Multimodality for people and goods in urban areas

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WP3.2 – Future Internet Technologies Roadmap for Transport and Mobility Preliminary report

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Deliverable Abstract

The objective of this document is a common understanding of some technologies which will contribute to the Future Internet and should be explicit for reader who are not involved in ICT research areas.

This Future Internet Roadmap (first version) provides an overview of the main Information and Communication Technologies which could be useful for the Transport area and will support a cross analysis with expert of Transport companies involved in Instant Mobility to better define technological mapping with Instant Mobility most relevant scenarios.

- The first paradigm for Transport is mobility and despite heterogeneous, mobile networks technologies are very promising.
- The second paradigm concerns the huge volume of data that traffic of vehicles and people produce. This huge volume of data has to be considered through two different forms which will always coexist: thousand short messages for dedicated information, or heavy rich content for multimedia dimension.
- The third paradigm is Transport 2.0 where travelers and drivers are part of the Transport ecosystem and require personalized applications relevant for social interactions and best multimodal services identifications.

This roadmap based on the four axis Internet of Networks, Internet of Services, Internet of People, Internet of Things, does not expect to be exhaustive but propose a vision Instant Mobility will share with the other projects of the Future Internet Public Private Partnership and external stakeholders because Transport 2.0 technologies should be useful for all these parties.

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1. Abbreviations

3GPP	3rd Generation Partnership Project
ATIS	Alliance for Telecommunications Industry Solutions - North America
ARIB	Association of Radio Industries and Businesses - Japan
CCSA	China Communications Standards Association
CS	Circuit Switched
CSD	Circuit Switched Data
CDMA	Code Division Multiple Access
CDN	Content Distribution Networks
EPC	Electronic Product Code
EDGE	Enhanced Data rates for GSM Evolution
ETSI	European Telecommunications Standards Institute
EVDO	EVolution-Data Optimized
GPRS	General Packet Radio Service
GPS	Global Positioning System
GSM	Global System for Mobile communications
GSMA	GSM Association
HSCSD	High Speed Circuit Switched Data
IaaS	Infrastructure as a Service
IEEE	Institute of Electrical and Electronics Engineers
IMT-2000	International Mobile Telecommunications
IP	Internet Protocol
ITU	International Telecommunications Union
iOS	iPhone Operating System
LTE	Long Term Evolution
LEO	Low Earth Orbit
MMI	Man Machine Interface
ME	Mobile Equipment
MS	Mobile Station
MT	Mobile Termination
MMS	Multi-media Messaging Service
PS	Packet Switched
PDC	Personal Digital Cellular
PaaS	Platform as a Service
PMR	Professional Mobile Radio
RFID	Radio Frequency IDentification
RTT	Round Trip Time
SMSC	Short Message Service Center
SMS	Short Message Services
SaaS	Software as a Service
TTC	Telecommunication Technology Committee – Japan

TIA	Telecommunications Industry Association - North America
TTA	Telecommunications Technology Association - South Korea
TA	Terminal Adaptation
TE	Terminal Equipment
TETRA	TErrestrial Trunk Radio
VM	virtual machines
WiMAX	Worldwide Interoperability for Microwave Access

2. Introduction

During the last fifteen years 4 majors trends have strongly modified our environment without so concrete innovation and new services for travelers and citizen in the transport area. The maturity of these trends provides a strong innovative ecosystem to develop the new multimodal transport system for 2015 and prepare a green and sustainable Horizon 2020.

- First trend: Mobile technologies

Nowadays, everyone owns its mobile device and sometimes more than one. The phone was transformed from family communication tool at home to a very personal accessory which allow everybody to reach anyone, anywhere you are. Coupling Internet with wireless technologies reinforces the customization of communication channel and anyone can consume his own content through streaming, peer-to-peer or video- on-demand services. Frequencies are now the most valuable resources and spectrum is always better optimized to provide more independent channel for all customers.

- Second trend: Internet… of course!

This trend has also deeply changed the world with new ways to share and provide information. If Internet is not really a technology but fully supported by IP, search engines and web crawlers, it has become one of the major tool for connectivity and sharing any kind of information. The improvement of graphics interfaces allows to submit any kind of content, from classical text to rich media as music or video. Dedicated services propose global environments to share your contents, social media, and every data becomes information! Of course Internet requires more and more resources to store, analyze, search and distribute all kind of contents and fixed networks, as the skeleton of Internet, have to reinforce bandwidth and data centers to support the Information World. All these Internet resources should be provide "as a service" to share in the best way what is available through a common access.

- Third trend: new interfaces

At the end of the 90's, computers are for experts and required program to exploit their underlying capacities. The Web 2.0 provides "web applications that facilitate participatory information sharing, interoperability, user-centered design,[1] and collaboration on the World Wide Web"[1] following Dale Dougherty[2] definition. But user-centered design is not fully completed as applications interfaces are not so standardized. Apple and Google with iOS and Android introduced new innovations with small applications available through stores. Each consumer can download its apps to enrich his environment but future interfaces have to provide user-friendly composition of applications to fulfill every need of the end-user and to reach the best of Web 2.0.

- Fourth trend: Internet of Things

This is one of the paradigms to claim a new version of the Internet Protocol from v4 to V6, because every small things in our environment would tomorrow interact together and communicate with humans. This trend is currently emerging, thanks to the Moore Law which as regularly improve power of chipset when size decrease dramatically. Several technologies are available and interoperability of things is the main weakness of this promising trend.

[1] http://en.wikipedia.org/wiki/Web_2.0
[2] http://en.wikipedia.org/wiki/Dale_Dougherty

3. Internet of Networks

Nowadays there are few places in the world where only one single network will give you access to Internet and connect you with all people. Despite this diversity of technologies, mobile and fixed lines are the main channels to be connected to networks. If for fixed lines we can have three major media – copper, fiber or cable, which is in fact copper or fiber! – wireless access can only use frequencies but there are more than ten technologies to optimize the use of frequency and depending of power and bandwidth, lots of protocols and wireless technologies have emerged since the end of the 20^{th} century. Convergence is the biggest challenge in the area of Internet of Networks because Internet is synonymous of a common and single access to the information when each device manages its own technology to provide a physical access to the network. Internet Protocol which gives its name to Internet is a higher protocol and IP V6 should provide common address system for all connected objects and build an abstraction layer upon all the physical networks. Hereunder is an overview of these physical technologies and how each of them try to propose some convergence models based on their historical strengths.

3.1 Mobile Networks

There are two main families for mobile technologies, depending of the type of services provided by their promoters: voice operators or data operators. From a technical point of view Voice operators support Circuit Switched (CS) technologies when data operators chose Packet Switched (PS) technologies. The first ones provide one of the greatest successes of European Industry with GSM standardization when the other support new rich services with the transfer of massive data in all type of devices. We expect a first convergence step with LTE and future 4G technologies despite the profusion of new protocols.

3.1.1 Wide Area Wireless Networks

To underline the complexity of what everybody knows as mobile networks, we would draw here a quick history of GSM and competitors to emphasize the high potential of innovation in this area.

In the context of this section, the term ***wide area*** defines areas which are larger than about 50 km.

Wide area wireless networks mainly target mobile communications. First networks were rolled out in the 80s. They are now labelled as 1G (first generation) networks.

There are different ways to classify wide area wireless networks. If one considers targeted types of users, networks can be either for professionals or for consumers. They can be classified as well according to the number of cells (area of land covered by one radio-transmission equipment) the user can use with the same mobile equipment. Finally, they can be classified according to the technology they use to transmit voice over radio frequency.

This section focuses on cellular (several cells) public (aiming consumers) networks, classified mainly according to technology. But some information about professional networks is provided as well, as those networks are still heavily used (for instance, about 20.000 professional mobile radio networks in France).

3.1.2 1G: First generation

1G cellular networks were introduced in the 80s. They were using analogue technology for voice transmission, along with digital signalling. Most of those networks have been discontinued, in the beginning of the 21^{st} century.

3.1.2.1 2G: Second Generation

The second generation of cellular networks is fully digital: voice is digitally encoded before being transmitted. 2G networks are deployed all over the world, serving more than two billion users.

Three main standards coexist:

- GSM (Global System for Mobile Communications) - originally from Europe, but now accounting for about 80% of all subscribers around the world
- cdmaOne or IS-95 - originally from the USA (CDMA: Code Division Multiple Access). CDMA is one possible technology to allow several users to share the same frequency band. cdmaOne is a brand, while IS-95 is the standard, also known as TIA-EIA-95)
- PDC (Personal Digital Cellular) - in Japan

When first GSM networks were rolled out in the mid-90s, they provided circuit switched data (CSD) capabilities, and short message services (SMS).

CSD throughput available to the user is around 8 kbit/s. Round trip time (RTT - the length of time for some bytes to be transmitted plus the length of time for the acknowledgement to be received) is around 1 s.

Usually, operators provide a modem interworking service for CSD. That means that a CSD call originated by a mobile terminal is routed to fixed phone number dialled by the mobile terminal. This phone number must be the number of a modem.

SMS allows for transmission of 160, 140 or 70 characters, depending on the alphabet being used. Messages transit via a Short Message Service Center (SMSC) providing a store and forward service. For instance, the SMSC queues a message sent to a mobile terminal which is not reachable. Usually, the operator does not provide any end to end acknowledgement to a message. Transmission time is usually less than a few seconds.

GSM standard describes a cell broadcast service. But usually this service is not available to an integrator because it uses a signalling channel to broadcast data. Misusing this important network resource could cause network outrages. Thus, mobile operators do not want to provide access to third parties..

Later on, several additional services were added to the core of existing GSM functions to improve data transmission:

- GPRS (General Packet Radio Service) well-known as 2.5G
- MMS (Multi-media Messaging Service)
- HSCSD (High Speed Circuit Switched Data)

Compared to CSD, GPRS is usually charged on a volume basis, instead of a call duration basis. Data throughput is between 20 kbit/s and 160 kbit/s, depending on various technical parameters of the mobile terminal (coding scheme, multislot class), and on quality of communication between the mobile terminal and the base station. Round trip time often reaches 1 s.

There are three different classes of GPRS mobile terminal:

- class A: the terminal can use GSM voice service and GPRS service at the same time. Only a few terminals of this type are available on the market
- class B: the terminal can use GSM voice service and GPRS service, but only one at a given time. Most GPRS terminals are of class B
- class C: switching between GSM voice service and GPRS service is manual

HSCSD provides data throughput up to 38.4 kbit/s. The main difference with GPRS is that network resources are fully allocated to the user, as long as the circuit is maintained by the user.

EDGE (Enhanced Data rates for GSM Evolution) was introduced in 2003. EDGE uses new methods for coding and transmitting data. This results in increased data throughput for GPRS, that can reach 400 kbit/s.

EDGE is often labelled as 2.75G.

GSM standards have been defined by the ETSI (European Telecommunications Standards Institute). Mobile operators and related companies are associated in the GSMA (GSM Association), formed in 1995.

3.1.2.2 3G: Third Generation

In the mid-80s, ITU (International Telecommunications Union) started to work on IMT-2000 (International Mobile Telecommunications). In the year 2000, IMT-2000 specifications were approved as specifications for 3G.

One of the key visions of IMT-2000 is to provide seamless global roaming, enabling users to keep their number and their handset all over the world.

In order to support IMT-2000 specifications, two global projects were started at the end of the 90s: 3GPP and 3GPP2.

The 3GPP (3rd Generation Partnership Project) was set up by the ETSI and several other Standards Development Organizations: ARIB (Association of Radio Industries and Businesses - Japan) , TTC (Telecommunication Technology Committee - Japan) , CCSA (China Communications Standards Association - China) , ATIS (Alliance for Telecommunications Industry Solutions - North America) , TTA (Telecommunications Technology Association - South Korea).

The original scope of 3GPP was to produce Technical Specifications and Technical Reports for a 3G Mobile System based on evolved GSM core networks and the radio access technologies that they support. The scope was subsequently amended to include the maintenance and development of the Global System for Mobile communication (GSM) Technical Specifications and Technical Reports including evolved radio access technologies (e.g. General Packet Radio Service (GPRS) and Enhanced Data rates for GSM Evolution (EDGE)).

The 3GPP2 (3rd Generation Partnership Project 2) was set up by TIA (Telecommunications Industry Association - North America), ARIB, CCSA, TTA and TTC.

The 3GPP2 aim is to provide global specifications for 3G systems, based on ANSI/TIA/EIA-41 standards for roaming, and evolutions of CDMA technology.

Given the fact that two different third generation projects were started, two different 3G systems coexist in the world. The one coming from 3GPP, named UMTS (Universal Mobile Telecommunications System), offers several radio interfaces: W-CDMA (Wideband Code Division Multpile Access), TD-SCDMA (Time Division Synchronous CDMA - in China only) and, with the latest UMTS release, HSPA+ (Evolved High-Speed Packet Access). UMTS handsets support GSM as well.

HSPA+ can provide peak data throughput up to 56 Mbit/s for downlink in theory (28 Mbit/s in existing services) and 22 Mbit/s for the uplink. The 3G system defined by 3GPP2 is CDMA2000. Handsets support IS-95 as well. The latest release, EVDO (EVolution-Data Optimized) can provide peak data throughput up to 15 Mbit/s for downlink.

Real data throughput may be quite lower than the figures above, depending on speed of mobile terminal, on traffic generated by other users, on distance from the base station, etc. Usually, users talk about 2 Mbit/s for stationary terminal, and 380 kbit/s for moving terminal (in a car).

3.1.2.3 Tomorrow fourth Generation : 4G

3G systems still do not support real broadband services. Consequently, ITU defined new targets for research, with IMT-Advanced: 100 Mbit/s for high mobility and 1 Gbit/s for low mobility.

Following figure provides ITU's view for IMT-Advanced capabilities:

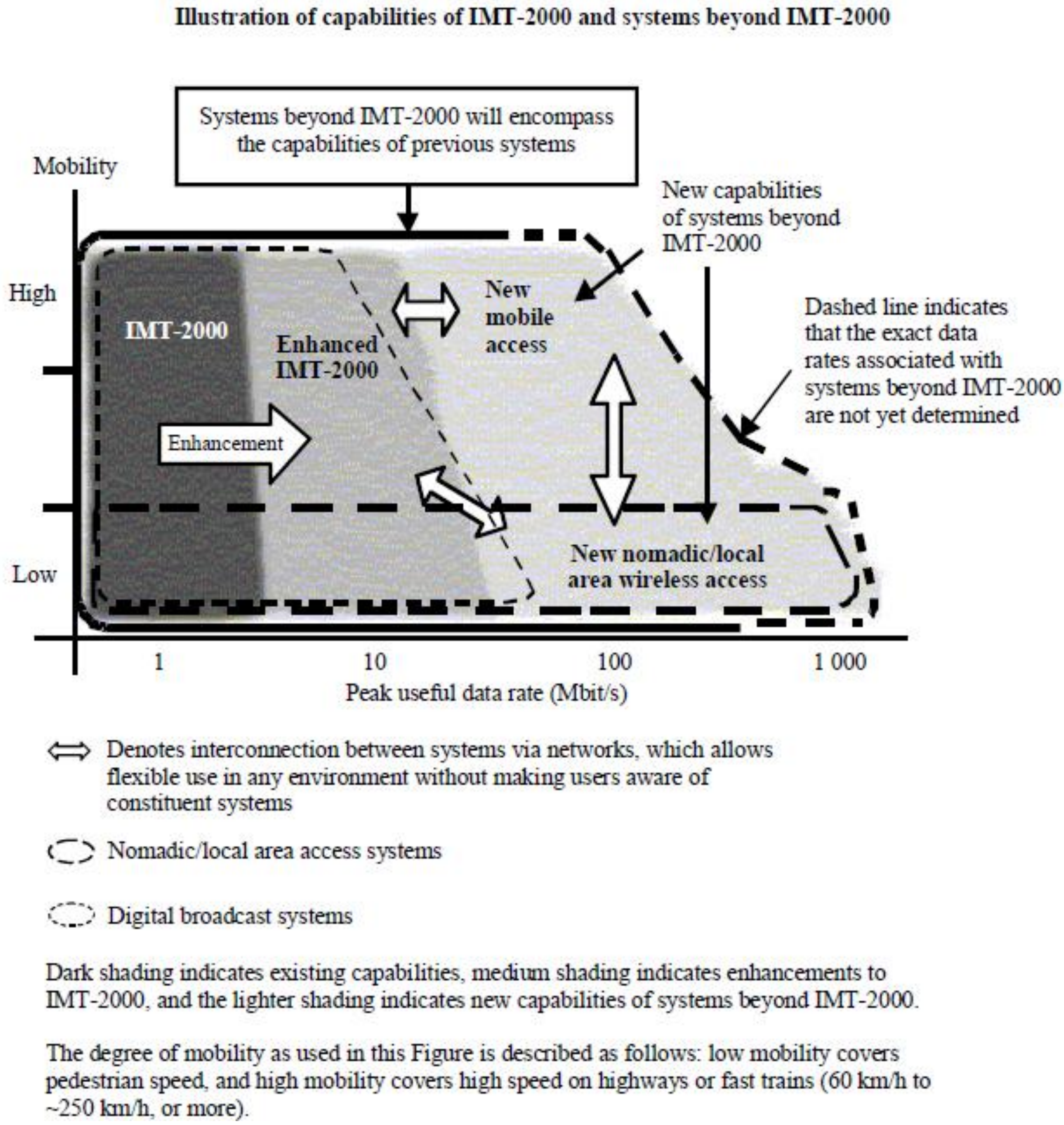


Figure 1: potential bandwidth for 4G

The source document is: *Recommendation ITU-R M.1645*. This same document provides a list of objectives, from various perspectives:

Perspective	Objectives
END USER	Ubiquitous mobile access Easy access to applications and services Appropriate quality at reasonable cost Easily understandable user interface Long equipment and battery life Large choice of terminals Enhanced service capabilities User-friendly billing capabilities
CONTENT PROVIDER	Flexible billing capabilities Ability to adapt content to user requirements depending on terminal, location

	and user preferences Access to a very large marketplace through a high similarity of application programming interfaces
SERVICE PROVIDER	Fast, open service creation, validation and provisioning Quality of service (QoS) and security management Automatic service adaptation as a function of available data rate and type of terminal Flexible billing capabilities
NETWORK OPERATOR	Optimization of resources (spectrum and equipment) QoS and security management Ability to provide differentiated services Flexible network configuration Reduced cost of terminals and network equipment based on global economies of scale Smooth transition from IMT-2000 to systems beyond IMT-2000 Maximization of sharing capabilities between IMT-2000 and systems beyond IMT-2000 (sharing of mobile, UMTS subscriber identity module (USIM), network elements, radio sites) Single authentication (independent of the access network) Flexible billing capabilities Access type selection optimizing service delivery
MANUFACTURER/ APPLICATION DEVELOPER	Reduced cost of terminals and network equipment based on global economies of scale Access to a global marketplace Open physical and logical interfaces between modular and integrated subsystems Programmable platforms that enable fast and low-cost development

It provides the following timeline as well:

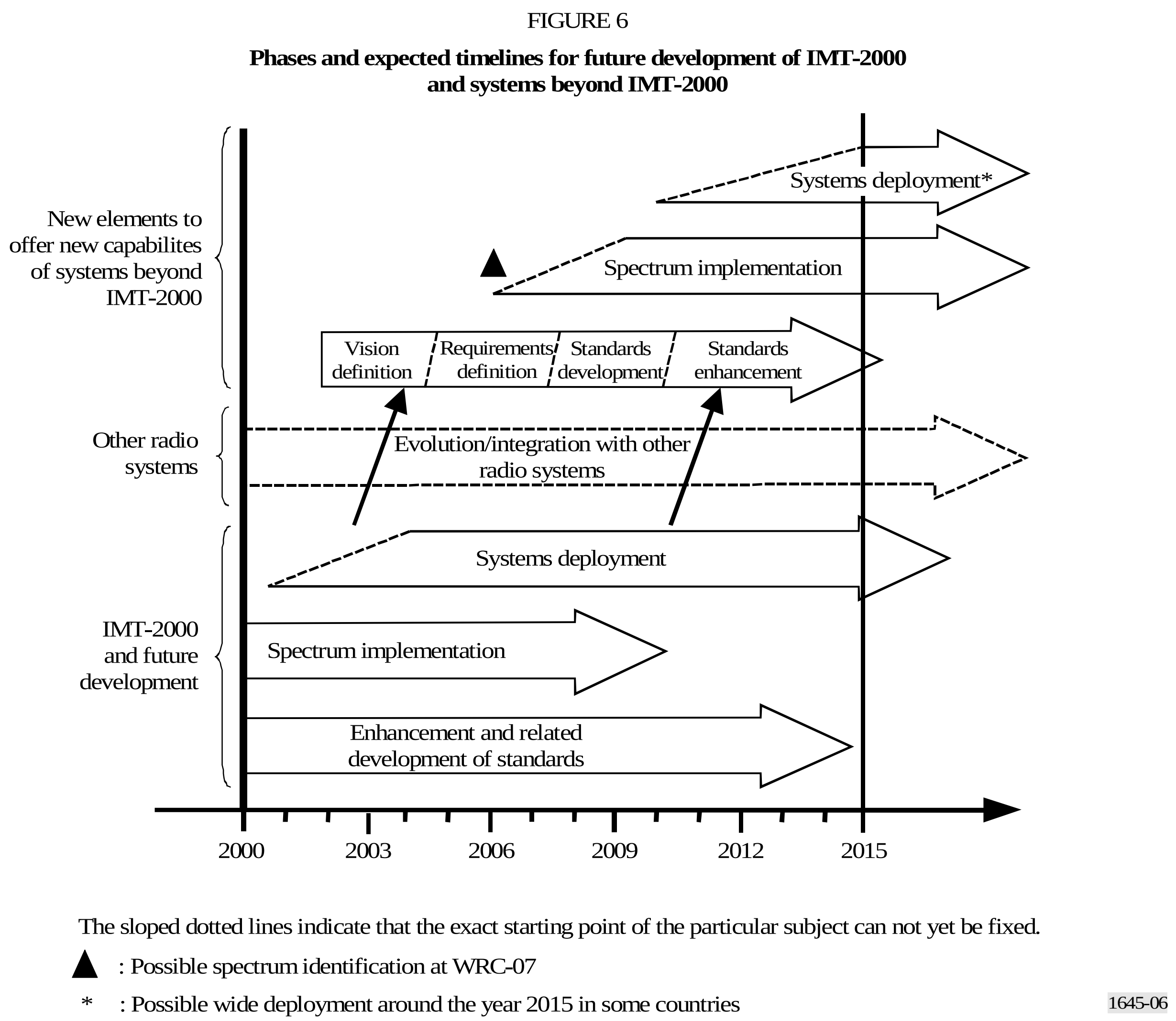


Figure 2: expected timeline for 4G

This document was written in 2003, but is still considered as valid by the ITU.

In order to ensure a smooth transition between current technologies and 4G, 3GPP launched the Long Term Evolution (LTE) project. LTE does not fully comply with IMT-Advanced requirements. This is only a step toward another standard, LTE-Advanced, which will define a real 4G network. LTE-Advanced will be forward compatible with LTE, while LTE is not compatible with 3G.

One critical point: 4G networks will use full packet based infrastructures, relying on version 6 of IP (Internet Protocol).

To support these evolutions, the main issues to solve are:

Provide compatibility with previous technology

Provide roaming between different technologies

Ensure a quick Return on Investment (ROI)

First LTE networks were commercially deployed in 2010, focusing on data services because of roaming constraints and obviously because voice devices were not available.

In European countries, 2015 should be the first year where all cities up to 40,000 inhabitants will be covered by LTE data and voice services with an ADSL similar bandwidth per end-user.

3.1.2.4 Wireless LAN

Some years ago, Local Area Networks (LAN) required some wireless connectivity, typically to allow users to connect their laptops to the LAN in an easy way. Wi-Fi was defined in this context (the term Wi-Fi does not mean anything. More precisely, it does not mean *Wireless Fidelity*).

Wi-Fi conforms to the IEEE 802.11 family of standards.

Wi-Fi range depends on the implemented 802.11 standard. It varies from 30 m (indoors) up to 250 m or more outdoors. But local regulation can restrict this range. Maximum data throughput depends on standard. Starting nowadays at 6 Mbit/s, it can reach 150 Mbit/s with 802.11n.

Wi-Fi does not provide for transparent mobility management.

WiMAX (Worldwide Interoperability for Microwave Access) was defined, in order to increase that range and compete with Wide Area Networks like LTE and 4G. WiMAX improves security, and provides one mobile version.

WiMAX conforms to the IEEE 802.16 family of standards.802.16e introduced support for mobility, in 2005.

Current versions of WiMAX provide throughput of up to 40 Mbit/s. Latest 802.16m aims at providing 100 Mbit/s for mobile terminals and 1 Gbit/s for fixed terminals. It was designed to fullfil IMT-Advanced requirements.

Few mobile version of Wimax were developed by ICT industry and the main promise of Wimax, IP voice for mobile networks, did not meet the market.

3.1.2.5 Professional Mobile Radio (PMR)

Professional Mobile Radio are radio communication systems used by organizations of professionals, e.g. taxi drivers, fire brigades, ambulances companies, field service companies, police forces, etc.

First PMR networks, more than 30 years ago, were using analogue technology. On a functional point of view, the main differences between those networks and the first cellular networks were functions specifically aimed at professionals: very fast call setup (less than one second), group calls, priority calls, etc.

In order to optimize frequency re-use, and infrastructure costs, so-called trunk networks appeared in the end of the 80s. It was then possible for different organizations to share the same infrastructure. As in first cellular networks, voice was transmitted in an analog way. An example of standard defining such a technology is MPT1327.

Later on, trunk networks migrated to digital technology as TETRA (TErrestrial Trunk Radio) or TETRAPOL, for instance. TETRA is an ETSI standard, first published in 1995. TETRAPOL was developed by Matra / EADS in the late 80s and specifications were opened.

Non-trunk, analogue PMR networks having to migrate to digital technology can use DMR (Digital Mobile Radio), defined by ETSI in Technical Specifications (TS) 102 361. Among other functions, these specifications define three different configurations for a network:

- equipments work in direct mode (unit to unit)
- equipments work in direct mode or using a base station for repeating
- equipments are part of a trunk network, communications being regulated by a controller function

Main functional differences between those digital networks and 3G networks are still related to a professional use:

- group call: one individual user calls a predetermined group of users. All parties in the group can hear each other
- all call: one-way voice call from any user to all users on a channel
- broadcast call: one-way voice call from any user to a predetermined large group of users

- open voice channel mode: allows users to monitor and participate to the voice channel activity
- packet data protocol that supports Internet Protocol (IP V4) and short data services

PMR networks support services for voice which are multicast for data networks but with high constraints on delays. PMR are not so much used for data transfer except for short data services.

3.1.2.6 Satellite

Several companies provide satellite data services or voice services. The main advantage of satellite communication is there is no coverage concerns with a constellation of satellites around the world. But to put in place dozen of satellites companies have to invest a lot and there are not able to update technologies. Terrestrial radio communications technologies would change three times during the life of a constellation. We have to consider that this technology is in addition of the previous ones and could be used in some technical areas with low bandwidth requirements

Typically company as Orbcomm specifically targets M2M market: asset tracking, management, and remote control. Orbcomm network uses a LEO (Low Earth Orbit) satellite constellation complemented by agreements with GSM and CDMA operators. To avoid interference, terminals are not permitted to be active more than 1% of the time, and thus they may only execute a 450ms data burst twice every 15 minutes. Typical data payloads are from 6 to 30 bytes. According to Orbcomm, 50% of messages are received in less than 1 minute, and 90% in less than 4 minutes.

Orbcomm plans to renew the constellation with 18 new generation satellites, between 2011 and 2014.

Globalstar started as a provider of voice services. Later on, they provided data services as well. As Orbcomm, Globalstar uses a LEO constellation.

Globalstar provides data terminals under their own brand. One of the terminals targets asset tracking and remote asset monitoring, including a GPS receiver, and a battery with an estimated life of 7 years, for two messages transmission per day what is very far of the use of smartphones with GPS functionalities..

Two-way data transmission can be performed at 9600 bit/s, using a Globalstar phone as a modem. Data compression using dedicated software can increase this throughput up to 38400 bit/s.

Data transmissions are charged on duration, on a 15-second burst basis.

Short message service is available as well, for up to 35 text characters.

Globalstar plans to renew the constellation with 18 second generation satellites, starting in 2011.

As previous companies, Iridium uses a LEO constellation. Ampng provided services, one specifically targets asset monitoring. It allows for short data messages transmissions: 1960 bytes maximum for uplink, 1890 bytes maximum for downlink. For a message of 70 bytes, latency is around 7 s. For a maximum length message, latency is about 20 s.

Iridium plans to renew the constellation with 66 new generation satellites, starting in 2015.

These examples are existing solutions which should be integrated in a global radio communication services and using Internet paradigm.

3.1.2.7 Terminals

In the above sections, the word terminal is used, without formal definition. In fact, depending on the point of view, this word can correspond to different elements (hardware and / or software).

In this section, we introduce vocabulary and related architecture defined by ETSI. Those elements were defined firstly for 2G. But they apply as well to other types of networks and this architecture is open to integrate any other mobile interface:

- a Mobile Station (MS) is a Mobile Equipment (ME) in combination with an identification mean (e.g. SIM card for GSM)

- a Mobile Equipment is made up by a Mobile Termination (MT) plus a Terminal Adaptation (TA), if applicable, plus a Terminal Equipment (TE), if applicable. When GSM architecture was designed, one of the requirements was to be able to use existing data terminals with mobile equipments. The Terminal Adaptation aim was to provide usual interfaces to those data terminals. With UMTS networks, data services are now supported from inception time. Consequently, the TA is considered as a part of the MT.
- the MT includes all functions required to use network services (radio transmission, speech encoding and decoding, flow control, error correction, etc.)
- the TE is an equipment which uses functions provided by the MT. It can interface directly to the MT, or use a TA to access MT functions

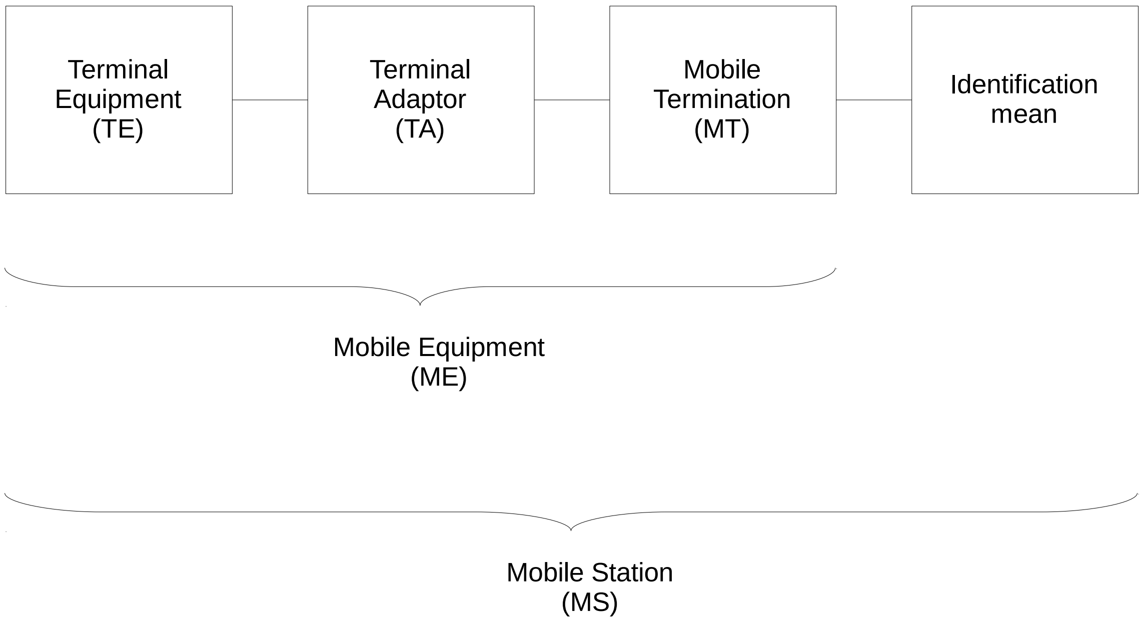


Figure 3: Mobile Equipment versus Mobile Station

A Mobile Station can be used by a human being, or integrated into a system, in order to allow the system to use functions of a given network.

If the user, the system and the network are added to the above diagram, we get this one:

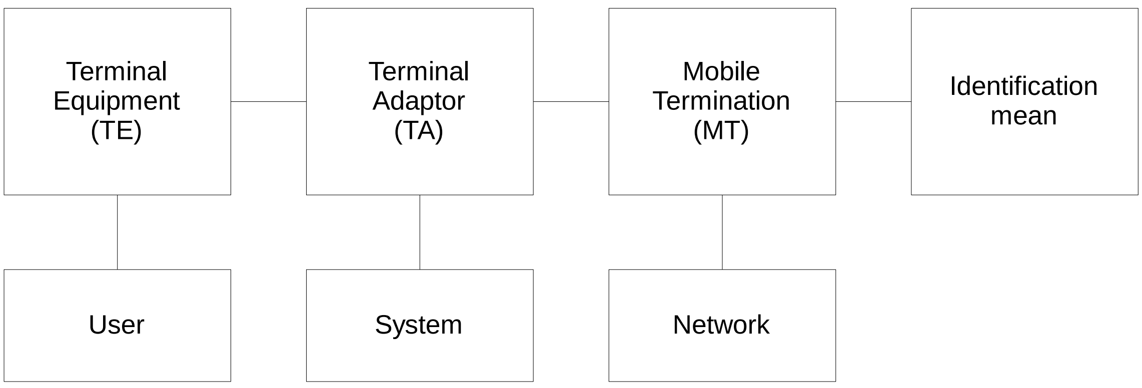


Figure 4: Mobile Equipment functional view

Usually, either the user or the system are using the Mobile Station, not both of them.

The user is presented a Man Machine Interface (MMI) by the Terminal Equipment, that allows him or her to interact with the Mobile Station. The MMI can include a display, a keyboard, etc.

The system uses what is named *AT commands*, to request services from the Terminal Adaptor, usually over a serial link, a USB port, a Bluetooth connection, an infrared connection, etc. When the Mobile Station is integrated in a system, usually, there is no Terminal Equipment.

This reference architecture can generate lot of different variants. Let's take a few examples:

- current 3G equipments support 2G networks as well. This means that they embed two Mobile Terminations
- some Mobile Stations designed to be integrated in larger systems provide a Terminal Equipment part, that allows the integrator to inject some application software into the equipment. This can allow for substantial cost reduction, for the mobile part of the system
- a Mobile Station including a Mobile Termination for Wi-Fi, another one for 3G, and a last one for 4G, plus some specific routing software in its Terminal Adaptor, can be used as a multi-wireless networks router, almost in a transparent way for the user. Such a Mobile Station can be provided in a USB key form factor.
- additional components can be included into the Mobile Station. For instance, a GPS (Global Positioning System) receiver, specific I/O (Input / Output) controller, etc.

more and more Mobile Stations for 3G provide an open Terminal Equipment, in the way that they accept application software developed by third parties. Very well-known examples are Android smartphones, Apple iPhone, etc.

With an integrator's point of view, which is the one which is of interest for us here, several possible segmentation of Mobile Stations are possible. The first one is about programmability:

- some mobile stations are programmable, i.e. they accept to execute software code developed by third parties. Some examples of such equipments are: Android smartphones, Apple iPhone, AirLink programmable modems[3] from Sierra Wireless, Telit terminals, etc.
- some mobile stations are not programmable, but can be used as dumb modems by another equipment like a PC. Some examples of such equipments are: 2G and 3G simple phones, many wireless modems, etc.

The second possible segmentation is based on the type of user using the mobile station:

- embedded equipments: those mobile stations are installed inside a vehicle, inside a machine, etc. and do not provide any MMI (apart some possible simple indicators like LEDs and or simple sensor like switches). No user interact with them.
- professional terminals: mobile stations installed on vehicle dashboard, next to a machine, etc. and designed for professionals (supporting harsh environment, with large keys if any, etc.)
- consumer terminals: mobile stations used by consumers.

A third possible segmentation is about relative importance of Mobile Station communicating part:

- for some Mobile Stations, the communicating function is the most visible one, possibly supplemented by a few other minor functions like phonebook, information about last incoming or outgoing calls, etc.
- for some Mobile Stations, the communicating function is almost hidden behind other functions like car navigation application, fleet management application, etc.

[3] The word *modem* is not appropriate in a purely digital context. But it is frequently used, even by manufacturers themselves.

Those few examples give a first idea of the complexity of related ecosystem. It is quite difficult to know today whether a given type of Mobile Station will take the precedence over all other ones, and, if any, which one.

But, whatever the type of a Mobile Station is, any new wireless technology that appears impacts its Mobile Termination. This usually means that the user needs to buy a new terminal, or that Mobile Stations installed in the field need to be replaced.

Research work has been done regarding so-called Software-Defined Radio (SDR). Thanks to SDR, one can imagine that in the future a new wireless network technology could be supported simply by updating some software in the terminal, provided that the radio part is of the right type.

But in fact, this architecture provides lots of modularity to introduce new functionalities and new technologies, in spite of consumers would have to change their devices. In the same way, chipsets are low consumers of energy and provide the same power that computers we bought ten years ago.

Devices implementing this architecture would follow Moore's law[4] in the following years and become more usual than computers and replace them for at least 50% of the European population.

3.1.2.8 V2X Radio technologies

These technologies are based on 802.11p which expect to support Intelligent Transportation Systems (ITS) and associated devices in environments "where the physical layer properties are rapidly changing and where very short-duration communications exchanges are required". This standard provides a two-way, short-range wireless communication very similar to Wifi technology (802.11b,g).

V2X technology expects to assess the surrounding vehicle environment based on accurate and precise data exchanges with other vehicles and roadside hotspots. The data exchanges include several elements: a vehicle's location, velocity, acceleration and path history, which can enable on board computers to predict trajectories and reduce the likelihood of collisions..

V2X are splitted in three categories, based on the communication characteristics of one of the receiver:

- V2V: vehicle to vehicle
- V2I: vehicle to infrastructure (road infrastructure)
- V2P: vehicle to pedestrian

One of the main challenge for V2X technologies is the definition of DSRC devices (Dedicated Short Range Communication) because as they will use "dedicated" short range communication and having mobile and embedded devices (V2V), mobile and portable devices (V2P) or static devices (V2I), that increase a lot the complexity of mobile systems and split up the potential market.

V2X technologies should provide vehicle awareness to avoid any conflict and damage on the road, but also traffic awareness with a better knowledge of vehicles flows in a city.

[4] http://en.wikipedia.org/wiki/Moore%27s_law

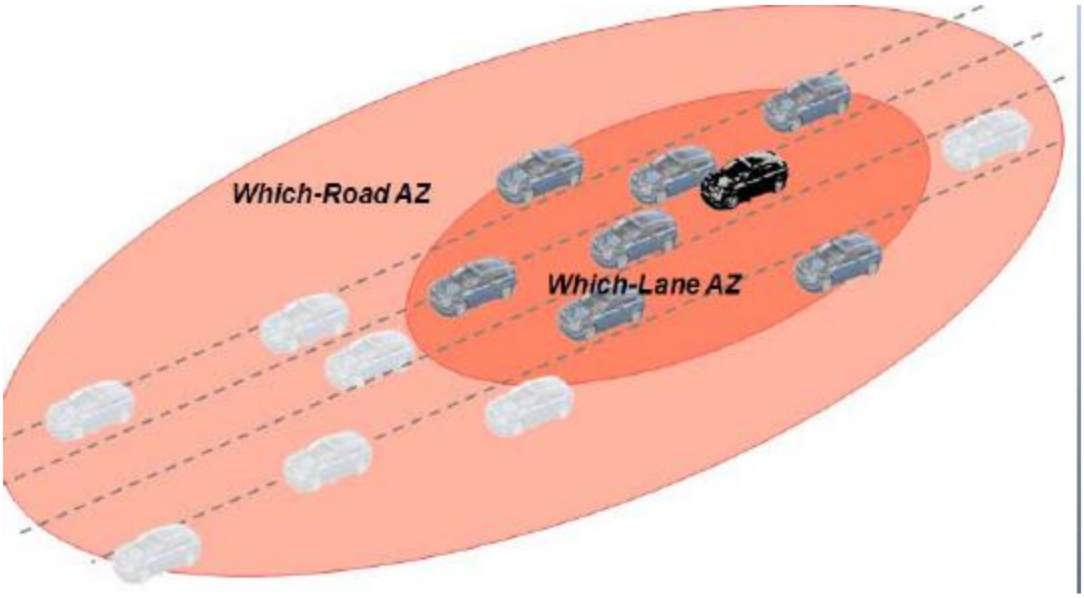


Figure 5: vehicle awareness with V2X technologies[5]

But Short Range Communications require lots of investments to cover a small area as a city. As these technologies are based on 802.11 family, they should take into account the interoperability with other mobile technologies.

3.1.2.9 Mobile technologies and localisation

Localisation services seem to be one of the main challenge for many industrial players for the next ten years. This competition was launched by services players as Google but also by devices manufacturers (Nokia, Apple) when then decided to include GPS components in mobile devices.

Using GPS services consume lots of energy for mobile devices and can drastically decrease the autonomy if using all the time. Other issue is that GNNS based solutions do not work indoors.

For some other privacy issues, the localization service is activated by end-users and localization is not always available despite this service does not consume lots of bandwidth and do sent only small messages.

New technologies as LTE and 4G, based on new network intelligence (IMS core) will be able to provide precise localisation based on device localization in the network (identification of a mobile cell) and with no additional cost should require an additional Location Network Service to refine localization in a cell based on more classical short messages systems.

Future Internet should provide roaming for localization services to assume that localization should be available independently of the selected operator

3.1.2.10 Conclusion

Among what we learn from the past and from today, we can list:

- average lifespan of a wide-area wireless network technology is between 15 and 20 years
- several technologies coexist on the market, possibly for several years before the oldest technology is phased out
- advanced functions are provided by professional mobile networks (very fast call setup, group call, broadcast call, guaranteed service availability, etc.), that are not yet available on public networks. Some of those professional users (firemen, police, ambulances, etc.) will not switch to public networks as long as those ones do not provide required functions.

[5] http://www.ibtta.org

- 2G, 3G and 4G networks will not provide full land coverage, for cost reasons. Only satellite networks are able to provide such coverage. But their limitations will still be numerous: transmission cost, terminal cost, latency time, throughput...
- most of consumer terminals will be programmable. What such terminals lack today compared to professional terminals is the ability to provide various I/O (inputs / outputs). But this could change rapidly. For instance, latest versions of Android offer a software library to use the USB port in host mode or in accessory mode.
- due to mass market effect, it is possible that those programmable consumer terminals replace professional programmable devices, at least for a few ranges of applications.

3.2 Fixed Networks

Fixed networks with their massive and complex infrastructure change slowly. The main change will be deeper penetration of fiber in the core networks but also for customers delivery. This improvement would appear in selected countries and dedicated urban areas but fixed networks will continue to deliver ten times more bandwidth than mobile channels. For fixed networks operators, bandwidth is the main advantage to innovate and include especially broadcast or multicast services, which are traditionally on-air services. The competition between fixed and mobile networks would be at its apogee between 2015 and 2020 when LTE and 4G mobile technologies would be available for European consumers.

Innovative technologies on fixed networks would increase customers experience using 3D video for virtual immersion and in parallel target personal experience as each end-user would be able to define its own program with record content where real-time changes could be integrated providing virtual immersion.

Fixed networks, which are dedicated to a limited set of devices, would also provide common access to Future Internet for all connected devices at home or in a business environment. This convergence would be supported by new protocol adaptation layers and new interfaces for devices. Smart boxes would be the main network interface, bridging all wireless technologies with fixed networks, and integrated home and offices “in the cloud” to deliver computational resources “as a service”.

Fixed networks were built for one to one communications when Internet provides a common access for many users to the same content. Future Internet would provide multicast protocols for fixed networks to optimize bandwidth resources. But one of the major complexity is that multicast mechanisms should be activated not only by networks management systems but also by fixed networks customers, typically to share content as video. User devices will integrate multicast intelligence to manage the right level of quality of service and to build on-the-fly the right partition of fixed networks end-users to define a real-time and no-permanent “social network”.

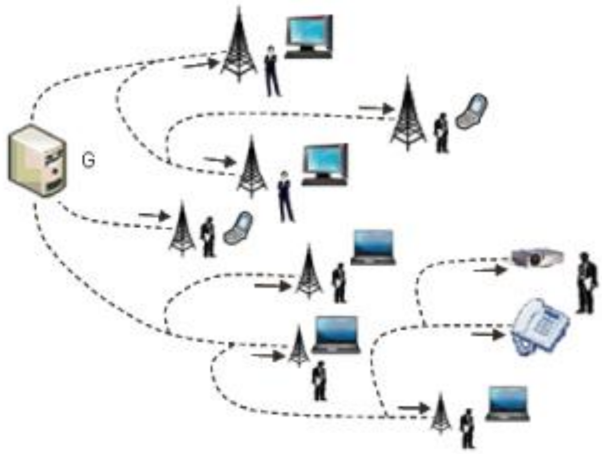


Figure 6: Multicast mechanisms

3.3 Mesh Networks

A **mesh network** is a wireless communications network made up of several radio nodes where each node have to collaborate to propagate as a relay the data of the other nodes. Nowadays, mesh networks could also use several mobile technologies to optimize short and wide range capabilities.

This kind of networks requires self-capabilities to supply missing resources and to define dynamically new routes to convey data with undefined quality of services.

3.3.1 Femto cells

A Femto cell is a very small cell (by size order: macro, micro,pico, femto) and the particularity of this cell is that it would use standard internet access to be connected to the core network of a mobile operator.

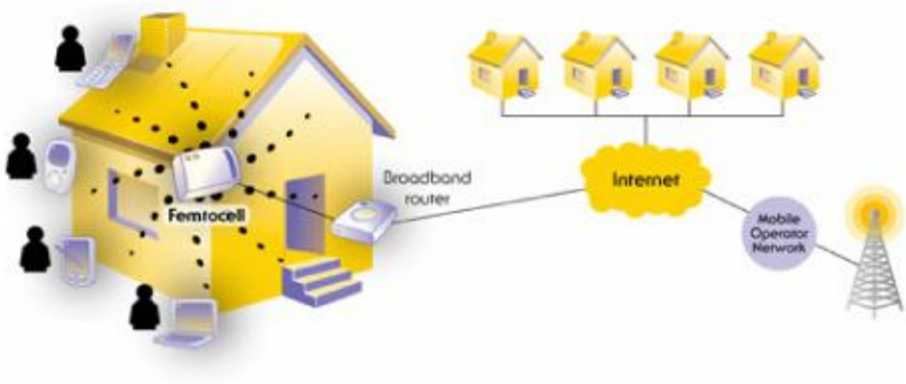


Figure 7: Femto cell for in-house mobile network

Femto cells could be encapsulated in a small box as classical xDSL boxes and provide to end customers or enterprises an optimized and high quality mobile coverage for short range area (classical range is about 15 – 20 meters).

A Femto cell is plug and play and quite autonomous for any configuration issues because its place is unknown by the mobile operator, could support temporary disconnectivity and based on the potential of large amount of Femto cells, dedicated configuration is impossible.

Femto cells provide an extensive vision of mesh networks where fixed and mobiles technologies converge to support the best services for the end-users but there are always include into a public network topology with dedicated characteristics, especially local access rights management to allow “group closed mode” (limited list of mobile devices) or “hybrid mode” (some devices are part of priority list).

Some other local services can also be supported as several payment models, PBX connectivity or automatic applications starting.

	NodeB / Macrocell	Microcell	Picocell	Femtocell
Coverage	Outdoor	Outdoor	Indoor	Indoor
Backhaul / Transport	TDM / ATM	TDM / ATM	TDM / ATM or IP	IP
Access control	Open	Open	Open	Open or closed
Auto-configuration	No	No	Partially	Yes
Installable by end-user	No	No	According to Tx power	Yes

Figure 8: characteristics of mobile cells

Future improvements about Femto cells should solved

- handover concerns from macro to femto cells which is impossible today
- cell localization to deliver rich services because the high level of granularity increase the complexity to identify clearly a device in a mobile network.

3.4 Content Networks

To deliver content under delay constraints and for thousands of customers is one of the new challenge for fixed networks. As IP is a best effort protocol, Future Internet should provide tools to manage in a better way Quality of Service and propose new backbone architecture to distribute services dynamically in the best subset of the network.

Beyond social media and the large amount of video available on the network, promising HD and 3D technologies have strongly emphasized these technical issues. Nowadays rich content traffic is growing of 50% each 5 years.

If Content Networks refer initially to a medium or a platform through which advertisers can make use of ads to reach out to their customers world wide, delivery or distribution mechanisms have a strong impact on networks infrastructures and technologies.

Content Distribution Networks (CDN) should be a major pillar of Future Internet with thousand servers and should support at least 30% of worldwide web traffic[6].The CDN would provide Content nodes as in the most “strategic” places in the worldwide network. Nodes of CDN have to be as close as possible from the main producers of content and the main consumers. This requires a dynamic allocation of resources, especially storage and bandwidth, and a high level of interoperability and peers connectivity.

When traditional fixed networks are built around hierarchical nodes, which are concentrating backbone resources for the higher level, and manage end users connectivity for the lower level, CDN introduce a new dimension to manage huge volumes of rich content and how to distribute them.

6 www.akamai.com

CDN are systems of computers with storage environments containing copies of data, placed at various points in a network so as to maximize bandwidth for access to the data from customers throughout the network. As Future Internet will provide worldwide access to any content, customers would access a copy of the data closed to their network access, as opposed to all customers accessing the same central server, so as to avoid bottleneck near that server.

Future Internet will provide tools and interoperability between CDN operated per several Content providers and to ease automatic reconfiguration of Content Servers, depending of the peak of bandwidth and real-time appetence for dedicated content.

4. Internet of Services

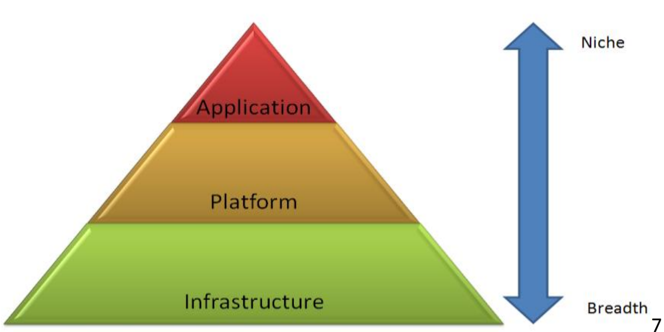
4.1 XaaS Trends

XaaS refers to all types of resources which could be provided “As A Service”, not hosted or owned directly by the end-customer.

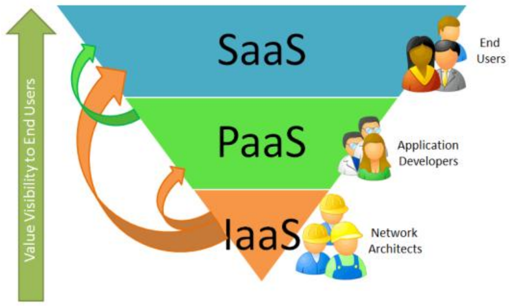
Initially used for Software As A Service (SaaS) which covers a new way to consume complex software first through elementary features and second from time to time, this technology has evolved to deliver the right Quality of Service for all consumers.

An extensive approach of “As A Service” includes today infrastructures (IaaS) to host physical resources for distributed storage, virtual machines (VM) when platform (PaaS) include development tools in this specific environment to manage in an easy way user sessions, access rights .

As a very simple model, the two lower layers describe Cloud Computing infrastructure which required new models for applications to use elementary features in a transparent way for any devices and anywhere you are.



[7]



[8]

Figure 9: XaaS technologies and users’ roles

Future Internet technologies should provide elementary features and composition tools where each user will be able to build its own environment. Based on Apps Store in the mobile world where consumers can download small applications, to connect some of them to have your custom software depending of your personal context including nomadic access is the next challenge for XaaS technologies.

Of course Security and Privacy are critical issues in a world where all content should be “somewhere in the network” and secure components would provide cryptography and anonymous mechanisms to protect business and private rights.

Cloud computing is nowadays a reality and the number of Cloud hosting providers would increase regularly. Future Internet should improve interoperability between in-house solutions and reinforce the pay-as-you-go model. Cloud hosting providers deliver nowadays “private cloud solutions” especially for B2B applications because of business, privacy and quality of service issues: data are the most valuable resources for companies and hosted applications have to be available in real-time.

Future Internet and XaaS technologies will be opened and provide common access to all resources as well as support closed communities environments. Business consumers would be able to define the content – and associated business models – they expect to share with customers, partners or suppliers.

[7] http://www.gogrid.com/
[8] http://www.saasblogs.com/

4.2 Applications Mash-Up

Mashups tools are generally customers applications which could be hosted online (SaaS) to use and combines data, presentation or functionality from several sources to create new services.

Future Internet will provide an extensive environment of what is only content aggregation proposing elementary features to build dedicated customers applications.

As a Service technologies will require lots of virtual machines to share some applications when end-users will use only 10% of the functionalities.

Future Internet will decrease the level of complexity of API (Application Programming Interfaces) and enhance new Human-Machine interfaces (HMI). This new HMI, which could be associated with Apps store mechanisms, will allow end-users with any programming knowledge to build its own software.

Using your customized software will also require your own data environment and new aggregation tools to retrieve those contents through CDN, to share them with smart things and to deliver them on the right devices.

Massive use of mash-up technologies will increase security concerns based on a huge connectivity with several third parties.

Future Internet will also provide Quality of Service mechanisms to assume availability of customized applications otherwise some of the main consumers could capture all the resources.

5. Internet of Things

Until 2009 netbook phenomenon, was a key trend where buyers chose machines that were essentially less powerful versions of traditional computers. 2009 was really a key point for market devices with the more than emerging smartphones market and the first tablets, which are basically using different processing chips and operating systems than those used over the past 30 years. Devices are more and more powerful, low-cost and low-power consumers. If during the three last decades the Moore's law was available for computers, it will now be relevant for small devices which are smart things populating IP v6 based Future Internet.

However, when looking at the future of computing devices, at least the next five years should well mark the tipping point as we move from a world of mostly standardized devices (computers, mobiles) containing standardized chips and software, to a far more heterogeneous environment with lots of new potential standards. The new wave of small applications and apps stores would define the most relevant standards for services and associated new business models.

Considering all connected devices as physical element of the Internet of Things, common management of smart devices based on heterogeneous of standards is the main challenge until 2015.

Internet of Things is not only a sensor network to collect data. Internet of Things include smart devices which can act independently depending of rules, processes and context awareness.

Internet of Things is not a virtual world where all smart things would interact together without any human interactions: Internet of Things would provide the best services for humans, which are part of the processes and rules. **People are the context awareness system for smart things.**

In this technological area, lots of protocols are available to support dedicated constraints in a B2B sector:

- EPC Global standard for RFID tags, mainly passive resources
- 6LowPan or Zigbee for metering and very low energy consumption
- ITS standards for connected vehicles

Are some examples of the great creativity of innovative providers in some vertical business domains. Being able to identify, discover and manage things is the main topic to launch concretely Internet of Things.

Future Internet should provide common IT services to include all connected devices in a worldwide community.

Semantic services are the first relevant family of services to provide common access to all type of things. Because of collection of data models with B2B dedicated associations, it is quite impossible to retrieve relevant information sources through different networks and to send them some data to trigger some local action.

Future Internet Things management: IP v6 should provide common protocol interface but the next five years will provide lots of solutions to support interoperability between B2B standards, especially based on a new category of smart devices: gateways. These gateways would provide protocol adaptation layers and local management features.

Part of Things management services are naming services because each standard provides its own naming system and this diversity increase complexity to reach and communicate with the relevant smart elements. If IP v6 could provide in theory single identifier per things, elaborated naming systems to support traceability would require interoperability and Future Internet should provide translation mechanisms to integrate Vertical markets constraints.

Real-time connectivity: nowadays Things are available from time to time based on connectivity and energy concerns. Future Internet should provide quite real-time connectivity and nomadic smart things, which require new tools to analyze in which context smart things would communicate. Real-time community would decrease a lot dedicated B2B dimensions to define the concrete Internet of Things.

6. Internet of People

Social media consists of various user-driven channels when social networks are "social structures made up of individuals (or organizations) called "nodes", which are tied (connected) by one or more specific types of interdependency"[9] or centre of interest.

Social media refers to a combination of at least three elements: social networks or communities, rich contents and Web 2.0 technologies .d Future Internet will introduce a fourth element: Internet of Things.

Web 2.0 technologies refer to web applications that facilitate information sharing, interoperability, user-centered design. Media coverage of Web 2.0 concentrates on the common applications/services such as blogs, video sharing, social networking and podcasting—a more socially connected Web in which people can contribute as much as they can consume.[10]

In an organizational setting, Social networks constitute group of one's peers, seniors, and subordinates who share privileged information. For Internet users who want to network with like-minded people without being subsumed into the crowd, Future Internet tools will provide the ability to create your own personal profiles, upload photos, connect with friends, send instant messages, write their own blogs, contribute to forums without to use several thematic social networks or social networks engines as some of them where launched recently.,

Future Internet technologies will provide new interfaces and simple tools to share easily any kind of content but the growing phenomenon include an overload of information which is very difficult to manage for everybody. A dedicated improvement in the future will be semantic tools to build automatic mechanisms to share and reference content, especially with smart things in user environments. People and smart things will be able to automatically share and read the same content, introducing some automatic process in an social networks where users manage everything by hand.

[9] http://en.wikipedia.org/wiki/Social_network
[10] http://www.jisc.ac.uk/media/documents/techwatch/tsw0701b.pdf

7. Future Internet platform services

Critical analysis of FI-Ware architecture based on previous topics describe in this document: to be done for M9 – correlated with Instant Mobility requirements