“Exploitation plans”

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The ACCORDANCE Project Consortium groups the following organizations:

Partner Name	Short name	Country
JCP-Consult	JCP	FR
Research and Education Laboratory in Information Technologies	AIT	GR
Alcatel-Lucent Deutschland	ALUD	DE
Deutsche Telekom AG	DTAG	DE
Telefónica Investigación y Desarrollo	TID	ES
University of Hertfordshire	UH	UK
Karlsruhe Institute of Technology	KIT	DE
Universitat Politècnica de Catalunya	UPC	ES
Euprocom Oü	EPC	EE

Abstract:
This deliverable includes the exploitation plans regarding the results and outcomes obtained during the course of the project of the partners of ACCORDANCE.

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Executive Summary

This document includes the exploitation plans of the partners contributing in ACCORDANCE. Continuation of the topics in upcoming research projects, the spreading of the findings within the respective entity for future research activities and/or product lines and the submission of filings for the sake of patenting are key exploitation activities.

The plans are arranged into three parts – industrial (vendor of solutions and provider of communication services), academic and consulting partners.

1. Exploitation plans industrial partners and telecom operators

1.1 ALCATEL-LUCENT DEUTSCHLAND (ALUD)

Roughly spoken the contributions of ALUD to ACCORDANCE have been in essence twofold. For once the fixed access group has mainly participated to work related to the optical access system relying on OFDM. Second, the wireless access group has developed and investigated solutions for integrating wireless access systems (here: LTE) into the converged optical transmission system.

Regarding the results related to work on the optical transmission the involved ALUD research teams discussed the Accordance subsystem demonstration results with the respective ALUD business groups. The exploitation plan included the discussion about future products to be able to provide advanced access solutions. The decision of the FSAN standardization group for the NG-PON 2 to be on a TWDM platform causes a delay of the Accordance OFDM access approach to be an appropriate input into product concepts for future wireline solutions. Contrary, the Accordance approach seems to be reasonable for wireless access solutions.

ALUD provided the achievements accomplished in ACCORDANCE to diverse standard bodies (FSAN, 3GPP). Members of the ALUD wireline and wireless research teams involved in the ACCORDANCE project joined and contributed to the respective groups in FSAN and 3GPP as well as in national (VDE) and European (CENELEC) standardization bodies so that the necessary links for potential interaction with standards bodies are established when the project results become appropriate for a product concept.

The exploitation of the results connected to the integration of wireless subsystems into the overall converged optical transmission network are as follows:

- The ideas generated in ACCORDANCE (split processing) have been shared internally with groups preparing and conducting co-creation projects between Alcatel-Lucent and potential customers. These ideas have been received very well and thus have resulted into the inclusion of a sub-project into the overall co-creation project with one of the biggest provider of wireless services worldwide. Here, these ideas have been

further investigated and developed under the light of existing installations of the partnering provider.

- Some of the ideas generated in ACCORDANCE (split processing) have been shared internally with the business divisions being in charge of developing the wireless product lines of Alcatel-Lucent.

Five invention submissions have been generated relating to work performed in ACCORDANCE by ALUD to strengthen the position of Alcatel-Lucent in the related markets:

1. Method for operating optical data transmission links, optical data transmission system and control unit. (filing number 11290125.1, status: published)
    a. Exploitation of adaptive modulation and transmit power control in OFDM signals to minimize the total interference level from optical beat interference in the upstream direction of OFDMA-based passive optical networks.

2. Apparatus, Method, And Computer Program For A Remote Unit And A Central Unit (filing number 11306097.4, status: examination)
    a. Means to enable efficient architectures for centralised radio access networks exploiting physical layer characteristics.

3. Apparatuses, Methods, and Computer Programs for a Remote Unit and for a Central Unit (filing number 12305202.9, status: examination)
    a. Means to enable efficient architectures for centralised radio access networks exploiting MAC layer characteristics.

The remaining two are still within the review process and may not be detailed, yet.

1.2 DEUTSCHE TELEKOM AG (DT)

Deutsche Telekom, Telekom Innovation Laboratories, has brought the ACCORDANCE access network concept, the technical approach and project results to the awareness of the internal business units and decision makers by establishing company-internal forums, such as meetings and internal workshops with the strategic and the operational departments in order to create awareness about the ACCORDANCE project and related results.

Network operators are aiming at increased access network cost efficiency by evolving towards Next Generation Optical Access (NGOA) networks: The main objective here is to lower productions costs while addressing increased user demands at the same time, which encompasses aspects like high network quality, network stability, availability and security as well as significantly increased bandwidth per user. The ACCORDANCE project results provide a deep understanding of the technical and architectural challenges as well as of the opportunities of an ODFM-based optical access network solution. The operators exploit these results for their network evolution strategy. Decisions regarding network architecture and technology solutions will be influenced by the knowledge gained in the ACCORDANCE project. Furthermore, operators are able to bring in their network requirements through standardisation activities and to influence technology development by this means – aiming at mass market production and cost-effective devices and systems fitting the requirements. Standardization activities in FSAN are an example where the ACCORDANCE approach and results have been discussed among several Deutsche Telekom stakeholders internally and requirements have been derived which were brought in to FSAN discussions.

Since the further development of access networks is a long-term business, the knowledge gained within ACCORDANCE will be valuable and used also in future discussions and decisions regarding the evolution of the optical and converged access network.

1.3 TELEFÓNICA INVESTIGACIÓN Y DESARROLLO (TID)

In a general approach, the ACCORDANCE project technology presents favorable projection from the point of view of a Telecom operator company. Apart from the advantageous and superiority feature of OFDM-based multiple access (against traditional modulation formats) in terms of downstream and upstream capacity and end-to-end low delay, as well as an important advantage for a converged network with heterogeneous requirements from different services. In addition, ACCORDANCE solution can be implemented for different market segments such as residential users, business and mobile backhaul even though for residential customers ACCORDANCE technology should be seen more as a long-term post-10G technology.

Another great benefit of the ACCORDANCE architecture from a Telecom operator company point of view is the possibility of node or central office consolidation. This means that operators companies could be able to switch-off unnecessary central offices, in this way, it will enable an optimum use of network resources (shared by a high numbers of users), a relevant reduction on operation and maintenance costs and an important real-state savings.

ACCORDANCE inside Telefónica Group

Telefónica I+D exploitation plans include the dissemination and proposal of ACCORDANCE related services through the different business units of the Telefónica Group, which currently offers services to more than 309 million customer (23% corresponds to fixed lines and 77% corresponds to mobile lines) at March 2012 and currently has more than 100 points of presence distributed in more than 60 cities and 40 countries, with a focus on the regions of Europe, United States and Latin America. Teléfonica points of presence are interconnected through multiple and diverse fibre optical infrastructures, including more than 20,000 km of underwater cable that guarantees optimal sturdiness and reliability in the communications that cross our network. Telefónica Group network, Tier-1 for Internet service, delivers more than 1.3 Tbps of data traffic daily at times of peak demand and transports more than 20,000 million international voice minutes a year, thus permanently maintaining an activated IP capacity that exceeds a total of 6 Tbps.

The FTTH Council Europe just release (October 17, 2012) a press document saying that Spain entered the ranking at 20th position with 1.42% penetration of FTTH technology[1], hence based on this information, ACCORDANCE technology in the future could substitute GPON or 10G-GPON through a migration phase in which can coexist all deployed technologies, but oriented to high profile clients and services that demand very high speed connections during initial rollout.

The Telefónica Group has wide range of business units, each one specialized in a specific field within the provision of telecommunications services, and all of them sharing a high grade of reliability, business efficiency and future projection. Representative examples of the long list of possible companies around the Telefónica Group that can be interested in the ACCORDANCE technology are the following:

- Telefónica International Wholesale Services (TIWS): is the organization within the Telefónica Group that provides global telecommunication services for fixed and mobile carriers, ISPs and content providers. Its portfolio includes international Voice, IP, Capacity, Satellite, Mobility, Platform and International Services for Corporations.
- Movistar: is the trademark in Spain and Latin America for all landline and mobile products and services.
- O_2: is the commercial brand of Telefónica Group that proves mobiles, fixed and broadband services in the UK, Ireland, Germany, the Czech Republic and Slovakia.
- VIVO: is the mobile brand of Telefónica Group in Brazil.

ACCORDANCE inside Telefónica services

The following list contains some possible services to be exploited using ACCORDANCE technology:

- Digital TV with HD/SD
- Video on demand (VoD) with HD/SD
- HD Multiconference
- High Speed Internet

[1] http://www.ftthcouncil.eu/resources/spain-and-luxembourg-join-leading-ftth-economies?media_id=2231

- LAN interconnection, VPN
- Streaming
- VoIP
- Cloud Services
- E-learning, e-health, e-government, etc.

All the proposed services cover different group of costumers, such as residential users, which could demand high definition TV or VoD services over IP, where high speed internet bit rate at 100 Mb/s or higher could be easily provided in both directions with ACCORDANCE technology. In the case of small-medium enterprises (SME) which typically have higher requirement than residential users with specific needs such as secure connections and resiliency, ACCORDANCE technology could be also a solid solution.

More concisely, ACCORDANCE technology could be a promising vehicle for Telefónica for the provision of high-speed Internet in urban zones where Internet is highly demanded. ACCORDANCE can provide different downstream/upstream configurations to business and residential clients with a wide bandwidth requirement.

The deployment, provision and exploitation of services that imply high speed Internet, multimedia and on demand access, reinforced with a total capacity, bandwidth allocation flexibility, number of users and network reach of OFDM-based networks, are of strong interest for Telefónica Group. One of the key advantages of ACCORDANCE technology is that isn't tied to any use therefore can be used with any service. For instance, Movistar Imagenio is an IPTV service provided in Spain oriented to residential market, that is being largely deployed and commercialized and could be implement through ACCORDANCE network easily due to the technology capacity potential, and using the same ACCORDANCE technology, mobile backhaul connectivity could be also provided.

Services using ACCORDANCE network

The multiplicity of services that can be provided by the ACCORDANCE system could raise several profitable exploitation business plans. One of the models that are expected to be among the most promising business plans is the Triple Play model. Triple Play relies on the

assumption that an integrated service offering will increase opportunity costs for customers who may choose different services from different service providers.

The point is that triple play strategy (that bundles voice, video, and data services) is oriented to increase the average rate per user (ARPU), so it is needed to innovate in services in order to call user attention to contract the new service. It is remarkable that these needs can be optimally fulfilled by the ACCORDANCE technology, rendering a unified infrastructure-sharing for the Triple Play solution. In addition, ACCORDANCE technology could be used to offer services to users who do not want triple play services, in this way, can be offered as solution for less demanding users.

Video on demand with current and future formats such as 3DTV and 4K Ultra HD television services allow users to watch and listen high definition digital video and audio content on demand. This kind of service could be offered through ACCORDANCE technology due to its high downstream capacity and bandwidth allocation flexibility.

In addition, Telefónica Learning Services (TLS) is a company within the Telefónica Group that specialises in offering comprehensive online learning solutions for Education and Training, which could to take good advantage of the technical possibilities in which a high bandwidth is needed as ACCORDANCE technology offers.

The capacity and the bandwidth allocation flexibility properties of ACCORDANCE make easier than ever for an e-learning service provider to get fast into the market. European initiatives in this field can benefit from the network with the enhanced multimedia transmission capacity that ACCORDANCE can provide.

There are two main services for e-learning according to its technical features that ACCORDANCE technology can fulfil them, such as:

- Real-time conversational e-learning service (Synchronous E-learning): This is similar to a multiconference service with less restrictive requirements in the interaction between the interlocutors. It is a moderated conference (teacher is the moderator) with a rigid flow control. The flow control has lower time constraints than a normal conference.

- Low-interactivity e-learning service (Asynchronous E-learning): In this case, the real-time constraints almost disappear because the interaction between the students and the teacher is based on no real-time interaction (e-mail, web exercises, off-line chat, etc.).

Integration with other networks

Nowadays, the coexistence, performance and technology availability of next generation network technologies are one of the most important issues that operators companies are facing inside their network evolution. Convergence in access networks is also important for operators in order to combine all existing service types and transmission resources into an easier and unified platform.

ACCORDANCE technology provides the flexibility to co-exist with G/E-PON and NG-PON systems and give an easy migration path from any previous PON technology, moreover, it provides the opportunity for convergence with wireless technologies; besides mobile base stations, FTTB/FTTC aggregation nodes and Legacy DSLAM/OLTs can be backhauled through the ACCORDANCE network (i.e., they can be thought of as normal OFDMA-PON ONUs).

In this way, ACCORDANCE solution is in line to address the main requirements that any Telecom operator could require for future networks, specially due to the converged nature of this technology, addressing a widespread portfolio of services and connectivity types and leading to CAPEX and OPEX cost reductions.

2. Exploitation plans academic partners

2.1 RESEARCH AND EDUCATION LABORATORY IN INFORMATION TECHNOLOGIES (AIT)

Through its participation in the ACCORDANCE project, AIT significantly strengthened its competence in the area of next generation optical access networks. Most importantly, this took place in various levels, ranging from the network architecture down to the physical layer technologies, and from the system design to the MAC layer. The topic of optical access was and remains one of the rapidly advancing areas in telecommunications with a large number of activities ranging from research to industrial standardization. Therefore, AIT has considered this project as a great opportunity to promote some of its original ideas in low cost IM/DD OFDMA-PON and multi-carrier, cross-layer resource allocation, matching perfectly with the project's targets. The success of the ACCORDANCE project and its visibility to the photonic research world allowed us to promote our research activities in the field and remain competitive with other research groups on an international scale, receiving already a large number of citations on our original work. This recognition in the topic of optical access networks is mostly contributed to the initial successful work performed under the ACCORDANCE project and brings new opportunities for future collaborations.

Stemming from the established collaborations within the ACCORDANCE project, AIT sought the extension of its activities in future optical access solutions and therefore successfully established and prepared the STREP proposal COCONUT that was accepted under FP7 call 8. This project targets the presentation of a novel PON network concept (which is a potential candidate for the upcoming PON generations) based on the use of coherent UDWDM technology as an enabler for extended access in terms of the number of users and types of services offered by the network. The experience from the MAC implementation activities undertaken by AIT in the course of ACCORDANCE will prove significantly beneficial for the work to be conducted in the framework of this project and increase its chances of success. Moreover, the expertise partly gained by AIT researchers throughout the ACCORDANCE project in terms of OFDMA-PON power consumption, largely facilitated the ongoing strategic partnership of AIT with the GreenTouch consortium.

Finally, AIT's PON MAC studies within ACCORDANCE are planned to be exploited to some extent in the ongoing national project PANDA, which is focused on the proof-of-concept for next generation PON access in Greece. In terms of future research activities and collaborations, AIT will also seek for new funding via both EU and national projects in upcoming relevant calls on similar research areas based on the experience gained via ACCORDANCE.

The exploitation of ACCORDANCE is not restricted to the field of research, since the generated knowledge is also considered as significantly useful within the educational activities of AIT. More specifically the courses on "Optical Communications" and "Broadband Networks" for the Masters degree on Telecommunication and Information Technology offered by AIT are to be updated to cover theory and examples regarding the physical layer and networking aspects of the ACCORDANCE project (i.e. OFDMA-PON. Additionally, throughout the duration of the project our group the internship of an international student was carried out, on topics related to the ACCORDANCE project activities (i.e. optical OFDM transmission).

2.2 UNIVERSITY OF HERTFORDSHIRE (UH)

UH has used the experience and outcomes obtained from the ACCORDANCE project in order to enhance the industry related involvement for its students while assisting the research focus in the optical access network with other industrial collaborators. The ACCORDANCE project has significantly reinforced the position of the UH optical networks research group in the areas of MAC protocols and algorithms design for next generation optical networks (NG-PONs), with additional focus on the architectural and transmission aspects of optical and wireless convergence. This allowed our group to enhance its competitive research profile which in turn is expected to generate new opportunities and future collaborations.

Such industrial as well as academic collaborations have already started to emerge, and—as a result—several and diverse national and international projects in the area of optical and wireless communication have been prepared and submitted. These include an Engineering and Physical Sciences Research Council (EPSRC) national project, SMART, that relies on the concept of innovative MAC algorithms that were investigated and developed in ACCORDANCE, to further enhance access networks. Also, the results obtained in ACCORDANCE with respect to optical and wireless convergence are used for preparation of subsequent national and European FP7 projects that aim to tackle the challenges that arise with such hybrid networks.

Furthermore, the additional expertise gained from ACCORDANCE is fed directly into the undergraduate and masters degree programmes. This aspect together with the association of PhD students with the ACCORDANCE project significantly contributed to the further development in the education of graduate engineers with high level practical skills and knowledge to support advanced telecommunication networks developments in the European Union. In particular, aspects of the ACCORDANCE activity were introduced into specific masters degree dissertation projects and at three PhD students that undertook a programme of research in an area related to the ACCORDANCE project.

UH contribution in ACCORDANCE has been primarily disseminated through highly rated scientific journals, as well as conference publications and through presentations at various optical and wireless next generation networks workshops. Publications include the IEEE

Journal of Lightwave Technologies (IEEE JLT), Journal of Optical Communication and Networking (OSA JOCN), International Conference on Transparent Optical Network (ICTON), and Access Networks and In-house Communications (ANIC) amongst others.

Finally, UH intends to use the experience obtained from ACCORDANCE, especially from MAC layer investigations and implementation of the resulting algorithms on embedded processors, in order to establish novel test-beds at UH premises. This involves development and testing of advance optical modulation formats and MAC designs in the context of the upcoming national and international research projects.

2.3 KARLSRUHE INSTITUTE OF TECHNOLOGY (KIT)

The exploitation activities of the KIT can be divided into scientific contributions in high quality journals and international conferences and education of students and junior scientists.

Several papers have been published in highly rated journals such as Photonics Technology Letters, Optics Express, or Journal of Optical Communication and Networking. Furthermore, the Accordance visibility in both the optical community and the reconfigurable hardware community has been increased through presentations of the Accordance network and the real-time processing in several major conferences. These include the Optical Fiber Communications Conference, the European Conference on Optical Communications, the Signal Processing in Photonics Communications, the Access Networks and In-house Communications, and the IEEE International Conference on Industrial Informatics. It should be noted that optical communications as is envisioned today heavily involves digital signal processing and thereby calling for a strong collaboration between the optical community and the reconfigurable hardware community. Such collaboration has been established inside the KIT where two institutes (the Institute of Photonics and Quantum Electronics and the Institute for Information Processing) are involved in several projects including Accordance. This helps to bridge the gap between optical and digital world.

Education wise, experiences and results gained from the Accordance project have influenced and enabled three core elements including lecture, lab course, and academic work. They have motivated and inspired students and young scientists for the field of optical access network technologies and OFDM.

1. Results and experiences gained from the Accordance project have influenced a lecture given at the Institute of Photonics and Quantum Electronics. The lecture is entitled “Optical Transmitters and Receivers”.
2. A lab course has been set up for graduate students who have passed their bachelor’s degree. In this lab course OFDM signaling in combination with analog (radio frequency) mixing is investigated. This is also done in the Accordance ONUs.
3. Several Bachelor’s and Master’s degrees have been acquired with work done on the Accordance and related projects.

2.4 UNIVERSITAT POLITÈCNICA DE CATALUNYA (UPC)

UPC's contribution to ACCORDANCE has been mainly disseminated and exploited in three different ways:

- scientific publications and presentations:
  - journals
  - international conferences (ECOC, ICTON, ANIC, ACP)
  - workshops in next generation PONs
- presentations in European projects concertation as CaON
- academic activities

The results obtained in ACCORDANCE gave rise to new ideas to develop and will continue in the form of a new research line to be followed by the group, as it fits in the research group path and interests in European project COCONUT, and Spanish projects ROMULA and WDM-doctor. Besides the technical publications, two invention patents have been submitted to the Spanish office for patents and brands:

- Method for reducing optical interference in passive optical networks (P201230271, status: examination)
- Signal amplitude codification/de-codification method by folding and auxiliary information tags (P201231426, status: examination)

Being an academic institution, UPC has also taken advantage of the ability to involve its students on the activities related to Accordance resulting in the completion of a total of 10 Master Thesis projects, and two more which are under way; and one PhD scholarship granted by the Catalan public research endowment fund, already in its 2nd year. These activities have greatly added to the dissemination and exploitation goals of the project for UPC.

Furthermore, the results and goals of ACCORDANCE have constituted a study topic in the subject "Microwave Photonics and Terahertz Technologies" included in the curriculum of three of the Masters offered by UPC, namely, the *Erasmus Mundus Master of Science in Research on Information and Communication Technologies* (MERIT), the *Erasmus Mundus Master in Photonics Engineering, Nanophotonics and Biophotonics*, and the Master's degree in Photonics.

3. Exploitation plans consulting partners

3.1 JCP-CONSULT SAS (JCP) AND EUPROCOM OÜ (EPC)

JCP and EPC contributions, and consequently exploitation paths within ACCORDANCE are different in comparison to technical Partners and mainly concentrated on project coordination and management as well as dissemination and financial management.

Due to relatively low involvement of Estonia and other NMS countries in ACCORDANCE-like FP7 projects, training received from JCP and experience itself obtained from that project is of extreme uniqueness for EPC. Knowledge obtained from the project already was applied towards one of EPC goals in the ACCORDANCE: increase participation of Estonia and neighboring NMS countries in FP7 (and H2020) R&D collaborative projects in the future. Thus, thanks to in-deep understanding of FP7 projects, EPC, with the help and consultations received from JCP already involved 6 Estonian companies into project proposals in FP7 ICT calls 7, 8, 9 and 10 (ongoing) and currently negotiating with Latvian and Lithuanian companies for their involvement in FP7 ICT Calls 10 and 11. In addition, ACCORDANCE in collaboration with FP7 OASE project (coordinated by JCP) organized a workshop in Tallinn (in February 2012), where more than 50 people (mainly from Estonia, but also Lithuania) from telecommunication industry attended. Special session on this workshop was dedicated to setting up of collaborative R&D projects. EPC intention is to involve several of these companies in the telecommunications R&D projects in the future FP7 calls for proposals and particularly in Call 11.

More specifically, based on outcome of ACCORDANCE (and other projects) JCP and EPC are planning development of special R&D projects training session material package. It will be based on following principles:

1. JCP involvement in other FP7 and national projects and related rich experience
2. EPC experience in collaboration with Baltic companies. It should be mentioned, that major obstacle for involvement of those companies is extremely low level of knowledge of FP7 projects. E.g. it turned out, that from four Estonian major telecommunication operators only 1 was informed about FP7, however never participated before. Many companies are

oriented towards national funding only and thus miss a lot of other opportunities. There are several reasons for that, and dissemination of ACCORDANCE results in Baltic states gave excellent opportunity to understand those reasons better. One of main reasons, is that a lot of FP7 related trainings and information days are being held by people having only theoretical knowledge of inner life of FP7 projects. As a result, Participants of those trainings often do not get real ideas about their possible contributions to such a projects.

Thus, based on that two principles, special package (that will also include knowledge obtained in ACCORDANCE, as well as other projects, where JCP participated) will be developed. That package will be based rather on real examples (real work performed by Partners, examples of approach to requirement specifications, interconnections between disciplines, demonstrations and testbeds launching etc.) than on theory and formal procedures. Then several trainings for Baltic States (Estonia, Latvia and Lithuania) will be conducted and JCP will also investigate possibility for conducting those trainings among its Customers in other NMS countries (Poland, Hungary). It is worth to mention, that thanks to extensive experience of JCP, this package will be dedicated not only to projects related to telecommunications, but also to other areas of R&D EU projects, such as search computing, audiovisual and content centric networking.

Additionally JCP will take advantage of ACCORDANCE technical content, together with FP7 project OASE for their dissemination, technical training and business modeling internal activites: technical packages will be prepared for training and information on NGOA. A workshop on NGOA was tentatively organized in Rennes, France in May 2012, but postponed most probably to end 2013.

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