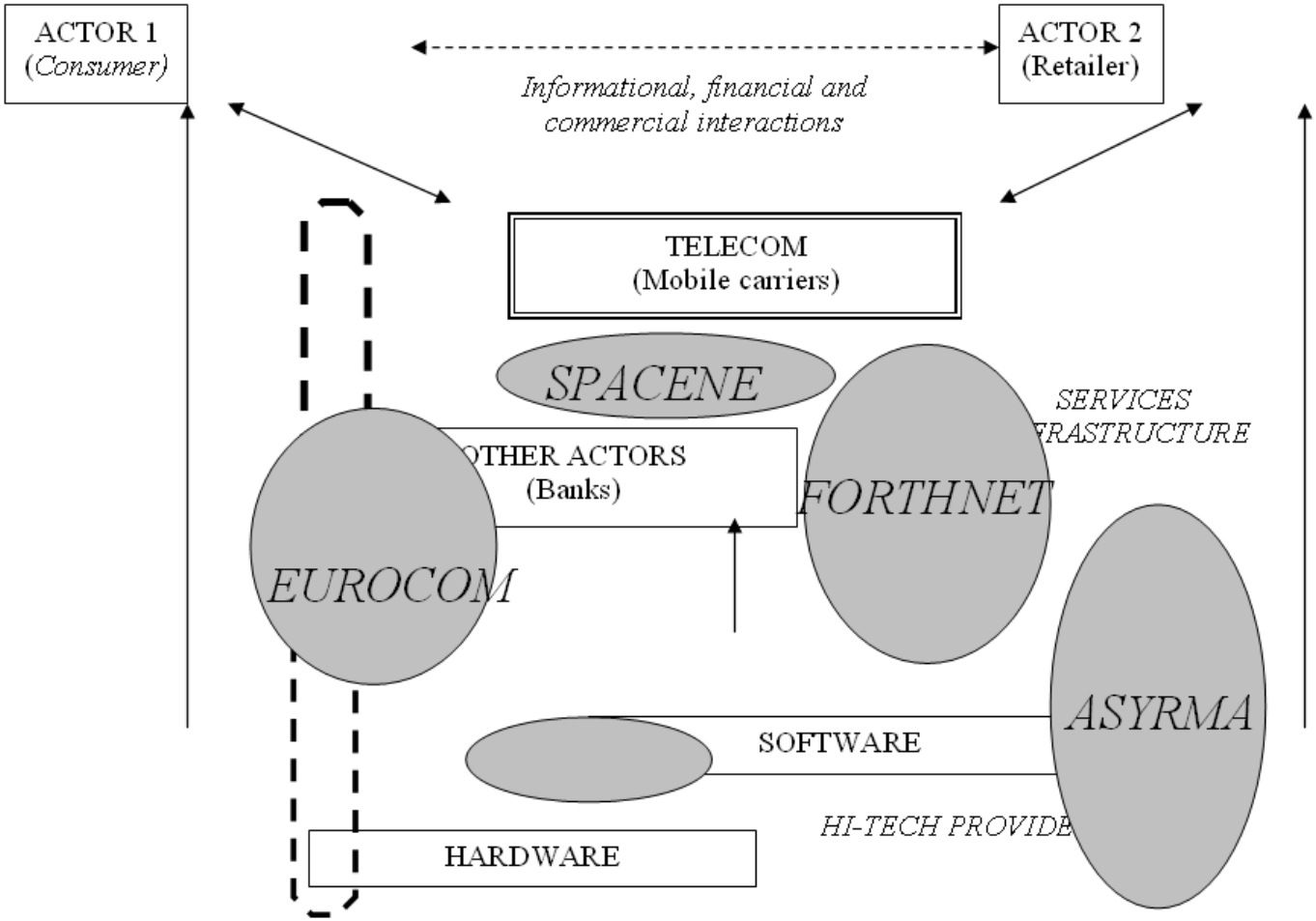
The first impression from the visual representation is that the investigated activities in all countries are spread out all over the map. The German matrix is significantly thinner than the rest, but refers to only two cases. The Danish and Greek matrices are much denser, referring to six and five cases respectively. The British matrix lies in between with four cases.

Figure 7. M-Commerce Industry Structure and Objects of Analysis in Denmark



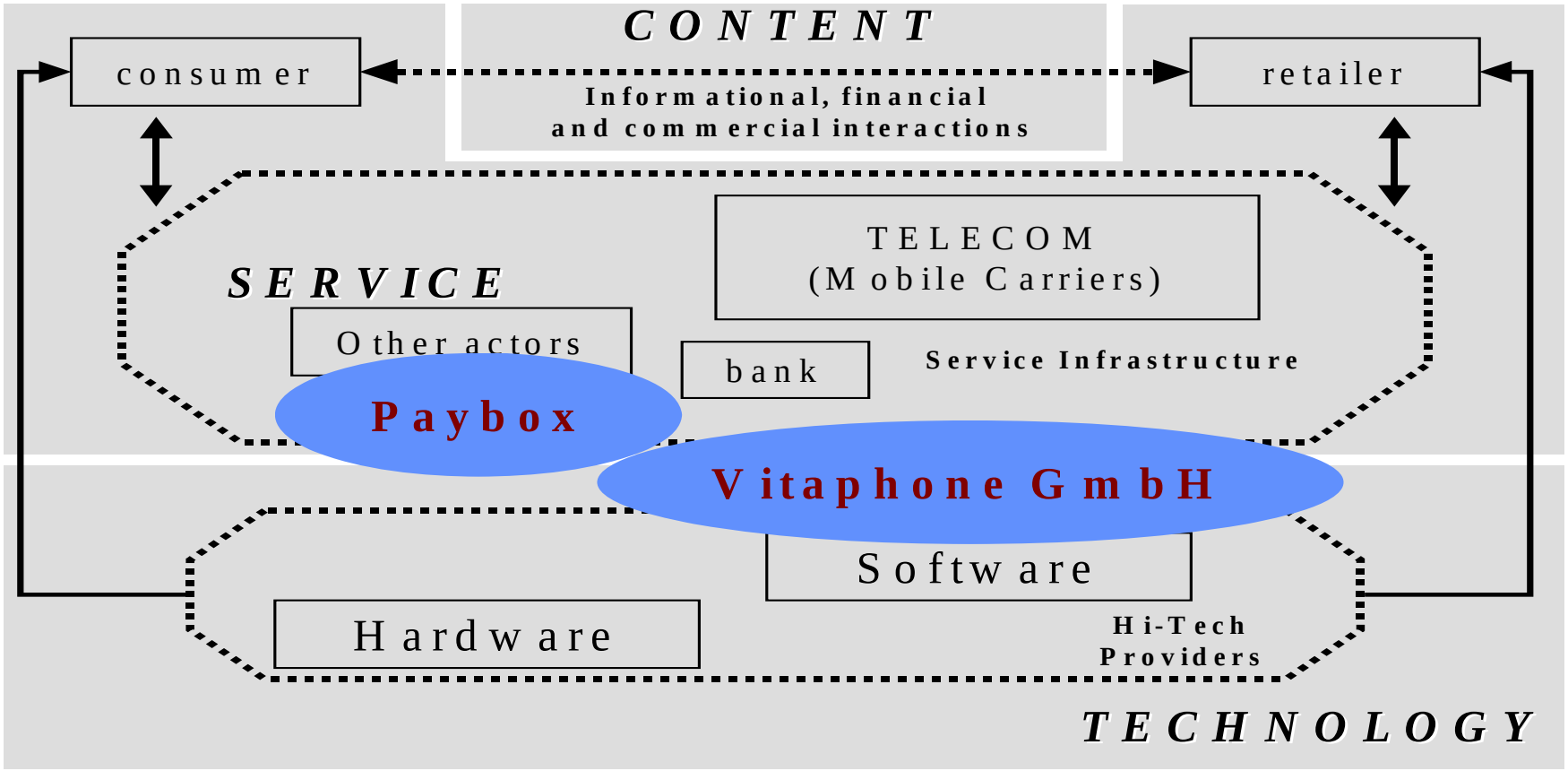
Source: Pedersen and Dalum (2003)

Figure 8. M-Commerce Industry Structure and Objects of Analysis in Greece



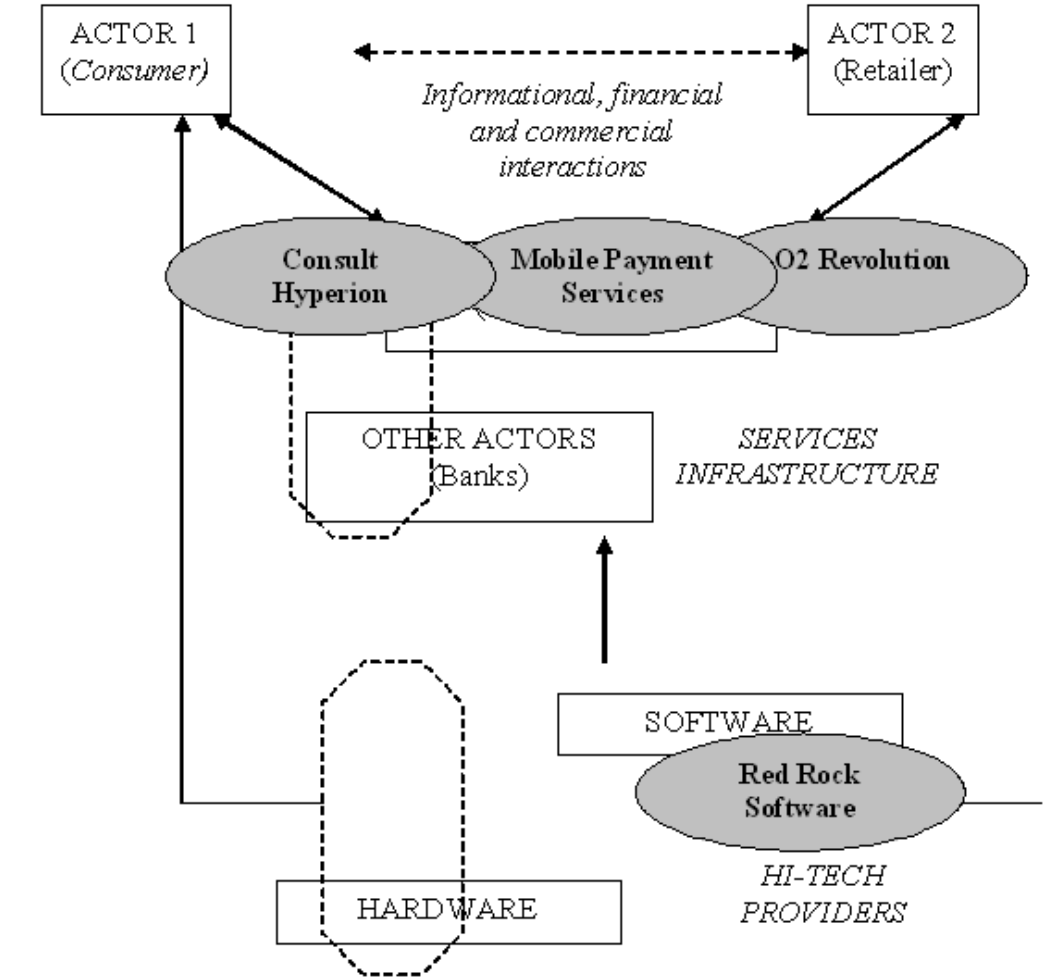
Source: Protogerou and Tsakanikas (2003)

Figure 9. M-Commerce Industry Structure and Objects of Analysis in Germany



Source: Kimpeler (2003)

Figure 10. M-Commerce Industry Structure and Objects of Analysis in the United Kingdom



Source: Mateos-Garcia and Steinmueller (2003)

Table 9. Type of Interactions of Key Actors Across All Investigated M-Commerce Cases

	Interaction with technology providers	Interaction with technology users	Interaction with technology co-developers
Larger size/power than the other party	The Digital Mall (D) Vitaphone GmbH (G) Revolution O2 (UK) Consult Hyperion (UK)	The Digital Mall (D) PMBS (D) Mobital (D) Net-Mill (D) Vitaphone GmbH (G) Asyrma (Gr) Spacenet (Gr) Bankpass Mobile (I) Redrock Software (UK) Consult Hyperion (UK)	PMBS (D) Spacenet (Gr) Eurocom (Gr) Bankpass Mobile (I) MPSA (UK) Consult Hyperion (UK)
Equal size/power as the other party	Mobile Content (D) Mobile Gatekeeper (D) Spacenet (Gr) Bankpass Mobile (I) Consult Hyperion (UK)	Mobile Content (D) Paybox.net AG (G) ACE (Gr) ForthNet (Gr) Spacenet (Gr) MPSA (UK) Redrock Software (UK) Consult Hyperion (UK)	The Digital Mall (D) Paybox.net AG (G) Spacenet (Gr) MPSA (UK) MMMS (UK) Redrock Software (UK) Consult Hyperion (UK)
Smaller size/power than the other party	Remote Monitoring (D) Mobile Gatekeeper (D) PMBS (D) Net-Mill (D) Paybox.net AG (G) ACE (Gr), Spacenet (Gr) Asyrma (Gr), ForthNet (Gr) Consult Hyperion (UK)	Net-Mill (D) Remote Monitoring (D) ACE (Gr) Eurocom (Gr) ForthNet (Gr) Asyrma (Gr) RedrockSoftware (UK) Consult Hyperion (UK)	Remote Monitoring (D) Vitaphone GmbH (G) ACE (Gr) Eurocom (Gr) Asyrma (Gr) Redrock Software (UK)

Closer inspection reveals that one of the three sets of partners receives more attention by the key actors: (technology) users. The middle column of each of the four country matrices contains relatively more entries than the other two. All three strategies – independent technology design, joint feature definition, and feature implementation – are heavily populated. A relative exception is the UK where the key actors in only two out of four cases have had cultivated explicit working relationships with technology users. The reason the other two (O2 and Simpay) didn't is apparently due to the fact that they include the largest European mobile telecom operators that (a) may feel they have the necessary 'pull' and (b) address the general public.

Heavy emphasis on interaction with users is important for business success. It also goes against the conventional wisdom developed in the first two sections of this report alleging that the European apparent weakness in rolling out successful m-commerce cases has been in large part due to a heavy technology strategic orientation and lesser ability to 'capture' consumer needs. The ability to 'capture' the needs may have been lagging, alright, but that does not seem to be a result of lack of effort on the part of the key players.

The second most active set of partners is technology co-developers (third column). Half the Danish cases, all German and Greek cases, and three-fourths of UK cases reported some kind of active interaction with co-developers. There are more cases here where key actors comply with the interface specifications defined by other co-developers and where they develop technology jointly with partners and somewhat less where the examined key actors are the ones who define the interface specifications for others to comply with. Notable exceptions include the PMBS case in Denmark where Sonofon is a large telecom player, Simpay in the UK including the four largest European mobile operators, and the Mobile Force (Eurocom) and Fleet Tracking (Spacenet) cases in Greece where smaller companies have managed to be ion the driving seat in their relationships with technology co-developers. The remaining key actors had either equal or less bargaining power than their co-developers.

Two conclusions result from this picture. First, relations with technology co-developers attract a lot of attention among m-commerce entrepreneurs in Europe. Second, if our sample is statistically representative, then, there appears that m-commerce entrepreneurs (key actors) mostly fight an uphill battle when it comes to collaborating with technology co-developers.

An interesting phenomenon arises when it comes to interaction with technology providers. By far the most widely used strategy among our examined key actors in the

two smaller countries (Denmark and Greece) is to purchase technology off-the-shelf. Four out of six in Danish cases and four out of five Greek cases followed that strategy. The same was true with one of the two German cases. Only three cases – one from each Denmark, Germany and the UK – where the key actor actually dominated the suppliers of technology were in the mix. The lesson is fairly apparent and concurs with conventional wisdom: m-commerce entrepreneurs (key actors) from small countries keep their ear close to the ground, are closer to the market, and make do with equipment that already exists in the market so that they decrease their dependency on technological advances that they cannot control.

Finally, one can infer from these tables that the negotiating power typically rests with the large mobile telecom operator. They provide a critical link that ties many of the pieces of the puzzle together, verifying the schematic of the m-commerce industry in Figure 8. They must thus occupy a central position in policies aiming at m-commerce. This raises interesting questions at a time when they are laden with a heavy debt burden.

4.4. Telecommunication Networks for Business Data[11]

4.4.1. Background

The area of telecommunication networks for business data concerns the development of fixed and mobile networks for value added services mostly directed to business users. The transmission of data is currently achieved through the use of different communication infrastructures, which extend beyond the boundaries of the firm. Data communication services have traditionally been defined either within the framework of the tariff structure of ('wired') network operators, e.g. leased data lines or packet service subscriptions, or as value added services not subject to tariff regulation. The advent of deregulation and the growth of data communication capabilities in the wireless network, which often uses the wired network to connect different wireless receiving stations, have increased and made significantly more complex the range of service offerings in this market. Network operators have traditionally been very active in collaborating with manufacturing supplier companies in relation to the design of switching, transmission and terminal equipment. However, other important actors are now playing a role in the definition of the network features and in the implementation of different infrastructures for the provision of customised services. These actors can be found in the users of these infrastructures, particularly big manufacturing and service firms and the government.

[11] This Section draws on the TENIA report "Telecommunication Networks for Business Data" by Nicoletta Corrocher which presents the cases in much greater detail. The report reflects the collective research activity of four consortium members that contributed annual reports on this area of hybrid activity.

The development of fixed and mobile networks for the provision of value added internet services is based upon the *fusion* of different technologies, firms' competencies and sectoral boundaries. The process of hybridisation in this specific case is identified in the emergence of an integrated model, whereby it is possible to envisage a division of labour within the vertical value chain for the provision of the above-mentioned services. Technological convergence in the telecommunications sector, particularly between the fixed and mobile technological environment, has driven the combination and integration of old and new technologies, as well as the coordination of different firms.

Recent technological developments have relied upon the process of digitalisation, which has considerably increased the capacity of the network, and upon the introduction of broadband infrastructure (fibre optics) and access technologies (the DSL family). Furthermore, a major boost has stemmed from the upgrading of the Internet. This network is based upon a traffic principle in which high capacity 'pipes' or backbone capacity are used to connect major centres of usage such as urban areas and international networks. In recent years there has been a considerable development of infrastructure capacity in order to serve the exploding demand for the carriage of Internet traffic, much of which consists of business data. Large companies wish to achieve high quality of service from their suppliers and the suppliers have responded by creating services which meet these needs.

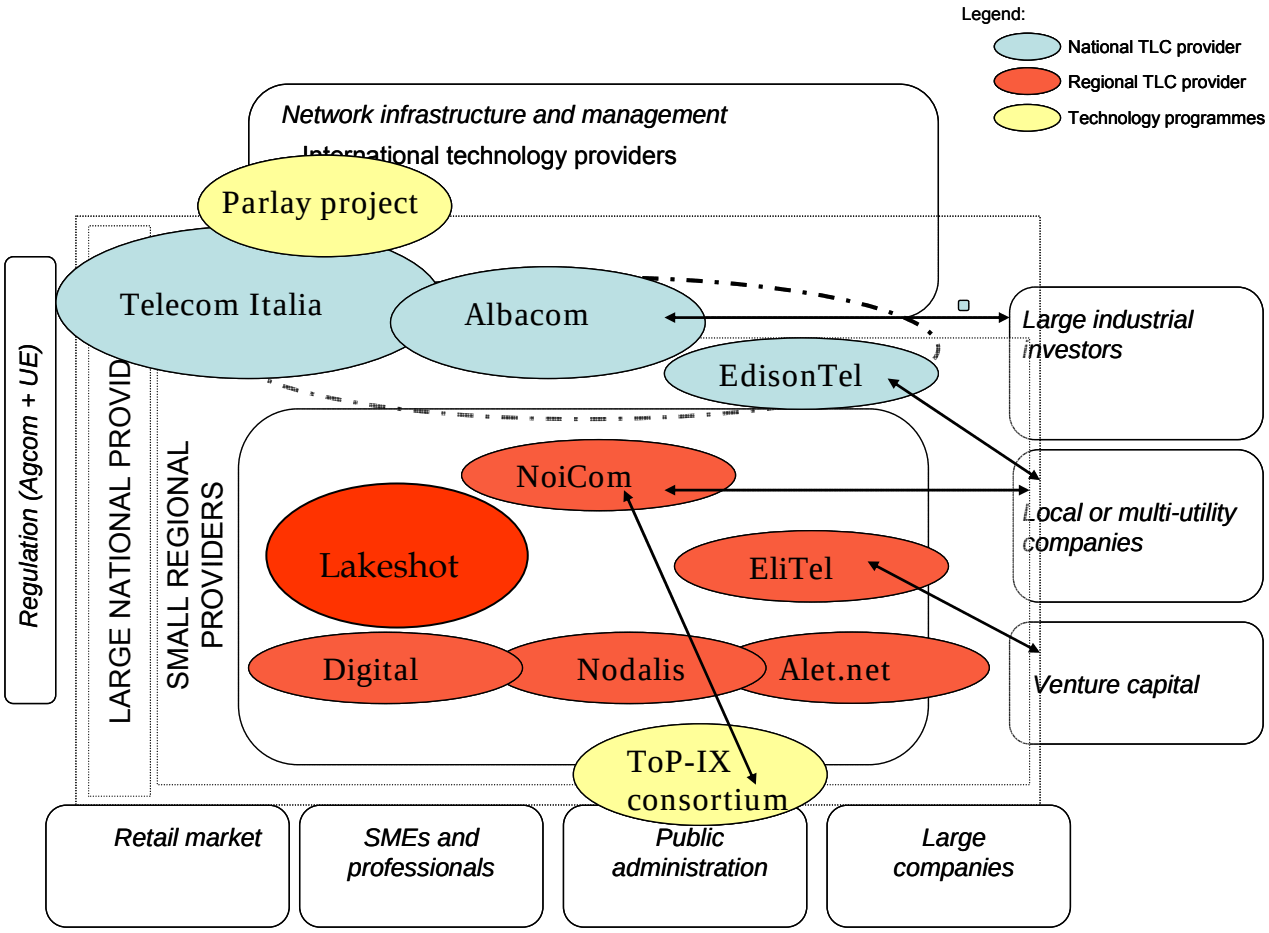
Many of these developments require the configuration of existing Internet routers, but a number of specialised developments can be found in the area of inter-business data communication. The design of the next generation Internet protocols involves an intensive interaction between service providers and equipment manufacturers with the aim of creating new Internet features that will facilitate the development of business data services. The increasing importance of broadband networks and the emergence of a wide range of possibilities to provide value added services to business users (which traditionally represent the most profitable segment of the market) have driven the entry of many companies in the sector, either start-up or existing firms belonging to different industries (typically consulting companies, utilities, software companies).

Another important trajectory of technological change in this sector is related to the emergence of wireless metropolitan area networks (MANs). In large urban areas, it is possible to develop business data communications, which connect multiple organisations through the development of an alternative wireless infrastructure. Wireless MANs are based upon dedicating a portion of the radio spectrum to data communication traffic that can be shared by a variety of different organisations. Service providers in this area must solve a number of important technical problems and secure regulatory approval for their

activities. While high-capacity MANs are still at a nacent stage of development, some wireless services such as stock market information systems have already been deployed. This is a difficult area because of the importance of regulatory approval for the commercialisation of services.

The project has concentrated on the two activities that best account for the technological development in the area of telecommunication networks for business data: dedicated backbone services and mobile links to the internet. A representation of the market for dedicated backbone services for business communications can be seen in Annex Figure 18. The analysis of these two hybrid activities is based upon ten case studies carried out in Denmark, Greece, Italy and the United Kingdom. Figure 11 below places these case studies in the relevant market structure schematic.

Figure 11. Representation of the Case Studies in the Market Structure



4.4.2. Description of the hybrid activities

As far as the dedicated backbone services are concerned, since the market and the related activities in telecommunications for business data are experiencing a rapid development, it is difficult to set a consistent and standardized classification of services, above all when monitoring companies' offering. The following list of services derives from our interviews in the two sub-areas:

Data transmission and Internet related services

- Virtual Private Networks (VPN): telecommunications companies offer the setting of a private connection between two points across the Internet. In this case users do not purchase any dedicated physical infrastructure, but the opportunity for private communication to travel securely over the dedicated virtual network. The connection can be guaranteed using different media technologies (DSL, optical fibre, satellite, wireless). It represents a low cost alternative to the installation of a physical private network which was previously the only alternative.

- Design and implementation of local and wide area networks (LAN and WAN), exploiting different media technologies.

- Implementation and management of Intranets and PBXs[12], including the design of private switches, the management of different access levels, security issues and the possible price differentiation among users.

- Basic Internet Services, managing the access to the Internet services and other related services (ftp, basic data transmission).

- Remote applications (Application service provider- ASP), managing from remote the applications and distributing them to the customers

- Design and implementation of unified messaging systems, that allow the integrated management of voice-mail, e-mail, fax and messaging tools, so that they can be managed from a single system.

- Design and implementation of e-business platforms, including the necessary infrastructures (databases, secure connections, payment systems) for e-commerce

[12] Private Branch Exchange (PBX) is a central switching system to handle voice and data communication in a local private network.

and e-procurement and the management of the system, together with the development of Electronic Data Interchange (EDI) formats and transactions.

- Voice over IP (VoIP): the opportunity to route and manage telephone calls via Internet networks (voice service).

Data management services

- Hosting services: the possibility for the customer to store its data (and usually web site) on the server of the telecommunications operator server, without the need for having a private data server and exploiting the network capacity of the provider.

- Housing services: the opportunity for the customer to maintain its own data server (i.e. hardware and software devices) in the dedicated infrastructure of the telecommunications operator server, exploiting the network connection of the provider.

- Database services: some telecommunications companies leveraged their IT competencies in order to provide also advanced IT services, such as the synchronization, control and update of databases and the supervision of (EDI) services

- Backup/Disaster recovery and other data management services, including services of data security and maintenance. It is often coupled with other hosting/housing services or with database management.

- Storage area network: with this service the customer purchase the possibility to store and access its data in a dedicated storage area, without having to purchase its own storage technology.

Multimedia services

- Video communication services, which includes the transmission of audiovisual data and more advanced applications such as video-streaming, video-conference, data-conference and multi-conference. The production of this service is quite complex, because of the various requirements in recording, compression and memorization. The process of routing of the video-services is complex, too, given the continuous needs of quality and efficiency and the specificity of the transmission that can be pre-programmed or on demand.

- Services for broadcasting and television that allow broadcasting (live or registered). Application which includes the transmission of audiovisual data and more advanced applications such as video-streaming, video-conference and multi-conference.

- Contents' services (information and news). Many telecommunications operators offer to provide (often through a dedicated company or business unit) the creation of multimedia contents such as presentations or news services.

- E-learning and distant learning services including the setting of the infrastructure and the development/implementation of dedicated software. These services are also provided by specialized companies that exploit the competencies of telecommunications operators for the infrastructural side.

The main activity of the telecommunication industry has traditionally been the management of voice telephone calls routed through national and international network infrastructures. The transmission of data has been made subsequently possible, with the exploitation of specific dedicated network infrastructures. The architecture of data services initially imitated the one of voice transmission, with data (files) sent via circuit switching through dedicated networks of twisted paired of copper wires. Through the design and development of hybrid platforms it is now possible to transfer digital contents using telecommunication networks. This evidence is fuelling the development and the introduction of new advanced data services, the increasing growth of the related telecommunications market segment and a consequent evolution of the overall industry. There is a common belief in the industry, perceived also during the analysis of the case studies, that in the long run telecommunication networks would not be the key market asset, but they will represent an infrastructural platform for telecommunications services. These services will instead become the core valuable output.

A critical step in the development of value-added data applications for businesses has been the emergence of wireless networks, which allow more flexibility, although being characterised by a lower quality of services and by important capacity constraints. The wireless Internet can be defined by access to the Internet on any wireless or mobile device and encapsulates a variety of wireless Internet access alternatives including wide-area networks (WANs), wireless local area networks (WLANs), and wireless personal area networks (PANs). Wireless local area networks (WLANs) are small-scale wireless networks with a typical radius of several hundred feet. A wireless local area network (WLAN) uses radio frequency (RF) technology to transmit and receive data over the air. The most prevalent form of Wireless Local Area Network technology is called WiFi

(Wireless Fidelity), which includes a host of standards including 802.11a[13], 802.11b, and 802.11g. Wireless Internet via WiFi offers blazing fast data speeds (11Mbps at the low end with 802.11b and 54 Mbps at the high end for 802.11a and 802.11g). WLAN transmits on unlicensed spectrum as agreed upon by the major regulatory agencies of countries around the world (such as the FCC) although there is some variation by country. While WiFi technology does not offer the degree of ubiquity as wide area networks, the WLAN's data speeds and relatively cheap costs have spurred it ahead in the popular market as a wireless internet solution.

The speed at which a WLAN performs depends on many things, from the efficiency of the wired network to the configuration of the building to the type of WLAN employed. As a general rule for all WLANs, data throughput decreases as the distance between the WLAN access point and the wireless client increases. The 802.11 standards support multiple data rates to accommodate the loss of signal strength while maintaining high quality in data packet reassembly. The WLAN client constantly performs operations to detect and automatically set the best possible speed. Subsequently, data rates may be listed as a series of numbers (such as 11, 5.5, 2, 1 Mbps for 802.11b at various ranges) to correspond to throughput at various ranges. The frequency at which 802.11b is transmitted permits it to penetrate solid materials allowing, in most indoor environments, a maximum range of 300 feet. The range and transmission speed is affected by the environment the WLAN is deployed in.

4.4.3. Factors that Explain the Formation of the Activities

The technological advancements, coupled with a favourable political attitude, drove the process of privatization and deregulation of the industry in the most advanced countries. To a different extent and with some peculiarities, all the countries have witnessed the entrance of new telecom operators, the implementation of mechanisms of regulations at the national level, and a general increase of competition in the industry. The structure of the industry has experienced a significant transformation in the last decade, following a series of technological and regulatory changes:

- The industry integrated a flow of innovations in ICTs, such as the introduction of optical fibres, the digitalization of transmitted data, the transition from circuit switching to packet switching, and the introduction of frame relay technologies. These innovations enhanced the speed and the transmission capacity of

[13] The Institute of Electrical and Electronics Engineers (IEEE) have established the IEEE 802.11 standard, which is the predominant standard for wireless LANs. Any LAN application, network operating system, or protocol including TCP/IP, will run on 802.11-compliant WLANs as they would over Ethernet.

telecommunications networks, lowering the price of data transmission and of network management and implementation.

- The convergence with Internet-related technologies (allowed by data digitalization) and infrastructures opened the path to new integrated applications, such as the transmission of data and files via e-mail or ftp services, the distant management of databases and informational systems. An important consequence is that *the* awareness of the possibilities of data transmissions is diffusing also among users.

- The convergence with multimedia technologies (allowed by the digitalization of multimedia data) further increased the application and opportunities of data transmission that could also encompass video and audio contents.

- The emergence of mobile telecommunications has created a new market-segment that has influenced the strategies and the dynamics of every telecommunications operator.

One of the main factors responsible for the development of dedicated network for business services has been the emergence of broadband technologies that actually helped the commercialization of advanced services. The most relevant technologies and network services for data transmission that are exploited by every telecommunications provider are the following:

- Integrated Service Digital Network (ISDN): it is the international standard for transmitting voice, video, images and data and to support advanced services simultaneously over the usual telephone line.

- X.25 packet switching: this technology breaks blocks of data into fixed bundles and routes them in the most economical way through any available communication media.

- Frame relay: a network service technology that packages data into bundles for transmission but does not use error correction routines, resulting in a cheaper and faster transition compared to packet switching.

- Asynchronous transfer mode (ATM): it facilitates the flow of data between different technology devices and systems of different vendors.

- Digital Subscriber Line (DSL): this term identifies the group of technologies (ADSL, SDSL, etc.) that provide high-speed access Internet or Intranets.

- Dense Wavelength Division Multiplexing (DWDM): technology that boosts the transmission capacity of optical fiber by using many different wavelengths to carry separate streams of data over the same fiber strands at the same time.

In the wireless environment, one of the major driving forces behind the development of mobile links to the Internet is demand for data access. There seems to be a huge demand for the combination of mobility and communication, which provides access to data and other corporate, commercial and communications services. Another driving force is the existence of "crowded" 2G networks, which especially in Japan have stimulated the development and deployment of 3G infrastructure and services. This has lead to an adoption of a preliminary 3G network not fully compatible with W-CDMA, forcing producers to make handsets, which cannot be used outside Japan. But the role of 3G is not seen merely as satisfying a growing demand for voice communication. The planned revenue and the potential disruption is rooted in data communication. However, other technologies are also available in that field. The two 3G standards UMTS and CDMA2000 can therefore be disrupted by other technologies capable of creating wireless access to the Internet.

All the platforms and information appliances for integrated consumer electronics and multimedia content are also important drivers that lead to a constant growth of the specific sector. Furthermore, Other social factors that acted as accelerators for these activities are the enormous success and wide use of mobile telephony and lately PDAs, for example the emergence of new high-speed/broadband technologies and the high expectations of the 3G telephony. The underlying concept that surrounds all these new developments is the possibility to have new types of "anywhere –anytime" applications that are based on the Web/Internet.

In terms of development stages, the first WLANs were created within firms for own use. However, as the demand for mobile connectivity grew and people became more mobile, WLANs soon gained popularity and were expanded to public places and even the home environment. Such wireless services are offered through mobile operators and wireless Internet Service Providers (ISPs), who collaborate with the traditional infrastructure vendors.

Most of the public WLAN ''hotspots'' (locations for Internet access) can be found in the Nordic countries. However, the market is also expanding in France, Germany and the UK where critical masses of users have already been formed. For example, in France, a strategic decision for the creation of more than 400 such hotspots in all metro stations in the city of Paris has been taken. More than 3,000 hotspots will also be developed in the

UK, covering mostly pubs. Large restaurants chains (like McDonals or Starbucks) and hotel chains (like Marriot) have already created the first hotspots, offering wireless Internet access to their customers. A significant interest has been expressed by the airports as well. Frankfurt's airport for example has been a pioneer in the area of hotspots, and others, such as the Athens International Airport (Eleftherios Venizelos) have followed. Businessmen who wait for their connecting flights are potential users of such hotspots, since they might want to get in touch with their office, check their e-mail, or get updated information. In fact, Lufthansa has set up a collaborative agreement with Cisco to purchase the networking equipment and the relevant infrastructure and is actually offering wireless Internet inside airplanes are travelling overseas.

However, certain concerns related to security issues have been also expressed. The relative ease, with which any user can access WLANs, even when the proprietary encryption is implemented, has been the major barrier for their further uptake in Europe. Many ICT security vendors recommend running Virtual Private Network (VPN) software across the WLAN to improve security. In any case, the situation will certainly improve significantly once the recently unveiled WiFi wireless protected access protocol rolls-out and further with the adoption of the 802.11i wireless security standard.(EITO, 2003)

The evolution of the mobile communication technology has lead to convergence between different ICT technologies. One of the crucial evolutionary stages of the industry is the convergence between mobile devices and the wireless network with the fixed network. The transmission of speech, text, pictures, etc. will be in focus. With the explosive development in data transmission and Internet access on the fixed net, there is an increasing demand for Internet access and data availability everywhere and all times. However, notwithstanding the process of convergence, there still is difference between the mobile Internet and wireless access to the fixed Internet.

4.4.4. Firm Characteristics and Emergence of Hybrid Activities

Regarding the dedicated backbone services, the services described above exploit the various communication technologies that have emerged over the years, such as twisted wire, coaxial cables, fibre-optic cables, radio-links and satellites or wireless devices. The selection and management of communication media is a choice of the telecommunications operator, given its overall technological strategy. This point will be more deeply addressed later. The telecommunications operator must be able to access (as owner or through lease/hire agreement) converged transmission networks, able to deliver voice, data and video in a single network infrastructure.

We can distinguish the following areas of activity:

- *Network technology provision*. In this area we find companies that design, develop and implement hardware and software innovations affecting the telecommunication industry (terminals and equipment). The knowledge bases come today from different fields such as new material science, electronics, IT and multimedia. As of today, the market of high technology solutions is almost globally standardized, with the same actors leading the advancement of telecommunications systems all over the word. Among the main operators there are Sony-Ericsson, Nortel, Alcatel, Cisco Systems and several specialized companies.

- *Network management*. This was previously uniquely managed by monopolies across Europe. Following privatization and liberalization, there are various large telecommunications providers that manage a private network (e.g. in Italy Albacom and Wind). Competition has resulted in some network duplication of networks in heavy-traffic routes, while in most countries former monopolists still own unique non-duplicated minor routes. The new implemented network has been created with the private networks of the largest companies or exploiting synergies with other existing physical networks (e.g. railway infrastructures, long-distance power lines, highways). Companies endowed with network assets have been active in the market, leasing their infrastructure to new entrants (often keeping shares in the new company) or trying to diversify in the telecommunications industry.

- *Wholesale market*. This is the market where biggest telecommunications providers sell or lease their not-exploited capacity to smaller operators who act as carrier, resellers or ISPs.

- *Development and commercialization of telecommunications data services*. Many new companies entered the telecommunications market after the liberalization, given the positive performance of telecommunications and Internet markets before 2001 and the convergence with IT activities. A smaller number of firms have acquired a national relevance (in Italy, for example Infostrada, Albacom, Tele2, Tiscali) while there are a lot of small companies that act locally as services reseller and ISPs. With reference to the Italian case, we can observe that the new entrants have various backgrounds:

    - New ventures that entered the market starting from IT capabilities backed by large industrial groups (Wind) or by foreign operators (Albacom)

- Multi-utility companies that tried to integrate telecommunications services into their service supply (energy, water, gas) (e.g. EdisonTel and a number of minor local actors).

- Small new ventures that focused on specific regions, financed by their own resources or by venture capital funds (e.g. Elitel)

- Internet operators that expanded their activities into the new liberalized market (the most successful example is Tiscali).

Up to now, it has been difficult to detect segmentation in the offering of services. Beside dimensional issues and resources, all the companies offering data services try to aggregate the widest range of services, to attract the highest number of customers. Looking at commercialization issues, all the companies had to develop capabilities in the commercialization of telecommunications and Internet services and in the management of customer relationships. This is because the competitive arena is completely new, in an industry previously focused on technology, dominated by a unique-service (voice) and with a monopolistic structure.

In the area of the mobile Internet-related services, the analysed cases in Denmark and Greece highlight interesting phenomena. In North Jutland, an important cluster of telecommunications companies accounted for a significant amount of the R&D activity in Northern Europe. The *density* of the cluster had increased during 1999-2000 and at the end of 2000 there was nearly 35-40 firms employing nearly 4,200 persons, which was about half of the total ICT employment in the region. Several firms were doing GSM development and the cluster became significantly denser compared to the peak of the 1G cycle. But compared to the most outstanding regional concentrations or clusters, such as Silicon Valley, Southern Sweden, Southern Finland, Munich and Cambridge, it was still sparse. The following firms in the cluster were said to perform R&D in UMTS in late 2000: L.M. Ericsson (125 employees), Siemens (350), Maxon (105), Shima (60) and Condat (20). Today the picture has changed; Maxon is focused on 2.5G, while Shima has been closed down. Ericsson has closed its UMTS development in North Jutland and Siemens has downsized its R&D staff from 350 to 200 during 2001-2003. Development of the basic 3G technologies does not appear to take place in the cluster to the same extent (in relative terms), as was the case in the initial GSM phase ten years ago. The crisis in the telecommunication industry and the increased complexity has made the players focus their R&D in larger units and form alliances. However the high complexity and the demand for an increased number of functionalities of the UMTS handsets open new

opportunities for specialisation. The demand for new functionalities and features of the 3G technologies are potentially disrupting for 2G, but also bring in other disrupters.

The IT Lighthouse has been divided into four fields, of which the local IT infrastructure is one. A series of nearly 90 IT projects have been started during 2000-2003. Under the label of North Jutland Netforum, an Aalborg University group is collaborating with the largest IT service firm in the region, KMD, and a small group of municipalities in order to design local optical fibre based network solutions, which will bring 'true broadband' to local government organisations as well as to private firms and consumers. Given that how to organise this infrastructure – and not least the 'last mile' problem - still is one of the fundamental barriers for diffusion of IT in general, such experiments are of considerable importance in their own right.

In Greece, a leading ISP (Otenet), is pioneering in the area of wireless internet and had announced that by the end of 2003, it would launch the ''OnWireless'' service. Otenet has been the first ISP that was operating in this specific activity by providing the Wireless Internet Zone (WIZ) service in the Athens International Airport and another hotspot in the hotel located nearby the airport (Sofitel). The company has adopted a coherent development strategy that will lead to the creation of at least 12 more hotspot locations by the end of 2003, in hotels, other national airports and convention centers. The specific service will require a pre-paid card (at a cost of 10 €, for 3 hours of Internet access), which will be possible to be used in all hotspots, created either by Otenet, or by other ISPs.

In order to be able to use a hotspot, a computer must be configured with a Wi-Fi[14]-certified radio, such as an external PC card or an integrated wireless LAN capability (for example Intel-Centrino). The latter is a new technological development in the area of mobile technology for wireless networks which can certainly give a great boost to the activity, as it provides wirelessly connection without a PC card, it enables extended battery life etc. This allows mobile technology developers and device manufactures to accelerate the further development of such services.

The airport's plans after the commercial launch of the WIZ service include the exploitation of the rest of the radio frequencies that are available. Leasing radio

[14] 802.11a and 802.11b are Wi-Fi standards that have been developed by the Institute of Electrical and Electronic Engineers (IEEE) for wireless LANs. 802.11a is a standard for wireless LANs operating in the 5 GHz frequency range with a maximum data rate of 54 Mbps. 802.11b is a standard for wireless LANs operating in the 2.4 GHz spectrum with a bandwidth of 11 Mbps. It is the frequency band for microwave ovens, cordless phones and Bluetooth devices.

frequencies actually refer to leasing Service Set Identifiers (SSIDs).[15] One such SSID has being leased to OTEnet, providing the public space with the necessary access technology, which is used now by passengers. The airport can exploit the rest of its SSIDs, by offering services to airline companies. For example, KLM may wish to shift the continuous communication between the checking counters and its back office located somewhere in the airport, accomplished today through a wired network, to the wireless network option. The benefit is that the airport company is not involved in a revenue sharing model with the provider, as it happens for the public space, where the provider and the airport will share the revenues of its exploitation either by a flat fee or by a per transaction/user of the service. Instead the airport company fully captures the agreed price for leasing its SSIDs. Furthermore, the company's managers are considering the exploitation of the content related to the wireless connection, perhaps by establishing a partnership with a content provider, as they do not have the necessary know-how to proceed to a wider, commercial exploitation of the content they would offer. Under consideration are also he expansion of the wireless coverage in the main terminal building to 100% (currently the coverage is around 60%) and beyond to also include other airport buildings.

4.4.5. Technological Characteristics and Firm Activity

The emergence of hybrid activities is the result of the interplay between technological characteristics and firm strategy. In the provision of value added services on both wired and wireless network, the existence of different technological solutions raises interesting issues with respect to the strategy of service development and commercialization. In the dedicated backbone services, firms adopt different strategies in response to technological opportunities. Advanced telecommunications infrastructural and software technologies are developed by few companies at global level. Most operators purchase these technologies "off the shelf". Because of the standardization process, it is not critical to establish long term relationships or co-design agreements (hardware and software systems). In addition, largest telecommunications providers invest in the development of knowledge about future technologies and market evolutions participating in international projects. Largest operators exploit some degree of customization in the designing and implementation of technological solutions, together with specialized national companies or with the support of large industrial companies. Smaller providers acquire all the technologies off-the-shelf, often after they are introduced in the wholesale market by largest operators. The critical issue is the behaviour of large companies, as they act as technology suppliers and telecommunications providers. Currently, there is no lack of

[15] A Service Set Identifier differentiates one WLAN from another, so that all access points and all devices attempting to connect to a specific WLAN are using the same SSID.

capacity in the market, so that infrastructures and services can be easily resold. Smaller actors, thus, pursue monitoring and design activities to be able to select and integrate the new advancements.

In the case studies two technology initiatives emerged as particularly interesting. The first (Parlay Group) is a global technology-oriented programme aiming to develop a new standard in the interface between telecommunications software and IT applications. It puts together all the main operators in the market and is coordinated by the biggest telecommunications players. The main objective for the participation of Telecom Italia is the opportunity to stay closer to technology advancements and to later quicker introduce the new applications in its offering. The second project has a different purpose, focusing on the strengthening of the technological endowment of a geographical region, in order to increase local business opportunities and region attractiveness. The sponsors of the projects are mainly public and the participation of NoiCom has the aim to establish its "regional visibility".

The *Parlay Group* is a project that aims to facilitate the implementation and the offering of applications that comprehensively exploit the possibilities of a telecommunications network using an IT-defined interface between applications environments and the telecommunications networks. As an example, a growing number of services request the integration between applications and telecommunications network services:

- *"Click-to-dial"* services, that request phone calls selecting a link from a web page.
- The queuing of the incoming calls to a call centre following the availability and the expertise of the operators.
- Informational systems based on the localization of users.

Nowadays, applications are implemented and managed by actors different from telecommunications network operators designing legacy fully customized (and not-reusable) solutions. Indeed, these products are not able to completely exploit the potentiality of a telecommunications network. In this sense the Parlay project represents a way to push forward the fusion of telecommunications and IT technologies, designing simpler and standardized interface devices. Parlay's features consent the definition of new business models based on telecommunication network openness to third parties' services and on the enrichment of the role of the network operator, from connectivity provider to advanced services provider. The major telecommunication system producers participate in the Parlay consortium (among the others Sony-Ericsson, Lucent, Alcatel and Siemens) together with network operators such as *BT* (which was one of the

founders of the project in 1998), *France Telecom, AT&T, NTT* and *Telecom Italia*. Also IT firms take part into the project (for example *IBM* and *Sun*).

The ToP-IX consortium (Torino Piemonte Internet exchange) is a territorial project developed in the area around Torino and aim to enhance the technological endowments of that area. NoiCom is one of the main technology participants. The project behind this consortium (similar to MIX, a project in the area near Milan) aims to exploit a new technology that offers a high quality Internet access, with relevant infrastructural and functional benefits for the territory. The rapid diffusion of Internet in the last year, as a matter of fact, is showing some limits because of the reduction of the qualitative level of the interconnections between operators. The Top-IX consortium plans to implement a NAP (Neutral Access Point), distributed over the territory in order to support locally the diffusion of Internet traffic and stimulate the growth of Piemonte as a regional system. It wants to support the growth of existing local initiatives and favour the participation of all the subjects participating to regional economic system (citizens, companies, Public administration and academic realities). The implementation of *Top-IX* systems exploits already cabled networks, in order to reduce the investments from its participants.

The economic and juridical structure of the consortium and the technological arrangement fuelled the participation of heterogeneous actors, both from the commercial and the technological perspective. The consortium acts as an interconnection platform oriented to services and aimed to lower the costs for the users. Commercial agreements are concluded directly by interested actors following a peer-to-peer approach, with full autonomy and without any interference from the governance of the consortium.

With reference to the wireless links to the Internet, the infrastructure projects of the IT Lighthouse in Denmark open up unique opportunities of creating field experiments with an optical fibre based local infrastructure that *also* contains extensive possibilities for WLAN access. The opportunity for the entire region is that the present growing pessimism, caused by troubles of the GSM developers to play a role in the UMTS world, could be changed with a vision focusing of combining some of the existing knowledge assets of the region and the country at large.[16] Two research teams at Aalborg University have proposed a joint Centre for Tele Infrastructure (CTIF) – joining the CPK research competence in wireless technologies with the wired infrastructure group.

[16] For details of this vision see the "Vision Nordstjernen" report (NOVI 2002) made by a group of university researchers and managers from the local ICT industry. Two of authors of the present paper were secretaries for this project.

Taking into account that a considerable set of competencies has been developed in the NorCOM cluster in developing 2G, 2.5G and – at least among some of the firms –in various parts of 3G technology as well as a significant competence has been developed in the Bluetooth field, itself an industry standard for data transmission over very short distances, there are several important points of departure, which may form an ideal background for coming at the forefront in wireless-to-wired data communications field – i.e. to become involved as a visible player in the early stages of a new technological life cycle. At the national level it is worth noting that there is a parallel cluster of optical communications equipment firms in the Copenhagen region as well as a strong competence at the Technical University of Denmark, DTU, in Copenhagen. These two clusters and their knowledge background at the respective two large technical universities are basically complementary, which is an ideal background for national co-operative R&D programs in this field.

This happens not only because of major technological breakthroughs, but *through the capability as a region* to combine unique field experiments in the area of wired and wireless telecom convergence with competence of several NorCOM firms and especially to be placed as a 'core player' in the international process of standardisation through documented user experiments. If some of the field experiments may prove successful the rumours could spread internationally, create visibility and attract some of the big global players. Echoes of the vision may be heard internationally – as happened successfully during the recent peak of the GSM cycle.

WLAN is, contrary to UMTS, using unlicensed spectrum and is highly deregulated. One of the main attractions of this technological solution is the possibility to build up small range high-speed wireless networks for low cost and to avoid the problem of carriers controlling the 'last mile', which is common to the fixed environment and is being solved by the activity of the national authorities. WLAN solutions have existed for a few years and are growing fast. Generally they can be classified in two groups: private networks not open to the public and public networks with access for users that pay some kind of fee. At the private network end many universities have adopted WLAN, thus providing Internet access around campus. There are many users also at the cooperative level, but they are more concerned with security issues. Many private consumers have installed WLANs in their homes[17] to avoid cabling and some allow others to use their connection in neighbourhood-shared access or in 'freenet', being a grassroots initiative in providing

[17] The firms seem to favour the faster and more expensive 802.11a, while home WLANs usually are of the 802.11b type.

hotspots with free Internet access, which especially is being built in the densely populated areas.

The public hotspots provided at hotels, cafés, airports, coffee shops etc. are stimulating the emergence of Wireless Internet Service Providers, WISPs, creating network of hotspots and thereby becoming carriers of wireless Internet access. They allow users access by signing up and paying a fee. The public hotspots are organised as independent hotspots at a single location, such as hotels and airports, or in a system of hotspots provided by a WISP. Both types are demanding a fee for access, but there is not often roaming between the independent public and WISP hotspots or even between the WISP networks. The WISPs are expanding their networks, especially in the US, and a few are trying to build 'national networks', but they still only cover small areas. The private hotspots seem to be both economically and technically feasible. Although there still are some problems with security the public hotspots are technical feasible, but still need to be proven economic feasible.[18] The producers of WLAN equipment such as Intel, IBM, Lucent, Cisco etc., are pushing WLAN along with the WISPs, who are trying to make money on wireless data access and thereby 'steal' the mobile data communications market before the rollout of 3G.

While incumbent carriers of fixed (wire-lined) telephony are challenged by new mobile carriers, the latter are now potentially challenged by the WISPs. However, there are advantages and disadvantages with 3G as well as WLAN solutions, which can hamper the activity of firms in the area. To mention a few, WLAN has higher speed, but is limited to hotspots, while the mobile networks are significantly slower but have much better coverage. The mobile networks allow the user to move around, but both networks have conflicting standards. WLAN is limited to data transmission and has security problems, while the mobile phones have small screens. WLAN and the mobile networks have different price structures and both seem to need a 'killer business plan'. The WLAN solutions are up and running, while 3G networks are at their very early stage in Japan and hardly existing in Europe and the US. On the one hand, the poor coverage and lack of roaming for WLAN can evidently benefit from the extensive geographical coverage of the mobile carriers, their strong customer base, roaming facilities, large-scale network management etc. On the other hand, the mobile carriers cannot neglect the WLAN technologies with their appealing speed. So there appear to be an evident potential for combinations of the two types of solutions. The flourishing field of WLAN has until now not received the same kind of media hype as the evolution of 3G in Japan and in Europe,

[18] One of WISPs, MobileStar Networks, who provided WLAN at the US Starbucks coffee shops filed for bankruptcy and was acquired by the Deutche Telekom's mobile operator VoiceStream.

but given the relative weakness of the US in mobile communications, it is of no surprise that the US media have been just recently focusing on WLAN solutions.

Certain concerns related to security issues have been also expressed. The relative ease, with which any user can access WLANs, even when the proprietary encryption is implemented, has been the major barrier for their further uptake in Europe. Many ICT security vendors recommend running Virtual Private Network (VPN) software across the WLAN to improve security. In any case, the situation will significantly improve once the recently unveiled WiFi wireless protected access protocol rolls-out and further with the adoption of the 802.11i wireless security standard.

Some companies think that it might be risky to invest in the creation of multiple WLAN hotspots, especially in a regime where the institutional framework concerning WLANs is still unclear. They believe that the main problem related to WLANs in EU as well, is the unclear institutional framework under which the wireless hotspots would operate. In addition, the wireless services mostly in terms of extra radio frequencies and pricing offered through a laptop or a PDA could range from Internet access to more specialized services, though the market for such services is still vague: firms that will be involved in this activity are not in a position to offer a complete package of services yet, since the whole activity is in its infancy.

The basic key actor in the provision of this service is of course the wireless Internet provider. It is extremely important that the provider offers the quality of services he is supposed to (such as fast Internet, security etc). Another actor that could have a significant role in the provision of the service is the content provider/developer, but for the time being such an actor does not exist. In the case of Athens airport, the situation so far involves the IT department playing the role of the content provider by offering relevant information (departures-arrivals), some advertisements etc. Nevertheless, the fact that the airport offers such a service becomes instantly evident to a passenger, since the wireless connection is one of the first indications that he/she actually sees when entering the airport area. The same holds for the airport' site, as it is clearly advertised in the first web-page. Finally, a networking equipment provider/manufacturer provided the necessary hardware infrastructure.

Generally speaking, when such services will become more popular, they will definitely involve a variety of actors: Many hotspot providers could emerge such as coffee shops, hotel chains, airport terminals convention centres etc, while the Wireless Internet Service Providers, will follow. Device and networking equipment manufacturers will see a new market arising and will try to provide the necessary equipment for the provision of the

services. All present users of the Internet are potential end users of these services. Finally the regulative framework for the interactions of these actors in this market will certainly be coordinated and directed by national regulatory authorities for telecommunications.

The potential disruptive effects of the WLAN technology vis-à-vis 3G may turn out to be a potential opportunity for different specialised companies across Europe. Given that development of 3G handsets has been organised by the large telecom operators in alliances, it is a very difficult field to enter – at least in the initial phase of the 3G technology life cycle. The risk of 3G becoming a major failure cannot be neglected in light of the heavy financial burden the 3G infrastructure is causing for the mobile telecom carriers. This is the basic background for the present true uncertainty about the future infrastructure, whether the 3G will win over WLAN solutions, or will the two co-exist as true complements.

4.4.6. Factors that Determine Diversification

This section highlights the process of diversification in the provision of fixed and mobile value added services as it emerged from the analysis of the case studies and that represents the main market issues in a context of evolving supply and demand. In the wired environment, we observe that the smaller operators invest in the higher degree of customization of their supply, while bigger providers try to develop more standardized offers. They consider that this differentiation can provide a relevant advantage for acquisition and management of customers in the business market, even if this strategy asks for a greater level of flexibility in technology solutions and integration capabilities. Smallest providers also perceive that informal channels (face-to-face consultancy) are still a rewarding channel to gain the trust from business customers. The reason of that can also be found in the relative lack of standardization of services and in the lack of telecommunications culture of the customers themselves. Largest provider leverage some scale economy, by focusing on the development of more standardized solutions to lower the price. Usually they agree to develop ad-hoc conditions or customized systems only for largest business companies.

All actors (especially new entrants) rely on different capability networks and partners. These networks variously include:

- Large industrial shareholders and users, who firstly invested in the telecommunications venture and through the upgrading of their own telecommunications systems, constituted the first customer base. In many case the

industrial investors also provided the new ventures with network-related assets and with financial resources, acting also as financial facilitators.

- Companies that help the commercialization of services. These companies can have different characteristics: multi-utility companies that want to complete their offering with telecommunications solutions; professional associations that propose specific services to their members; other kind of companies that exchange the implementation of a telecommunications system with the possibility to target its customer base. The range of agreements is wide and tries to exploit any kind of cross-commercialization.

- Mobile telecommunications companies. While the biggest players are linked to a mobile group, the smallest providers are looking for possible partnerships. However, the foreseen advantages are not so clear form an operative point of view.

The management of technology and innovation is rather different for bigger and smaller provider. Both must operate in a market where the technologies are developed "outside", but the relative distance from the innovation locus asks for different competencies and actions. In the case of Italy, for example, the biggest players (Telecom Italia, Albacom through the capabilities of BT) cannot radically influence technology development (so far) but can invest in the acquisition of knowledge about future advancements through the participation to international projects and forum. This participation should give them a better understanding of market evolution together with the opportunity to introduce more quickly the new advancements. It also legitimates these players among the most relevant ones. Biggest players usually have R&D business units that are dedicated to these tasks and to the planning of technological advancements. Another new issue, indeed, is the ability to manage network upgrading and service development. In the previous monopolistic model, there were rarely commercial innovations and technological upgrading was planned by looking only at the foreseen savings in maintenance costs. Today all players must plan their projects (also the ones that require a high degree of financial investments) in a context of market uncertainty and strategic competition. Smaller providers have not enough resources to influence or look closer at market advancements. Their R&D competencies are focused on the monitoring of the technologies introduced by bigger providers. In this case, R&D is not focused on development, but on the monitoring and integration of different technologies and solutions, which is a difficult task to develop. Technology-experts in smallest companies are the most critical professionals to provide successful technology supply and business advantages.

Marketing, commercial and communication activities have become critical in an industry that was previously dominated by technology drivers. Companies must actively look for customers and must develop the ability to manage customer care activities. This evolution has not been easy, neither for big operators. In this context, the efficiency of billing systems has been one of the first objectives of most firms. Telecommunications advanced services are a brand new field, also for the users, and are based on rather complex concepts and technologies. While previously only large firms could design some kind of private telecommunications system, today there are a wide range of opportunities also for SMEs and professionals. Sometimes, the customers themselves do not fully understand the existing opportunities or are not able to evaluate their business needs about telecommunications services. Many small companies report that one of the biggest values they bring to customers is the definition of opportunities. One relevant activity of telecommunications operators in this initial phase is the ability to frame the need of the potential customers and to envisage possible solutions.

Paradoxically, the extensive diffusion of wired networks has so far indicated their inherent limitations: long time of development, high cost and large scale of investment, infeasibility of recapturing even partially an unsuccessfully invested capital. Despite the technological progress achieved so far, the wired communications speed currently offered to the public is significantly inferior to that of the wireless networks (for example, in Greece it is estimated that it is 35 times lower). Moreover, the local loop, in other words the connection of the end user to the network, is remaining under a monopoly regime which is further enhanced by the authorities' regulatory interventions. Finally, after the global crisis in the telecommunications sector it is widely supported that its further technological development will be possibly attained through decentralized, small-scale organizational schemes. This assessment is further enhanced by the fact that community wireless telecommunication networks are operating at the moment in more than 200 cities worldwide.

The massive investments required to build the coming 3G infrastructure together with the substantial financial problems of the telecommunications sector in general (both in the hardware industry and in the telecommunications services) has driven the attention on what is coming next. Usually 4G has loosely been defined as the complete integration between the wired and the wireless spheres of telecommunications with speeds of data communications of 100 Mb/s and in operation in, say, 2010. There is however a certain ambivalence prevalent in the terminology at present. 'Premature' versions of 4G are much closer – in fact already available. The potential disrupter is Wireless Local Area Networks, WLAN. This is a technology that makes short distance high-speed wireless Internet access possible. The interesting aspect is that this technology represents a way

of accessing the 'usual' wired Internet, while the mobile Internet constitutes another field. The dominant emerging WLAN standard is the US IEEE 802.11, which so far appears to have out-competed the European ETSI standard of HyperLAN2. The WLAN 802.11b solution is already at the market under the nickname of WiFi, which operates in the 2.4 GHz band and can offer speed up to 11 Mb/s within distances up to 100-130 m.

Given that 3G at best can offer data transmission in the area of 300-400 Kb/s within, say, 2-3 years, WLAN based solutions may seem very attractive even in the short run. The users will have to move to hotspots, such as hotels, airports, railway stations, cafés, petrol stations, to be able to reach the Internet, but they will do so at speeds that far exceed present high-speed access solutions (DSL or cable TV modem based) at, say, 512 Kb/s. Instead of waiting for the 3G visions, users may demand a kind of surrogate 4G solution where they will have to move in the terrain with their laptop PCs (or PDAs) *and* mobile phones. The latter may eventually be needed only as an encrypted access device to get access to the 'real' Internet through a laptop PC. Such a solution requires an infrastructure of hotspots.

4.5 Multimedia[19]

4.5.1. Introduction

This section addresses the multimedia sector, particularly the three evolving hybrid business of E-Learning, E-Books and Digital TV and Broadband Services. It is structured as follows. First, there is a brief introduction to the multimedia sector in the European context and some national differences are highlighted. Special attention is drawn to the three specific hybrid business segments. Second, the cases are characterised by adopting a model of industry structure that makes it possible to focus on the relationships and knowledge interactions between the players involved. Third, fusion and interaction processes that have affected the technology dynamics and innovation activities of the sector are identified using the TENIA "Interaction and Power Matrix". As the multimedia sector is defined in a broad sense including business activities of electronic publishing, the development of electronic content and learning management systems as well as digital television and broadband services, the key actors, roles and relationships within the sector seem at first sight to be diverse and complex. Nevertheless, some shared characteristics for the sector as a whole do become visible and can be applied to other activity areas. Fourth, in the final part of this section critical factors for success as well as

[19] This Section draws on the TENIA report "Multimedia Sector" by Simone Kimpeler which presents the cases in much greater detail. The report reflects the collective research activity of all five consortium members that contributed annual reports on this area of hybrid activity.

difficulties of the fusion activities within the multimedia sector are derived from the preceding analysis. An assessment of the knowledge combination observed in the cases is made: can we describe the multimedia sector as a sector of hybrid activities, of completed fusion or even of the emergence of new sectors?

The discussion is based on the findings of sixteen cases, four E-Learning cases, seven E-Book cases and four Digital TV and Broadband Services cases, show in Table 10.

Table 10. Multimedia Sector Cases

MULTIMEDIA SECTOR
E-Learning
• Business-wissen.de, b-wise GmbH, Germany • e-Learn, Exodus SA, Greece • ESTIA, 01 Plifororiki SA, Greece • Intelearn Ltd., Greece
E-Books
• Active Books, Germany • Authors Online, Great Britain • Book Selectra, Great Britain • Context, Great Britain • Gemstar eBook, Germany • IPM-Net, Italy • Guaraldi, Italy • Rightscom, Great Britain
Digital TV and Broadband Services
• ARD Online Kanal, Germany • Flextronics, Denmark • T-Online Vision, Germany • TV2 Nord, Denmark

4.5.2. The Multimedia Sector

Multimedia technologies are defined in TENIA as a number of diverse technologies that allow visual and audio media to be combined in new ways and using new platforms for the purpose of data storage, presentation or processing. Applications include information, communication as well as entertainment and education systems. Thus, multimedia technologies are characterised by media integration and aim at interactivity between producers and recipients. Special attention is drawn to three evolving hybrid business segments based upon multimedia technologies:

- e-learning technologies;
- e-books and;
- digital TV and broadband services on the Internet platform.

These business segments were analysed in case studies and have been characterised as different technology fusion and knowledge processes. All business segments share basic characteristics, as the hybrid activities identified in the cases are not confined to any individual organisation, but take place as the result of sustained interaction between diverse and changing inter-firm network along all the phases of technological development, from design through implementation to the provision of support services.

The broad set of business segments analysed within the multimedia sector demands a flexible definition of "innovation activity" so the TENIA study, besides focussing on activities like research, development and implementation operations, also includes the provision of support services and the transmission of user feedback into the re-development process of products and services.

The sector is described according to the three business segments defined below. Of course, there are other business activities besides these three within the sector, such as the printing industry, broadcasting industry, advertising etc. But taking the definition of hybrid activities outlined in the TENIA framework, these three fields have been selected as examples of the emergence of hybridisation within a so-called traditional sector.

E-Learning

Electronic learning (e-learning) technologies are Internet-based technologies used in different learning contexts like basic and further education in private or work environments. E-learning is distinguished from classical face-to-face learning concepts as it allows learning without the physical presence of tutors and learners. Three types of e-learning technologies are defined according to different platform concepts:

- CBT: computer-based-training as offline multimedia learning.
- NBT: net-based-training as learning in intranets.
- WBT: web-based-training, as e-learning portals in the Internet.

The main components of the e-learning process are content, services and infrastructure. The content is either off-the-shelf or custom-developed and includes course structure,

multimedia applications and learning modules. Learning services are, for example, assessments, technical and systems integration, site management and hosting, maintenance, and online mentoring. The technical infrastructure is important for the learning management system, launching courses, tracking progress as well as creating, storing, and delivering the content in the form of learning objects.

The possibilities of network-based training have been the subject of a wide range of both academic and practical studies and trials at both national and international levels. The broad base of experience in this field only dates back a few years – primarily since the arrival of powerful intranets and extranets, the associated tools and appropriate didactic and organisational concepts. There are two main fields of application for e-Learning:

- e-Learning in the educational framework as innovative solutions in academic and applied courses of study and the corresponding changes in the research landscape and knowledge society;

- e-Learning in the working environment as innovative solutions for the development of companies and their communications and organisational culture.

At the European level, major efforts have been made since the mid-90s to develop "virtual learning" and to adapt activities to the needs of the information society with the help of new media, educational institutions and educational processes. In the "eEurope 2002" programme adopted by the European Council, members were called on to promote multimedia teaching and learning material generally and, specifically, teaching material for the Internet, to develop and install the corresponding hardware and to create or prepare the associated educational structures. The "eEurope 2005" programme places great emphasis on improving the infrastructure in the field of e-learning, and programmes for virtual learning are now being packaged. More specifically, the intention is that, by 2005, Europe should have modern online public services including e-government, e-learning services, e-health services and dynamic e-business environments. As an enabler for these, Europe needs a widespread availability of broadband access at competitive prices as well as a secure information infrastructure.

In terms of e-learning, the specific action plan has set targets to have a sufficient ratio of broadband access and e-learning facilities in schools and universities by 2005. Suggested actions include the adoption of a specific e-learning program (by the end of 2002) and the creation of virtual campuses for all students, as all universities will offer on-line access for students and researchers. Additionally, the development of a university and research computer-supported co-operative system is planned by the end of 2003. The Commission will launch research and piloting actions to enable the deployment of

Europe-wide computer-supported networks and platforms based on high performance computing infrastructures and GRID technologies. Furthermore, there are actions planned to achieve the reskilling necessary for the knowledge society by providing the key skills needed to adults, improving their employability and overall quality of life. All these actions will take advantage of the possibilities offered by e-learning.

E-learning is only one of several learning technologies, but with the growing importance of the Internet as an omnipresent communication and information medium, e-learning might be the most important learning technology in the near future. For example, for web-based training, the training modules are available online and users can learn independently within their individual contexts. Apart from schools and universities, e-learning is also used in further education and professional training. Adoption of e-learning by firms, organisations or the public sector can have major advantages compared to other forms of corporate training, as knowledge is one of the most valuable resources for a firm, providing sustainable competitive advantage. There are some important advantages of e-learning to be mentioned: content can be distributed quickly throughout the organisation in a structured manner and certainly at a lower cost than other current practices. E-learning involves no travel costs, is convenient with regard to timing and location since the employee can follow a home-based approach, enables easy updating of the content and constant monitoring and tracking of the student's or employee's performance. Current concepts of e-learning, as discussed at the international e-learning congress "Learntec" in Karlsruhe, Germany, this year, are based upon the combination of learning modules to be used individually on- and offline together with face-to-face teaching/training sessions. This approach is called "blended learning". The reason for this shift away from pure distance learning to a combination of distance and classical face-to-face or "classroom" learning are due to the results of user requirements and success factor analyses of the first e-learning pilot projects carried out so far. The attempts to implement e-learning tools in learning processes showed that, for most of the learning contents, exclusive distance learning solutions are not enough. Instead users as well as trainers asked for additional face-to-face situations in order to form personal relationships and provide personal support. Of course, the requirements vary according to learning situations, content and context.

E-Learning Market Conditions

However, so far the adoption of e-learning practices by firms has not been too popular in Europe. Recent survey data from the e-business w@tch 2003, including 15 sectors of the EU-15 economies, shows rather low application, even among very large European firms: only 12 % of the small firms (0-49 employees), 15 % of the medium-sized (50-249) and

27 % of the very large ones (250+) use e-learning tools in their internal business processes.

Looking closer at selected e-learning markets in Europe, different types of players on the demand side as well as on the supply side are relevant for a successful development. From a customer's perspective, the market segments are academic, on-the-job, and private e-learning. According to an early study of the e-learning market by Berlecon Research[20] (2001), the different players on the supply side are from the fields of technology (24 %), content development (30 %), and additional services (12 %) for e-learning. Combinations of these activity backgrounds are likely, up to full-service activities (34 %).

The structure of the e-learning market in general is comprised of a broad variety of roles and functions which are relevant for market success. Some players might represent different combinations of market functions and thus follow different business models. The technology side develops, produces and provides the specific hardware and software for e-learning. On the content side, the learning modules are developed, produced and distributed. A service provider is involved to reach the users of e-learning technologies. In the case of web-based training, users need Internet access, sometimes a payment infrastructure as well as instructions and presentations of the learning content within their personal context.

Success factors for e-learning applications include the compatibility and interoperability of hardware and software, the suitability of specific learning materials, e-learning affinity of the target group and the learning environment, as well as other framework conditions. Another important aspect for successful learning courses is the commercialisation of the courses. Looking at academic e-learning market activities, only very few universities, at least in Europe, have been able to implement successful marketing strategies for their e-learning courses, e.g. reach users outside the university who are not involved in their traditional offline course programmes. By offering e-learning to new target groups, a lot of universities would be able to re-finance their innovative activities and open up new financial resources. This is especially true for education systems like the German one, where structural reforms of the education and academic system are currently under way.

In an evaluation study recently carried out of a German e-learning support programme, the following market trends for e-learning were identified:

[20] Berlecon Research (2001) “The Growing Market for E-learning – Requirements, Participants and Prospects of the German Market”.

- expected growth rates have to be adjusted;
- strong efforts towards market transparency;
- market consolidation;
- small niches are in focus;
- at the same time, technology is dominated by big players;
- marketing and sales are of growing importance;
- combination of e-learning and services as added value, e.g. e-HR, Edu-Commerce;
- controlling in education;
- standardisation processes and norms;
- combination of technology and didactics are on R&D agenda;
- no killer-application;
- "blended learning" as strongest trend;
- training-on-the-job;
- problem-oriented learning;
- action-learning;
- soft-skill learning modules;
- knowledge management and communities of practice.

The various national TENIA reports have shown that there are some national differences as well as similarities to be found in the business field of e-learning. As is well known, the current market for e-learning in Europe is still in its infancy. A more combined paradigm seems likely to emerge, at least in the short term, where traditional training and e-learning tools supported by the relevant digital content will intermesh. This is why there is likely to be a growing demand for such services – especially integrated e-learning solutions – while the content or the infrastructure will tend to be consolidated.

E-Book

Information technologies and telecommunications are affecting the development of the traditional publishing market too. Technological innovations have radically modified the systems for data elaborations, transmission and archiving, allowing the transfer of information in different formats (e.g. text, audio, images). These changes have driven the transfer of products and processes of the publishing industry on digital platforms, with a strong impact on the value chain related to the production of books. Digitalisation technologies are thus leading the transition from "traditional" to "digital" publishing activities, allowing for the emergence of innovation opportunities, such as:

- The separation of physical and virtual processes by delivering immaterial contents, which allows the same information to be delivered using different formats. It is then possible to design different commercial configurations of the same contents using bundling strategies between supports and channels.

- Through the introduction of new distributive channels (Internet, mobile phones), publishers can separately commercialise different "versions" of the same book directed to different niches of the market.

- The integration of new technologies is used to develop new products (multimedia products, e-book hardware, e-ink, e-paper).

- It is possible to combine different types of content (text, audio, picture and video) in one product.

- Process innovations (e.g. print-on-demand) affect the established activities of production and modify the way in which typical publishing activities are performed.

- Brand new concepts in editorial production, such as multimedia, hypertext, interaction are explored.

Print-on-demand is another new process which complements and in some way substitutes the traditional printing process through the use of digital files that allow the storing and transferring of the informational contents to a paper-based document. Printing thus becomes an on-demand process where the technical characteristics of print are defined in a separate step. In this way, the traditional paper-based document, printed in a fixed number of copies and kept in storehouses, is substituted by a single digital copy kept in a data or web server. Without affecting the standard editorial processes, the distribution becomes leaner by eliminating the storing and substantially

reducing the production costs of the book. Furthermore, print-on demand can be exploited in product distribution through the use of e-commerce.

Until now, the market has demonstrated that all the new systems for the production and distribution of digital and traditional products tend to co-exist which results in an interesting pool of market niches.

E-book is a literary product published in a digital format (electronic text) using specific software and hardware. It can be conceived as a systemic product, whose characteristics and functionalities depend upon all elements of the product system itself. These elements comprise the following:

- *Electronic text* as literary content.
- *E-book format* as an electronic format in which the text is saved with specific additional characteristics of reading, visualizing, formatting and browsing as compared to the more diffused electronic format (txt, rtf, doc). There is still competition for the development of a single leading e-book format (main competitors are Microsoft and Adobe) because the format embeds the key features for the compatibility with e-book readers, e-book devices and Digital Rights Management (DRM) applications.
- *E-book reader* (software): a reading program that permits the reading of a specific e-book format. There are now different e-book readers (e.g. Microsoft Reader, Adobe Acrobat Reader, Palm Pilot Reader) on the market, all compatible with one or more e-book formats.
- *E-book reader device* (hardware): the physical reading equipment. An e-book can also be read using PCs, laptops or palm devices, but there are dedicated appliances (e-book readers) being developed. In general, e-book readers look like a large palmtop, without a keyboard and with a high-resolution LCD screen. Their design resembles that of paper books, trying to reproduce the ergonomic characteristics of traditional books. E-book readers usually allow different software readers to be used.

In other words, the notion of e-book involves a literary piece which is transformed into a digital format (e-book format) and is readable using specific hardware (e-book reading device) with the help of specific software (e-book reader).

There are several additional functionalities made possible by the electronic format. It can include audio-visual dimensions and hyper-textual links. This makes it possible to convey

additional information to the user, enabling a broader learning experience. E-books can be used both off-line and on-line. The value added by the on-line reading mode is based, for example, on the possibility of real time updating and links' navigation. By reducing the costs of updating, an e-book can guarantee a quicker diffusion of contents. Also of importance is that reader devices have a large memory, storing between 10 000 and 150 000 pages in order to offer many books simultaneously. Developers of e-book readers are focussing on solutions to increase readability and free formatting. Clear Type (Microsoft) and CoolType (Adobe) technologies offer good results in terms of clarity and ease of reading. The appearance of the text is freely modifiable in relation to needs and preferences, and it is possible to select the size, typology, and neatness of the character, as well as the characteristics of the screen.

Besides digitalisation, many different technological innovations, concerning both hardware and software applications, have affected the development of e-books:

- mobile computing and the diffusion of palm devices;
- development of standards for the editing and distribution of digital contents;
- creation of hardware and software solutions explicitly dedicated to e-books;
- enhancements of technologies for visual displaying and rendering;
- first development of technologies for digital rights management.

Three different e-book systems can be distinguished:

- reading devices (e.g. Gemstar International/RCA with Rocket eBook and GEB 2200);
- PDA-devices (personal digital assistant) with E-Book function (e.g. Franklin eBookMan) and.
- software for reading electronic documents (Acrobat Reader, eBookReader or MS Reader).

E-Book Market Conditions

As of today, notwithstanding the continuous progress in product development, publications on digital supports and specifically e-books do not represent a true alternative to paper ones. World-wide, e-book sales are still not relevant when compared to the overall revenues of the publishing industry (less than 1%). Predictions about the

future of this product are mixed. Some forecast a development corresponding to the development of the technology and the increased interest of users, while others do not believe in a wide diffusion. Most analysts agree in that e-book features can be better exploited in specific market niches, such as the ones listed in the following table.

Table 11. Market Niches for E-Books

E-book Reader	Mobile Business	Mobile Learning
medical handbooks; legal and technical manuals; tour guides.	sales force automation; on-site technical assistance; financial promoters.	continuous on the job education; foreign language courses; educational texts.

These markets do indeed show particular needs that e-book features could meet: continuously updated information, huge quantity of data, relevance of non-sequential consultation, and importance of search tools. A small dedicated market niche has developed over time. This niche is of little relevance when compared to the main market. Producing, selling and trading books have undergone a profound structural change in the last decades. The following developments are characteristic for this change:

- The sector is undergoing a structural change, which is taking place regardless of the existence of information and communication technologies (ICT). Current developments include an increasing concentration, the internationalisation of competition and the extension of the product line to the "non-book" multimedia sector (e.g. software, video).

- The Internet has created a new infrastructure for communication and transaction. Thus different forms of online book distribution have been created, e.g. online mail order like amazon.com, new publishers, producers and distributors of digitised print-on-demand books. These new possibilities of direct selling and producing compete with the traditional selling methods of the book trade.

- Finally new forms of producing and using books are emerging on the market. Among these are concepts and patterns such as "mobile publishing", "ePublishing", "content brokerage" or "eBooks". If such types of book production become established on the market, the distribution of printed books via traditional bookshops would be decisively affected.

The activities concerning e-books among the main publishing companies look like exploratory actions, rather than specific interests. More efforts have been directed towards the adoption of on-line selling platforms than the commercialization of e-books.

The technological situation in the sector is still rather fluid and unstable, with a diversity of solutions available in software, hardware and digital rights management solutions. This has caused incompatibility problems and hindered the widespread adoption and use of e-books. Several standard-setting bodies, such as the Open eBook forum, have tried to address this situation by bringing together some of the largest industry players and promoting the adoption of common interoperability standards. When defining the case study pool we incorporated companies engaged in a wide range of activities from e-retailing to the provision of Digital Rights Management consultancy, with the aim of reflecting the diversity of collaborative experiences that can be found in the e-book sector.

A survey carried out by the printing industry association (AKEP 2003) showed that activities like digital printing and distribution are very important for many traditional publishing houses in Germany. For 75% of them, electronic publishing is – despite the high investments needed – part of their business activities. Yet, online publishing, e-books or publishing-on-demand do not lead to significant increases in turnover. For 60 % of the publishers less than 5% of their turnover was generated by these activities. More than half of them think that the break-even point in this business segment has not been reached yet. Two thirds think that in 10 years time half of their turnover will be achieved digitally.

In the years 1999 and 2000 reading devices were successfully presented at the Frankfurt book fair and triggered a lot of interest within the industry (book retailers, publishers, etc.). The Frankfurt e-book award was presented for the first time in 2000. Microsoft entered the e-book market with its MS Reader*. The company adopted a software-based approach in which digital contents/books can be viewed on the PC with the aid of software developed specifically for this activity. Interest in the e-book market is being intensified by the Microsoft launch. Mid-2002 the Gemstar e-book GmbH entered the German market with the Rocket e-book produced by NuvoMedia. A broad range of readers is targeted with this device. The GEB 2200, a SoftBooks Press development comprising a colour display, was introduced to the market in 2001. Originally this device was intended for professional use only (companies, science).

Digital TV and Broadband Services

The present transition of the broadcasting industry from analogue to digital TV is said to be disruptive to the industry, and is compared with the shift from analogue to digital network technologies in the mobile communications industry. Digital TV is not only a different way of broadcasting with better quality pictures and sound, it also offers the

possibility of interactive services. It allows for more channels within the same frequency band and makes it possible to add different services to the TV signal. The most interesting new features of digital TV are the possibility for enhanced content and interactivity. Interactive digital TV however requires a backward channel to link the user and the service provider. This is generally provided by a modem or cable network in the telephone line.

Most of the television sets on the market are still analogue and these require a converter (set-top box) to access the digital signal and services, but digital TV sets are beginning to appear.

The transition process to digital TV has proved to be less simple than originally envisaged and even though many governments have set a date for turning off the analogue broadcasting signal, usually within a 10-15 year period e.g. US and Germany in 2006, Sweden in 2008, these countries still only have a low penetration of digital TV. This is partly related to the differences in standards for broadcasting, receiver devices and software platforms. The broadcasting standard affects the possible transmission method which sets the requirements for the receiver device, which in turn is also influenced by the software platform that allows enhanced content.

Digital TV services can be broadcast by satellite, cable and terrestrial (the signal can be received by an ordinary antenna) or through optical fibres. Fixed line Internet can also be used as a mode of delivery, but a high bandwidth is required for digital signals, which was not possible at a reasonable cost until recently.

The Internet combined with compression techniques for digital signals has also created possibilities for video-on-demand, downloading (pirate) movies and other services.

The technical change in the digital TV industry is very rapid and several sub-standards for broadcasting and services have emerged, but these are mainly proprietary. However, in Europe, government interest has moved towards digital TV based on open standards and in particular the DVB (digital video broadcasting) standard with the MHP substandard for interactive services (multimedia home platform). Since the industry is highly regulated through licenses,, public service TV stations and the transmission network, governments wield considerable power. The digital TV industry may potentially be disrupted by Internet technologies, since the features of interactivity and transmission of data/pictures overlap to some extent. The entrants to the digital TV industry originate from both traditional TV/consumer electronics and the computer industry, where firms are developing set-top boxes, MHP software etc.

Several different standards for broadcasting digital TV exist in Japan, Europe and US. Work on a pan-European platform standard began in the early 1990s. The European Launching Group was founded in 1991 and its participants included a broader group of manufacturers, broadcasters and regulatory bodies. The group drafted and signed a memorandum of understanding in 1993 whereby the rules were set by under which the standard would be established and implemented. The group was renamed the Digital Video Broadcasting (DVB) Project and then worked on developing a complete digital television system based on a unified approach. The European Telecommunication Standardisation Institute (ETSI) later transformed these specifications into a European standard. The European DVB organization however quickly realized that satellite and cable would be the first to deliver digital TV since the technology was less complicated and the regulatory system less strict. Digital satellite and cable broadcasting systems were therefore to be developed quickly and terrestrial follow later. Consequently three standards were agreed upon: DVB-C (cable), DVB-S (satellite) and DVB-T (terrestrial). But even though the content is the same, the DVB broadcasting standards DVB-S, DVB-C and DVB-T are not compatible since they apply to different modulation methods. Transmission of digital TV by satellite, cable or terrestrial uses the same frequencies as a similar transmission of analogue TV, but the three forms of distributions have different capacities. The development of the DVB standard is now moving towards IP (Internet protocol) by DVB, i.e. set-top boxes are assigned an IP address. The receiver device also fulfils another function since it can be equipped with a return channel that allows interactivity and thus a wide possible range of services.

The platform of the receiver device in digital TV has mainly been running on proprietary operating system software, since the set-top box or satellite receiver are being subsidised by the TV stations. In the development of set-top boxes for terrestrial digital TV with enhanced content and interactivity, the focus has been on using the open DVB 'sub-standard' MHP (multimedia home platform).

The terrestrial digital TV market is highly dependent on policy decisions and the future broadcasting structure is determined by policy decisions. In countries with some degree of licence fee financed public service TV, the government will most likely ensure that these TV stations are not in a worse situation when broadcasting digital TV. However several problems in key areas still seem to be unsolved; set-top boxes based on the MHP platform are still rare and they still lack certain features which would allow all the services, interactivity and enhanced content that digital TV is supposed to provide.

With the conversion to digital TV on the one hand and the increasing availability of broadband connections in private households on the other, convergence scenarios of TV

and Internet are experiencing another boom. From a technical point of view, television as the classical broadcasting media can be transformed into a more interactive media form, allowing for greater viewer control and choice in the digital era. Likewise, Internet is considered to be a classical interactive media. Increasing the bandwidth via DSL or cable modem connections enables users to watch streaming video or to download complete movies (video-on-demand) to their computers. This means that in some areas the Internet might be transformed into a quasi broadcasting media.

Digital-TV and Broadband Services Market Structure

Digital TV represents a disruption to the TV manufacturing industry. Due to the disruption it could be possible for new firms and diversifiers from different industries to enter the market. But the digital TV industry itself may be disrupted by Internet technologies, since the features of interactivity and transmission of data/pictures overlap. Especially the area of refraction in digital TV is characterized by moves from the traditional TV sector as well as from the computer and Internet sides. The growth of the digital TV industry has been hampered, since the roll-out has not been as fast as was anticipated. This has slowed down the technological development of set-top boxes, software etc. because the firms seem to be waiting for the wider diffusion of digital TV before up-scaling their development activities.

The transition from analogue to terrestrial digital TV will open up a mass market, but when, where and how much depends mainly on political decisions. Likewise, business models are lacking and it is still uncertain if viewers are prepared to pay for the better quality picture, enhanced content and interactivity. The TV companies are competing using different transmission methods which each have their own advantages and limitations. The satellite companies and subsequently digital satellite TV have had a head start, as the DVB-S standard was created first, the competition is tougher and the regulations less strict.

At present, broadcasting digital TV by satellite is dominant in Europe, but terrestrial digital TV is now emerging and delivering Internet access to homes using optical fibres is becoming a real alternative as a transmission mode. The first attempt to introduce digital TV in the UK and Sweden was unsuccessful because consumers did not want to buy converter equipment (set-top box) or pay extra for digital broadcasting. In the UK, the business model was changed and digital TV has since become more successful., Terrestrial digital TV is also being broadcasted in Finland, but this form of transmission has only been ‘fully’ implemented in the city-state of Berlin in Germany, where analogue transmission has been stopped. Denmark seems to have lost the opportunity to become

a first mover or even be among the first, even though the diffusion of digital TV has been slow all over Europe. The new Danish plan is not ambitious and unfortunately has some similarities with the Swedish approach. As a result the diffusion of digital TV is still sparse.

This raises the question of who will be prepared to buy a set-top box if the services and TV channels are likely to remain limited in the near future? Without interactivity or enhanced content, users are missing many of the benefits of digital transmission and, in combination with a long transition period, this could result in an undesirable chicken-and-egg situation with users waiting for services before buying digital receivers and broadcasters and regulators waiting for customers before expanding the networks and enhancing content and services. In countries with some degree of licence fee financed public service TV, the government will most likely ensure that these TV stations are not in a worse situation when broadcasting digital TV, which could result in a slow diffusion of digital TV. This seems to be the case in Denmark and Germany.

Looking at digital broadcasting services via the Internet, it has to be said that the convergence of TV and Internet is still at a very early stage. Both spheres will have to be examined and analysed separately for some time to come. This is because the markets, key players, and business strategies are still very different in the field of digital TV compared to the field of broadband Internet. Also, consumers seem to be reluctant to change their patterns of TV-/Internet-use. There are also differences and specific requirements in the field of regulation and technology.

However, the companies supplying the technical platform do not develop and offer the applications themselves. This is mainly done by content providers and TV stations. Consequently, content providers have to bring their new interactive services in line with the technical parameters of technology and network providers.

Examples of interactive TV services include:

- *Electronic Program Guides (EPG)* are on-screen navigation instruments which provide additional information to the current TV-programming. TV viewers can get information about starting times, short descriptions of the content and a program listing of the different channels. Technically, EPGs are part of the set-top box (STB) software and can be navigated by the STB-remote control. But, unlike the videotext-service, EPGs are complex tools for navigation and orientation in the digital TV world which is evolving into a multi-channel broadcasting environment with a multitude of TV-programs to choose from. With an EPG, a TV viewer can "bookmark" subjects of interest (special feature films, adventure movies, newscasts

on money and finance, travel programs, etc.). Each time a program from the individual priority list is being broadcast, an icon will appear on the screen drawing the viewer's attention to the respective starting time.

- *Online Channels.* Because the digital TV data stream can transport much more data than an analogue signal, additional graphic information can be broadcast within the data stream. This feature can be used to create special online channels containing either content which refers to the current broadcast (companion content) or to different, program-independent subjects (independent content). Companion content, for example, can provide additional information to a newscast displaying background information in the form of text, graphics, maps or pictures. Using a split-screen-technique, the TV-newscast can be viewed in parallel in a smaller window (picture-in-picture).

- *Internet services: E-mail/WWW/transactions.* The technical provision of a back-channel from the user to the provider becomes necessary if the provider wants to offer Internet services over the television set. While online channels constantly feed the set-top box with data being broadcast in a data carrousel, internet services are on-demand (information is only transmitted if requested). For this reason, Internet services like e-mail, World Wide Web or chat are only feasible where a back-channel can be provided. Most often this is done by connecting the set-top box to the telephone outlet or by using a cable-TV network which is capable of bi-directional communication. In these cases, almost all the applications that are currently available via the Internet can be made accessible to TV viewers. One important drawback of using a TV screen is that text is often displayed in a lower quality since Web-sites were created for the resolution capacity of a computer monitor. Web-like applications can, however, be created especially for the TV-environment using bigger fonts and layouts. Principally this opens up the possibility of e-shopping for TV viewers.

- *Interactive services on the digital TV platform.* TV-stations, programmers and independent media companies are beginning to offer new services such as Electronic Program Guides (EPG), Online Channels, Webcasting services, Web-Access, etc.

- *Broadband Services on the Internet platform.* Broadband Internet services like Video on Demand, Online-Gaming, multimedia mail, Streaming audio and video have become possible with the advent of new access technologies to the Internet. These technologies comprise DSL (upgraded telephone network), cable modems

(upgraded cable-TV network), satellite (hybrid or two-way requiring regular satellite dishes), DVB-T (enabling push-services in a hybrid system), UMTS (3G mobile telephone network), WLAN (wireless access in hotspots, requiring laptop and card), and Power line modems.

From a technology point of view, broadband applications use the same backbone infrastructure as traditional Internet applications. However, within the computer-mediated network of the Internet, there are several bottlenecks which need to be overcome when delivering high bandwidth-applications to private users. These bottlenecks are identified in Figure 7 as the local switch, the Internet Service Provider (ISP) and the different sub-networks and server infrastructures which make up the Internet.

In fact, broadband Internet providers, e.g. technology or telecommunication companies, have already started to build up a "Parallel Internet" for their broadband customers, which delivers the contents and services offered without using the traditional Internet infrastructure. This is one way to overcome the bottlenecks which are usually beyond the control of telecommunication companies. Broadband providers have therefore built up their own infrastructures consisting of broadband exchanges and broadband ISPs, and regional data-centres, where popular websites are stored on proxy-servers. Content providers can feed this broadband network directly with programmes and services without forfeiting bandwidth.

Programme and application providers have to feed their content to one central or several regional digital play-out centres. Here the service information data is inserted into the digital TV data stream (multiplex) and the signal is encrypted.

The technology and content chain for digital TV services consists of three central components: the content/application (service), the middleware/software and the digital set-top box (hardware). The middleware/software is used at both ends of the technical chain, meaning that programmers use it to create the application, and set-top boxes use it to decrypt, retransform and display the application on the TV screen. If the respective application requires active feedback by the user, a return channel needs to be provided.

One of the central questions in the discussion about the future of interactive TV is: who should pay for the set-top boxes? There are three possibilities: the programme provider, the network provider or the consumer. The answer to this question is closely linked to the business models of the respective companies and the prevailing market conditions.

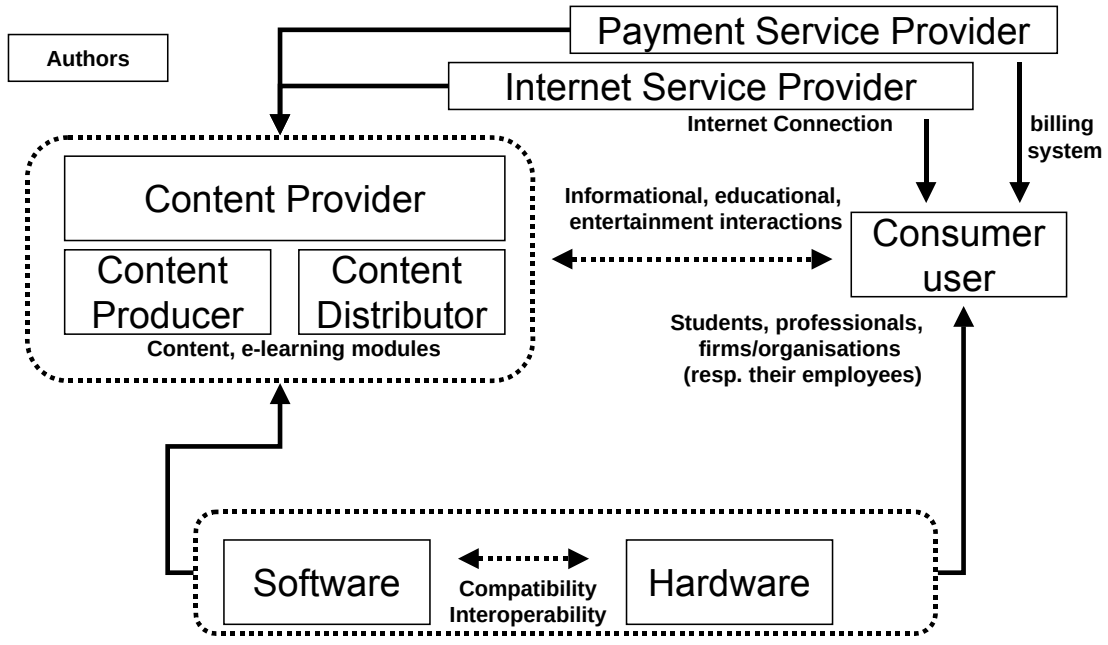
There are general conditions for the development of new interactive TV applications on the digital platform which play important roles on different levels. In order to assess these overarching development factors, a variety of aspects have to be considered. These aspects can be made more explicit in a MHP case study. In general the following aspects have to be considered:

- competition between PC-based interactive services and TV-based services (availability of same applications on different platforms, development of the broadband Internet market and competition from broadband Internet Entertainment Portals);
- general convergence tendencies between computer/Internet and TV;
- providers' strategies concerning the convergence, principal possibilities of refinancing investments in technology and marketing;
- questions concerning technical standardisation;
- regulation of new services and infrastructure regulation.

4.5.3. Hybrid Activities

The cases analysed by TENIA are described and characterised by adopting a model of industry structure that allows the focus to be placed on the relationships and knowledge interactions between the actors involved.

Figure 12. Sector Structure Multimedia



The sector structure model reveals the relevant actors of the multimedia industry and their specific roles and relationships. The complexity of the whole industry, which was also evident in the case descriptions, is based on the mutual interdependencies of the actors. Although the special qualities of each business field have been described above, it is still possible to illustrate the overall industry structure (Fig.3). There are four main activity fields within the multimedia sector: technology providers, content producers and providers (including authors), service providers and consumers. The technical part includes hardware and software producers and providers. For this group, it is of great importance to achieve compatibility and interoperability of systems and devices, e.g. through standards. Another technical role is fulfilled by content providers, producers and distributors, depending on the different business fields and activities involved. In some cases the authors form part of this group of actors, in other cases they are excluded and have to negotiate their collaborations. Content providers and technology providers are both involved in the standard setting processes and defining the technological base. Which actors play an active role and which have to adapt to already existing definitions differs from business case to business case. By definition, new platforms are developed and implemented in hybrid or fusion activities. This brings in a third group of actors: the service providers, who enable the users to access the platform and the digital multimedia content. With regard to the market situation of the three business fields which have been analysed, an important, still open-end process is the development of payment solutions. And finally, there are often direct links between all the groups of actors and the end users.

According to the case studies, the dynamics of technology (for hardware and software) can be characterised by three trends:

- The hardware segment shows continuous power enhancements, evolution and uncertainty in a context where network externalities and standards settings matter.
- The whole sector is capital-intensive, with high fixed costs of production coupled with low reproduction costs and DRM.
- Software development is affected by interconnection compatibility.

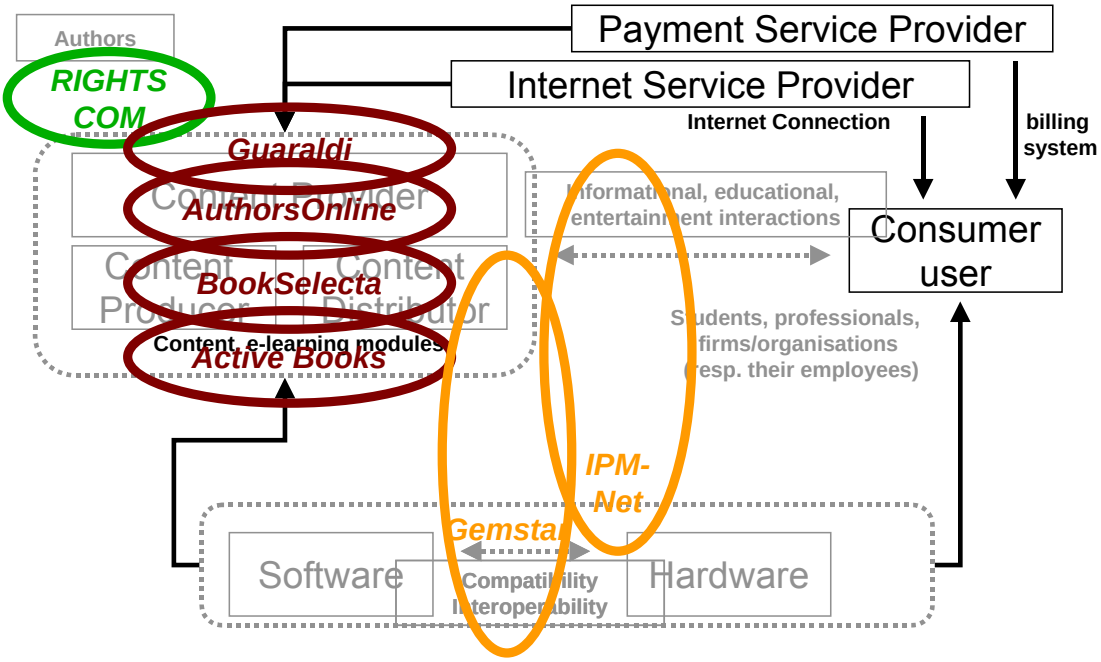
A definition of the position of the business cases within the sector structure model is given below as well as the analysis of the specific power relationships between the actors, especially between technology providers and service providers.

Description of Hybrid Activities

E-Book Cases

The location of the e-book cases within the industry structure model reveals the relationships and interdependencies of the actors involved. One case, Rightscom as an agent for DRM, is located in-between the content production part and the authors. Four cases are publishers in a broad sense, including traditional publishing houses with e-content activities like Guaraldi and the Junfermann Verlag (active books) as well as online bookstores like BookSelectra and Authors online. In addition, two cases of technology providers were analysed: the reading device producers Gemstar and IPM-Net.

Figure 13. Position of E-book Cases in the Multimedia Industry Structure



The in-depth case studies show that the co-operation between e-book device suppliers and e-book service providers, converting documents into digital text and sometimes also selling digitised books, is quite important for the market development. Another main theme that has emerged from the case studies is the significance of institutional design and close communications for the success of joint innovative endeavours.

Some case studies served to highlight the fact that communication between innovating partners in the development of hybrid technologies is not only used to transmit technical information for co-ordinating innovative tasks, but also to negotiate and implement marketing activities. Concerning the former function, actors use communication to transmit, explicitly or implicitly, their objectives and intentions to other partners in the

innovative network. A lack of alignment between actors' objectives may become a source of potential conflict and trigger the need for negotiation.

Close communications, whether formal, informal, or both, seem to be considered the best way to make sure that information about needs, problems and possibilities is efficiently transmitted within the innovating network. Communication is also used in order to build up reputation and trust. Trust which has grown through previous and existing interactions is useful in order to form relationships with new clients and partners. In many cases this is initiated by a recommendation from a third party.

So even though network effects and the need for interoperability between the different components of hybrid technological platforms appear as the basic drivers for collaboration, mechanisms that guarantee a degree of alignment in the behaviour of those engaged in joint innovative efforts should also be included as necessary for successful technology development, close communication being one of them (other example would be financial incentives). In interviews with the selected e-book companies, the interview partners emphasised the continuity of such contacts. In the context of evolvable business models and technological systems which have to be constantly modified and re-adapted to the circumstances of a dynamic environment, it is essential to maintain sustained contacts and an uninterrupted information flow during all stages of the innovation process.

The case of Rightscom highlights the importance of industry forums as a gateway to valuable networks where these contacts can be established.

Technologies that target mass markets require a wide range of features and options to facilitate their seamless integration into the technological infrastructures of users with relatively "standard" needs and business models. One such example is BookSelecta which, as described earlier, is a second generation feature of new industrial activity development in which a degree of stability has been achieved in the platforms for providing services. It is possible to significantly reduce the potentials for conflicts if a joint definition of the technological requirements is made for the platform being developed.

Guaraldi has adapted to the existing technological and market tendencies and supported the diffusion of popular standards. The hardware for the production and management of contents is not considered critical, since this is standardised and can be acquired from different producers. In contrast, the software platform underlying the management of content and all the related sales processes is a critical component. Guaraldi stresses that relationships along the value chain have to be collaborative in nature in order to

implement a successful system and be able to acquire a market share with benefits for all the participants. Relationships with competitors are competitive on the commercial side, but collaborative on the technological side, with the common goal of promoting new offers.

According to IPM-Net, the critical players for e-book development are both the firms that develop hardware components for visualisation and communication tools and the organisations developing DRM solutions. DRM could be the crucial issue for industry growth, convincing authors and contents producers to distribute digitally. Relationships with other companies are usually long-term. They are dedicated to the commercialisation of existing hardware and software exchange, but also to co-operations for developing new components and applications.

It is easy to observe that there are complementarities between the hardware firms and content/software providers. These companies can stimulate the growth of the market, which is currently emerging and uncertain, by adapting and converting their production structures. Another important transformation concerns the expectation of integration between reading software and Internet browsers. A convergence would enable different applications to function with different media within one software with direct plug-in.

The companies analysed are not large or influential enough to participate actively in the development of core technologies or standards. They both acquire and adopt technologies "off-the-shelf" and integrate them in their activities. The companies act in a market where demand is not fully developed and must be stimulated. At the same time, competition is currently not a major issue and so far, t a dominant design has not yet emerged. Feedback from users is crucial in order to obtain an installed base and to find profitable directions for the further development of their product range.

Multimedia products are systemic as they need complementary elements in order to be utilized. The product value – above all as it is perceived by the customer - cannot be entirely controlled by the publishers (who can be fully responsible for the contents), but is also affected by the characteristics of the devices that complement the contents. Therefore, the interactions between companies involved in any product component and the dynamics of the different technological paradigms are very relevant and must be explicitly considered.

When moving towards a digital framework, as in the case of e-books, publishers definitely need to consider the dynamics of hardware and software components:

- The hardware segment shows continuous power enhancements, evolution and uncertainty in a context where network externalities and standards setting are crucial. Production is very capital-intensive and costs decrease steadily with the increase of the installed-base of users.

- The main issues affecting software development are the interconnection compatibility, the high fixed costs of production coupled with the lowest possible reproduction costs and the importance of property rights management.

In such an interconnected environment, developing standards is crucial to increase the potential value of the product, allowing for a wider expansion of applications and users. For this reason, until now competition in the e-publishing market has been difficult because of the antagonism due to incompatible standards (e.g. Adobe's format versus Microsoft's). The development of one single standard would guarantee that content and reading appliance producers refer to common technical specifications that ensure adequacy, accessibility and availability of the electronic content over different e-book platforms. Consequently, content providers could disregard the technical differences of the individual reading appliances and users could access any published title regardless of which appliance they possess.

The continuous technology evolution further complicates the market development because a "dominant design" has not yet emerged. The most important limitations are the incomplete integration of multimedia contents and the lack of internal mechanisms for protecting the documents and guaranteeing copyrights. The development of a reliable and efficient DRM standard is crucial to ensure a relevant flow of investments in this sector and is perceived as such by the companies interviewed. On the contrary, the emergence of a standard e-book format or software is not compulsory so long as the different producers agree on compatibility constraints.

Many analysts have the feeling that the market is still waiting for better designs and capabilities (readability, technological features, costs, portability). The risk that older products might not be compatible with the next generations of solutions is preventing widespread investments in this product.

The competitive dynamics of the sector have also changed significantly:

- new players have entered the industry, such as technology developers (hardware and software producers), distributors of electronic contents, service providers;

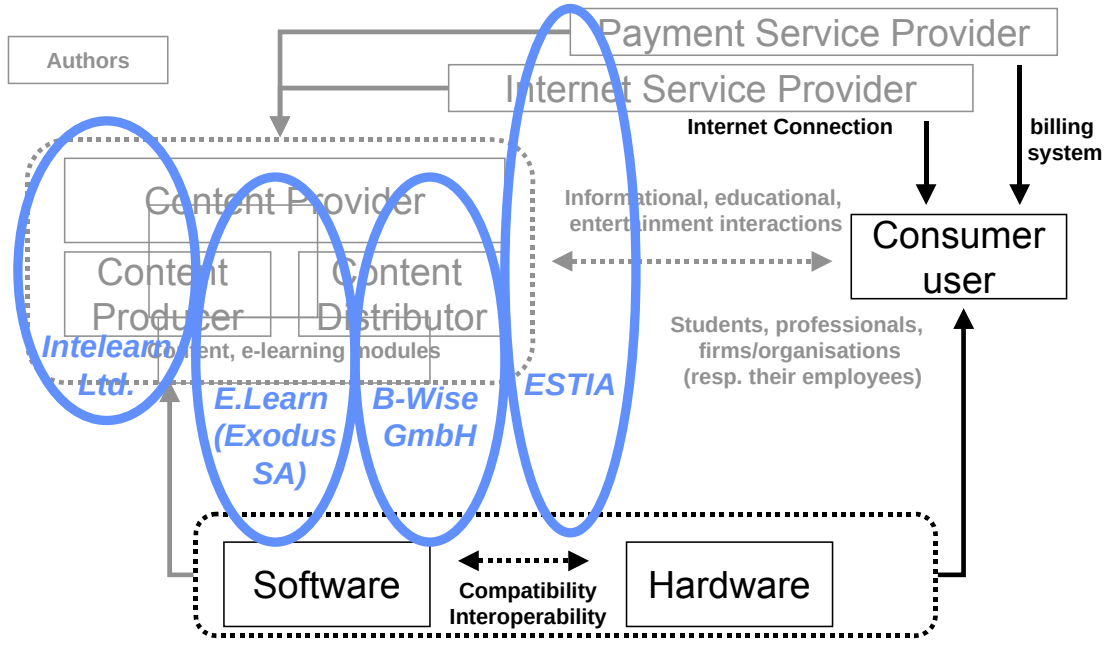
- because of the new methods of content production and distribution, established publishing companies within the traditional value chain need to form relationships with many different firms, both upstream and downstream.

The segment of digital publishing shows specific features: it consists of small (but growing) diversified niches of products, markets and technologies. New key actors come from different markets and are endowed with various competencies and experience (publishing or media companies, technology developers and Internet companies). The leading companies of the sector are active in many international markets. Internationalisation is driven by scale economies, scope economies, and by product characteristics, such as the small incidence of transfer costs.

The production and distribution of a digital publication require dedicated capabilities. Publishers now have to deal with IT and telecommunication issues and manage the contents in order to render them suitable for the new fruition media. In the subsequent distribution phase, publishers have to understand new channels' specificities. Therefore, companies in this market are expected to develop flexibility, knowledge integration capabilities and the predisposition to partnership agreements.

E-Learning Cases

Figure 14. Position of E-Learning Cases Within the Multimedia Industry Structure



Looking at the industry structure of e-learning and the positions of our cases within this structure, it is interesting how closely all the firms are located within the activity fields of software development and content provision. Two firms, Exodus SA and b-wise GmbH,

are active in almost exactly the same field: software development for content management system and content provision for e-learning. ESTIA is not involved with content development or production but with the technology provision for e-learning. Intelearn Ltd. on the other hand, is not active in technology provision but in the provision of content by producing educational software.

There are different relevant business strategies for financing e-learning products and services. These include premium membership fees for the platforms, advertising, or e-learning participation fees. Additional strategic partnerships with publishers or external e-learning tutors are difficult to quantify.

Only one firm says that it is satisfied with the demand situation at the moment. It sees a lot of potential for increased marketing activities and new distribution partners, but has no resources to implement a new strategy. The market is considered a little reticent, and e-learning is still a new technology that requires a certain level of user know-how and experience. Companies are restrained about spending money on e-learning for their employees. And there is not enough market transparency, which is an important issue when companies are reluctant to invest in e-learning for their employees.

The financial support comes from banks and venture capitalists, and in most cases, was described as not sufficient at the moment. One firm stated that the financial conditions are very bad. The seed capital was around 150 k€, one third equity finance (three owners) and two thirds outside capital. No profit has been realised yet. Financial bottlenecks came up after the seed capital was spent (~ 1 year). The current financial situation is growth inhibiting as the market potential is there, according to the interview partner. Another case is a good example of how an R&D co-operative agreement, a project subsidised by the European Union (5th Framework Programme), led to direct commercialisation of the R&D outcome. The development of a learning platform began at the end of 2001 and was completely self-financed. The 2nd edition of the product is currently under development and due to be launched in the market by September 2003. The other two cases are based on own funds.

Looking at the role of technology providers in the industry, it is interesting to see that the open source community is very important for the technological development for some firms. Others use the technology of a dominant (international) player and hope that this strategy keeps doors open to future co-operation partners. The companies using open source software often offer custom-based solutions and continue to develop their product each time it is implemented. The Greek developers explained that they have to cope with customers' mistrust of Greek products, since there is a widespread belief that foreign

products are better, even though it is often evident that these are not adapted to the exact needs of the Greek firm.

It becomes obvious that, for the time being, the provision of e-learning services cannot be realised efficiently because of the lack of the necessary network infrastructures. Despite national differences, there is still a lot of market potential.

Competitors in the e-learning market include Internet and multimedia agencies, especially small-sized and freelance online service providers, consultants, trainers and university teachers offering online tutorials. At the same time these are important co-operation partners, using the portal to promote their own business activities and put their courses online with the help of the content management software. However, the main competition for the Greek developers is from the several multinationals that act as resellers in the Greek market for foreign e-learning tools (usually from the USA).

All firms focus on more or less the same target groups as users of their e-learning products. These comprise, on the one hand, individuals in the further education market, professionals like business managers. On the other hand, firms or organisations are also focused customers who purchase e-learning modules for in-house web-based training of their employees. A third group are users within the education sector like students. It is important to emphasise that customers are not just individuals but also institutions. In most cases, the decision to implement an e-learning tool is not taken individually but by persons responsible for this within the organisation like human resource managers, executives, system administrators, etc. Industrial companies and public administrations/

organisations form an autonomous target group, as they might book a complete e-learning course for their employees and purchase company-specific e-learning modules.

This makes it clear that the key actors in this industry are not so much the users themselves, but rather those responsible for making the decision about whether or not their organisation will support the use of the e-learning tool. These decision-makers are

- Educational organisations and academic institutions that offer e-learning services to their students (i.e. the Greek Open University offers synchronous learning to its students, while the Technological Education Institute of Larissa provides asynchronous learning with ESTIA).

- Private firms (large and SMEs) that wish to dynamically manage all the procedures that are related to the provision of distance training services via the Internet and

- Other organisations, usually from the public sector.

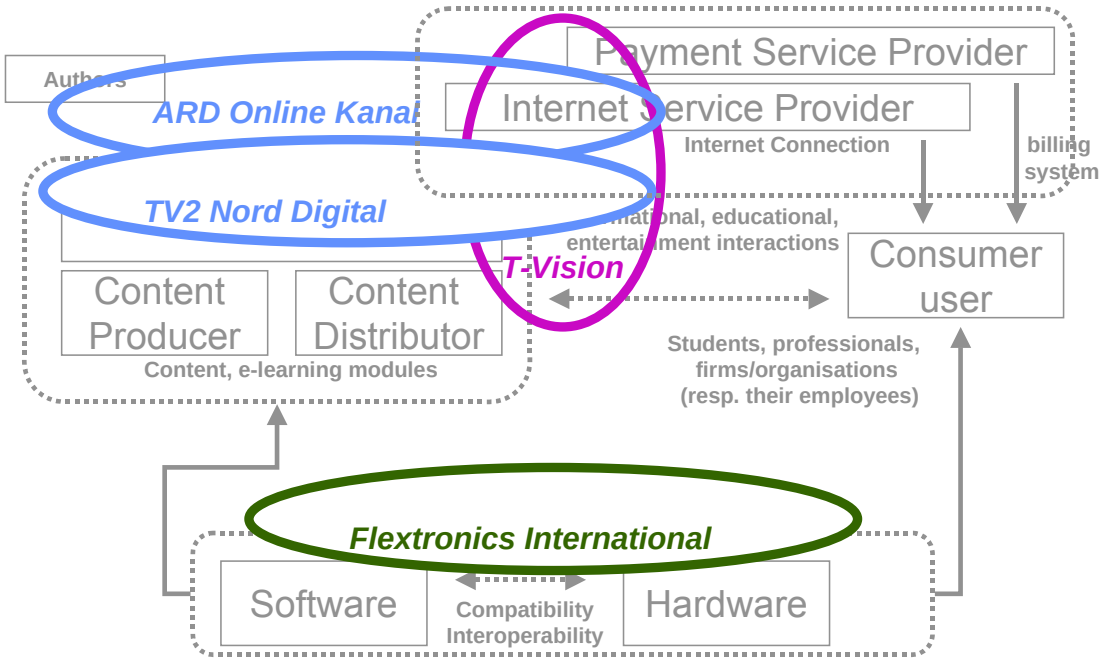
Nevertheless, the role of the users of e-learning platforms or any educational software in general is still quite important since they might impede its further spread. Academic institutions and big public organisations can be considered major players in the near future because their adoption of e-learning practices, considering the vast numbers of potential users within public or private organisations, could give the market of e-learning applications a great boost.

Other important actors in the e-learning industry are the application developers for e-learning solutions, the Internet service providers, content providers and application service providers. Hardware providers (manufacturers of PCs, CD-ROMs, etc.), are not considered as key actors in the specific cases, since their contribution is more or less given.

Finally, we should mention the role of certain actors who are considered as very important, even though their involvement is indirect: experts in their role of content evaluators. The role of experts is crucial because e-learning is first and foremost a process of teaching specific knowledge despite the high technology involved, and as such it should comply with all the basic principles of educational procedures as well as state-of-the-art knowledge.

One firm sees a lack of partners in the field of marketing and distribution as currently most of the marketing and new business activities are based upon already existing contacts. These include very useful contacts to former employers and project partners who are now co-operators and also clients.

Figure 15. Position of Digital TV and Broadband Service Cases Within the Multimedia Industry Structure



The digital TV and broadband services industry structure is very complex and the markets and types of actors vary in different national settings. Thus, the TENIA cases can only highlight some characteristics which cannot be interpreted as the most important ones for the European industry, but critical for the analysed market in Denmark and Germany.

Application providers are usually the established TV broadcasters who create new interactive services to accompany and enrich their traditional TV-programming service. But other media companies and independent service providers can offer new services on the digital TV-platform as well. For example, small- or medium-sized companies can use the new platform to sell their products or services using micro-payment forms like pay-per-view or pay-per-use and become active in the new field of t-commerce. To do so, they have to co-operate with the platform and/or network provider as well as with the software company in order to comply with technical parameters and programming requirements.

Application providers need software authoring tools, the so-called Software Development Kits (SDK) to programme their services. The software needed to create appealing interactive services is highly complex and was developed by specialised software

companies. Service providers can usually choose among different firms and systems. On the end-user side, the corresponding software has to be incorporated in the set-top box. The Application Programming Interface (API) has to be compatible with the software used by the service providers in order to understand and correctly interpret their programming commands. A related issue here is the hardware equipment and its technical specifications at the user's premises.

Co-operation and Hybrid Activities

The collective quality of hybrid activities, evoked by the modular nature of the platforms and the location of competencies across various actors, implies a vital need for co-ordination at several different levels including incentives management, resources contribution and task allocation. This necessity for co-operation within hybrid activities is the main result of the study, as defined by the TENIA theoretical framework. Therefore, the key issue of communication between the innovating partners has been addressed from diverse perspectives, in an attempt to determine not only the organisational shape of the communication channels, but also the objectives of establishing those channels, as perceived or revealed by our interviewees, and the process through which they have been established. All the cases show that co-operation is crucial and that often new intermediaries are needed within traditional sector structures to support new emerging co-operation needs. The role of intermediaries is either taken on by traditional, already established actors, who recognise the need for new activities, or by new actors entering the market due to emerging opportunities. The case studies confirm that the processes of fusion and technological innovation have affected the traditional multimedia industry in many ways. The case studies shed light on certain activities of specific importance for the changes in the sectoral structure. First of all, the trend towards digitalisation of content is crucial. Print on demand in the publishing industry and digital products in general which are delivered by new technology and platforms were identified as an important development in most countries. Additionally, the hardware development, e.g. devices for mobile computing represents an innovative activity which cannot proceed without the co-operation of hardware producers and content providers. For these developments to be put into practice, standards' setting for editing and distributing digital content is required. This is where most of the current problems of market development are located. The enhancement of multimedia technologies like visual displays and content management systems has already led to the appearance of new actors on the market whose relationships to traditional actors are quite well-established already in most of the cases analysed. The so-called convergence of traditional technologies with Internet-related technologies is an important issue which has not yet been resolved. In addition, solutions

for digital rights management are required due to the importance of authorship and publishing rights, and standard setting processes in this area have only just begun.

4.5.4. Fusion and Interaction Processes

Different key actors for the multimedia sector were identified in the TENIA case studies. First of all, there are new actors like application developers who have taken on the role of intermediates between other, often traditional actors and are particularly important in providing the link to users and content providers/authors. Another group of key actors are traditional publishers and distributors, who are facing two problems in their fear of market loss: first, they have to make a relevant choice of content to provide, and, second, they have to achieve a scale of acceptance which is difficult because of the diversity of market expectations and needs. For this group, although the technology is available on the market, there is still the problem of authoring electronic content. Users form a third group of relevant actors. Because of the presence of new channels of communication, they are often involved in the process of technology development at an early stage. A lack of sufficient communication with important lead users and thus a technology development which does not take user needs into account seems to be one reason for market failure. Especially in the e-book sector and the broadcasting sector, national education systems are often another important group. In some countries, like Germany, national education systems follow a "Öffentlich-rechtlicher Bildungsauftrag" which means that public broadcasting programmes and educational media have to provide high quality educational content (like an "educational mission"). This has slowed down private competition in the market. It should also be borne in mind that national education systems are important lead users for educational content and could thus play a far more important role as a demand factor for the development of electronic content markets. Additional groups of identified actors are publishers and distributors, consultants (providing expert knowledge and contacts for example regarding DRM), hardware producers of user devices and access technology as well as network providers and operators acting as intermediates for user access to the Internet.

Different fusion and interaction processes between these separate bodies of competencies and knowledge have affected the technology dynamics and innovation activities of the sector. With the help of the TENIA “Interaction and Power Matrix” (Table 12), the important actor relationships can be compared in the cases analysed.

Table 12. Interaction and Power Matrix

	Interaction with technology providers	**Interaction with technology users**	**Interaction with technology developers**
Larger size/power than the other party	feature request (supply contract)	independent design of the technology (taking into account feedback from selected users)	definition of interface specifications (with which other developers of other components of the platform have to comply)
	Gemstar, Rightscom; Authors online, Book Selecta; context ARD Online Kanal	Guaraldi, Authors online Intelearn, Exodus, 01P T-Online Vision ARD Online Kanal	Gemstar, Rightscom, Authors online; Book Selecta Exodus, 01P T-Online Vision
equal size/power	joint definition of features	joint definition of features (maybe through a partnership or within a standard setting forum)	joint development of the technology (possible within a standard setting organisation)
	Intelearn, Exodus, 01P T-Online Vision ARD Online Kanal	Intelearn, Exodus, 01P Gemstar, IPM-Net Active Book, b-wise	IPM-Net, b-wise
Smaller size/power	off-the-shelf purchase of the technology	feature implementation	compliance with interface specifications (defined by other co-developers)
	Active Book, Guaraldi IPM-Net Intelearn, Exodus, 01P, b-wise T-online Vision		Active Book, Guaraldi IPM-Net b-wise ARD Online Kanal

For all enterprises, various interactions with other, less powerful parties were identified. These include interaction with technology providers, technology users and technology developers. Feature request by supply contract is the main activity of the interactions with technology providers. Interactions with technology users are characterised by an independent design of technology which takes feedback from selected users into account. The interaction with technology developers (and co-developers) includes the definition of interface specifications with which other developers of other components of the platform have to comply.

The relevant parties are important as a source of useful contacts, as providers of information about user needs and technology requirements and because they may be able to solve communication problems caused by different understandings of the market and user needs. Enterprises involved in more than one type of interaction with different parties often adopt the role of intermediates, e.g. to transmit user feedback to technology developers (like AuthorsOnline). In these cases, technology problems were assessed, and partners for further co-operations were selected by offering new channels for market communication.

In the cases where all technology developments were carried out in-house, the reasons were absence of specialised providers in the market or the need for a progressive replacement of systems due to the emergence of issues like piracy.

In the cases where interactions are based upon equal size/power of partners, these focus on joint definitions of features of the technological platform, both for interactions with technology providers and with technology users. Interactions with technology developers, in the cases of equal sized partners, are established to jointly develop the technology, including standard development. Good examples for these equal power activities are the e-book cases, in which platform providers and developers are offering new distribution channels to developers and owners of already existing content (e.g. Guaraldi, b-wise).

Looking at companies which are smaller than their collaboration partners and have less market power has shown that their interactions are concentrated on off-the-shelf purchases of technology from providers and compliance activities with interface specifications defined by other co-developers. They have had little co-operation with users, e.g. for feature implementation.

Analysing the interactions has revealed the importance of creating close, sustained relationships that do not depend on specific members of partner organisations, and in which future commitments, responsibilities and modifications in the technical infrastructure are clearly established from the start so as to reduce uncertainties for the success of new industrial activities.

Additionally, the case studies have revealed some technology characteristics for hybrid activities in the multimedia sector. The technological situation for the multimedia sector in general is still instable. A diversity of solutions exists and causes incompatibility problems. This also hinders a widespread adoption and use of multimedia technologies and applications, especially in the digital TV and TV over the Internet markets. Another important reason for the instable technological situation is the slow standardisation process which is lagging behind innovation (e.g. open book forum). For the

standardisation process, a US/European divide adds to the obstacles, caused primarily by insufficient communication between the different interest groups. In all the markets analysed with the case studies, there are only very limited interactions between technology developers.

Some sectoral patterns of diversification can be described. Regarding technology developments, a conflict between customisation vs. standardised solutions is observable. On the one hand, new technology platforms allow a high degree of customisation as new communication channels to users are developed. On the other hand, recent technological developments, especially the integration of IT innovations in traditional production chains, meet a demand for standardised solutions in order to automate the production and product development processes. Cultural aspects of sectoral diversification are driven by the willingness of traditional actors to co-operate with new actors, especially the application providers. The high importance of communication activities and collaboration of actors for fusion processes is crucial for the success of new hybrid activities and results in a cultural change within the sector. Another driver for sectoral change is the emergence of new business strategies. Many small firms are innovative because of their close interaction with users, but they still have difficulties reaching a critical mass of users. This shows that some of the new business strategies should be revised or at least modified towards more effective marketing activities.

4.5.5. Knowledge Combination in the Multimedia Sector

The multimedia sector is defined in a broad sense including business activities of electronic publishing, the development of electronic content and learning management systems as well as digital television and broadband services. The key actors, their roles and relationships within the sector seem to be diverse and complex at first sight. Nevertheless, some characteristics for the sector as a whole have been described in the previous chapters. In this final part of the multimedia sector report, critical factors for success as well as problems of fusion activities within the sector will be summarised under the umbrella of knowledge combination activities. The key question is: based on an assessment of the knowledge combination activities, is it possible to describe the multimedia sector as a sector of hybrid activities, a sector of completed fusion or of a new sector emerging from the traditional one? Which of the three stages of sector development (from hybrid through fusion to new activities) applies here?

The TENIA case studies have illustrated how the process of fusion leads to an interaction between separate bodies of competencies and knowledge in the development of innovative products and services. In some of the cases it could be observed that these

interactions crossed traditional knowledge boundaries between organisations and services. The most important factor of success identified is a user-centric focus of technology and platform development. This should be combined with close communication, co-operation and customisation with other market parties including inferior as well as superior actors in the fields of technology provision and development. In some cases, however, the user-based development and implementation of technology was not sufficient for a successful business strategy and an analysis of market relationships revealed that, although key users were involved in designing a new product or service, the critical mass of users needed to cover the market was not reached. It was not always clear whether the critical mass of users simply did not exist or existed as a target group but had not been reached yet by (incomplete) marketing activities. One major difficulty for the firms analysed was the lack of market transparency, which is closely related to the problem of not reaching a critical mass. Of course, market transparency is also missing on the users' side. Many different technology solutions have emerged in each of the analysed markets (e-book, e-learning and digital TV) and transparency is not given yet with regard to user benefits and prices. Another obstacle identified is the mismatch between multimedia technology demands and the skills required to use these technologies and applications. Even if the ability to use a device is given, specific literacy still has to be developed by users in order to be able to make full use of the application in their everyday processes.

It was also pointed out that public demand and public procurement are both key drivers in the multimedia sector, especially when regarding educational content. In some of the analysed regions, market deregulation is still in progress and the commercialisation of the market is slow because of the protection of state-owned content providers.

Additionally, in some regions, the Internet diffusion and the widespread use of broadband access, which are key success factors, are still low. In these regions, public procurement activities would be a suitable measure to foster the market development.

These observations allow the following conclusions to be drawn. First of all, two sub-phases of fusion processes were identified for the multimedia sector in Europe. In the first phase, the technology platform is the key issue; this is superseded in the next phase by attracting users. This means that the primary aim of the business strategy for innovative activities in the sector is firstly to develop and implement a new technology platform. In addition, we were able to show that this technology development should occur as a collaborative activity between the different parties involved, based on the formation of new relationships and the integration of new communication channels, including one to the lead users. Most of the cases analysed in the TENIA project were

able to reach this first goal of their business strategy, but still face immense problems in reaching a critical mass of users to finance their business.

As users and co-developers are so crucial for the process of developing and implementing the technology platform as well as for the market success, all the fusion processes need to have sustained contacts and an uninterrupted information flow during all stages of the innovation process.

It is not easy to avoid the conflicts between meeting user demands by offering customisation and the need for norms and standards in technology implementation. In any case, industry forums play an important role as a gateway to networks and co-operation. They are also helpful when developing standards and establishing reputation and trust between the collaboration partners.

Thus, hybrid activities in the multimedia sector can be described as:

- still evolving markets;
- complex relationships;
- often not having achieved a critical customer-base;
- and are characterised by a strong demand for digital content (not only from individuals but from society).

It may be concluded that the multimedia sector is an example of incomplete fusion.

The sector is still facing a lack of user skills and media literacy, and in some regions, the Internet diffusion and a widespread use of broadband access is lagging behind. The TENIA case studies demonstrated that all systems for the production and distribution of digital as well as traditional multimedia products and services tend to co-exist, giving rise to market niches.

The multimedia sector, as an example of incomplete fusion, has not yet found a solution to combining the knowledge of all the relevant actors. Causes and effects, as mentioned above, co-exist and depend upon different sub-markets within the sector. The fusion activity of the multimedia sector cannot be integrated into the traditional publishing industry or at least has not been integrated so far. Critical for the sector is the fact that the different market niches, where fusion activities are emerging, are often very small, with a small economic scale. Last but not least, educational products and services are not easy to sell as long as private and public educational systems co-exist. It will be interesting to observe the future developments, especially in regions where lifelong

learning concepts are being developed to reorganise educational systems. This may influence the complex co-evolution of technology (to stimulate networking activities), IT-literacy and lifelong learning culture, solutions for DRM, diffusion of complementary products and services and result in a higher market transparency.

These issues also represent possible targets for policy actions which, with regard to the different stages of development within the regions, should be developed individually for each region. A policy recommendation for the EU, despite different regional settings and developments is to support the establishment of communication channels between the relevant actors, mainly between traditional players and firms involved in hybrid activities which develop new platforms, and user groups.

IV. CONCLUSIONS AND POLICY IMPLICATIONS

1. Main Conclusions

1.1. M-Commerce

For a few years now, mobile e-commerce has been touted as the next big frontier for European ICT companies. Strategy and policy analysts have been in perfect harmony in their calls for concerted efforts to conquer that frontier. The driving factors justifying support to m-commerce in Europe are plenty. On the business front, both entrepreneurs and established companies sense a significant opportunity for profit, given the affinity of Europeans with their mobile phones. Phone penetration is reaching saturation levels in man y parts of the continent implying that the mobile phone has become the most widespread medium of communication. Companies would love to be able to reach all those millions of phones with their advertisements; they would love to be able to offer their products at the fingertips of the consumer. Others see a great opportunity in facilitating such transactions. On the policy front, m-commerce is seen as the holy grail of mobile telephony. Even more, it is considered as the best shot that the European ICT industry has to take global leadership in creating broad and potentially very profitable markets. European policy makers take it as a matter of pride to be able to extend the tremendous success of the European industry with the second generation of mobile phones (GSM) to the third generation and beyond and to the marvelous opportunities that those provide through features such as broadband, always on, fast transmission. M-commerce is seen as a natural extension of mobile telephony. Even better, the whole package agrees quite well with the Lisbon policy for the knowledge economy.

M-commerce necessitates the alignment of resources and capabilities residing in hitherto independent and information-based sectors including telecommunications, computer hardware, software, entertainment, creative content, news distribution, and financial services. There is currently no consensus on how best to combine such resources and capabilities: bring them under common management or promote (complex) collaboration between independent owners. Regulatory hurdles such as those applying to antitrust and those delineating the boundaries of the banking sector also play a very important role in this milieu. For example, banks cannot turn into mobile operators in order to handle mobile payments, while operators cannot turn into banks in order to transfer money between users and let the user have an account. The operator can, however, collect money on the telephone bill. Unsurprisingly, m-payment has become one of the biggest barriers for successful m-commerce.

The supply of m-commerce service requires the digitalization of products and service information in order to create and deliver value. It clearly, then, requires the fusion of technologies residing in different industrial domains to create 'hybrid' activities. In this document report, the terms technology fusion and hybrid activity have been identified with mobile e-commerce. Technology fusion is thought to describe the process of combining knowledge in the construction of complex integrated technological systems necessary to support m-commerce, whereas a hybrid activity is the one that involves the combination of distinct competences or knowledge drawn from service and manufacturing related activities such as m-commerce. Firms in various sectors that combine into the fledgling m-commerce hybrid are already engaged in a variety of intense interactive relationships with each other. The case studies developed by the consortium members aimed at studying these interactions to identify processes involved in 'hybridization' and to examine progressive and dysfunctional elements in these processes.

Several **important findings** emerged from the eighteen m-commerce cases examined in Denmark, Germany, Greece, Italy, and the United Kingdom. They are listed below in no particular order.

- The mobile telecom operators remain key to m-commerce and maintain very significant negotiating power, primarily because of size and because they 'control' contact with users. Their interaction with the other m-commerce partners is often about using the network to test applications. Mobile operators provide a critical link that ties many of the pieces of the puzzle together, verifying the schematic of the m-commerce hybrid used in this document.

- The price structure created by mobile telecom operators in Europe seems to be blocking market entry at the moment. In the least, the imposed price structure is making other partners quite unhappy.

- The financial system can block the m-commerce development process by not supporting the establishment of a viable m-payment system. The financial support system must also occupy a central position in policies aiming at m-commerce.

- The extent of interaction with technology users has been quite widespread, in line with best practice in technology management.

- Interaction with technology co-developers has also been fairly extensive. Relations with technology co-developers have attracted a lot of attention among m-commerce entrepreneurs in Europe. In our cases it appeared that m-commerce

entrepreneurs (key actors) mostly fight an uphill battle as they are relatively less able than technology co-developers to determine technology characteristics.

- Regarding the interaction with technology providers, m-commerce entrepreneurs (key actors) from small countries seem to keep their ear close to the ground, position closer to the market, and make do with off-the-shelf equipment in order to decrease their dependency on technological advances that they cannot control.

- One of the utmost European successes in m-payment systems examined by a partner has maintained a neutral position between the fundamental columns of m-commerce – mobile network operators and banks. Given the strong pull that both operators and banks exert, this may be the right positioning for success. It is also a difficult position to maintain.

- Open platforms and consumer-centric focus seem to be the way to go for establishing a long-term winning proposition for m-payment. While many industry participants are professing standard openness, however, they still try to maintain at least partial control of the standard. One would like m-payment to be usable on every mobile phone, in every network, and with every bank account, at low and transparent cost.

- The four largest European mobile operators are currently cooperating to create the standards of m-payment. Their consortium is impressive but one wonders whether a European payment system can be established without the active participation of the banking sector.

- The importance of institutional design and close communications for the success of joint innovative endeavors cannot be overemphasized.

- Close communications, whether formal, informal or both, seem to be considered the best way to ascertain that information regarding needs, problems and possibilities is efficiently transmitted within the innovating network. Thus, even though network effects and the need for inter-operability between the different components of hybrid technological platforms appear as basic drivers for collaboration, mechanisms that guarantee a degree of alignment in the behaviors of those engaged in joint innovative efforts, close communication being one of them (other example would be financial incentives) should be put into place for successful technology development.

- In a context of evolvable business models and technological systems, which have to be constantly modified and re-adapted to the circumstances of a dynamic

environment, there is a very important need to maintain sustained contacts and a uninterrupted information flow during all the stages of the innovation process (in which we include developmental stages).

- Communication between innovating partners in the development of hybrid technologies is not only used in order to transmit technical information for the coordination of innovative tasks, but also to negotiate and to carry out marketing activities: in what refers to the former function, actors use communication to transmit, explicitly or implicitly, their objectives and intentions to other partners in the innovative network. Communication is also used in order to build up reputation and trust.

1.2. Business Data Communications

The emergence of hybrid activities within the area of communication networks for business data concerns the development of fixed and mobile networks for the provision of value added services mostly directed to business users. Data communication services have traditionally been defined either within the framework of the tariff structure of ('wired') network operators, e.g. leased data lines or packet service subscriptions, or as value added services not subject to tariff regulation. The advent of deregulation and the growth of data communication capabilities in the wireless network, which often uses the wired network to connect different wireless receiving stations, have increased and made significantly more complex the range of service offerings in this market. Network operators have traditionally been very active in collaborating with manufacturing suppliers in relation to the design of switching, transmission and terminal equipment. However, other important actors are now playing a role in the definition of the network features and in the implementation of different infrastructures for the provision of customised services. These actors can be identified in the users of these infrastructures, particularly big manufacturing and service firms and the government.

The project dealt with the two activities which best account for the technological development in the area of telecommunication networks for business data: dedicated backbone services and mobile links to the Internet. The analysis is based upon ten case studies carried out in Italy, Denmark, Greece and the UK by means of interviews with firms and other relevant actors. The examined cases focused primarily on:

- The objectives with which the actors establish interactions with technology providers, technology co-developers, and users.

- The factors that enabled the formation of the activities (incentives structure, role of key actors).

- The strategies adopted by those actors in the development of hybrid activities.

- The problems faced during these interactions.

The **major findings** can be summarised as follows:

- The market has yet to recover from the slowdown that followed the boom of 1998-2001. The existing operators do not foresee additional entry into the market. Instead, they expect a process of consolidation among the existing players given that some of them have yet to reach a critical customer base. They perceive the market as exploiting the establishment of liberalisation with no need for further capacity investments.

- Two main interrelated factors can reportedly play a critical role in the development of the market for hybrid telecommunications/IT services:

  - The role of demand in the understanding the opportunities and the services offered by the new technology solutions.

  - The commitment of public administration to act as a key user in the development and in the diffusion of broadband services.

Reportedly, many potential customers have yet to progress from the typical mindset of the standardized telecommunications service (voice) offered by a monopolist. The recent technological advances (Internet and the convergence of telecommunications, and multimedia) and new operators have widened the number of opportunities. Sometimes, the services are based on technologies and architecture that are, however, poorly understood by potential users, implying a risk that users cannot efficiently evaluate and exploit the new services and to translate technology advancements into business opportunities. Telecom operators insisted in the case studies that one of their important competencies is to be able to frame the customer needs and to present available opportunities. For example, a recent survey conducted by national telecommunications associations in Italy investigated the level of knowledge of broadband opportunities among business users and reported a wide differential among industries and among companies of different size. Finance and Services are the most confident industries with broadband solutions, while Trade and Manufacturing are lagging behind. Large companies seem much more capable of leveraging the new technologies than small companies and not just because of the availability of resources.

- The situation is even more complex and uncertain when turning to examine the mobile environment. The uncertainties emerging from the case studies are of a global character. Although the institutional set-ups differ between the main group of players in Europe, the US and Japan, there is a very open ended situation, where various different outcomes have chances for survival and growth. Policy measures and/or coordination between groups of actors may be of utmost relevance for establishing industry standards in the current transitional phase between technological life cycles.

1.3. Multimedia

Multimedia technologies were defined in TENIA as a number of diverse technologies that allow visual and audio media to be combined in new ways and using new platforms for the purpose of data storage, presentation or processing. Applications include information, communication as well as entertainment and education systems. Thus, multimedia technologies are characterised by media integration and aim at interactivity between producers and recipients. Special attention was drawn to three evolving hybrid business segments based upon multimedia technologies, including e-learning technologies, e-books, and digital TV and broadband services on the Internet platform. These three fields were selected as examples of the emergence of hybridisation within a so-called traditional sector and case studies have been carried out. The **major findings** of the multimedia case studies can be summarized as follows.

All business segments share basic characteristics, as the hybrid activities identified in the case studies are not confined to any individual organisation, but take place as the result of sustained interaction between diverse and changing inter-firm network along all the phases of technological development, from design through implementation to the provision of support services. The complexity of the whole industry, which was evident in the cases, is based on the mutual interdependencies of the actors. There are four main activity fields within the multimedia sector: technology providers, content producers and providers (including authors), service providers and consumers.

According to the case studies, the dynamics of technology (for hardware and software) can be characterised by three trends:

- The hardware segment shows continuous power enhancements, evolution and uncertainty in a context where network externalities and standards settings matter.

- The whole sector is capital-intensive, with high fixed costs of production coupled with low reproduction costs and DRM.

- Software development is affected by interconnection compatibility.

Close communications, whether formal, informal, or both, seem to be considered the best way to make sure that information about needs, problems and possibilities is efficiently transmitted within the innovating network. Communication is also used in order to build up reputation and trust. Trust which has grown through previous and existing interactions is useful in order to form relationships with new clients and partners. In many cases this is initiated by a recommendation from a third party.

The necessity for co-operation within hybrid activities is the main result of the study. All the cases show that co-operation is crucial and that often new intermediaries are needed within traditional sector structures to support new emerging co-operation needs. The role of intermediaries is either taken on by traditional, already established actors, who recognise the need for new activities, or by new actors entering the market due to emerging opportunities. A lack of sufficient communication with important lead users and thus a technology development which does not take user needs into account seems to be one reason for market failure.

To sum up, the case studies confirm that the processes of fusion and technological innovation have affected the traditional multimedia industry in many ways. Different key actors for the multimedia sector were identified. First of all, there are new actors like application developers who have taken on the role of intermediates between other, often traditional actors and are particularly important in providing the link to users and content providers/authors. Another group of key actors are traditional publishers and distributors, who are facing two problems in their fear of market loss: first, they have to make a relevant choice of content to provide, and, second, they have to achieve a scale of acceptance which is difficult because of the diversity of market expectations and needs. Additional groups of identified actors are publishers and distributors, consultants (providing expert knowledge and contacts for example regarding DRM), hardware producers of user devices and access technology as well as network providers and operators acting as intermediates for user access to the Internet.

- Analysing the interactions has revealed the importance of creating close, sustained relationships that do not depend on specific members of partner organisations, and in which future commitments, responsibilities and modifications in the technical infrastructure are clearly established from the start so as to reduce uncertainties for the success of new industrial activities.

- The technological situation for the multimedia sector in general is still unstable. A diversity of solutions exists causing incompatibility problems. This also hinders a

widespread adoption and use of multimedia technologies and applications, especially in the digital TV and TV over the Internet markets.

- The high importance of communication activities and collaboration of actors for fusion processes is crucial for the success of new hybrid activities and results in a cultural change within the sector. The most important factor of success identified is a user-centric focus of technology and platform development.

- Public demand and public procurement are reportedly key drivers in the multimedia sector, especially when regarding educational content. In some of the analysed regions, market deregulation is still in progress and the commercialisation of the market is slow because of the protection of state-owned content providers.

- As users and co-developers are critical for developing and implementing the technology platform as well as for market success, all fusion processes need to have sustained contacts and an uninterrupted information flow during all stages of the innovation process. In any case, industry forums play an important role as a gateway to networks and co-operation. They are also helpful when developing standards and establishing reputation and trust between the collaboration partners.

- Educational products and services are not easy to sell as long as private and public educational systems co-exist. It will be interesting to observe the future developments, especially in regions where lifelong learning concepts are being introduced in educational systems. This may influence the complex co-evolution of technology, IT-literacy and lifelong learning culture, solutions for DRM, diffusion of complementary products and services and result in a higher market transparency.

2. Policy Implications

2.1. By Sector

2.1.1. M-Commerce

The following **policy implications** emerge as the most prominent in this hybrid activity area:

- The most pressing issue for the mobile commerce industry today – and, thus, an issue of utmost importance for policy – seems to be the lack of a credible m-

payment system.[21] The inability of setting up a viable form of m-payment, in turn, hinders the formulation of sound business models. Two major complications in the fledgling industry have been technology and incentive alignment across several players in different sectors.

- Mobile telecom operators must occupy a central position in policies aiming at m-commerce. Their relative size, direct contact with the consumer, and central position in the network of organizations linking forces to provide viable m-commerce solutions make mobile telecom operators indispensable targets of public policy.

The combination of the two points above with the fact that the financial health of several large mobile telecom operators has been weakened as a result of the 3G license auctions in a few European countries a few years ago makes for a potentially alarming situation. The pressure for 'results-now' can make the operators uncooperative for establishing long-term m-payment solutions with fair terms for other important partners with less powerful negotiating position such as content providers. Delay to take corrective action on the part of governments will negatively affect the whole m-commerce industry.

- Interaction between the different stakeholders in m-commerce becomes key in a context of fast evolving business models and technological systems. Maintaining sustained contacts and uninterrupted information flows across all stages of the innovation process becomes imperative. Policies that facilitate networking between the various economic agents while, at the same time, remain vigilant for anticompetitive behavior and continuing opportunities for entry of new players are of paramount importance.

Part of this role can be played by the European Framework Programmes for research and technological development that can create fora for such communication. Well-balanced competition policy will also be key. Finally, mechanisms that guarantee a degree of alignment in the behaviors of those engaged in joint innovative efforts and financial intermediation must be in place.

[21] On the same issue see also several publications of the Electronic Payment System Observatory (ePSO) such as Centeno (2002). Krueger (2002) has looked at the e-money regulation in the EU.

2.1.2. Telecommunication Networks for Business Data

The analysis highlighted several **strategic considerations** and points of possible **policy intervention**:

- The diffusion of the new services is affected by factors that reside both in the demand side and in the supply side:

  -Business users need to advance their grasp of the opportunities offered by the new technologies and link them better to their business strategies.

  -Telecommunications providers should improve their commercial capabilities in terms of being better able to convey a clear message to the customer.

  - Public policy can facilitate the interaction of the supply and demand sides by both assisted training efforts targeting SMEs and by providing financial incentives.

- In the past few years there has been an explicit commitment by European public institutions to foster the diffusion of broadband technologies and services. Different national ministries have announced the implementation of a number of initiatives, considering that advanced telecommunications/IT solutions represent the next technological advances to be exploited. The rationale for the public intervention is the consideration that the mere 'natural' reduction of prices might not represent a sufficient reason for the diffusion of technology.

- The presence of substantial public procurement could be effective by making available a large customer base for the introduction and deployment of new solutions. Broadband technologies could be adopted and applied to national and regional public institutions, public education and healthcare buildings and implementing projects that can exploit the potentiality of advanced digital and multimedia solutions as a stimulus for the diffusion of broadband solutions and for related technological advancements. The thorny issue here will, of course, be in the process of public demand allocation among communications providers.

- The Nordic and European experience, so far at least, have fostered a common understanding of the significance of international coordination efforts ex ante. But the general crisis in the telecom service industry as well as among the equipment vendors starting in 2001 coupled with the huge rents that some of the major European governments have extracted from the service providers in the auctions

for 3G licences has determined a high degree of uncertainty in the shift from the 2G life cycle to 3G. The outer poles of the future scenarios may be represented by:

- 3G systems may dominate the mobile communications networks with WLAN solutions as a complementary service basically controlled by the incumbent mobile carriers.

- 3G may prove to be a new 'Titanic' in Europe, if not Japan, because the US telecom industry may strike back by not adopting a 3G system at any large scale, but exploit the 2.5G options and combine them with the evolving opportunities offered by more decentralized WLAN experiments.

- Given such uncertainties it may prove relevant for a region involved in these technologies to put forward field experiments with the patterns of telecommunications services seen from a user perspective, including firms, government agencies at all levels as well as private consumers. To organise such efforts a key point is to involve various experiments with the telecom infrastructure. The aim can be to be prepared for different future trajectories, if not to influence these outright. Even small regions may eventually influence the future development abroad if they may use their potential institutional advantages in terms of organising field experiments that may be visible internationally. The interaction between suppliers, customers and knowledge institutions that such experiments require is a necessary condition for a successful innovation. Social experimentation with different solutions, however, assumes a general public that is prepared to take risks and accept that taxpayer's money may be lost, but not necessarily wasted, through such a process.

- National and regional policies cannot create competitive high tech clusters out of nowhere. Nevertheless, some of the components behind the emergence of such clusters have definitely been the outcome of deliberate policy efforts and long-term struggles. Examples discussed in this project related to Scandinavian regions, especially North Jutland in Denmark.

- In an effort to ensure easy and cheap public access to all stored digital information, the regulatory context determining the operation of transmission and reception stations in the 2.4 GHz zone could be revisited and readjusted. Issues here are, for example, the operation of wireless hotspots, and the extension of free transmission zones for public use in 5, 5.2 and 5.5 GHz.

2.1.3. Multimedia

The multimedia sector appears to be an example of incomplete fusion and has not yet found a solution to combining the knowledge of all the relevant actors. The findings suggest several items deserving **policy consideration**, including:

- Networking among different actors is key. Governments may have a role to the extent that collaboration between stakeholders achieved through the market is considered insufficient or unsatisfactory.

- Uncertainty about technology standards creates instability. The question of standards, however, is not new and does not have a clear answer. Government involvement to facilitate technological compatibility may not be a good idea in a rapidly changing technological environment where solutions are changing fast. On the other hand, locking into some technology through public education procurement may have such an effect.

- Public demand and public procurement are reportedly key drivers in the multimedia sector, especially with regards to educational content. If used wisely, public procurement can then play an important role in determining technological trajectories and winning paths.

- Multimedia may take off in education as modern concepts of lifelong learning are being introduced in educational systems. The complex co-evolution of technology, new IT-literate generations and lifelong learning culture, solutions for DRM, and diffusion of complementary products and services is expected to create new dynamics. The government role here is more on the demand side, making sure that IT-literacy and lifelong learning are ingrained in society.

- Market deregulation is still in progress in some regions and the commercialisation of the market is slow because of the protection of state-owned content providers.

2.2. Cross-Cutting

The examined six hybrid activity areas reflect some of the classic characteristics of early-stage, fluid technology sectors where large incumbent players with related specializations and strengths vie for dominance with nimble, small, technologically intensive companies and where extensive market and technological uncertainties overshadow the deployment of the necessary resources. As hybrid, however, they are also deeply influenced by the

convergence of technologies into common technological paradigms. As such, they reflect extensive interaction among economic agents whose primary business span across different technological fields and even across different industries. They get together in order to achieve hybridization in the form of a technology platform, a set of standards, or a set of value chain relationships.

It must be emphasized that the identified important issues and bottlenecks cutting across the six hybrid activity areas are not just, or even mostly, related to technology. They rather reflect regulation, payment systems, market fragmentation, consumer unfamiliarity with available technologies, standards, and the effective use of government procurement. Hence, the relevant policy concerns are broader, akin to those that the economics, business and policy literature has proposed in relation to the social construction of competitive innovation systems. We have isolated the following areas for policy consideration in the examined hybrid activity areas:

- **Networking** among economic agents with different business and technological concentrations and capabilities proves to be key for innovation. Consequently, policies facilitating inter-organizational partnerships are clearly relevant. Such policies include the European Framework Programmes on RTD as well as national collaborative R&D programmes. They also include other policies that affect partnerships directly such as antitrust (competition policy) and intellectual property protection. Still, it is important that public authorities remain vigilant against the possible dark side of inter-firm collaboration that may lock firms into unproductive relationships or inferior technologies.[22]

- **Power relations** among agents are often asymmetric. This may lead to situations where one agent type has too much power within the networks. This was clearly identified in the case in m-commerce where a relatively small number of global mobile telecom operators have much more negotiating power than other agents. While in some situations this may work out as a catalyst for partnerships by forcing difficult agreements, it may prove counterproductive in situations where the powerful party is under stress for immediate business results (several large European operators currently carry a heavy burden due to debts incurred during the bidding for 3G licenses a few years ago). In such cases, the imposition of unfavourable conditions for other partners may actually hinder agreements for 'patient' solutions and long-term returns.

[22] R&D collaboration and relevant policy issues have been considered in greater length in other research projects sponsored by the European Commission. See, for example, Caloghirou and Vonortas (2000), and Caloghirou, Ioannides and Vonortas (2003, 2004).

- **Technology standards**. Technological uncertainty creates confusion. It has long been known that early-stage, 'fluid' industries are characterized by the 'anarchic' search of dominant designs that we have observed in the examined areas.[23] Still, the questions of the optimal timing for the imposition of standards and of the best mechanism for doing so have never before been so important for competitiveness. This is the result of the fast pace of innovation, intensive competition among players from many different parts of the world, very high stakes in terms of high investments-high payoffs, and progressively lesser opportunities to gain competitive advantage through other means of direct government intervention. Technology standards have, in other words, become a potent strategy tool as the case of the second generation mobile technology proved for Europe.

- **Public procurement**. Market fragmentation in the examined hybrid areas has often hindered the necessary investments in individual technologies. It was clear from our interviews that industry looks at public procurement as a way of establishing de facto standards and of providing competitive advantage through scale economies and faster rides down the technology learning curves. Exactly because public procurement has a role of standards by its mere size, all the considerations regarding the optimization of the timing and the appropriate vehicles for establishing standards apply here as well. In addition, governments will be under severe pressure and may make mistakes when the choice between technology quality and future prospects, on one hand, and cost and competitive national players, on the other, is not an easy one to make.

- **Technology diffusion – User familiarity** with available technology. It should not come as a surprise that governments with sound innovation policy approaches try to balance the supply-side science and technology policies with demand-side policies to facilitate the uptake of advanced technologies by the general public (i.e., beyond public procurement). This is typically achieved through broad campaigns to demonstrate the use and familiarize the population with new technologies. Regional 'field experiments' also partly play this role. Principal targets in such campaigns are small and medium-sized enterprises (SMEs) and individual consumers. The Lisbon policies of the European Community that aim at establishing in Europe the most advanced knowledge economy in the world have a strong flavour of such an approach.

[23] In the common parlance one often hears about the intensive search for 'killer applications'.

- **Regulation**. Market deregulation has been important in speeding up innovation through competition in the past couple of decades. All examined hybrid activity areas have benefited significantly from deregulation. Needless to say, the deregulation process can be driven to unnecessary extremes: there is some optimal level of regulation necessary for markets to work properly. The optimal level of regulation is activity-specific.

- **Technological bottlenecks**. At a time of rapid technological advance, systemic complexity, and heavy private sector investments in new technologies, developed country governments cannot and should not try to foretell and heavily influence future technological developments. Such practice will more often than not lead to disasters through unproductive lock-ins in the wrong fields.[24] A more appropriate role for 'intelligent' governments would be to try to foresee emerging shortages of specialized resources in narrowly defined areas and try to alleviate those before they become binding for the system as a whole through the existing interdependencies.

Such selective intervention reflects, of course, the general policy advise emerging from complexity theory: rather than firmly commanding the boat rushing downstream in a fast-flowing river, the boatman paddles strategically to avoid disastrous crashes on the rocks and dangerous dead-ends and to facilitate smooth, flexible, and fast riding downstream to the extent possible. The analogy is good as far as it goes, however: in this case it is limited to the extent that the river has a finite end whereas science and technology presents us with an 'endless frontier'.

We conclude with a comment on technology foresight. While TENIA did not involve a formal technology foresight exercise, it did explore the possibility of using extant data on partnerships and patents for creating early pictures of emerging hybrid activities. Our resources were limited and the data available to us proved of somewhat limited value, primarily because it was relatively old for the examined hybrid activities that kept evolving as the project was unfolding but also because important detailed information on partnerships was missing. Nevertheless, we did obtain some encouraging results and remain convinced that foresight exercises based on quantitative techniques can provide the basis of 'early warning systems' that would be quite useful for 'smart' governance.

[24] Technology forecasting is markedly different from technology foresight. We think that the latter is a quite valuable activity that will assist in the early identification of bottlenecks.

V. DISSEMINATION AND EXPLOITATION OF RESULTS

1. Dissemination of Results During the Life-Time of the Project

An extensive set of research papers and reports has been produced by the five partners during the life-time of the project. They are listed separately in Section 6 of this report. These documents are being disseminated freely to interested parties. Partners, on their own initiative, have made presentations drawing on this material in scholarly and professional meetings and conferences.

The coordinating team had created early on a website for the needs of the project where working papers and reports were periodically posted. This website now displays all the outputs of the project listed in Section 6 plus this report. The website is hosted by the Laboratory for Industrial and Energy Economics at the National Technical University of Athens and can be found at the address:

http://www-liee.chemeng.ntua.gr/tenia.htm

The kick-off meeting was organized at Ipswich, England, in conjunction to consultations with personnel from British Telecom for the needs of the project. The company became aware of TENIA at that point. A large number of companies in all five countries of the partners were interviewed for the needs of the project and also became aware of it during the process. Finally, the final project meeting was organized in Brussels in February 2004 and was kept open to officials of the European Commission in an effort to disseminate the results as widely as possible. Invitations were sent out to several officials in DG Research.

2. Dissemination of Results After the Completion of the Project

The five project partners are currently in discussions among themselves and with publishers the possibility for various collective publications. These include:

- A special issue to a journal. Professor Bent Dalum and probably one or two representatives of the coordinating team will edit and collate a set of research papers from TENIA to appear in a respectable, peer reviewed, academic journal. Negotiations are under way.

- An edited book. Professors Yannis Caloghirou, Stavros Ioannides, and Nicholas Vonortas, representing the coordinating team, will edit a volume to be released by a well known publishing house with international market reach. The exact structure of this tome has yet to be finally determined. Candidate material includes the

conceptual framework for TENIA, the three sectoral reports, the five country reports, other research papers, and appropriate introductory and concluding chapters.

- Articles in refereed journals. All partners are interested in academic publications. To the best of our knowledge, several refereed publications will be pursued independently. Candidate journals include those specializing in the field of science and technology policy such as Research Policy, Science and Public Policy, Journal of Policy Analysis and Management, and in the field of technology management such as Industrial and Corporate Change, R&D Management, and Technovation.

Four out of five partners (LIEE-NTUA, CESPRI, SPRU, and IKE) are parts of well known universities in their respective countries and involve extensively in educational programmes. Material from TENIA will certainly find its way to the classroom for graduate and undergraduate courses dealing with Science and Technology Policy and technology management.

All senior staff of the partner teams (Prof. Y. Caloghirou, Prof. S. Ioannides, Prof. N. Vonortas, Prof. B. Dalum, Prof. F. Malerba, Prof E. Steinmueller, and Dr. Kimpeler) will be available to brief staff of the European Commission on the results of the study upon request.

We anticipate several presentations in academic and professional fora by senior staff involved in the project.

The results of this research will be disseminated by each partner in their respective countries through public lectures, presentations, and direct communications with the relevant ministries.

The partners will make an effort to forward the final report of TENIA to all companies that were interviewed for the needs of the project.

The methodology developed in the project and the databases will provide valuable support to policy makers at the national and European levels interested in the emergence and nurturing of hybrid activities combining knowledge-intensive services and high tech manufacturing.

Finally, the results of TENIA will feed into further research work of the partners. For example, ISI has already stated that:

- The project results are of importance for the project "Regional Innovation Systems & Strategies in European Candidate Countries (RISECCO)" on behalf of the European Commission (2004-2005).

- Results of Sector Report Multimedia are of relevance for the project "Monitoring eLearning" on behalf of the Office for Technology Assessment of the German Bundestag, (2003-2004).

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VII. ANNEXES

Nominated Sectors for TENIA Analysis That Were Eliminated

Discussion of candidate activities involved reflection among the consortium members and industrial experts on electronics technology. This annex notes the activities that were considered but ultimately put aside for various reasons ranging from disagreements among the partners about the significance of the candidate area to an absence of partner contact resources to pursue the area.

Candidates put aside in the electronic commerce area:

- *Internet conversion of airline flight reservation systems*

Airline flight reservation systems were traditionally based upon dedicated and 'session' terminal applications. Internet-based services are now becoming a more important area for application development. The extent and nature of the 'conversion' process is likely to involve collaboration between service and hardware companies given the needs for security and authentication. At this time, airline travel is severely depressed due to the events of 11 September. Examination of this area might be seen as positive by the companies involved, particularly if presented as an 'exemplary' study of technology management.

- *Logistics systems employed in parcel and other transport applications*

The use of shipment monitoring and tracking systems is increasing at a rapid rate. These involve significant use of specialised terminals and handheld devices as well as growing use of Internet systems. Of particular interest is the use of wireless systems that provide 'real-time' monitoring of the movement of goods through transportation networks. This area has been studied in a variety of European Framework projects and was a focus area in the 4th Framework Telematics Application Programme. Although such logistical services are usually thought of as distinct from electronic commerce they have very strong linkages to areas more traditionally thought of as business-to-business electronic commerce such as just-in-time delivery and 'automatic' inventory replenishment.

Candidates put aside in the area of telecommunication of business data:

- *Next Generation Internet*

The design of the next generation Internet protocols involves an intensive interaction, both public and private, between service providers and equipment manufacturers with

the aim of creating new Internet features that will facilitate the development of business data services. This is a relatively large and complex area, but one that can be examined in reference to the activities of specific companies.

- *Wireless MANs*

In large urban areas, it is possible to develop business data communications spanning multiple organisations through the development of an alternative wireless infrastructure. Wireless MANs (Metropolitan Area Networks) are based upon dedicating a portion of the radio spectrum, which can be shared by a variety of different organisations, to data communication traffic. Service providers in this area must solve a number of important technical problems and secure regulatory approval for their activities. While high-capacity MANs are still at a nascent stage of development, some wireless services, such as stock market information systems, have already been deployed. This is a difficult area because of the importance of regulatory approval for the commercialisation of services.

Candidates put aside in the area of multimedia:

- *Multimedia Projection Systems for Events and Buildings*

The development of complex displays such as those used at events or on buildings in public areas involves collaboration between equipment suppliers and service companies. One of the first year research students at SPRU is conducting his DPhil studies in the larger area defined by 'events production' within the context of the 'built environment' programme, which focuses upon the management of project-based firms. This sector is characterised by continuous interaction between companies offering innovative hardware solutions and the companies offering services. Little formal R&D occurs in this area of activity, but it represents a significant activity of European innovation and employment.

Table 13. Selected technological macro-classes

H01B 11/00	**Communication cables**
H03J	Tuning resonant circuits; selecting resonant circuits
H03J 1/00	Details of adjusting, driving, indicating or mechanical control arrangements for resonant circuits in general
H03J 3/00	Continuous tuning
H03J 5/00	Dicontinuous tuning; selecting predetermined frequencies; selecting frequenciey bands with or without continuous tuning in one or more of the bands
H03J 7/00	Automatic frequency control; automatic scanning over a band of frequencies
H03J 9/00	Remote-control of tuned circuits; combined remote-control of tuning and other functions
H04L	Transmission of digital information
H04L 1/00	Arrangements for detecting or preventing errors in the information received
H04L 5/00	Arrangements affording multiple use of the transmission path
H04L 7/00	Arrangements for synchronising receiver with transmitter
H04L 9/00	Arrangements for secret or secure communication
H04L 12/00	Data switching networks
H04L 13/00	Details of the apparatus or circuits covered by groups 15/00 and 17/00
H04L 15/00	Apparatus or local circuits for transmitting or receiveing dot-and-dash codes
H04L 17/00	Apparatus or local circuits for transmitting or receiveing codes wherein each character is represented by the same number of equal length code elements
H04L 19/00	Apparatus or local circuits for step-by-step systems
H04L 21/00	Apparatus or local circuits for mosaic printer telegraph systems
H04L 23/00	Apparatus or local circuits for systems other than those covered by groups 15/00 to 21/00
H04L 25/00	Dc systems
H04L 27/00	Ac systems
H04L 29/00	Arrangements, apparatus, circuits or systems not covered by a single one of groups 1/00 to 27/00

Table 14. Patents and patenting firms by technological class and by country (1978-1998)

	PATENTS	FIRMS		PATENTS	FIRMS		PATENTS	FIRMS
H01B 11/00			H03J 5/00			H04B 10/00		
DE	23	12	DE	34	12	DE	167	29
FR	18	9	FR	5	5	FR	118	29
IT	1	1	IT	1	1	IT	35	8
JP	9	6	JP	23	11	JP	268	36
UK	6	6	UK	3	3	UK	89	17
US	68	28	US	10	8	US	307	70
H03J 1/00			H03J 7/00			H04L 1/00		
DE	34	14	DE	40	16	DE	66	20
FR	6	3	FR	13	8	FR	73	29
IT	4	2	IT	2	2	IT	6	4
JP	25	10	JP	55	21	JP	121	26
UK	1	1	UK	8	5	UK	42	18
US	13	9	US	9	9	US	144	47
H03J 3/00			H03J 9/00			H04L 11/00		
DE	13	6	DE	12	8	DE	75	8
FR	4	3	FR	0	0	FR	31	18
IT	1	1	IT	10	6	IT	6	2
JP	7	5	JP	7	4	JP	42	13
UK	2	2	UK	1	1	UK	32	17
US	5	3	US	4	4	US	160	43
H04L 12/00			H04L 17/00			H04L 25/00		
DE	285	42	DE	3	1	DE	156	24
FR	205	54	FR	0	0	FR	85	39
IT	23	6	IT	0	0	IT	8	6

JP	531	58	JP	0	0	JP	134	28
UK	130	30	UK	0	0	UK	42	25
US	1029	140	US	0	0	US	217	70
H04L 13/00			H04L 21/00			H04L 27/00		
DE	9	3	DE	0	0	DE	114	23
FR	2	2	FR	0	0	FR	140	35
IT	1	1	IT	0	0	IT	21	8
JP	3	3	JP	0	0	JP	269	28
UK	0	0	UK	0	0	UK	48	26
US	3	3	US	1	1	US	271	96
H04L 15/00			H04L 23/00			H04L 29/00		
DE	0	0	DE	1	1	DE	20	11
FR	0	0	FR	0	0	FR	36	20
IT	0	0	IT	0	0	IT	1	1
JP	0	0	JP	3	3	JP	84	19
UK	0	0	UK	1	1	UK	12	6
US	1	1	US	5	4	US	268	69
H04L 5/00			H04L 7/00			H04L 9/00		
DE	44	17	DE	116	23	DE	64	15
FR	63	21	FR	94	36	FR	52	22
IT	8	4	IT	15	8	IT	2	2
JP	41	12	JP	127	20	JP	78	20
UK	10	9	UK	30	14	UK	26	14
US	88	36	US	147	56	US	214	67

Table 15. Selected Keywords

Multimedia	Wireless Application Protocol
Internet Protocol	Asynchronous Time Division Multiplexing
Asynchronous Transfer Mode	Closed Circuit Television
Local Area Network	Internetwork Packet Exchange
Mobile Phone	Transport Control Protocol
Code Division Multiple Access	Carrier Sense Multiple Access with Collision Detection
Wireless Network	Data Encryption Standard
Compact Disc	Desktop Multimedia Broadcasting
Ethernet	Digital Communication Service
Time Division Multiple Access	Fibre Distributed Data Interface
Cable Television	Fibre to the Home
IMode	Global Mobile Personal Communication Systems
Digital Subscriber Line	High Digital Subscriber Line
Wide Area Network	Hybrid-Fibre Coaxial Cable
Interactive Television	Local Area Network Emulation
Digital Audio Broadcasting	Micro Browser
Video-on-Demand	Musical Instruments Digital Interface
Advanced Intelligent Network	Synchronous Data Link Control
Global System for Mobile Communication	Virtual Private Circuit
Hypertext Markup Language	Wireless Markup Language
Network Interface Card	Universal Mobile Telecommunication System
Digital Video Broadcast	Virtual Private Networks
Digital Versatile Disc	Direct Broadcast Satellite
General Packet Radio Service	Wireless Internet
High Definition Television	Electronic Data Interchange
Synchronous Optical Network	Cell Relay
Broadband Access	System Network Architecture
Metropolitan Area Network	Token Ring
Fast Ethernet	Integrated Service Digital Network

Table 16. Keyword Occurrence in Patent Abstracts* (1995-1996; 1998-1999)

Keyword	Number of patents	1995-1996	1998-1999
Multimedia	486	190	193
Internet Protocol	193	19	130
Asynchronous Transfer Mode	190	80	58
Local Area Network	185	75	69
Mobile Phone	180	35	106
Code Division Multiple Access	163	35	97
Wireless Network	149	34	78
Compact Disc	121	45	43
Ethernet	114	32	51
Time Division Multiple Access	82	35	22
Cable Television	74	26	24
IMode	61	21	25
Digital Subscriber Line	51	10	28
Wide Area Network	48	21	16
Interactive Television	46	15	30
Digital Audio Broadcasting	35	10	18
Video-on-Demand	24	18	4
Advanced Intelligent Network	20	6	4
Global System for Mobile Communication	18	5	8
Hypertext Markup Language	18	8	6
Network Interface Card	18	5	10
Digital Video Broadcast	17	5	10
Digital Versatile Disc	16	0	10
General Packet Radio Service	14	1	7
High Definition Television	12	5	6
Synchronous Optical Network	12	2	8
Broadband Access	11	2	3
Metropolitan Area Network	9	2	6
Fast Ethernet	8	0	8

Token Ring	8	4	3
Integrated Service Digital Network	6	3	0
Universal Mobile Telecommunication System	6	1	5
Virtual Private Networks	6	1	4
Direct Broadcast Satellite	5	3	1
Wireless Internet	5	0	5
Electronic Data Interchange	3	0	2
Cell Relay	2	1	1
System Network Architecture	2	1	0
Wireless Application Protocol	2	0	2
Asynchronous Time Division Multiplexing	1	1	0
Closed Circuit Television	1	0	1
Internetwork Packet Exchange	1	1	0
Transport Control Protocol	1	0	0

*The following keywords did not appear in any patent: Carrier Sense Multiple Access with Collision Detection; Data Encryption Standard; Desktop Multimedia Broadcasting; Digital Communication Service; Fibre Distributed Data Interface; Fibre to the Home; Global Mobile Personal Communication Systems; High Digital Subscriber Line; Hybrid-Fibre Coaxial Cable; Local Area Network Emulation; Micro Browser; Musical Instruments Digital Interface; Synchronous Data Link Control; Virtual Private Circuit; Wireless Markup Language.

Table 17. Selected Triples of Words (frequency >150)

Keyword	Frequency
PRINTED CIRCUIT BOARD	1624
SURFACE ACOUSTIC WAVE	434
DATA PROCESSING SYSTEM	388
LIQUID CRYSTAL DISPLAY	385
MOBILE COMMUNICATION SYSTEM	383
OPTICAL RECORDING MEDIUM	342
CENTRAL PROCESSING UNIT	319
DIVISION MULTIPLE ACCES	276
MAGNETIC RECORDING MEDIUM	268
GRAPHICAL USER INTERFACE	267
DIGITAL SIGNAL PROCESSOR	258
CATHODE RAY TUBE	256
FIELD EFFECT TRANSISTOR	254
PRINTED WIRING BOARD	235
SIGNAL PROCESSING CIRCUIT	232
LOCAL AREA NETWORK	227
MOBILE SWITCHING CENTER	227
RANDOM ACCESS MEMORY	227
WIRELESS COMMUNICATION SYSTEM	222
SERVICE CONTROL POINT	217
BASE STATION MOBILE	216
BASE STATION CONTROLLER	208
RADIO COMMUNICATION SYSTEM	201
VOLTAGE CONTROLLED OSCILLATOR	197
IMAGE PROCESSING APPARATUS	192
PRINTED CIRCUIT BOARDS	190
ELECTRODE ACTIVE MATERIAL	189
PLASMA DISPLAY PANEL	178
DIGITAL SIGNAL PROCESSING	176

Table 18. List of Keywords for RJV Database

M-Commerce

IPv6 Wireless Internet

M-commerce

Mobile application

Mobile application developer

Mobile commerce

Mobile (wireless) Internet

Mobile middleware

Mobile network infrastructure

Mobile financial services

Mobile services

Mobility WAP based services

Wireless e-commerce

Wireless m-commerce

Wireless networking

Wireless portal network

Wireless service provider

Educational Software, E-book/Cross media

Content Management System

Computer based learning (CBT)

Content delivery platforms

Content chunking

Cross media

Cross media platforms

Desktop multimedia broadcasting

Digital content

Digital paper

Digital libraries

Digital delivery platforms

Digital rights management (DRM)

Distributed learning

Educational platforms

Educational multimedia

E-content or Electronic-content

E-learning

Electronic (virtual) universities

E-publish

E-book

E-paper

Interactive learning

Interactive multimedia

Interactive publishing

Learning application providers

Learning management systems (LMS)

Mobile learning

Multimedia mobile messaging

Multimedia mobile learning

New media

Protocol SCORM

Protocol AICC

Real time multimedia collaboration

Remote learner

Remote tutor

Semantic multimedia

Virtual book

Web based learning (WBT)

Digital TV

All in one TV sets

Interactive TV

ITV and DSL

IPTV

IP broadcasting

Protocol VoIP

Protocol H.323

Protocol T.120

Protocol SIP

Cable iTV

WEB TV

Set-top box

Application Programming Interface (API)

Multimedia Home Platform (MHP)

Digital Video Broadcasting (DVB)

Common Interface (CI)

Conditional Access (CA)

Cable Modem

Digital Video Recorder

MPEG 4

Crossover Links

Companion Content

Streaming Media

DAVIC

DOCSIS

Playout Center

Online Channel

Dedicated networks infrastructure and services

Anytime-anyplace access

Application service provider (ASP)

Dedicated Backbone Services

Dedicated Wide Area Netorks (WAN)

Dedicated network services

Enterprise Networks

Intelligent Virtual Private Networks (IVPN)

Inter-business Data Communication

Internet service provider (ISP)

Private Network Connections

Third-party Networks

Unique private IP

Wireless Ad Hoc Networking

Virtual Private Networks (VPN)

Virtual Private Dial Networks (VPDN)

Mobile links to the Internet

XML

Internet Protocol version 6 (IPv6)

WAP gateways

Wireless Application Protocol (WAP)

Wireless Internet Service Provider

Wireless Markup Language (WML)

HTML (compact HTML)

Micro Browser

iMode (information mode)

2.5 Generation (GPRS, CDMA, TDMA, CDPD)

3 Generation (W-CDMA, CDMA-2000)

IP enabled phones

IP enabled devices

Mobile enterprise workers

Mobile VPN

Table 19. Frequency of Participation by Type of Entity

Frequency of Participation	Firm		University		Research		Other	
1	566	76,1	123	65,8	58	67,4	125	91,9
2	92	12,4	34	18,2	13	15,1	8	5,9
3	40	5,4	12	6,4	2	2,3	2	1,5
4	17	2,3	6	3,2	4	4,7	1	0,7
5	7	0,9	3	1,6	2	2,3		
6 to10	13	1,7	8	4,3	4	4,7		
>10	9	1,2	1	0,5	3	3,5		
Total	**744**	**100,0**	**187**	**100,0**	**86**	**100,0**	**136**	**100,0**

Table 20. Distribution of Participating Entities by Type and Hybrid Activity

Hybrid Activities	Firm	University	Research	Other
Dedicated networks	42	17	2	9
M-commerce	171	38	22	35
Mobile links to the internet	145	46	21	7
Digital TV	213	30	20	15
Educational software, e-book/cross media	323	130	49	74
Total	**894**	**261**	**114**	**140**

Table 21. Research Partnership Type by Hybrid Activity

Hybrid activity	RJV Type							
	F-F	F-U	F-U-O	F-U-R	F-U-R-O	F-O	F-R	F-R-O
Dedicated Networks	1	4	2		1		1	
M-commerce	3	8	4	9	6	1	1	1
Mobile links to the internet	4	8	2	15	7	2	2	
Digital TV	7	10	2	8	3	7	8	5
Educational software,e-books/cross media	13	14	12	27	14	6	11	5
Total	**28**	**44**	**22**	**59**	**31**	**16**	**23**	**11**

Figure 16. Size of Research Partnerships in Hybrid Activities and Rest of RJVs in Framework Programmes

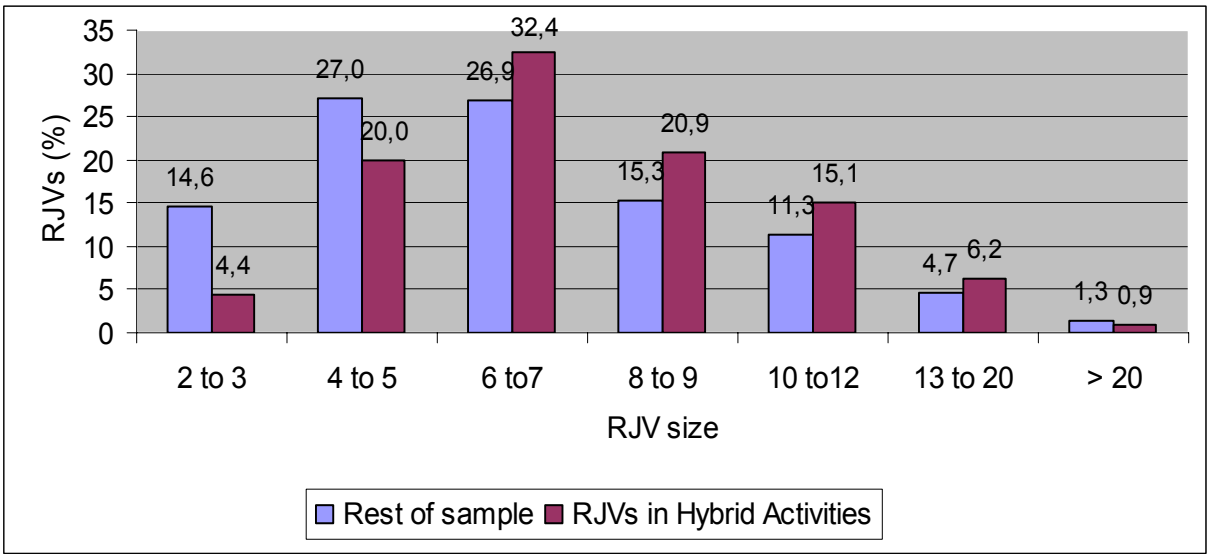
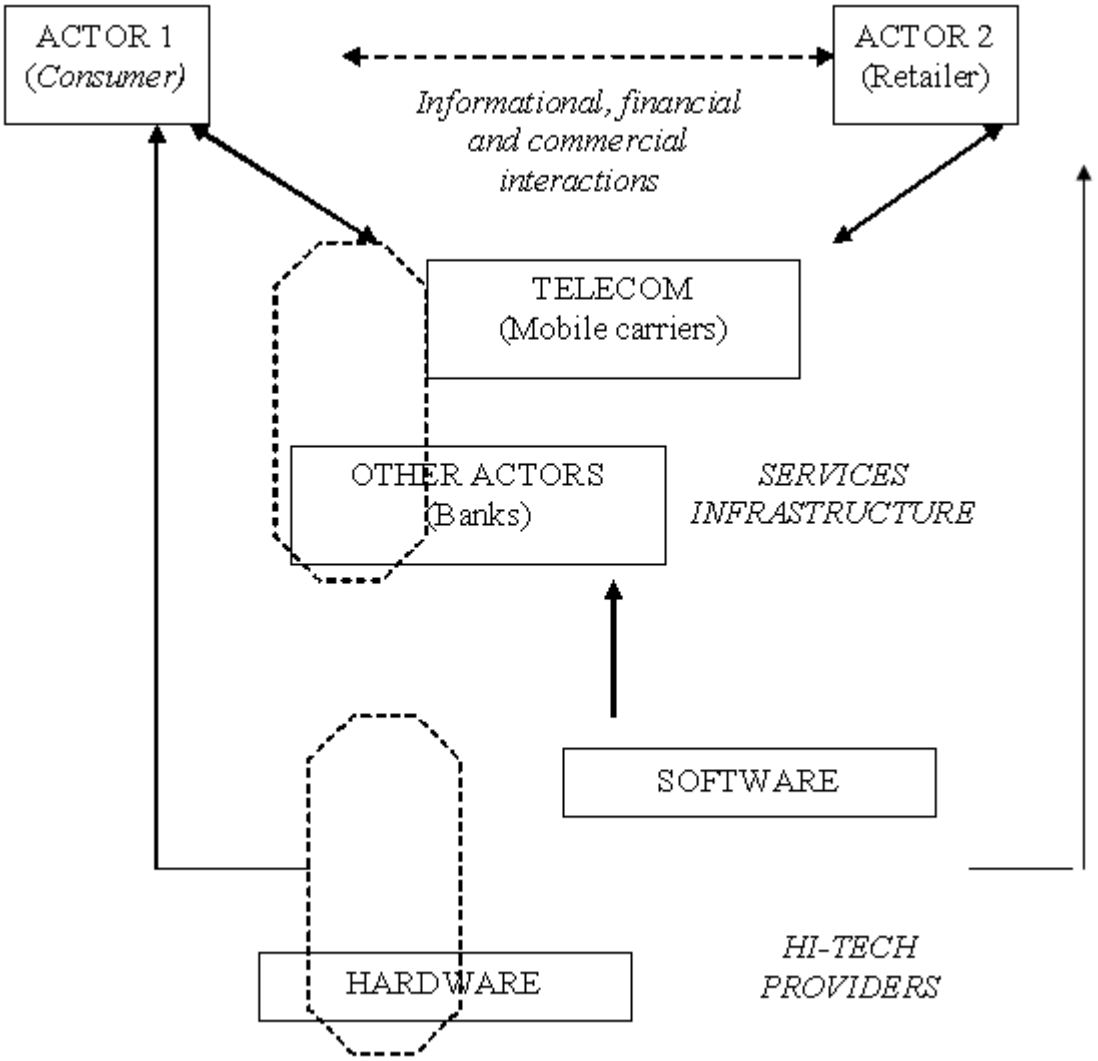


Figure 17. The M-Commerce Industry Structure



Source: Mateos-Garcia (2003)

Table 22. Type of Interactions among the Key Actors in the Danish M-Commerce Cases

	Interaction with technology providers	Interaction with technology users	Interaction with technology co-developers
Larger size/power than the other party	**Feature Request** (I.e. a supply contract) **The Digital Mall** with small IT service providers	**Independent design of the technology** (taking into account feedback from selected users, or including as many features as possible) **The Digital Mall** with focus groups **PMBS** with test users **Mobital** with users **Net-Mill** with buyers of their applications and test users	**Definition of interface specifications** (with which other developers of other components of the platform have to comply) **PMBS** with content providers
Equal size/power as the other party	**Joint definition of features** (provision of feedback for technological design). **Mobile Content** with operators and hardware suppliers **Mobile Gatekeeper** with content providers	**Joint Definition of features** (maybe through a partnership or inside a standard setting forum). **Mobile Content** with content providers and customers	**Joint development of the technology** (possibly inside a standard setting organization). The Digital Mall: the bank with the operator
Smaller size/power than the other party	"**Off-the-shelf" purchase of the technology** **Remote Monitoring** with the operator **Mobile Gatekeeper** with an operator **PMBS** with terminal providers **Net-Mill** with hardware suppliers	**Feature Implementation.** **Net-Mill** with large wholesale companies Remote Monitoring with the hospital	**Compliance with interface specifications** (defined by other co-developers). **Remote Monitoring** with hardware supplier

Source: Pedersen and Dalum (2003)

Table 23. Type of Interactions Between the Key Actors in the German M-Commerce Cases

	Interaction with technology providers	Interaction with technology users	Interaction with technology co-developers
Larger size/power than the other party	**Feature Request** (I.e. a supply contract) **Vitaphone GmbH** own patent	**Independent design of the technology** (taking into account feedback from selected users, or including as many features as possible) **Vitaphone GmbH** with end-users	**Definition of interface specifications** (with which other developers of other components of the platform have to comply)
Equal size/power as the other party	**Joint definition of features** (provision of feedback for technological design).	**Joint Definition of features** (maybe through a partnership or inside a standard setting forum). **Paybox.net AG** - offering full service customisation of payment solutions	**Joint development of the technology** (possibly inside a standard setting organization). **Paybox.net AG**
Smaller size/power than the other party	**"Off-the-shelf" purchase of the technology** **Paybox.net AG** - with software and hardware suppliers - it is part of the strategy to use existing standards and products	**Feature Implementation.**	**Compliance with interface specifications** (defined by other co-developers). **Vitaphone GmbH** with multipliers (retail)

Source: Kimperler (2003)

Table 24. Type of Interactions among the Key Actors in the Greek M-Commerce Cases

	Interaction with technology providers	Interaction with technology users	Interaction with technology co-developers
Larger size/power than the other party		**Asyrma** (with the Public: metro stations, bus stations – parkings, etc; with firms selling their products through vending machines) **Spacenet** (with the Public, i.e Ministry of Public Order, etc)	**Spacenet** (with specialized application providers i.e sensors, logistics software, etc) **Eurocom** (with a content provider)
Equal size/power than the other party	**Spacenet** (with hardware manufacturers related to vehicle and control center equipment)	**ACE** (firms with mobile workers in general, consumers goods industry to contact its retail outlets, civil engineering/construction firms, etc.) **ForthNet** (with FAHP, tourists agents, any firm that needs to inform recipients about something) **Spacenet** (with radiotaxis, transport companies, Wackenhut, etc)	**Spacenet** (with AVL systems/application developers and cartographic content provider)
Smaller size/power than the other party	**ACE** (with Infoquest and HP for hardware, servers and PDAs) **Spacenet** (with GPS/GIS developers; with Cosmote, a mobile network operator) **Asyrma** (with vending machines manufactures) **ForthNet** (with a mobile network operator)	**ACE** (with independent salesmen) **Eurocom** (with small users-young people) **ForthNet** (with small users) **Asyrma** (with the small users)	**ACE** (with Vodafone, a mobile network operator) **Eurocom** (with Cosmote, a mobile network operator) **Asyrma** (with a mobile network operator)

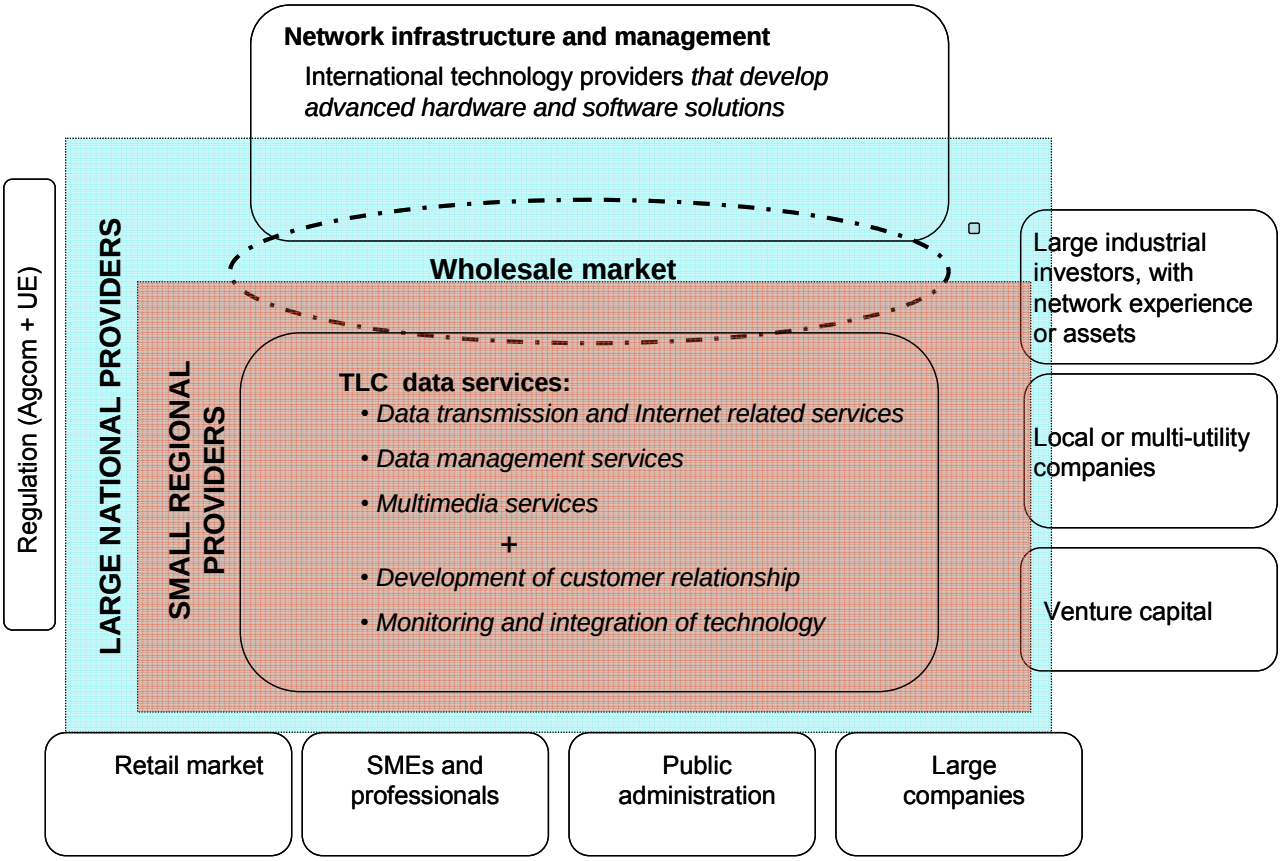
Source: Protogerou and Tsakanikas (2003)

Table 25. Type of Interactions among the Key Actors in the British M-Commerce Cases

	Interaction with technology providers	*Interaction with technology users*	*Interaction with technology co-developers*
Larger size/power than the other party	**Revolution O2** (With Pinpoint and software application developers), **Consult Hyperion** (with large technology developers as implementer)	**Redrock Software** (with small users), **Consult Hyperion** (with small clients as implementer)	**MPSA** (with software developers), **Consult Hyperion** (with other consultancy firms in the Chyp Retail Alliance)
Equal size/power as the other party	**Consult Hyperion** (with technology developers)	**MPSA** (with banks), **Redrock Software** (with medium users), **Consult Hyperion** (with medium clients as implementer)	**MPSA** (interactions inside the association, and with some large hardware developers), **Redrock software** (with ICC) **Consult Hyperion** (with technology developers in industrial forums)
Smaller size/power than the other party	**Consult Hyperion (**with small technology developers as implementer)	**Redrock Software** (with large users) **Consult Hyperion** (with large clients as implementer)	**Redrock Software** (with mobile carriers, hardware and software providers)

Source: Mateos-Garcia (2003)

Figure 18. Market of Dedicated Backbone Services for Business Communications



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