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**Abstract:**

This report is the second deliverable of the FP6-project “Broadband in Europe for all: a multi-disciplinary approach project (BREAD)”. It is a multi-technological analysis of the ‘broadband for all’ concept, with an update of the listing of multi-technological key issues, a first gap analysis and first roadmaps on how to tackle these issues.

The deliverable also contains information on ongoing regional and national broadband initiatives in Europe (EU25) and around the world. The information includes an analysis of the broadband market in these countries with overview of available technologies, infrastructures, operators, pricing,.... It also includes a summary of the broadband policy in these countries.

This document builds further on the overview of the state-of-the-art on broadband issues, summarized in the first BREAD-deliverable (available via [www.ist-bread.org](http://www.ist-bread.org))

Out of the country studies, an analysis is presented factors affecting broadband development first from a classical theoretical framework, which is composed of the supply/demand - infrastructure/content matrix. However, when drawing on the elements which were identified in the country studies, it then uses a framework composed of four categories, i.e. country configuration, legacy situation, competition, and public policy, where the key criterion is the susceptibility of the factors affecting broadband to be themselves influenced by broadband policy. This approach allows identifying those areas where government action can really make a difference. Finally a quick look is taken at some potential inhibitors of broadband development and at broadband applications and user needs.

This document does not claim to be complete, but is intended to give directions, indications and current trends in the field and will evoke input on new projects, new technologies and new developments to be included in the next editions of this deliverable..

**Keyword list:**

Broadband for All, multi-technological, multi-disciplinary analysis, socio-economic

## **Disclaimer**

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## A1. Annex I – Project list

### A1.1 Home Network

#### A1.1.1 Related projects

##### A1.1.1.1 MMAC<sup>1</sup>

Within the framework of the Japanese Multimedia Mobile Access Communication Systems project **MMAC** multimedia information is transmitted at ultra high speeds and with high quality "anytime and anywhere", details of the MMAC system specifications are:

*High Speed Wireless Access* (outdoor, indoor): Mobile Communication System which can transmit at up to 30 Mbit/s using the SHF and other band (3-60 GHz). It can be used for mobile video, telephone conversations.

*Ultra High Speed Wireless LAN* (indoor): Wireless LAN which can transmit up to 156 Mbit/s using the millimeter wave radio band (30-300 GHz). It can be used for high quality TV conferences.

*5GHz Band Mobile Access* (outdoor, indoor): ATM type Wireless Assess and Eathernet type Wireless LAN using 5GHz band. Each system can transmit at up to 20-25Mbit/s for multimedia information.

*Wireless Home-Link* (indoor): Wireless Home-Link which can transmit up to 100Mbit/s using the SHF-and other frequency bands band (3-60GHz). It can be used for between PCs and Audio Visual equipments transmit multimedia information.

##### A1.1.1.2 House<sub>n</sub><sup>2</sup>

This is a multi-disciplinary project lead by researchers at the Massachusetts Institute of Technology, USA. This project includes also advanced communication technologies, e.g. Rondoni, J.C. Context-Aware Experience Sampling for the Design and Study of Ubiquitous Technologies M.Eng.<sup>3</sup>. Thesis Electrical Engineering and Computer Science, Massachusetts Institute of Technology, September 2003. "The paradigm of desktop computing is beginning to shift in favour of highly distributed and embedded computer systems that are accessible from anywhere at anytime. Applications of these systems, such as advanced contextually-aware personal assistants, have enormous potential not only to abet their users, but also to revolutionize the way people and computers interact.

##### A1.1.1.3 European projects

###### **WINNER<sup>4</sup>**

Wireless World Initiative New Radio, Integrated Project (38 partners), IST-2003-507581, Action Line: Mobile and wireless systems beyond 3G,

The key objective of the **WINNER** project is to develop a totally new concept in radio access. This is built on the recognition that developing disparate systems for different purposes (cellular, WLAN, short range access etc.) will no longer be sufficient in the future converged Wireless World. This concept will be realised in the ubiquitous radio system concept. The vision of a ubiquitous radio system concept is providing wireless access for a wide range of services and applications across all environments, from short-range to wide-area, with one single adaptive system concept for all envisaged radio environments. It will efficiently adapt to multiple scenarios by using different modes of a common technology basis. The concept will comprise the optimised combination of the best component technologies, based on an analysis of the most promising technologies and concepts available or proposed within the research community. The initial development of technologies and their combination in the system concept will be further advanced towards future system realisation. Compared to current and evolving mobile and wireless systems, the **WINNER** system concept will provide significant improvements in peak data rate, latency, mobile speed, spectrum efficiency, coverage, cost per bit and supported

<sup>1</sup> MMAC, <http://www.arib.or.jp/mmac/e/what.htm>

<sup>2</sup> House<sub>n</sub>, [http://architecture.mit.edu/house\\_n/](http://architecture.mit.edu/house_n/)

<sup>3</sup> Thesis, [http://architecture.mit.edu/house\\_n/web/publications/publications.htm](http://architecture.mit.edu/house_n/web/publications/publications.htm)

<sup>4</sup> Winner, <https://www.ist-winner.org/>

environments taking into account specified Quality-of-Service requirements. The concept will provide the wireless access underpinning the knowledge society and the eEurope initiative, enabling the "ambient intelligence" vision. To achieve this impact, the concept will be derived by a systematic approach. Advanced radio technologies will be investigated with respect to predicted user requirements and challenging scenarios. The project will contribute to the global research, regulatory and standardisation process. Given the consortium pedigree, containing major players across the whole domain, such contributions will have a major impact on the future directions of the Wireless World.

#### **FUTURE HOME<sup>5</sup>, IST 2000-28133 (closed)**

The Future Home project focuses to create a solid, secure, user friendly home networking concept with open, wireless networking specification. The project introduces usage of IPv6 and Mobile IP protocols in the wireless home network. It specifies and implements prototypes of wireless home network elements and service points. It develops new services that use capabilities of the network and verify feasibility of the concept in user trial. The networking concept defines a wireless home networking platform (HNSP) with network protocols and network elements. It defines the wireless technologies and network management methods for supporting user friendliness and easy installation procedures as well as management of the wireless resources. The wireless technologies are Bluetooth, WLAN, and HiperLAN/2.

#### **BROADWAY<sup>6</sup> The way to broadband access at 60GHz, IST-2001-32686**

BROADWAY aims to propose a hybrid dual frequency system based on a tight integration of HIPERLAN/2 OFDM high spectrum efficiently technology at 5GHz and an innovative fully ad-hoc extension of it at 60GHz named HIPERSPOT. This concept extends and complements existing 5GHz broadband wireless LAN systems in the 60GHz range for providing a new solution to very dense urban deployments and hot spot coverage. This system is to guarantee nomadic terminal mobility in combination with higher capacity (achieving data rates exceeding 100Mbps). This tight integration between both types of system (5/60GHz) will result in wider acceptance and lower cost of both systems through massive silicon reuse. This new radio architecture will by construction inherently provide backward compatibility with current 5GHz WLANs (ETSI BRAN HIPERLAN/2). BROADWAY is obviously part of the 4G scenario, as it complements the wide area infrastructure by providing a new hybrid air interface technology working at 5 GHz and at 60 GHz. This air interface is expected to be particularly innovative as it addresses the new concept of convergence between wireless local area network and wireless personal area network systems.

#### **NEWCOM<sup>7</sup>, Network of Excellence in Wireless Communications,**

Action Line: Mobile and Wireless Systems beyond 3G, FP6-507325

NEWCOM (more than 60 partners) aims at creating a European network that links in a cooperative way a large number of leading research groups addressing the strategic objective "Mobile and wireless systems beyond 3G".

NEWCOM will implement an elaborate plan of initiatives which revolve around the key notion and strategic choice of a Virtual Knowledge Centre: NEWCOM will effectively act as a distributed university, organised in a matrix fashion: the columns will represent the seven NEWCOM (Disciplinary) departments, while the rows will represent NEWCOM projects.

NEWCOM (Disciplinary) departments:

- Department 1 Analysis and Design of Algorithms for Signal Processing at Large in Wireless Systems
- Department 2 Radio Channel Modelling for Design Optimisation and Performance Assessment of Next Generation Communication Systems
- Department 3 Design, modelling and experimental characterisation of RF and microwave devices and subsystems
- Department 4 Analysis, Design and Implementation of Digital Architectures and Circuits
- Department 5 Source Coding and Reliable Delivery of Multimedia Contents
- Department 6 Protocols and Architectures, and Traffic Modelling for (Reconfigurable / Adaptive) Wireless Networks
- Department 7 QoS Provision in Wireless Networks: Radio Resource Management, Mobility, and Security

<sup>5</sup> FUTURE HOME, <http://future-home.org>

<sup>6</sup> Broadway: <http://www.ist-broadway.org/description.html>

<sup>7</sup> NEWCOM, [http://dbs.cordis.lu/fep/cgi/srchidadb?ACTION=D&CALLER=PROJ\\_IST&OM\\_EP\\_RCN\\_A=71453](http://dbs.cordis.lu/fep/cgi/srchidadb?ACTION=D&CALLER=PROJ_IST&OM_EP_RCN_A=71453)

## NEWCOM projects

- Project A Ad Hoc and Sensor Networks
- Project B Ultra-wide Band Communication Systems
- Project C Functional Design Aspects of Future Generation Wireless Systems
- Project D Reconfigurable radio for interoperable transceivers
- Project E Cross Layer Optimisation

**MediaNet<sup>8</sup> Action Line: Networked Audio Visual Systems and Home Platforms, FP6-507452**

The project (IP with more than 30 partners) aims at developing technologies, infrastructure and service solutions enabling the easy exchange of digital content and audio-video content between creators, providers, customers and citizens. MediaNet will identify and develop a set of representative and appealing end-to-end applications, key enabling technologies, reference architecture and its key interfaces for an easy and smooth exchange of content all along the media supply chain. By developing and maintaining a shared vision, all stakeholders are guaranteed of the effective and seamless work between all subparts of the media chain.

The project covers three complementary domains: media networking, multimedia services, and content engineering. The project will develop new management service platforms for broadband access networks and open home networking, and storage solutions. Wireless communication solutions for audio-video content, new end-to-end service provisioning over shared public and private infrastructures, mixing video broadcast over broadband access, content on demand, and interactive online applications will be proposed, as well as personal multimedia communications supported by portable terminals and person-to-person communication services over IP.

A common open and shared delivery platform will be created covering the broadband access and the home domains, where all devices and services will interoperate, combining advanced multimedia content, services, and communications in public and residential environments. MediaNet, which is centered at the intersection of the audio-video, PC and telecom industries actively participates in the development of such next generation connected digital applications and devices by addressing some of its technical key issues:

- the development of an open multi-vendor/multi-service business reference architecture and a technical roadmap ,
- broadband access and home networking to support multiple overlay end-to-end applications by third parties;
- shared services, infrastructures, and equipment while assuring investment protection, interoperability and competition;
- Digital Rights Management (DRM) and end-to-end content protection solutions;
- N-Services, e-Service platforms, Digital Video Broadcasting over IP, Multimedia Home Platform, gateways, wireless solutions for audio/video streaming, open distributed storage, Multimedia communications over IP services and terminals, MPEG4/AVC encoding and decoding circuits, HQ A/V streaming over IP.

**MOCCA<sup>9</sup> The Mobile Cooperation and Coordination Action, FP6-2004-IST-2**

Action Line: Programme Level Accompanying Measures

The MOCCA coordination action will facilitate collaboration between projects addressing mobile and wireless issues, within the European Research Area (ERA), between projects in the ERA and research programmes in Asia and the US, and between researchers and projects in the ERA and their counterparts in the developing regions of the world. It will address this collaboration in the context of the research and development of future mobile and wireless systems, including the services and applications they serve. MOCCA will facilitate European and international collaboration regarding research on future wireless systems and their applications. It will pave the way towards harmonised international standards for future mobile and wireless systems so that the systems meet the needs of users worldwide. The MOCCA approach is open to all. All interested ERA projects will be invited to participate in the activities organised by the project. Inter-continental collaboration with all major mobile and wireless research programmes and standardisation fora will be supported. MOCCA results will lead to the development of future applications, services and wireless networks, which meet the needs of users worldwide, building on Europe's strength in the mobile sector. In the long term, MOCCA results will improve the impact of the research results of the ERA wireless related projects on global standardisation activities and in the global market.

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<sup>8</sup> <http://www.ist-ipmedianet.org/home.html>

<sup>9</sup> <http://mocca.objectweb.org/>

**WIND-FLEX<sup>10</sup>, Wireless Indoor Flexible High Bitrate Modem Architecture, IST-1999-10025 (closed)**

A high bit-rate flexible and configurable modem architecture is investigated, which works in single-hop, ad hoc networks and provides a wireless access to the Internet in an indoor environment where slow. The main emphasis is in the OSI layers 1 and 2. The best possible performance with a reasonable complexity is attained by using a jointly optimised adaptive system which includes the multiple access method, diversity, modulation and coding, and equalization and decoding. The system is not optimised in advance but it will be adaptive and configurable in the run time. This is a step towards a SDR (Software defined radio), which is presently too far in the future due to technological problems. Bit rates from 64 kbit/s up to 100 Mbit/s are considered at the frequency band of 17 GHz. Modulation was OFDM with 128 subcarriers, channel bandwidth was 50 MHz, modulation schemes BPSK, QPSK, 16QAM, 64QAM. The bit rate is variable depending on the user needs and channel conditions. Flexibility is attained by using a multicarrier modulation method even though single-carrier methods will be also considered. Best possible methods are used including joint diversity, modulation and coding (such as space-time coding) in the transmitter and joint equalization, decoding and channel estimation (such as per-survivor processing) in the receiver. The work is done in high quality research groups who are using compatible simulation tools so that almost full (off-line) simulation is possible. The driving force is research, not the existing standards.

**NGN INITIATIVE<sup>11</sup> Next Generation Networks Initiative, IST-2000-26418 (closed)**

The NGN Initiative's mission is to establish the infrastructure to operate the *first* open environment for research on the whole range of Next Generation Networks (NGN) topics to be discussed, consensus achieved and collective outputs disseminated to the appropriate international standards bodies, fora, and other organisations. Being of worldwide interest, it is inevitable that some of the Internet-related topics addressed here will also be covered in the US Next Generation Internet (NGI<sup>12</sup>) programme. Inputs to Eu-FP6 programme.

**WWRI<sup>13</sup> Wireless World Research Initiative, IST-2001-37680 (closed)**

The WWRI was an accompanying measure under the IST-programme in the Fifth Framework Programme. The project started in June 2002 for 10 months. Key players in the wireless sector initiated the WWRI project to provide a launch pad to the wireless community (industry and academia) for a balanced cooperative research programme for the Wireless World. The work done in WWRI was useful for the preparation of Integrated Projects for the 6th EU Framework Programme.

**A1.1.1.4 National projects**

WIGWAM is part of the Central Innovation Program "Mobile Internet" which is funded by the German Ministry of Education and Research (BMBF). The objective of WIGWAM is the design of a complete system for wireless communication with a maximum transmission data rate of 1 Gbit/s.

The targeted spectrum is the 5 GHz band and the extension bands 17, 24, and 60 GHz. Depending on the mobility of the user, the data rate should be scalable.

The goal is a "1 Gbit/s component" of a heterogeneous future mobile communication system. All aspects of such a system will be investigated, from the hardware platform to the protocols, which are subject to very strong requirements given the extremely high data rate of 1 Gbit/s.

The main application area is the transmission of multimedia content in so-called hot-spots (see figure below), in home scenarios, and in large offices where an enormous data rate back-off is necessary, e.g. to supply the user with short-term high data rates, or to enable a true plug-and-play without any frequency planning (particularly important in home scenarios). In order to be able to include such a high data rate air-interface into a future heterogeneous mobile communications system, also high mobility applications are covered.

<sup>10</sup> WINDFLEX, <http://labreti.ing.uniroma1.it/windflex/>

<sup>11</sup> NGNI, <http://www.ngni.org/overview.htm>

<sup>12</sup> Next Generation Internet, <http://www.ngi.de/>

<sup>13</sup> <http://www.ist-wwri.org/project.html>

### ***A1.1.2 Related Initiatives***

Internet Engineering Task Force (IETF)<sup>14</sup>, IPv6 Forum<sup>15</sup>, Universal Plug and Play Forum<sup>16</sup>, Open Services Gateway Initiative (OSGi), 4DHomeNet<sup>17</sup>.

#### **4DHomeNet**

offers 4DAgent™ and a remote management system that supports OSGi Service Platform Release 2. The system shows how home network operators can remotely manage their OSGi-based distributed residential gateways. 4DHomeNet also shows how OSGi Frameworks and DVB-MHP can work together providing a user-friendly interface via a TV set.

#### **Broadband Wireless Association<sup>18</sup>**

The BWA offers to members an independent voice that is heard by regulators and licence authorities primarily throughout Europe but with strong links to North America and the Pacific Rim. It also offers essential technical and market information in its promotion and facilitation of the broadband wireless industry. Members of the Association are from all parts of the wireless industry including operators, vendors, research groups and consultants. The association conducts a number of activities, which may result in direct benefits by its members.

#### **TDD Coalition<sup>19</sup>**

The TDD Coalition is a consortium of manufacturers and operators promoting the use of TDD duplexing technology in broadband wireless networks.

#### **OFDM Forum<sup>20</sup>**

The OFDM Forum is a voluntary association of hardware manufacturers, software firms and other users of orthogonal frequency division multiplexing (OFDM) technology in wireless applications. The OFDM Forum was created to foster a single, compatible OFDM standard, needed to implement cost-effective, high-speed wireless networks on a variety of devices. OFDM is a cornerstone technology for the next generation of high-speed wireless data products and services for both corporate and consumer use. With the introduction of the IEEE 802.11a, ETSI BRAN, and multimedia applications, the wireless world is ready for products based on OFDM technology.

#### **Wireless Communication Association<sup>21</sup>**

The Wireless Communications Association International (WCA, founded in 1988) is the non-profit trade and professional association for the wireless broadband industry with member companies on six continents representing the bulk of the sector's leading carriers, vendors and consultants. The WCA's mission is to advance the interests of the wireless carriers that provide high-speed data, Internet, voice and video services on broadband spectrum through land-based systems using reception/transmit devices in all broadband spectrum bands. The WCA is an established leader in government relations, technology standards and industry event organization. General fixed wireless access scope (including free space optics). The members provide services or products in spectrum bands as UHF, 2.1, 2.3, 2.5, 12, 18, 23, and 28 GHz.

#### **MMAC-PC<sup>22</sup>**

Japan: Multimedia Mobile Access Communication Systems Promotion Council (founded 1996). The objective of the Council is to realize MMAC as soon as possible through investigations of system specifications, demonstrative experiment, information exchange and popularisation activities and thereby contribute to the efficient use of radio frequency spectrum.

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<sup>14</sup> IETF, <http://www.ietf.org/>

<sup>15</sup> ipv6forum, <http://www.ipv6forum.com/>

<sup>16</sup> plug and play forum: <http://www.upnp.org/>

<sup>17</sup> 4DHomeNet, [www.4dhome.net](http://www.4dhome.net)

<sup>18</sup> BWA, <http://www.broadband-wireless.org/home.htm>

<sup>19</sup> TDD coalition, <http://www.tddcoalition.org/>

<sup>20</sup> OFDM Forum, <http://www.ofdm-forum.com/index.asp?ID=92>

<sup>21</sup> Wireless Communication Association, <http://www.wcai.com/>

<sup>22</sup> MMAC-PC, <http://www.arib.or.jp/mmac/e/about.htm>

**Wireless World Research Forum<sup>23</sup> (WWRF)** WWRF is a global organisation, which was founded in August 2001. Members of the Forum are: manufacturers, network operators/service providers, R&D centres, universities, and small and medium enterprises. WWRF provides a global platform for discussion of results, exchange of views to initiate global cooperation towards systems beyond 3G.

#### **WiMedia Alliance**

The WiMedia Alliance is a not-for-profit open industry association formed to promote wireless personal-area network (WPAN) connectivity and interoperability for multiple industry-based protocols. The WiMedia Alliance develops and adopts standards-based specifications for connecting wireless multimedia devices, including application, transport, and control profiles; test suites; and a certification program to accelerate widespread consumer adoption of "wire-free" imaging and multimedia solutions. (IEEE 802.15, 1394, WiMedia Alliance's Convergence Architecture, WiMCA), MBOA (Multiband OFDM Alliance). The WiMedia Alliance charter is to develop a specification based on the IEEE 802.15.3 standard with a strong focus on an ultra-wide band physical layer (802.15.3a). The Alliance will establish a certification and logo program and promote the WiMedia brand<sup>24</sup>. Alliance activities include coordinating with other standards bodies, promoting the allocation of UWB spectrum at international regulatory bodies. The Alliance is committed to intelligently leveraging as many existing technologies as possible with the end-goal of developing an easy-to-understand consumer system for interoperable wireless multimedia devices. The WiMedia Alliance serves the consumer electronics, PC and mobile communications markets. Products specific to these markets as well as emerging convergence products will benefit from simple wireless connectivity.

WiMedia-enabled products will meet the demanding requirements of portable consumer imaging and multimedia applications and support peer-to-peer connectivity and isochronous as well as synchronous data. WiMedia technology will be optimised for low-cost, small-form factor, and quality of service (QoS) awareness and will enable multimedia applications that are not optimised by existing wireless standards.

#### **Wi-Fi Alliance<sup>25</sup>**

Wi-Fi, short for *wireless fidelity* and is meant to be used generally when referring of any type of 802.11 network, whether 802.11b, 802.11a, dual-band, etc. The term is promulgated by the Wi-Fi Alliance. It is a non-profit international association formed in 1999 to certify interoperability of wireless Local Area Network products based on IEEE 802.11 specification, (WLAN). The alliance is targeting three purposes: To promote Wi-Fi worldwide by encouraging manufacturers to use standardized 802.11 technologies in their wireless networking products; to promote and market these technologies to consumers in the home, SOHO and enterprise markets; and to test and certify Wi-Fi product interoperability. A user with a "Wi-Fi Certified" product can use any brand of access point with any other brand of client hardware that also is certified. Typically, however, any Wi-Fi product using the same radio frequency (for example, 2.4GHz for 802.11b or 11g, 5GHz for 802.11a) will work with any other, even if not "Wi-Fi Certified." Formerly, the term "Wi-Fi" was used only in place of the 2.4GHz 802.11b standard, in the same way that "Ethernet" is used in place of IEEE 802.3. The Alliance expanded the generic use of the term in an attempt to stop confusion about wireless LAN interoperability.

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<sup>23</sup> WWRF, <http://www.wireless-world-research.org/>

<sup>24</sup> <http://www.caba.org/standard/wimedia.html>

<sup>25</sup> <http://www.wi-fi.org/>

### A1.1.3 Related Standards

#### A1.1.3.1 Wired Standards

The IEEE-1394a standard (also called Firewire and i.Link)<sup>26</sup> defines a serial bus that allows for data transfers up to 400 Mbit/s over a twisted-pair cable, and extension up to 3.2 Gbit/s using fibre is underway.

USB<sup>27</sup> (Universal Serial Bus) defines a serial bus that allows for data transfers up to 480 Mbit/s over a twisted-pair cable, but using a master-slave protocol instead of the peer-to-peer protocol in IEEE-1394a. Both standards support hot plug-and-play and isochronous streaming, via centralised media access control, which are of significant importance for consumer-electronics applications. The disadvantage is that this sets a limit to the cable lengths between devices.

IEEE 802.3xx Ethernet: has evolved via 10 Mbit/s Ethernet and 100 Mbit/s Fast Ethernet using twisted-pair cabling, into Gigabit Ethernet, providing 1 Gbit/s using twisted-pair cabling or fibre and 10 Gigabit Ethernet, providing 10 Gbit/s, which is also based on fibre or copper cabling.

#### A1.1.3.2 Wireless Standards

Wireless Metropolitan Area Network, WMAN	Cordless Systems	Cellular mobile radio	Wireless Local Area Network, WLAN	Wireless Personal Area Network, WPAN
DAB DVBT ETSI HiperMAN ETSI HiperACCESS IEEE 802.16	DECT	2G GSM 3G IMT2000	ETSI HiperLAN MMAC IEEE 802.11	HomeRF IEEE 802.15 UWB Bluetooth ZigBee

Table 1: Wireless Standards

Area	IEEE	ETSI	Forum/Alliance
WAN	802.20	3GPP, EDGE	
LAN	802.11	HiperLAN	Wi-Fi*
MAN	802.16	HiperMAN, HiperACCESS	WiMAX**
PAN	802.15	HiperPAN	WiMedia

Table 2: Global wireless standards

##### A1.1.3.2.1 WLAN Standards

Standard	Transfer Method	Frequencies	Data Rates Supported (Mbit/s)
802.11 legacy	FHSS, DSSS, infrared	2.4 GHz, IR	1, 2
802.11b	DSSS, HR-DSSS	2.4 GHz	1, 2, 5.5, 11
"802.11b+" non-standard	DSSS, HR-DSSS (PBCC)	2.4 GHz	1, 2, 5.5, 11, 22, 33, 44
802.11a	OFDM	5.2, 5.8 GHz	6, 9, 12, 18, 24, 36, 48, 54
802.11g	DSSS, HR-DSSS, OFDM	2.4 GHz	1, 2, 5.5, 11; 6, 9, 12, 18, 24, 36, 48, 54

Table 3: Overview of the IEEE 802.11 Standards<sup>28</sup>

<sup>26</sup> 1394 Trade Association, <http://www.1394ta.org>

<sup>27</sup> USB, <http://www.usb.org>

<sup>28</sup> [http://en.wikipedia.org/wiki/IEEE\\_802.11](http://en.wikipedia.org/wiki/IEEE_802.11)

ETSI HiperLAN/2 operating in the 5 GHz band (licence exempt bands) using OFDM modulation and TDMA (time division multiple access). The standard provides 25 Mbit/s short range, wireless access and WLAN applications in indoor and campus-wide usage. Typical indoor and outdoor coverage is 50 m and 150 m, respectively. User mobility within local service area is supported. The Hiperlan/2 standard has now been merged with 802.11a, giving some features such as power control and QoS.

HiSWANa (Japanese) is a WLAN standard in the 5GHz band and has a MAC structure similar to that of HiperLAN/2. But, unlike HiperLAN/2, HiSWANa does not offer direct-link mode which allows terminals to transmit to one another without routing through an access point. HiSWANa also uses a listen-before-talk mechanism similar to 802.11a to reduce uncoordinated interference. The HiSWANa MAC combines key features of both 802.11a and HiperLAN/2, at the expense of increased overhead.

#### A1.1.3.2.2 Wireless personal area networks, WPANs

*Wireless PANs* typically have a short range-of-use and are intended to set up connections between personal devices. The most widely deployed standard in this class is Bluetooth<sup>29</sup>. Its capability is providing 1 Mbit/s for few connected devices in a small network, called a piconet. Its range is between 10 and 100 meters depending on the transmission power and the environmental conditions. The used transmission-band for Bluetooth lies in the 2.4 GHz ISM band. The HomeRF standard, like Bluetooth, also works in the 2.4 GHz ISM band. From an initial maximum data rate of 1.6 Mbit/s, it has been extended to 10 Mbit/s<sup>30</sup>. HomeRF has a range of 50 meters at this speed. It is not interoperable with its strongest competitor, IEEE 802.11b, however.

The IEEE 802.15<sup>31</sup> standard is intended to go a step further. In this context the *WiMedia Alliance*<sup>32</sup> has been established. 802.15 integrates the Bluetooth standard and harmonizes it with the IEEE 802 family, such that it is IP and Ethernet compatible. The objectives of 802.15 are a high-bit rate solution providing up to 20 Mbit/s and beyond, and a low bit-rate one (IEEE 802.15.4, also known as ZigBee). Within IEEE 802.3 the study group 3c<sup>33</sup> was formed in March 2004. The group is developing a millimetre-wave-based alternative physical layer (PHY) for the existing 802.15.3 Wireless Personal Area Network (WPAN) Standard 802.15.3-2003. This mm-wave WPAN will operate in the new and clear 57-64 GHz unlicensed band defined by FCC 47 CFR 15.255. The 60 GHz WPAN will allow high coexistence (close physical spacing) with all other microwave systems in the 802.15 family of WPANs. In addition, the 60 GHz WPAN will allow very high data rate applications such as high speed internet access, streaming content download (video on demand, HDTV, home theatre, etc.) real time streaming and wireless data bus for cable replacement. Data rates in excess of 2 Gbps will be provided.

Within IEEE 802.15.3 task group 3a coordinates the activities of the ultra-wideband (UWB) technology<sup>34</sup>. It is a promising high-speed, low-power wireless technology for home entertainment or personal area network. While providing wireless distribution for TV programs, movies, games and intensive data, UWB claims also that it is assured that such distribution will not interfere with other wireless transmissions common at home. In February 2002, the FCC allocated 7,500 MHz of unlicensed spectrum for UWB devices for communication applications in the 3.1 GHz to 10.6 GHz frequency band. The UWB system provides a WPAN with data payload communication capabilities of 28, 55, 110, and even at 220, 500, 660, 1000 and 1320 Mbps are expected.

There exist two proposals for UWB, one is based on multi-band OFDM transmission and the other on direct sequence spreading (DS-UWB). Two different bands are defined: one band nominally occupying the spectrum from 3.1 to 4.85 GHz (the low band), and the second band nominally occupying the spectrum from 6.2 to 9.7 GHz (the high band).

The DS-UWB system employs direct sequence spreading of binary phase shift keying (BPSK) and quaternary bi-orthogonal keying (4BOK) UWB pulses. Forward error correction coding (convolutional coding) is used with a coding rate of  $\frac{1}{2}$  and  $\frac{3}{4}$ .

The OFDM System consists of 13 sub bands of 528 MHz width each. There are 128 subcarriers in each sub band with QPSK modulation and convolutional coding.

In cooperation with the 1394 Trade Association (TA) a protocol adaptation layer (PAL) has been developed between the wired IEEE1394 and the IEEE 802.15.3 MAC. The PAL also adapts the IEEE P1394.1 bridging specification to wireless use. The result is a 'wireless FireWire' capability, which can be implemented with any standard or non-standard physical layer, including Ultra Wideband PHYs. The PAL permits IEEE 1394 devices

<sup>29</sup> Bluetooth, <http://www.bluetooth.com>

<sup>30</sup> HomeRF, <http://www.pcworld.com/news/article/0,aid,64024,00.asp>

<sup>31</sup> IEEE 802.15, <http://grouper.ieee.org/groups/802/15/>

<sup>32</sup> WiMEDIA, <http://www.wimedia.org/>

<sup>33</sup> IEEE 802.15.3 SG3c, <http://www.ieee802.org/15/pub/SG3c.html>

<sup>34</sup> Ultra Wide Band, <http://www.uwbforum.org/standards/specifications.asp>

and protocols to be used in a wireless environment at speeds up to 480 Mbit/s per second, while allowing compatibility with existing wired 1394 devices. The standard will move consumers one significant step closer to controlling home networks, HDTVs, and other advanced electronics systems wirelessly, just as they now use remote controls to change TV channels or audio output<sup>35</sup>.

A1.1.3.2.3 Third generation mobile communication systems (cellular)

For the development of 3G the ITU established the IMT2000 (International Mobile Telecommunications at 2000 MHz) standard. 3G networks will provide mobile multimedia, personal services, the convergence of digitalisation, mobility, the Internet, and new technologies based on the global standards. The international standardisation activities for 3G are mainly concentrated in the different regions in the *European Telecommunications Standards Institute (ETSI) Special Mobile Group (SMG)* in Europe, *Research Institute of Telecommunications Transmission (RITT)* in China, *Association of Radio Industry and Businesses (ARIB)* and *Telecommunication Technology Committee (TTC)* in Japan, *Telecommunications Technologies Association (TTA)* in Korea, and *Telecommunications Industry Association (TIA)* and *T1P1* in the United States. In order to harmonise and standardise in detail the similar ETSI, ARIB, TTC, TTA, T1 WCDMA, and related TDD proposals the 3rd Generation Partnership Project<sup>36</sup> (3GPP) was established.

In general IMT-2000 consists of four systems and two main technologies summarised in Figure 1. The systems are UMTS, CDMA2000, DECT and UWC-136 (EDGE), while the technologies apply TDMA and CDMA, i.e. time- and code division multiplexing. UMTS (Universal Mobile Telecommunications System) UTRA-FDD and UTRA-TDD are the European versions of IMT-2000.

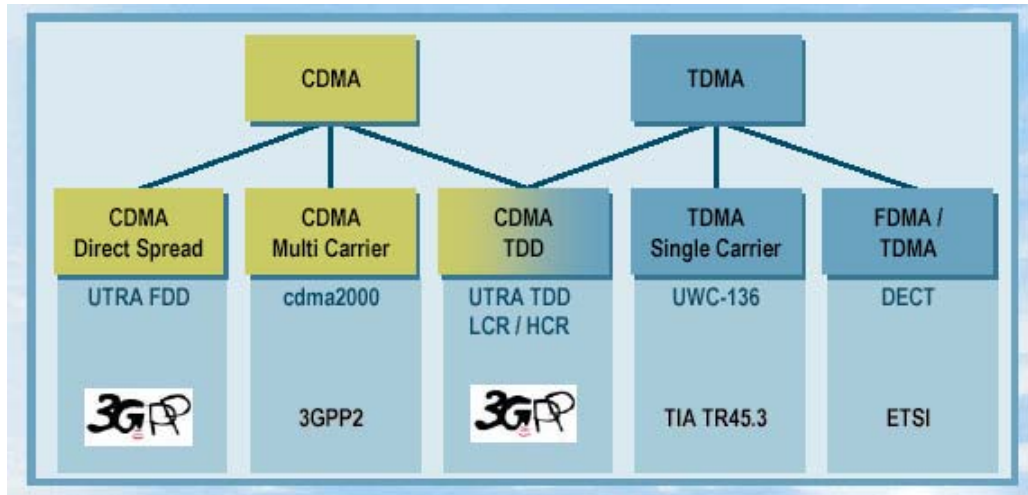


Figure 1: IMT2000 radio interfaces and access techniques (Source: Chr. Menzel, SIEMENS AG)

<sup>35</sup> <http://www.1394ta.org/Press/2003Press/december/12.08.a.htm>

<sup>36</sup> <http://www.3gpp.org/>

## A1.2 ACCESS NETWORK (L1 & L2)

### A1.2.1 PLC

#### A1.2.1.1 Related projects

##### A1.2.1.1.1 IST FP6 OPERA

OPERA: Open PLC European Research Alliance for new generation PLC networks. The strategic objective of this proposal is to offer low-cost broadband access service to ALL European citizens using the most ubiquitous infrastructure, Power Lines. Overcoming all barriers that prevent today PLC from being a mass commercial technology that competes effectively with existing technologies through the development of a new PLC generation integrated with existing backbone technologies and EMC full compliant. All efforts will be focused on obtaining: an improved performance in transmission speed, ready- to-sell and low-cost products, a complete system specification, an unique international regulation, full inter-operability with existing back haul and in-home technologies and a higher market share.

##### A1.2.1.1.2 IST FP5 Project: 6power (Ipv6, QoS & POWER line integration) <sup>37</sup>

- Research native Ipv6/Ipv4 and related protocols or advanced network services (QoS, security, multicast, mobility, ...) support over broadband Power Line, in several platforms/devices, including the necessary standardisation activities
- Large-scale deployment of very high speed broadband PLC over 45 Mbps (access network)
- Research and identify different models for Power Line applications into real life
- Field trial and Evaluation, network prototypes, interconnected with other Ipv6 trials

#### A1.2.1.2 Important supporting organisations and relevant standards for PLC

##### A1.2.1.2.1 PLCforum

The PLCforum ([www.plcforum.org](http://www.plcforum.org)) is an international association representing the interests of manufacturers, energy utilities and other organisations (Universities, other PLC Associations, consultants, etc.) active in the field of access and in-home PLC technologies. The PLCforum concentrates on regulatory issues (lobbying for satisfactory regulatory framework), technology (interoperability, standardisation), sound business cases and marketing (wide awareness of PLC)

##### A1.2.1.2.2 PUA (PLC Utilities Alliance)

The aim of PUA (no website) is to get a closer cooperation among utilities to promote and influence the PLC industry development in Europe (European utilities with a total of more than 100 million electrical customers). PAU concentrates on four key areas: regulation and standardisation (favourable environment for PLC, open PLC access standard), technology development, business sustainability and sourcing strategy.

##### A1.2.1.2.3 HomePlug® Powerline Alliance, USA <sup>38</sup>

#### HomePlug 1.0

Non-profit industry association, formed in March of 2000 by a group of industry leading companies to enable standards based powerline home networking products. The first industry standard was released in June 2001.

##### A1.2.1.2.4 CENELEC

#### EN 55022

Amendment 1 Information technology equipment – Radio disturbance characteristics – limits and methods of measurement

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<sup>37</sup> [www.6power.org](http://www.6power.org)

<sup>38</sup> [www.homeplug.org](http://www.homeplug.org)

**EN 50065-1**

Signalling on low-voltage electrical installations in the frequency range 3 kHz to 148.5 kHz – Part 1: General requirements, frequency bands and electromagnetic disturbances (Table 4).

Band	Frequencies (kHz)	Application
A	9 to 95	Out of house transmission
B	95 to 125	In house transmission
C	125 to 140	In house transmission based on a specific multiple access protocol
D	140 – 148	In house transmission
E	From 150	Radio bands,...

*Table 4: CENELEC Bands for Data Transmission over 230/400 V Power Line Networks  
(transmitter power  $\leq 5$  mW)*

**PrES 59013**

(draft for vote) This document deals with the coexistence of Access PLT systems and in-house PLT systems in the spectrum from 1.6 to 30 MHz (access: 1.6 MHz to 12.7 MHz, in-house: 14.35 to 30 MHz). The specification of the maximum transmit PSD is not the subject of this document.

**EN 50083-8**

Cabled distribution systems for television, sound and interactive multimedia signals - Part 8: Electromagnetic compatibility for installations

A1.2.1.2.5 ETSI PLT (Power Line Telecommunications)

**TS 101 867**

Defines the splitting of the HF spectrum for PLC from 1.6MHz to 30MHz into a frequency band from 1.6 to 10 MHz for the access domain, and a frequency band from 10 to 30 MHz for in-house PLC

**TS 101896**

reference network architecture

**TR 102049**

QoS for in-home TLP

A1.2.1.2.6 FCC, USA

**Standard Part 15, Subpart B**

Fieldstrength limits for unintentional radiators (in the 1.6 to 30 MHz band, 30 m distance, quasi peak detector: 30 dB ( $\mu\text{V}/\text{m}$ ) constant, with 40 dB/decade of correction factor for different distance)

A1.2.1.2.7 RegTP Germany

**NB30**

(proposal) RegTP: Regulating administration for telecommunications and posts. Limiting curve for the "radiation of telecommunications services in and alongside of cables" (including CATV, xDSL, and PLC) for the frequency range 9 kHz to 3 GHz (in the 1 to 30 MHz band, 3 meter distance, peak detector, measured in  $\text{dB}(\mu\text{V}/\text{m})$ :  $40 - 8.8 \cdot \log(f/\text{MHz})$ )

A1.2.1.2.8 ANSI, CEBus TSC, USA

**Standard EIA-600.31 / Power Line Physical Layer and Medium Specification**

This standard specifies the CEBus Power Line (PL) Physical Layer and Medium portion of the CEBus system. Its purpose is to present all the information necessary for the development of a PL physical layer for a CEBus device.

## ***A1.2.2 Cable***

### ***A1.2.2.1 Related projects***

- CASSIC (FP5 R&D project extending a decentralised IPCABLECOM architecture to video services). Packet Cable Multimedia project (CableLabs, USA): generalisation of IPCABLECOM voice over IP architecture to multimedia services
- NGNA: Next Generation Network Architecture launched in the US to address service convergence with video in cable network
- Packet Cable: Cable Labs project defining a complete IP architecture for Voice Over IP and multimedia services.
- CABLEHOME: Cable Labs project extending the IP architecture to the Home network, and covering QoS, security, device provisioning and management.
- DOCSIS 3.0: Cable Labs project defining layer 1 and layer 2 interface requirements for cable modem and CMTS, to extend the current DOCSIS specifications to video services transports and extend the capacity accordingly.
- Packet Cable Multimedia: extension of the packet cable framework to generalised multimedia services, and defines Policy and QoS signaling protocols, event message generation for resource accounting, and security interfaces.

### ***A1.2.2.2 Related standard bodies***

#### ***A1.2.2.2.1 US based organisations:***

- CableLabs (USA) is pre-standard body owing to the main US cable operators in charge of several projects:
  - Cable Modem for cable network physical and MAC layer standardization (DOCSIS); main releases are DOCSIS 1.0 (for best effort services), DOCSIS 1.1 (supporting QoS and Intserv model), and DOCSIS 2.0 (providing additional mechanism to mitigate the upstream disturbances).
  - Packet cable to define an VOIP architecture; main release are packet cable 1.0 specifications (adapted for Europe as IPCABLECOM standards)
  - Cable Home to provide an architecture for end to end QoS
  - Packet Cable multimedia to define an IP architecture for multimedia services.
- SCTE: in charge of ratifying the standards for cable in the USA.

#### ***A1.2.2.2.2 European based organisations***

- EuroCableLabs: recently created by the main European cable operators, in charge of defining and studying new research topics for cable networks, technology standard development with European standard bodies and foras, vendors certifications for the cable standards.
- TcomLabs: in charge on interoperability of EuroDocsis and IPCABLECOM equipment.
- ECCA: European Cable Communication Association (URL), including MSOs and defining requirements for cable networks
- DVB: in charge of standardisation for the transport layers, middleware and all aspects related to audiovisual content.
- CENELEC TC 209: producing standards for physical layer related issues in cable network.
- ETSI-AT: in charge of European version of Packet Cable, DOCSIS and CABLEHOME specifications.

#### ***A1.2.2.2.3 Worldwide organisations:***

- ITU-T SG9: covers all standards related to cable

### ***A1.2.2.3 Related main standards***

- ES 201 488: EuroDOCSIS standard
- ES 200 800: DVB Cable Return Channel standard
- TS 101 909 (part 1 to 25): IPCABLECOM standards
- EN 300 429: DVB-C downstream Physical layer and framing standard

- EN 50083 (part 1 to 10): CENELEC standard on physical layer aspect of cable networks.

### **A1.2.3 Satellite**

#### **A1.2.3.1 Related projects**

- FP5 SATIP6: STREP on definition of upper layer architectures for QoS and signalling.
- FP6 MOSSA: SSA on mobile satellite access, in close relation with ASMS TF
- FP6 SATLIFE: STREP on development on RCS based regenerative and bentpipe satellite access architectures
- FP6 SATNEX: NoE on all satellite access aspects
- FP6MAESTRO: Integrated Project in charge of hybrid satellite terrestrial (UMTS) networks for mobile terminals
- TWISTER: The objective of the TWISTER Integrated Project is to support the development and widespread adoption of satellite communication services to deliver broadband services for rural areas.
- ASMS TF : independent, industry-led body, created at the initiative of EC and ESA, committed to the successful introduction and development of advanced (including 3G and beyond) mobile satellite communications systems and services.
- ASTRANET, Wildblue, Teledesic: deployment projects of fixed (Astranet, Wildblue) and mobile (Teledesic) satellite access systems.

#### **A1.2.3.2 Associations**

##### **GVF**

Global VSAT Forum includes diverse types of organisations (operators, vendors, service providers, etc.) to act in an independent manner for the general promotion of the global VSAT Industry, whether this be technology or service based.

##### **ESOA (European Satellite Operators Association):**

ESOA represents the interests of European satellite operators with key European organisations including the European Commission, Parliament, Council and the European Space Agency as well as any other relevant international organisations. ESOA's objective is to ensure that satellites benefit from the appropriate political, industrial and regulatory environment to fulfil their role in the delivery of communications.

#### **A1.2.3.3 Standards**

Standard bodies and consortia: ETSI SES, DVB

For broadcast video and data applications:

- DVB-S: Provides physical layer for broadcast audiovisual and data transport
- DVB-S2: Evolution of DVB-S, provides per frame adaptive modulation and coding, and better overall efficiency than DVB-S.

For interactive applications:

- DVB-RCS which can use DVB-S or DVB-S2 (definition in progress) as the forward path
- DOCSIS with modified physical layer used in the USA (Wildblue)
  - ETSI TC SES : Satellite Earth Stations & Systems, divided into the following main activities related to broadband:
    - ETSI TC SES/GRM on on the GEO Mobile Radio Interfaces
    - ETSI TC SES/BSM on Broadband Satellite Multimedia
    - ETSI TC SES/S-UMTS on the Satellite Component of UMTS/IMT-2000
    - ETSI TC SES/MAR ESV for Maritime & Railways Satellite Earth Stations on Board Vessels & Trains
    - ETSI TC SES/ECSS on European Co-operation for Space Standardisation
- ITU R – SG4 for fixed satellite services
- ITU WP 6S (Broadcast services satellite delivery).

## **A1.2.4 Broadband Wireless Access**

### **A1.2.4.1 Related projects**

#### **BROADWAN<sup>39</sup>**

“Broadband services for everyone over fixed wireless access networks”, Action Line: BB4All, FP6-001930  
25 partners cooperate within an Integrated Project since December 2003. The major goals are:

- Development of economical realistic network architecture to provide true broadband services for all citizens in Europe.
- Motivate advanced utilisation of broadband services at all levels of the society by performing wireless demonstrations and trials in rural areas @ 5 and 42 GHz
- Bring European industry in the lead for next generation wireless solutions.
- BROADWAN is organised in three main technical areas:

The area “Broadband access network requirements and architecture” concentrates on topics related to user and system requirements, novel network architectures and advanced management of heterogeneous networks. The evolving broadband market will be characterised and technical-economical analyses performed. These studies will be used to identify the most appropriate network architectures, enabling widespread deployment of broadband access networks in Europe. Connection costs, available services, security and ease of use will be important factors for determining the possible network solutions, which will provide broadband connections for all (residential, SMEs, public authorities, organisations, educational institutions etc).

“Wireless access systems” focuses on topics for development and research related to the heterogeneous wireless access network. These comprise broadband fixed wireless access systems (BFWA) (2.5 GHz to 43.5 GHz) including wireless LANs, satellite access, and interactive terrestrial broadcast systems. Development of more cost efficient IPv6 systems with better resource utilisation and flexibility is planned for both the high capacity 40 GHz and the 5 GHz bands. The introduction of broadband fixed wireless access systems (BFWA) based on the IEEE 802.16 standard will provide ADSL-like services and operating in either licensed or unlicensed bands below 20 GHz. The systems are expected to make it economically interesting to extend the coverage in rural areas as well as offering nomadic usage in densely populated areas.

The area “Broadband network utilisation” concentrates on topics related to efficient deployment and use of broadband access throughout Europe. This includes planning guidelines and handbooks, network planning tools, trials and demonstrations, dissemination of results including inputs to standardisation, training seminars for network designers and decision makers and efficient co-operation with national programs.

#### **Embrace<sup>40</sup>**

Efficient Millimetre Broadband Radio Access for Convergence and Evolution, IST-1999-11571, (closed)

The main goal is to develop a low cost radio access system for the mass market. This will be achieved through efficient utilisation of radio frequency bands and optimisation of transmission capacities for a variety of users and usage. A prototype will be developed using MPEG-2 in the downlink and an uplink using multiple frequency time division multiple access. Time division duplex will be studied as an alternative to the frequency division duplex, realised in the hardware prototype. Star and mesh network allowing for network capacity growth as business grows, will be studied. The access network shall inter-operate and multiplex effectively with other common networks. Solutions allowing for nomadic users and route diversity (switching between two or more base stations) will be developed. Planning tools that take into account obstruction from the topography and man-made structures, the effects of atmospheric propagation conditions and the antenna radiation patterns, will be developed.

#### **Other projects & activities:**

- FP6 NoE NEWCOM: Network Of Excellence in Wireless Communications
- FP6 P MAGNET: My Personal Adaptive Global NET
- partially FP6 CAPANINA: Broadband capability from aerial platforms
- FP5 IST NEXWAY: Networks of excellence in wireless applications and technology
- COST 290: Traffic and QoS Management in Wireless Multimedia Networks <sup>41</sup>
- German Research-Ministry: WIGWAM: Wireless Gigabit with Advanced Multimedia Support <sup>42</sup>
- Japan: Multimedia Mobile Access Communication Systems (MMAC) <sup>43</sup>

<sup>39</sup> Broadwan, <http://www.broadwan.org/>

<sup>40</sup> Embrace, <http://www.telenor.no/fou/prosjekter/embrace>

<sup>41</sup> <http://www.cs.tut.fi/~yk/cost>

<sup>42</sup> [http://www.pt-dlr.de/PT-DLR/kt/WIGWAM\\_Projekte.html;internal&action=\\_framecontent.action&Target=\\_self](http://www.pt-dlr.de/PT-DLR/kt/WIGWAM_Projekte.html;internal&action=_framecontent.action&Target=_self)

#### A1.2.4.1.1 Standardisation

The issue FWA has been facing, is the delay in deployment whereas technological knowledge was progressing; therefore a variety of standards have been produced, and were not massively deployed yet, most of the system using proprietary features:

On the physical and MAC layers:

- EN301199, which had been produced initially by DVB EN 301 199 was established with in mind to create an harmonized standard for point to multipoint systems with similar architectures, i.e. between cable and wireless access systems. In summary the downstream link uses DVB-S as the physical layer, with a TDM scheme. Only FDD is allowed between the downlink and the uplink. The uplink uses TDMA with IP over ATM framing (to support low latency services like VOIP), and RS coding scheme. While some LMDS systems are deployed using this technology, both the cable and wireless standards have low industry support and will not be implemented in the future.
- ETSI BRAN Hyperaccess standard, fixed wireless broadband access network focusing on frequencies above 11 GHz, more particularly 31.8-33.4 and 40.5- 43.5 GHz bands, 25-60Mb/s (single carrier).
- ETSI BRAN HIPERMAN the European broadband wireless metropolitan area access standard, f< 11GHz, 10-25Mb/s (OFDM)
- DVB-RCS: As satellite feeders can be used for wireless, DVB-RCS can also be a potential technology for mm wave wireless access.
- IEEE: The LMSC working group (LAN/MAN Standards Committee or IEEE project 802) develops LAN and MAN standards mainly for the lowest 2 layers according to the OSI model. There are three subgroups that deal with mobile wireless: 802.11, 802.16 and 802.20.
- The 802.11 Working Group is responsible for developing WLAN standards; it has developed 6 standards until now. In addition to the 802.11a and b standards, 802.11 standards are being developed to extend the physical layer options, improve security and quality of service features or provide better inter-operability. Vendors are likely to offer proprietary implementations of these features before the IEEE finalizes the standards.
- The 802.16 Mobile Broadband Wireless Access (MBWA) Working Group focuses on fixed broadband wireless access for the LAN and MAN environment. They have defined 4 standards. The Task Group e will extend the standards to support subscriber stations moving at vehicular speeds and will specify a system for combined fixed and mobile broadband wireless access. It intends to fill the gap between very high data rates wireless local area networks and very high mobility cellular systems.
- IEEE 802.16.1 - Air interface for 10 to 66 GHz using a TDM scheme in downstream with adaptative burst profiles on which modulation and coding can be changed from burst to burst. FDD and TDD schemes are possible, and a mesh option is defined.
- IEEE 802.16.2 - Coexistence of broadband wireless access systems.
- IEEE 802.16.3 - Air interface for licensed frequencies, 2 to 11 GHz using OFDM/OFDMA physical layers.
- The work of 802.16.1 is the farthest along, and it's likely that it could generate the most interest in the industry, as it is targeted at available frequency bands.
- An 802.16 wireless service provides a communications path between a subscriber site and a core network (the network to which 802.16 is providing access). Examples of a core network are the public telephone network and the Internet.
- The 802.20 Mobile Broadband Wireless Access (MBWA) Working Group aims at developing a specification for an efficient packet based air interface that is optimised for the transport of IP based services. The scope of this WG is the specification of physical and medium access control layers of an air interface for interoperable mobile broadband wireless access systems, operating in licensed bands below 3.5 GHz, optimised for IP-data transport, with peak data rates per user in excess of 1 Mbps. It supports various mobility classes up to 250 Km/h in a MAN environment. At the time of writing, this WG is composing a Requirements Document.

On coexistence in different frequency ranges:: ETSI TM4

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<sup>43</sup> [http://www.nkgw.ics.keio.ac.jp/~tanaka/MMAC\\_demo.html](http://www.nkgw.ics.keio.ac.jp/~tanaka/MMAC_demo.html)

### ***A1.2.5 Radio-over-fibre/Microwave Photonics related projects***

- FP6 NEFERTITI: Network of Excellence on broadband Fiber Radio Techniques and its Integration Technologies.
- FP5 OBANET (IST-2000-25390): Optically Beam-Formed Antennas for Adaptive Broadband Fixed and Mobile Wireless Access Networks.
- FP4 FRANS: Fibre Radio ATM Network and Services
- ATHOC (AC037): ATM Applications over Hybrid Optical Fibre Coax
- RNRT: OPTIMM opto-millimetric systems for optical relay to hertzian wideband connection at 60GHz.

### ***A1.2.6 XDLS***

#### ***A1.2.6.1 Related projects***

##### **FP6 project MUSE (Multi Service access Everywhere) <sup>44</sup>**

The overall objective of MUSE is the research and development of a future low-cost, full-service access and edge network, which enables the ubiquitous delivery of broadband services to every European citizen. In order to achieve broadband for all, MUSE will investigate access and edge networks that have the following target features:

- low investment cost and operational expenses: the residential subscriber should spend no more than 50 Euro/month depending on the offer of broadband applications and services,
- multi-service and multi-hosting capable: suited for many types of known and yet unknown services with the appropriate QoS (Quality of Service) over a single common infrastructure, as well as for hosting various (competing) service providers in that same infrastructure,
- open service enabling access platform: allow for new revenue-generating services and for collaborative business models in which each player in the value chain gets his fair share,
- first mile solutions scalable in both bandwidth and user density, that can reach at least 80% of the European citizens and are ready for a cost effective migration of the bandwidth to 100 Mbit/s per subscriber by the year 2010, well integrated in an end-to-end view: appropriate inter-working with the metro/core network and the home network,
- plug and play for the end-user.

MUSE aims at a consensus view of the future access and edge network achieved by the co-operative research of almost all major players in Europe.

Standardisation is key to achieve low cost and interoperable solutions. MUSE will re-affirm the position of the European industry in international standardisation. MUSE aims to define a set of standards allowing for interoperability between access network elements and CPE across the different network layers.

The concepts of MUSE and the interoperability will be proven by prototypes in end-to-end lab trials. The following deployment scenarios will be validated:

- Migration scenario featuring a hybrid access network of ATM and packet (Ethernet, IP) network elements and CPE with embedded service awareness and application enablers;
- Non-legacy scenario showing access nodes, various first-mile solutions, and CPE that are optimised for native Ethernet and IPv6 throughout the home and access network;
- FTTx scenarios integrating new concepts for access technologies - VDSL, optical access, and feeders for wireless services -, and service-aware CPE.

The scope of the project is broadband access for residential subscribers. Research will be carried out on access and edge network architecture, access and edge node functionality, innovations of first mile solutions, and the interworking with the home and SOHO network.

##### **FP 6 project Ubroad: Ultra High Bit Rate Over Copper Technologies for BB Multiservice Access <sup>45</sup>**

U-BROAD aims to develop and integrate advanced access technologies for the delivery of “true broadband” content over Ethernet based networks to the customer premises, while providing interfaces to both legacy and next generation core networks. U-BROAD’s major challenge is to quadruple the total bandwidth currently available to the end user over copper.

<sup>44</sup> <http://www.ist-muse.org>

<sup>45</sup> [http://cas.et.tudelft.nl/research/ubroad/ubroad\\_pressrelease.pdf](http://cas.et.tudelft.nl/research/ubroad/ubroad_pressrelease.pdf)

### *A1.2.6.2 Standardisation initiatives and technical initiatives:*

- ITU-T (<http://www.itu.int/>)
- The ITU-T has already published a series of recommendations on xDSL. xDSL is also under study within ITU-T SG 16 Multimedia services, systems and terminals (<http://www.itu.int/ITU-T/studygroups/com16/index.asp>) (now incorporating FS-VDSL (<http://www.fs-vdsl.net/>))
- DSL forum (<http://www.dslforum.org/>)
- DSL Forum is an international industry consortium of nearly 200 leading service providers, equipment manufacturers and other interested parties, focused on developing the full potential of broadband DSL to meet the needs of the mass market. With the established goal of 200 million customers by 2005, the DSL Forum works to streamline processes, develop specifications and share best practices that set the stage for effective deployments, and explosive global DSL growth. By developing new standards and embracing new applications, the DSL Forum is tailoring DSL to meet the needs of the next generation of multi-media services and the online community
- ANSI Standards Committee T1 Telecommunications, Working Group T1E1.4, “xDSL Access” ([http://www.t1.org/t1e1/\\_e14home.htm](http://www.t1.org/t1e1/_e14home.htm))
- Working Group T1E1.4 develops standards and technical reports for systems and associated interfaces, for high-speed bi-directional digital transport via metallic facilities. The work of this group focuses on the physical layer transceiver functionality typically involving advanced digital transmission techniques. The Working Group makes recommendations to T1E1 on related matters before US and international standards organizations.
- ETSI TM6 (<http://www.etsi.org>) ETSI is active in the definition of physical layer standards for digital subscriber line (DSL) technologies.
- IETF (<http://www.ietf.org/>) The focus of the IETF is on the control and management of xDSL networks, e.g., the adslmib working group (<http://www.ietf.org/html.charters/adslmib-charter.html>).

### *A1.2.6.3 Standards:*

#### *A1.2.6.3.1 ITU-T*

- G.991.1 High bit rate Digital Subscriber Line (HDSL) transceivers
- G.991.2 Single-pair high-speed digital subscriber line (SHDSL) transceivers
- G.992.1 Asymmetrical digital subscriber line (ADSL) transceivers
- G.992.2 Splitterless asymmetric digital subscriber line (ADSL) transceivers
- G.992.3 Asymmetric digital subscriber line transceivers 2 (ADSL2)
- G.992.4 Splitterless asymmetric digital subscriber line transceivers 2 (splitterless ADSL2)
- G.992.5 Asymmetrical Digital Subscriber Line transceivers - Extended bandwidth ADSL2 (ADSL2+)
- G.993.1 Very high speed digital subscriber line foundation
- G.994.1 Handshake procedures for digital subscriber line (DSL) transceivers
- G.995.1 Overview of digital subscriber line (DSL) Recommendations
- G.996.1 Test procedures for digital subscriber line (DSL) transceivers
- G.997.1 Physical layer management for digital subscriber line (DSL) transceivers
- H.610 Full-Service VDSL - System architecture and customer premises equipment
- H.611 Full-Service VDSL - Operations, Administration Maintenance & Provision aspects
- H.Sup3 Operator requirements for full-service VDSL in ITU-T Recommendations H.610 and H.611
- L.19 Copper networks for new services and systems ISDN, HDSL, ADSL and UADSL
- L.19 Multi-pair copper network cable supporting shared multiple services such as POTS/ISDN/xDSL

A1.2.6.3.2 Q.833.1 Asymmetric digital subscriber line (ADSL) - Network element management: CMIP modeETSI

- ADSL ETSI TS 101 388
- ETR 328
- HDSL ETSI TS 101 135
- SDSL ETSI TS 101 524 (Transmission and Multiplexing (TM); Access transmission system on metallic access cables; Symmetrical single pair high bitrate Digital Subscriber Line (SDSL) )
- VDSL TS 101 270-1 V1.2.1 (Transmission and Multiplexing (TM); Access transmission systems on metallic access cables; Very high speed Digital Subscriber Line (VDSL); Part 1: Functional requirements). TS 101 270-2 V1.1.1. (Transmission and Multiplexing (TM); Access transmission systems on metallic access cables; Very high speed Digital Subscriber Line (VDSL); Part 2: Transceiver specification )

*A1.2.6.4 Future developments:*

- ADSL
- DTS/TM-06025.
- SDSL
- DTS/TM-06022
- DTS/TM-06032

## **A1.2.7 FTTx Updated June 2005, small update January 2006**

### *A1.2.7.1 Related projects*

#### **FP5 project GIANT (GIgaPON Access NeTwork)** <sup>46</sup>

In the GIANT project, a next-generation, optical access network optimised for packet transmission at Gigabit/s speed will be studied, designed and implemented. The resulting GigaPON will cope with future needs of higher bandwidth and service differentiation in a cost-effective way. The studies will take into account an efficient interworking at the data plane and control plane with a packet-based metro network. The activities will encompass extensive studies defining the new GigaPON system. Innovative transmission convergence and physical medium layer subsystems will be modelled and developed. An important outcome of the system research will be the selection of a cost-effective architecture and its proof of concept in a lab prototype. Recommendations will be given for the interconnection between a GigaPON access network and metro network. Contributions will be made to relevant standardisation bodies.

#### **FP5 project TONIC (TechnO-ecoNomICs of IP optimised networks and services)** <sup>47</sup>

TONIC is a project that concentrates on techno-economic evaluation of new communication networks and services, in order to identify the economically viable solutions that can make the Information Society to really take place.

TONIC's main objectives are:

- to assess the new business models associated with offering IP-based mobile services in a competitive context.
- to evaluate the cost and benefits of providing broadband access to both competitive and non-competitive areas, and to determine the most appropriate network infrastructure from an economic viewpoint.
- to analyse the results of the above studies in order to formulate pertinent recommendations to policymakers, network operators and service providers regarding communications investment strategies.

#### **FP6 project MUSE (Multi Service access Everywhere)** <sup>48</sup>

MUSE is a large integrated R&D project on broadband access. Within the 6th Framework Programme, MUSE contributes to the strategic objective "Broadband for All" of IST (Information Society Technologies). The overall objective of MUSE is the research and development of a future low-cost, full-service access and edge network, which enables the ubiquitous delivery of broadband services to every European citizen.

MUSE also contains techno-economic activities which objective is to provide a validation of the different architectural and technological choices which will be developed within the MUSE subprojects. The MUSE techno-economic activities develop further the former IST TONIC project methodology.

#### **FP6 project E-NEXT** <sup>49</sup>

E-NEXT is an FP6 Network of Excellence that focuses on Internet protocols and services. The general objective of E-NEXT is to reinforce European scientific and technological excellence in the networking area through a progressive and lasting integration of research capacities existing in the European Research Area (ERA)

#### **German project MaiNet: Multimedia Access and Indoor Networks.**

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<sup>46</sup> <http://www.alcatel.be/Giant/>

<sup>47</sup> <http://www-nrc.nokia.com/tonic/>

<sup>48</sup> <http://www.ist-muse.org>

<sup>49</sup> <http://www.ist-e-next.org>

MaiNet is a part of the MultiTeraNet national research initiative on optical communication technologies in Germany (<http://www.multiteranet.de/>). The focus of MaiNet is the development of new concepts for broadband access and indoor networks

### A1.2.7.2 *Standardisation initiatives and technical initiatives:*

Two important standardization bodies are: Ethernet in the First Mile Alliance (EFMA) and Full Service Access Network (FSAN).

- EFMA (<http://www.efmalliance.org/>) promotes standards based Ethernet in the First Mile technology and encourages the utilization and implementation of Ethernet in the First Mile as a key networking technology for local subscriber access networks. EFMA especially promotes and supports the IEEE.802.3ah standard (<http://www.ieee802.org/3/efm/index.html>) which focus is to bring Ethernet technologies in the access area.

The IEEE.802.3ah standard consists of four parts:

- Ethernet in the First Mile over point-to-point Fibre (EFMF)
  - Ethernet Passive Optical Network (EPON)
  - Ethernet in the First Mile Operations, Administration and Maintenance (EFM OAM)
  - EFM over Copper (EFMC)
- FSAN (<http://www.fsanweb.org/>) is not a standardization body. The members of FSAN are telecommunications services providers and equipment suppliers. The mission of FSAN is to drive applicable standards, where they already exist, into the services and products in the industry, while simultaneously advanced its own specifications into the appropriate standards bodies to provide further definition to the Full Service Access Network.

FSAN defined requirements for APON (ATM PON), BPON (Broadband PON) and GPON (Gigabit PON), and it consists of two working groups: OAN-WG (Optical Access Network – Working Group) and OAM-WG (Operation and Maintenance – Working Group).

- OAN-WG mainly handles physical interface between OLT and ONT and standardisation is carried out by SG15 (Study Group 15, which is discussing standards for optical transmission technology and the physical medium network) in ITU-T, and they feed their recommendations into ITU-T G.983 and G.984 family.
- OAM-WG discusses the management interface between NMS (Network Management System) and EMS (Element Management System), and this is standardised by SG4 (Study Group 4, study group on telecommunication management) in ITU-T, which results into ITU-T Q.834 series.

Next to EFMA and FSAN, two other important standardization bodies in the field of FTTx are: the PON forum and FTTH council.

- The PON Forum (<http://www.ponforum.org>) is focused on the business and marketing aspects of the PON industry. Technical issues related to PON are being handled by a number of industry standards and advocacy groups and are not being addressed by the PON Forum. The PON Forum will liaise with these groups and will offer business and market information to help drive their efforts. Thus, the PON Forum has two primary goals: Evangelize the PON market, agnostic of technical variations of PON and Identify market needs to be fed back to the various technical and advocacy bodies (EFMA, FSAN, ITU, IEEE, etc).
- The FTTH Council ([www.ftthcouncil.org/](http://www.ftthcouncil.org/)) is a market development organization whose mission is to educate, promote, and accelerate FTTH and the resulting quality-of-life enhancements. The Fibre to the Home (FTTH) Council is a non-profit organization established in 2001 to educate the public on the opportunities and benefits of FTTH solutions. FTTH Council members represent all areas of broadband industries, including telecommunications, computing, networking, system integration, engineering, and content-provider companies, as well as traditional telecommunications service providers, utilities and municipalities. There also exists a FTTH Council specifically for Europe: FTTH Council Europe (<http://www.europeftthcouncil.com/>)

### A1.2.7.3 Standards

A1.2.7.3.1 IEEE (<http://www.ieee802.org/3/ah/>)

IEEE 802.3ah

The work of the IEEE P802.3ah Ethernet in the First Mile Task Force is complete with the approval of IEEE Std 802.3ah-2004 at the June 2004 IEEE Standards Board meeting

ITU-T (<http://www.itu.int/>)

The ITU-T has already published a series of recommendations on PONs (G.983, G.984 and Q.834, Q.838 series) and also one on a point-to-point optical access system (G.985).

- G.983.1 (10/98) Broadband optical access systems based on Passive Optical Networks (PON)
- G.983.1 (07/99) Corrigendum 1
- G.983.1 (11/01) Amendment 1
- G.983.1 (03/02) Corrigendum 1 (1999) / Erratum 1
- G.983.1 (03/03) Amendment 2
- G.983.1 (01/05) Broadband optical access systems based on Passive Optical Networks (PON)
- G.983.1 (05/05) Amendment 1: Appendixes PICS (Protocol Implementation Conformance Statement) for OLT and ONU in G.983.1
- G.983.2 (04/00) ONT management and control interface specification for ATM PON
- G.983.2 (06/02) ONT management and control interface specification for B-PON
- G.983.2 (03/03) Amendment 1
- G.983.2 (01/05) Amendment 2
- G.983.3 (03/01) A broadband optical access system with increased service capability by wavelength allocation
- G.983.3 (06/02) Amendment 1
- G.983.4 (11/01) A broadband optical access system with increased service capability using dynamic bandwidth assignment
- G.983.4 (12/03) Amendment 1: New Annex A - Performance monitoring parameters
- G.983.4 (01/05) Corrigendum 1
- G.983.5 (01/02) A broadband optical access system with enhanced survivability
- G.983.6 (06/02) ONT management and control interface specifications for B-PON system with protection features
- G.983.7 (11/01) ONT management and control interface specification for dynamic bandwidth assignment (DBA) B-PON system
- G.983.8 (03/03) B-PON OMCI support for IP, ISDN, video, VLAN tagging, VC cross-connections and other select functions
- G.983.9 (06/04) B-PON ONT management and control interface (OMCI) support for wireless Local Area Network interfaces
- G.983.10 (06/04) B-PON ONT management and control interface (OMCI) support for Digital Subscriber Line interfaces
- G.Imp983.1 (10/03) Implementors' guide for Recommendation G.983.1
- G.Imp983.2 (01/03) Implementors' Guide to G.983.2 (2002)
  
- G.984.1 (03/03) Gigabit-capable Passive Optical Networks (GPON): General characteristics
- G.984.2 (03/03) Gigabit-capable Passive Optical Networks (GPON): Physical Media Dependent (PMD) layer specification
- G.984.3 (02/04) Gigabit-capable Passive Optical Networks (GPON): Transmission Convergence Layer specification
- G.984.4 (06/04) Gigabit-capable Passive Optical Networks (G-PON): ONT management and control interface specification
  
- G.985 (03/03) 100 Mbit/s point-to-point Ethernet based optical access system

- Q.834.1 (04/01) ATM-PON requirements and managed entities for the network element view
- Q.834.1 (06/04) ATM-PON requirements and managed entities for the network and network element views
- Q.834.2 (04/01) ATM PON requirements and managed entities for the network view
- Q.834.3 (11/01) A UML description for management interface requirements for broadband Passive Optical Networks
- Q.834.3 (06/04) A UML description for management interface requirements for broadband Passive Optical Networks
- Q.834.4 (07/03) A CORBA interface specification for Broadband Passive Optical Networks based on UML interface requirements
- Q.834.4 (01/04) Amendment 1
  
- Q.838.1 (10/04) Requirements and analysis for the management interface of Ethernet passive optical networks (EPON)

## ***A1.2.8 HAP Research***

### ***A1.2.8.1 Capanina Project***

CAPANINA is a European project supported by the European Framework 6 initiative ([www.capanina.org](http://www.capanina.org)). The project consists of 13 European partners, supplemented and strengthened by collaboration with the National Institute of Information and Communications Technology of Japan. It is a €9.9M project involving 60 people and has the aim of providing “Broadband for All” from high altitude aerial platforms. The project started in Nov 03 and is due to run for 3 years.

The research is divided into 4 areas namely

#### **A1.2.8.1.1 Applications and services**

- This workpackage will evaluate candidate applications and operating scenarios for delivery by broadband HAPs. The study will provide marketing and business models and will generate information of network requirements. The most suitable applications will be selected e.g. those that require a high capacity in both directions. Cost and revenue analysis will be performed on these applications, as will risk analysis.
- Currently the project has identified 5 candidate applications:
  - Broadband internet access for residential/SOHO market
  - Broadcast based broadband e.g. HDTV
  - Special events and disaster recovery broadband connections
  - WiFi on trains and bus-coaches – this is seen as “a compelling argument” providing up to 120Mbit/s to a high speed train
  - Internet backhauling
  - These applications and associated business models will form the basis of a deliverable due to be issued in mid-May 2005.

#### **A1.2.8.1.2 Communications Links and Networking**

- This workpackage will address all aspects of the physical communication links including HAP↔HAP, HAP↔Satellite and HAP↔Ground Node. The work will build on previous studies in HELINET to identify suitable access standards extending coverage to new requirements, such as high-speed mobile access and available equipment. Changes to support the new high mobility application and architecture will be fed back to the relevant standards bodies.

Propagation studies will complement existing applicable measurements, with new HAP specific environmental measurements. Path impairments, such as Doppler effects, rain outage and multipath interference, and mitigation will be investigated. Test bed measurements will contribute.

Advanced signal processing techniques will be developed to minimise power drain while mitigating environmental effects and managing the high aggregate data rates. Resource allocation strategies will mitigate the mobility and interference issues, while making efficient spectral usage, maintaining QoS, and sharing the spectrum with terrestrial and satellite operators.

End-end networking and inter-working with other technologies will be of paramount importance.
- Progress in this section includes:
  - Demonstration of both the rf and optical links in trial 1 (described below)
  - Modelling of same spectrum re-usage for cell coverage by different HAPs. Here different HAPs would broadcast using the same frequency to a cell. The signals would be separated by the directional nature of the ground antenna and the physical separation of the HAPs
  - Modelling on interference to ground BFWA base-stations. This work is to be fed into standards bodies as a discussion document for methodologies for standards
  - Accelerometer studies to understand stability and its impact on tracking technology
  - Doppler studies and mitigation of e.g. tunnels for the high speed rail application

#### A1.2.8.1.3 Communications Nodes

- This workpackage will generate the equipment and techniques for the HAP and the ground nodes. The equipment will be employed in the test bed and other trials. The workpackage will also develop techniques such as smart antennas and the signal processing for beam forming and optical links. The work will cover mm-wave transmission at around 28GHz and free space optical links. The HAP antennas will need to be stabilised and use pointing, acquisition and tracking techniques. RF antenna work will investigate controlling beam shape and direction. The high speed vehicle connection is anticipated to be the most stringent requirement, with both mechatronic and electronic (phase array) steering are anticipated to be required. Beamforming algorithms will be developed. Again here low power consumption will be important. Free space optical links will allow high capacity connections. These will be used to augment connections to ground based back haul stations (in clear air conditions). Optical interplatform links will not suffer rain & cloud outages as they are well above cloud levels and can replace terrestrial links (none available or lower infrastructure) and provide spatial diversity and backhaul availability e.g. if it is raining at one ground site to allow optical connection (and capacity) at another site. The project will design and produce HAP and ground optical terminals, and make measurements of the communication channels. The workpackage includes work to design and prototype a mechanical optical beam steering unit, and also to simulate non-mechanical methods such as 2D laser phase arrays
- As described above the equipment has been demonstrated successfully in the first trial. The payload shape for the second and third trials is different, and work is progressing on the equipment for the second trial in summer 2005. Other progress includes:
  - Lens antenna demonstration
  - Modelling of smart antenna to reuse a frequency for several users

#### A1.2.8.1.4 System Test Bed

- The system test bed will work in collaboration with the other workpackages. The applications and services identified in WP1 will be trialled to fixed users. Measurement data will be generated for the high speed train applications and the propagation environment for the fixed user will be accurately characterised. Three platforms will be used:
  - 300m altitude 15m tethered aerostat, will demonstrate:
  - Broadband FWA (BFWA) of up to 120Mbit/s to fixed user (28GHz) and associated propagation measurements / End-end network connectivity / Services / Suitability of tethered aerostat capability in its own right / Optical backhaul communications (622 Mbit/s)
  - Stratospheric balloon
  - Selection of BFWA tests from 1 (28/32 GHz or 47/48 GHz) - station keeping, payload, make-up of equipment / Propagation measurements / Optical communications / Backhaul link (up to 622 Mbit/s) point, acquire and track / Comparison with Japanese trial
  - Trials with Japanese partners on Hawaii
  - Details have been agreed for this trial with the platform being the NASA pathfinder plus aircraft. The trial will include a free space optical pod. The Japanese partners NICT and Japan Stratosphere Communications are providing the vehicle and logistics for the 3<sup>rd</sup> trial.
- Achievements here include:
  - The first set of test bed trials have already been completed using a low altitude tethered balloon at Pershore UK. Bi-directional rf transmission was demonstrated and several broadband applications were trialled. Optical tracking tests were also carried out. The weather was unusually bad for summer in the UK in this case; however this provided useful stability data with the wind moving the aerostat 5-10 times in excess of that expected for a stratospheric platform. Tracking could still be achieved. While the Capanina project uses this trial as a stepping stone to the stratospheric platform vision, some organisations, including the Capanina partner SkyLINC, are developing solutions using tethered aerostat platforms similar to that used here.
  - Work is progressing on target for the second trial in summer 2005
  - The details of the collaborative trials with the Japanese have been agreed

Capanina does not include research into the platforms themselves. There appear to be difficulties in generating funding for research projects upon these lines within the EU framework because of the way funding is organised. This appears to be a frustration for those involved in the project. Many of the interesting issues to be solved in these types of projects are aeronautical. Some interested parties mention it is a pity that the EU is not taking a lead in developing these technologies.

There are a number of other research projects in this area:

- USE-HAAS is an EC framework 6 project which started on 1st March 2005. Its objectives are to develop a roadmap and research strategy for High Altitude Airships and High Altitude Aircraft
- NASA has just announced continuation of its research in the High Altitude Long Endurance Remotely Operated Aircraft project. This project uses the lessons learned from the Environmental Research and Sensor Technology project (1994 – recently) which has recently concluded. The project is planned to last 15 years<sup>50</sup>
- The Korea Aerospace Research Institute is in the 5th year of a 10 year program to develop a stratospheric airship<sup>51</sup>
- The Japanese “SkyNet” project<sup>52 53</sup> is a big (€100M to date) project for delivery of broadband and 3G communications. Working in conjunction with a NASA spin off they have recently demonstrated communication provision from their Pathfinder Plus aircraft.
- An ESA study into the delivery of Broadband from HAPs<sup>54</sup>
- British National Space Centre contract into the study of V-band for HAPs and satellites
- EPSRC study contract into delivery of 3G from HAPs
- A similar Korean 3G delivery project
- Indonesia Post and Telecoms HAPs project
- UK companies Advanced Technologies Group (Stratsat)<sup>55</sup> and Lindstrand Balloons<sup>56</sup> developing HAPs
- There are several initiatives in the US. SkyStation and Angel Technologies<sup>57</sup> have carried out a number of studies. Angel Technologies solution uses a piloted aircraft. Sanswire<sup>58</sup> has announced it will develop HAPs for high speed internet delivery, has demonstrated its “stratellite” and announced an agreement to build and launch “stratellites” in South America There are several projects being financed for “Homeland Security” purposes. Boeing is involved in these activities
- As mentioned above SkyLINC Ltd<sup>59</sup> and Platforms Wireless International<sup>60</sup> are developing tethered aerostat solutions.
- ITU has had wide activities related to HAPs

<sup>50</sup> Del Frate J.H.: “Developing Technologies for High Altitude and Long Endurance”, 5th Stratospheric Platform Systems Workshop, Tokyo, Japan, Feb 23-24, 2005

<sup>51</sup> Kim D-M., Lee Y-G., Lee S-J., and Yeom C-H.: “Research Activities for the Development of Stratospheric Arship Platform in Korea”, 5th Stratospheric Platform Systems Workshop, Tokyo, Japan, Feb 23-24, 2005

<sup>52</sup> <http://www2.nict.go.jp/mt/b181/english/spf/strat-e.htm>

<sup>53</sup> <http://www.tele.soumu.go.jp/e/system/satellit/skynet.htm>

<sup>54</sup> <http://telecom.esa.int/telecom/www/object/index.cfm?fobjectid=8188#3>

<sup>55</sup> [http://www.atg-airships.com/prod/stratsat\\_frames.htm](http://www.atg-airships.com/prod/stratsat_frames.htm)

<sup>56</sup> <http://www.lindstrand.co.uk/>

<sup>57</sup> <http://www.angeltechnologies.com/>

<sup>58</sup> <http://www.sanswire.com/>

<sup>59</sup> <http://www.skylinc.co.uk/>

<sup>60</sup> <http://www.plfm.net/>

## ***A1.2.9 Mobile***

### ***A1.2.9.1 Related projects***

#### **Belgium regional project:**

FWO WOG: Broadband communication and multimedia services for mobile users, [Jan 2004 - Dec 2008]  
(Coordinator: UGent + 22 other partners)

#### **European projects**

FLEXINET

### ***A1.2.9.2 Standardization***

#### **3GPP**

UMTS is being standardized by 3GPP ([www.3gpp.org](http://www.3gpp.org)). The webpage gives access to all standards free of charge. In addition the GSM standards have been renumbered and are also available free of charge from the 3GPP site.

#### **IEEE, ETSI**

#### **IETF**

Within the IETF several working groups study the support of mobility in the IP network:

- IP routing for wireless/mobile hosts (mobileip): this WG has concluded end 2003. Work has been moved to the mip4, mip6 and mipshop WG's
- Mobility for IPv4 (mip4): this WG focusses on deployment issues and on addressing known deficiencies and shortcomings in the protocol that have come up as a result of deployment exercises.
- Mobility for IPv6 (mip6): The primary goal of this working group is to enhance base IPv6 mobility by continuing work on developments that are required for wide-scale deployments.
- MIPv6 Signaling and Handoff Optimization (mipshop): This WG will complete the work on FMIPv6 and HMIPv6 begun in the mobileip group.
- Next Steps in Signaling (nsis) WG: investigates the support of end-to-end QoS in the internet, both wired and wireless. It studies how to signal QoS and where to signal QoS.
- Context transfer, handoff candidate discovery and dormant mode host alerting (seamoby) WG aims to develop routing protocols that allow real-time services (low latency, low packet loss) to work over an IP infrastructure and with minimal disruption across heterogeneous wireless and wired technologies. This WG will handle issues such as the transfer of context information between the old and the new point of attachment, seamless handover, dormant mode of mobile hosts and IP paging

## **A1.3 GENERAL TOPICS IN ACCESS**

### ***A1.3.1 Video in broadband networks***

#### ***A1.3.1.1 Related projects***

##### **ENTHRONE**

Action Line: Networked Audio Visual Systems and Home Platforms

The primary goal of the ENTHRONE project is to provide a solution for seamless access to multimedia content with end-to-end quality of service through integrated management of content, networks and terminals, while respecting intellectual property rights (IPR). A service provider may build a complete system based on the ENTHRONE solution, but the project does not provide all the components required by a service provider (in particular, a service provider will have to add the front-end through which a user will be able to access services).

To achieve this goal ENTHRONE will provide an off-the-shelf infrastructure for end-to-end Quality of Services (QoS) management. The project aims to develop an integrated management solution covering the audio-visual distribution chain from end to end, harmonizing the functionality of the individual components in the chain. This solution will support an end-to-end QoS architecture over heterogeneous networks, applying to a variety of audio-visual services, delivered to a variety of different terminals. The project is expected to contribute to the global public standardisation efforts in the field of:

##### **MediaNet**

Action Line: Networked Audio Visual Systems and Home Platforms

The project (IP with more than 30 partners) aims at developing technologies, infrastructure and service solutions enabling the easy exchange of digital content and audio-video content between creators, providers, customers and citizens. MediaNet will identify and develop a set of representative and appealing end-to-end applications, key enabling technologies, a reference architecture and its key interfaces for an easy and smooth exchange of content all along the media supply chain. By developing and maintaining a shared vision, all stakeholders are guaranteed of the effective and seamless work between all subparts of the media chain.

The project covers three complementary domains: media networking, multimedia services, and content engineering. The project will develop new management service platforms for broadband access networks and open home networking, and storage solutions. Wireless communication solutions for audio-video content, new end-to-end service provisioning over shared public and private infrastructures, mixing video broadcast over broadband access, content on demand, and interactive online applications will be proposed, as well as personal multimedia communications supported by portable terminals and person-to-person communication services over IP.

A common open and shared delivery platform will be created covering the broadband access and the home domains, where all devices and services will interoperate, combining advanced multimedia content, services, and communications in public and residential environments. MediaNet, which is centered at the intersection of the audio-video, PC and telecom industries actively participates in the development of such next generation connected digital applications and devices by addressing some of its technical key issues:

- the development of an open multi-vendor/multi-service business reference architecture and a technical roadmap ,
- broadband access and home networking to support multiple overlay end-to-end applications by third parties;
- shared services, infrastructures, and equipment while assuring investment protection, interoperability and competition;
- Digital Rights Management (DRM) and end-to-end content protection solutions;
- N-Services, e-Service platforms, Digital Video Broadcasting over IP, Multimedia Home Platform, gateways, wireless solutions for audio/video streaming, open distributed storage, Multimedia communications over IP services and terminals, MPEG4/AVC encoding and decoding circuits, HQ A/V streaming over IP.

## DANAE

Action Line: Networked Audio Visual Systems and Home Platforms

DANAE proposes to address the dynamic and distributed adaptation of scalable multimedia content in a context-aware environment. Its objectives are to specify, develop, integrate and validate in a testbed a complete framework able to provide end-to-end quality of (multimedia) service at a minimal cost to the end-user. An application will be specifically developed and implemented on a demonstrator, to illustrate the new service concepts pioneered by the Project.

The work will cover:

- the definition of scalable media formats with their associated meta-data,
- their adaptation to the session context for making full featured distributed multimedia scene
- adaptation through global optimization of audio, video, 2D graphics, 2D/3D virtual characters and the transport and delivery of multimedia content to the end-user.

Error resilient and efficient (in terms of bitrate and required processing power in the player) coding schemes will be studied to cater for the specific constraints introduced by the existing multiplicity of networks and terminals. The interrelationship of content adaptation and scalability with Digital Rights Management (DRM) and charging issues will also be explored.

As an outcome, an advanced MPEG-21 chain will be produced. Finally potential new business models will be analyzed that would allow assessment of the commercial viability of the new services pioneered by DANAE.

### A1.3.1.2 *Standardisation initiatives*

Whereas ETSI, IETF and ITU are the known standardization organisms dealing with general telecommunication matters, specialized groups like DVB, ITU-T, ISO-MPEG4 and MPEG21 have been covering the various audio – visual issues. Also to be mentioned are OSGI, FIPA (<http://www.fipa.org/>), and ISMA (<http://isma.tv/index.html>) which work respectively in the fields of Home Gateway architecture, intelligent agents and multimedia streaming respectively. The initiative TV Anytime (<http://www.tv-anytime.org/>) addresses all the issues related to Local storage. It has to be noted that committees like ETSI (TISPAN), IETF (avc, ipdvb, dccc) are covering now video aspects.

#### A1.3.1.2.1 DVB

The DVB Project<sup>61</sup> has provided a complete solution for digital television and data broadcasting across a range of delivery media where audio and video signals are encoded in MPEG-2. DVB, in conjunction with ETSI and CENELEC, generated international standards for the delivery media: satellite, cable, terrestrial, wireless. These standards are divided into families corresponding to the media, e.g. DVB-S refers to satellite standards, DVB-C refers to cable systems, DVB-T refers to terrestrial systems, etc.

Initially, the focus was on the infrastructural elements of the standard broadcast chain. The scope was later expanded to include the infrastructural layers of interactive services.

Besides Physical layers development and Local storage, DVB other important activities related to broadband are:

- The maintenance of the MHP specification, and the development in the following areas:
  - Extension of the MHP features to a PVR (Personal Video Recorder) environment
  - Exploration of new areas for MHP like mobile environment
- The utilization of DVB-T in a mobile environment (DVB-H), cooperation between broadcast and interactive network for Audio-Video content delivery (DVB-CBMS), and new physical layer for satellite (DVB-S2).
- Content protection (DVB-CPT)
- The definition of an end to end IP architecture for video related services (DVB IPI), including network, session and resource reservation protocols
- The definition of transport layers for new coding schemes (MPEG4, Windows Media 9,..)
- DVB collaborates closely with the other related groups like TV-Anytime and MPEG.

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<sup>61</sup> The Digital Video Broadcasting Project DVB, founded in 1993, is a market-led consortium of broadcasters, manufacturers, network operators and regulatory bodies in the television industry, committed to designing a global standard for the delivery of digital television services, <http://www.dvb.org/>

#### A1.3.1.2.2 MPEG4<sup>62</sup>

The MPEG-4 standards provides a set of technologies achieving standardised ways to:

- Represent units of aural, visual or audiovisual content, called “media objects”. These media objects can be of natural or synthetic origin; this means they could be recorded with a camera or microphone, or generated with a computer;
- Describe the composition of these objects to create compound media objects that form audiovisual scenes;
- Multiplex and synchronize the data associated with media objects, so that they can be transported over network channels providing a QoS appropriate for the nature of the specific media objects; and
- Interact with the audiovisual scene generated at the receiver’s end.

MPEG-4 therefore provides an interoperable representation of rich media content that can be consumed seamlessly by platforms of different manufacturers. MPEG-4 multimedia information provided by different content providers and delivered by various network providers can be displayed in a controlled and unambiguous way. Finally, through the definition of profiles and levels, MPEG-4 provides interoperable scalability of high-end down to low-end solutions.

In summary MPEG4 addresses the 2 main issues of multimedia content scalability and interoperability; the current challenge of MPEG4 is its large adoption by all the actors of the multimedia chain; some areas of interest are:

- New audiovisual coding schemes; for video H.264 has already been standardized and provides a significant gain (around 50%) over MPEG2.. However, H.264 is not completely scalable. Scalable solutions been investigated in the context of MPEG-21 (now MPEG4), within an ad-hoc group called SVC (Scalable Video Coding) and a new scalable standard backward compatible with H264 has been adopted. Among the longer term emerging technologies allowing for scalable video representation, wavelet-based solutions, which offer similar performances and very good scalability for adaptation to heterogeneous network and terminal environments are being investigated. Loss and error resilience for transmission on networks that do not provide any QoS guarantee are also part of the requirements for these emerging systems. To include MPEG4 content in to the current MPEG2-DVB transport system
- The adoption of MPEG4 in the mobile environment
- MPEG4 usage in electronic cinema
- Synergies between MPEG4 and DVB-MHP.

#### A1.3.1.2.3 MPEG21<sup>63</sup>

The multimedia content delivery chain encompasses content creation, production, delivery and consumption. To support this, the content has to be identified, described, managed and protected. The transport and delivery of content will occur over a heterogeneous set of terminals and networks within which events will occur and require reporting. Such reporting will include reliable delivery, the management of personal data and preferences taking user privacy into account and the management of (financial) transactions.

The MPEG-21 multimedia framework has the objective to identify and define the key elements needed to support the multimedia delivery chain as described above, the relationships between and the operations supported by them. Within the parts of MPEG-21, MPEG elaborates the elements by defining the syntax and semantics of their characteristics, such as interfaces to the elements. MPEG-21 addresses the necessary framework functionality, such as the protocols associated with the interfaces, and mechanisms to provide a repository, composition, conformance, etc.

The seven key elements defined in MPEG-21 are:

- Digital Item Declaration (a uniform and flexible abstraction and interoperable schema for declaring Digital Items);
- Digital Item Identification and Description (a framework for identification and description of any entity regardless of its nature, type or granularity);

<sup>62</sup> <http://www.m4if.org/>

<sup>63</sup> [http://mpeg.telecomitalia.com/working\\_documents.htm](http://mpeg.telecomitalia.com/working_documents.htm)

- Content Handling and Usage (provide interfaces and protocols that enable creation, manipulation, search, access, storage, delivery, and (re)use of content across the content distribution and consumption value chain);
- Intellectual Property Management and Protection (the means to enable content to be persistently and reliably managed and protected across a wide range of networks and devices);
- Terminals and Networks (the ability to provide interoperable and transparent access to content across networks and terminals);
- Content Representation (how the media resources are represented);
- Event Reporting (the metrics and interfaces that enable Users to understand precisely the performance of all reportable events within the framework);

#### A1.3.1.2.4 Other committees

##### Transport and delivery aspects:

- IETF AVT (Audio-Visual Transport) working group dealing with the specification of RTP payload formats;
- IETF DCCP (Datagram Congestion Control Protocol) working group aims at defining a new protocol called **DCCP**;
- IETF ROHC (Robust Header Compression) working group;  
IETF IPDVB : group has the task to develop new protocol architectures to enable better deployment of IP over MPEG2/DVB transport. This includes transmission efficiency and link layer support for unicast-multicast.

##### QoS and routing aspects:

- IETF DiffServ (Differentiated Services) working group;
- IETF RPS (Routing Policy System) working group related to routing policy; the goal is to define a language called Routing Policy Specification Language (RPSL) to describe routing policy constraints.
- IETF Policy Framework (policy) working group,
- IETF QoS Routing (qosr) working group,
- IETF **MPLS** (**M**ultiprotocol **L**abel **S**witching) working group.

##### QoS signalling:

- IETF NSIS (Next Steps In Signalling) working group: The goal of the NSIS group is to define a next-generation signalling architecture and a generic signalling protocol;
- IETF RAP (Resource Allocation Protocol) working group proposed a policy framework which intends to "establish a scalable policy control model for RSVP.";

##### Session and application signalling:

- IETF MMUSIC WG
- IETF SIP (Session Initiation Protocol) working group.
- IETF SIPPING (Session Initiation Proposal Investigation): SIPPING describes the requirements for any extension to SIP.
- ICAP (Internet Content Adaptation Protocol) working group.
- IETF Media Feature Sets working group;
- IETF CDI working group: defining protocols to allow the interoperation of separately-administered content networks

##### Coding, streaming, content adaptation:

- ISMA (Internet Streaming Media Alliance): Initiative aiming at specifying complete solutions of multimedia streaming (see. <http://isma.tv/index.html>);

- ISO/MPEG-21 DIA (Digital Item Adaptation): Specifies the syntax and semantics of tools that may be used to assist the adaptation of Digital Items. The tools could be used to satisfy transmission, storage and consumption constraints, as well as Quality of Service management by the various Users;
- ISO/MPEG-21 SVC (Scalable Video Coding): New MPEG initiative aiming at defining a fine grain scalable coding solution for video signals, amenable to network or terminal adaptation.
- The World Wide Web Consortium (W3C) consortium;
- The Web3D consortium: It produced the X3D specification. X3D is an extensible open file format standard for 3D visual effects, behavioural modelling and interaction. It provides an XML-encoded scene graph and a language-neutral Scene Authoring Interface (SAI). The XML encoding enables 3D to be incorporated into web services architectures and distributed environments, and facilitates moving 3D data between applications. The Scene Authoring Interface allows real time 3D content and controls to be easily integrated into a broad range of web and non-web applications.

## A1.4 CORE AND METRO

### A1.4.1 Optical metro / CWDM

#### A1.4.1.1 Related IST-FP5- projects

- FP5-IST APPTECH Project, on line <http://www.ist-optimist.org/prdc.asp?id=38>
- FP5-IST BIGBAND Project, on line <http://www.ist-optimist.org/prdc.asp?id=45>
- FP5-IST DAVID project, on line <http://david.com.dtu.dk/>
- FP5-IST FASHION project, on line <http://www.ist-optimist.org/prdc.asp?id=26>
- FP5-IST METEOR Project, on line <http://www.ist-optimist.org/prdc.asp?id=12>
- FP5-IST NAIS Project, on line <http://www.ist-optimist.org/prdc.asp?id=32>
- FP5-IST NEWTON Project, on line <http://www.ist-optimist.org/prdc.asp?id=31>
- FP5-IST OPTIMIST consortium: EU Photonic Roadmap, on line <http://www.ist-optimist.org/>
- FP5-IST STOLAS project, on <http://www.ist-stolas.org/>
- FP5-IST TOPRATE project, on line <http://www.ist-optimist.org/prdc.asp?id=28>
- FP5-IST TUNVIC Project, on line <http://www.ist-optimist.org/prdc.asp?id=19>

#### A1.4.1.2 Related IST-FP6- projects

- FP6-IST e-Photon/ONe NoE, on line <http://e-photon-one.org/>
- FP6-IST LASAGNA Strep, on line : <http://www.ist-lasagne.org/>
- FP6-IST NOBEL Integrated Project, on line <http://www.ist-nobel.org/>

### A1.4.2 Optical backbone

#### A1.4.2.1 Related Technical Initiatives

##### A1.4.2.1.1 Optical Internetworking Forum (OIF)

The OIF is an open industry organization of equipment manufacturers, telecom service providers and end users dedicated to promote the global development of optical internetworking products and foster the development and deployment of interoperable products and services for data switching and routing using optical networking technologies. The Technical Committee is divided into six working groups, focusing on specific areas. Currently the Working Groups are: Architecture Working Group, Carrier WG, Interoperability WG, OAM&P WG, Physical and Link Layer WG and Signalling WG.

The goal was to design and test a resilient and managed transport network realised by an OTN carrying different clients (e.g. SDH, ATM, IP-based) with inter-working and interconnection between layer transport networks and domains. The identified requirements will be validated in a testbed where IP-routers and SDH equipment will be integrated over an OTN infrastructure.

Project LION which has recently ended. It studied the implementation of an Intelligent Optical Network based on an Automatic Switched Optical Network [ASON] using Generalised MPLS as a control plane.

The test-bed showed the interconnection of 3 optical network domains [constructed by each of the partners Siemens, Tellium and TILAB] together with Network Management Systems [by T-Nova, Cisco]. The demonstrator used OXCs and OADMS, and showed the operation of signalling interfaces, demonstrating restoration and path set-up and tear down. The project studied successfully:

- Traffic/demand model for ASON/ASTN networks
- Definition of guidelines on the optimisation of the transport network evolution (flexible connection provisioning, control plane, management plane, resilience, ...)
- ASON for survivability/ resilience using the ASON flexibility
- Study of ASON dimensioning and dynamic traffic conditions resulting in a joint optimisation planning scheme

#### A1.4.2.1.2 FP5 IST STOLAS

Burst Switching represents a networking technology of growing interest across Europe, as it would appear to offer good network dynamics and granularity, whilst not stretching the technology too greatly. It also seems a good contender for Grid networking as it offers the ability to schedule time slots, associating them with particular applications. OBS projects are represented in the last EU research Framework-as represented by the STOLAS project, and in a number of national projects. The STOLAS project, currently running, looks at label switched networks and how best to implement the functions of routing, monitoring and control. Key components and subsystems being developed here are label-controlled cross-connect/routers, edge routers [where the burst/packets are assembled] and OADMs. The STOLAS project aims to improve the throughput of packet-switched networks by novel optical routing techniques based on stacked optical labels.

STOLAS' specific objectives are:

- To assess the networking possibilities of optical label switching theoretically
- To demonstrate high-speed modulation and fast wavelength switching of widely tuneable lasers
- To develop multi-channel 2R regenerators in a hybrid technology
- To develop optical-label-controlled cross-connect and add/drop nodes
- To study monitoring and control aspects of optical label-routed networks
- To build a limited network testbed and to validate the key system functionality
- To contribute to standardisation processes

#### A1.4.2.1.3 FP5 IST Fashion

A number of projects [funded by EU and National Governments] continue to focus on very high speed transmission. The general objective of the FASHION project is to assess the techno-economical potential of optical time-domain multiplexing (OTDM) in high speed flexible optical networks. OTDM point-to-point transmission and time-domain routing will be investigated for single-channel data rates of 160 Gbits/s and higher. The transmission reach is planned to be extended to 500-1000 kms allowing wide all-optical networks. Supported by the analysis of physical system limitations, network concepts including economical considerations will be developed for mixed wavelength-division multiplexed (WDM) and OTDM multi-terabit systems. Time-domain add-drop multiplexers will be developed including an assessment of their impact on the transmission performance. System operation and capabilities will be evaluated in both laboratory and field experiments. For realistic networking applications, particular emphasis will be put on compact and reliable modules by exploiting and enforcing advances in component technology.

Project FASHION [lead by Siemens] has recently demonstrated a very successful trial at 160 Gbit/s over installed fibre [in the BT UK network]. FASHION implemented an OTDM network comprising 16 x 10 Gbit/s channels; with multiplexers, demultiplexers and OADMS. A possible application of this technology might be in the metro layer, where huge growths in traffic foreseen by the rapid deployment of broadband access makes the technology interesting to consider and evaluate.

#### A1.4.2.1.4 FP5 IST DAVID

The main objective of the project was to propose a packet-over-WDM network solution, including traffic engineering capabilities and network management, and covering the entire area from MAN to WAN. The project will utilise optics as well as electronics in order to find the optimum mix of technologies for future very-high-capacity networks. On the metro side the project will focus on a MAC protocol for optical MANs. The WAN is a multilayered architecture-employing packet switched domains containing electrical and optical packet switches as well as wavelength-routed domains. The network control system is derived from the concepts underlying MPLS and ensures a unified control structure, covering both MAN and WAN. The project is now completed.

#### A1.4.2.1.5 FP6 NOBEL

Next generation Optical network for Broadband European Leadership (NOBEL) is an Next generation Optical network for Broadband European Leadership (NOBEL) is an Integrated Project (IP) in the 6th Framework Programme. The NOBEL project runs for two years starting in January 2004. The NOBEL consortium consists of 32 industrial and academic partners and is lead by Telecom Italia.

The main goal of the IST Integrated Project NOBEL is to find and to validate experimentally innovative network solutions and technologies for intelligent and flexible optical networks, thereby enabling broadband services for all. Specifically, the main objectives of NOBEL are:

- to define network architectures, evolutionary guidelines and a roadmap for core and metro optical transport networks towards intelligent data centric solutions (based on optical and electrical switching, e.g. ASON/GMPLS);
- to identify main drivers for the evolution of core and metro optical networks supporting end-to-end broadband services, and to derive technical requirements in accordance to this;
- to study efficient traffic/network engineering and resilience strategies in multi-layer/domain/service networks and interworking issues;
- to assess and describe social and techno-economic aspects regarding the deployment of network solutions and technologies for intelligent and flexible optical networks;
- to evaluate solutions for providing end-to-end Quality of Service;
- to identify network architectures, concepts and solutions for advanced packet/burst switching;
- to propose simplified strategies for the end-to-end management and control of intra/inter-domain connections in multi-layers networks (e.g. IP over Optics);
- to find enhanced solutions and technologies for physical transmission in transparent optical networks;
- to identify the key functional requirements from the architectural, management, control and transmission viewpoints and translate them into specifications, feasibility studies and prototype realizations for multi-service/multi-layer nodes with flexible client and adaptable transport interfaces;
- to assess existing technologies, components and subsystems in terms of efficiency and cost-effectiveness, deriving requirements and specifications for next generation components and subsystems, with respect to the network solutions identified;
- to integrate the prototype solutions of for multi-service/multi-layer nodes into existing test beds for experiments on advanced functionality.

#### A1.4.2.1.6 FP6 LASAGNE

All-optical LABEL-SwApping employing optical logic Gates in NETwork nodes (LASAGNE) is a Specific Target Research Project (STREP) in the 6th Framework Programme. The LASAGNE project runs for three years starting in January 2004. The LASAGNE consortium consists of 10 academic and industrial partners and is lead by Universidad Polit cnica de Valencia.

The LASAGNE project aims at studying, developing and testing All-Optical Label Swapping (AOLS) techniques. Similarly as the FP5 projects STOLAS, DAVID and LABELS, the subject of the LASAGNE project will be Optical Packet Switching (OPS)/Optical Burst Switching (OBS) networks. However, the main difference is that in those FP5 projects the header is still processed electronically – while the payload is switched all-optically –, whereas in the LASAGNE project also the header will be processed all-optically. The main objectives of the LASAGNE project are:

- Designing and realising new optical logic gate architectures to implement all-optical label-swapping and packet routing functionality in network nodes. To implement the necessary intelligence the LASAGNE project intends to design and realise optical gates integrating commercially available subsystems such as Mach-Zehnder interferometers (MZIs) incorporating semiconductor optical amplifiers (SOAs).
- Demonstration of an all-optical routing node capable of managing high-speed labelled packets. The basic functionality of this node to be demonstrated are: label extraction, label erasure, label comparison, wavelength conversion, label generation and insertion
- Studying optical networking aspects of AOLS and disaster recovery strategies, in accordance with the definition of the architecture of the AOLS node. Not only technical but also economical implications of the proposed AOLS node structure will be investigated in these network studies.

#### A1.4.2.1.7 FP6 e-Photon ONE

This European Framework Program 6 Network of Excellence (NoE) aims at integrating and focusing the rich know-how available in Europe on optical communication and networks, both in universities and in research

centres of major telecom manufacturers and operators. The set of available expertise ranges from optical technologies, to networking devices, to network architectures and protocols, to the new services fostered by photonic technologies. The NoE will contribute to the Strategic Objective “Broadband for All”, with a particular focus on “low cost access equipment”, on “new concepts for network management, control and protocols”, and on “increasing bandwidth capacity in the access network as well in the underlying optical core/metro network (including in particular optical burst and packet switching)”. The main technical focus of the NoE is to show which are the potential advantages of optical technologies in telecom networks with respect to electronic technologies. A strong integration among the participants to the NoE will favour a consensus on the engineering choices towards the deployment of cost-effective optical technologies in networking that will support the future Internet, hopefully providing inputs to the standardisation bodies and guidelines to the operators, as well as competitive advantages to European telecom equipment manufacturers

#### *A1.4.2.2 National Projects*

##### *A1.4.2.2.1 OPSNET Project*

EPSRC funded project in collaboration with University of Cambridge and University of Strathclyde. The OPSnet project researches optical packet switching, in particular building upon the results obtained from the earlier EPSRC (Engineering and Physical Sciences Research Council UK) project WASPNET, which demonstrated a prototype switch within a network environment. As many of the networking issues facing the development of an optical backbone layer have come into focus during the past year, a clearer idea of the functions and performance needed from optical packet switching are starting to emerge. For example new technologies and technical approaches are required to enable operation at 40 Gbit/s, with scalability to >100 Gbit/s. The networking issues associated with the integration of the optical backbone layer and the IP layer require effective solutions. Fundamental choices between synchronous and asynchronous packet operation have to be made, which have major impacts on the hardware solutions. Expected outcomes are concerned with understanding:

- the relative merits of asynchronous and synchronous packet operation, and the impact of asynchronous operation on switch and network performance.
- the impact of data traffic statistics on switch design
- the design of an asynchronous optical packet switch for 40 Gbit/s operation
- a network demonstrator supporting an end-to-end connection across the electronic and optical domains will support these activities.

A number of industrial partners are associated with this proposal namely; BT Laboratories Fujitsu Telecommunications and Marconi Communications

##### *A1.4.2.2.2 MultiTeraNet*

The MultiTeraNet program is the major national German research initiative on optical communication technologies in Germany. It was launched in June 2002 and will be finished in September 2006. 14 companies, 3 Fraunhofer institutes and 9 universities are participating in the research program. The total volume is about 50 million Euro, with public funding of about 60%.

Part of the research activities are devoted to the wide area core network.

The 39 projects of the MultiTeraNet program are divided in for main research areas.

- Flexible optical networks
- Usage of fibre capacity
- Access network technologies
- Key components

In the “flexible optical network” projects cluster the main objectives are modelling and design of optical and optoelectronic transport networks and also laboratory experiments and field trials. Projects in the fibre usage projects cluster will be working on e.g. increase of spectral efficiency, adaptive impairment compensation techniques, and new modulation techniques.

These two thematic areas and the “key components” project cluster will develop advanced solutions for the core and metro networks

### ***A1.4.3 Most important standards for Metro / CWDM networking / Backbone***

#### **ITU-T<sup>64</sup>**

- CCITT G707 (03/96) standard defining SDH protocols
- G.695 **Optical interfaces for coarse wavelength division multiplexing applications** This Recommendation provides optical parameter values for physical layer interfaces of coarse wavelength division multiplexing (CWDM) applications with up to 16 channels and up to 2.5 Gbit/s. Applications are defined using two different methods, one using multichannel interface parameters and the other using single channel interface parameters. Both unidirectional and bidirectional applications are specified.
- G.694.1: **Spectral grids for WDM applications: DWDM frequency grid**
- G.694.2 **Spectral grids for WDM applications: CWDM wavelength grid** This Recommendation provides the wavelength grid for coarse wavelength division multiplexing (CWDM) applications. This wavelength grid supports a channel spacing of 20 nm. The wavelength grid in this version of this Recommendation has been moved by 1 nm to align it with current industry practice while maintaining symmetrical nominal central wavelength deviations.
- G.7042 / Y.1305 **Link capacity adjustment scheme (LCAS) for virtual concatenated signals** This Recommendation specifies a methodology for dynamically and hitlessly change (i.e. increase and decrease) the capacity of a container that is transported in a generic transport network (e.g. over SDH or OTN network using Virtual Concatenation). In addition, the methodology also provides survivability capabilities, automatically decreasing the capacity if a member experiences a failure in the network, and increasing the capacity when the network fault is repaired.
- G.7041 / Y.1303 / **Generic Framing Procedure (GFP)** This Recommendation specifies interface mapping and equipment functions for carrying packet oriented payloads including IP/PPP, Ethernet, Fibre Channel, and ESCON (Enterprise Systems Connection) payloads over optical and other transport networks. This recommendation, together with ITU-T Recommendation G.709 on Interfaces for Optical transport networks provide the full set of mappings necessary to carry IP traffic over DWDM systems.
- G.707 / 2000 / **Virtual Concatenation (VCX)** VCX enables several individual standard SPEs to be combined to form a single higher capacity link. VCX allows a more dynamic bandwidth provisioning in SDH/SONET networks.
- G. 871 **Framework of Optical Transport Network Recommendations**
- G.872 (1999), **Architecture of optical transport networks;**
- G.8010-8012 & G.8021: **Draft Rec. Ethernet over Transport Network Architecture (ETNA)** ([http://www.itu.int/newsarchive/press\\_releases/2004/15.html](http://www.itu.int/newsarchive/press_releases/2004/15.html))
- G.8080, **Architecture for the Automatic Switched Optical Network (ASON)**”;
- SG13 **“Multi-protocol and IP-based networks and their interworking”**
- G.807, **“Requirements for the Automatic Switched Transport Network (ASTN)”**
- G.709 **“Interfaces for the optical transport network (OTN)”**

#### **IEEE**

- IEEE 802 LAN/MAN Standard Committee<sup>65</sup>
- IEEE 802.3 CSMA/CD (Ethernet)<sup>66</sup>
- IEEE standard defining the 10 Gigabit Ethernet (10GbE)
- IEEE 802.17/ Resilient Packet Ring<sup>67</sup>  
Support for dual counter rotating ring topology  
Full compatibility with IEEE 802 architecture as well as 802.1D, 802.1Q and 802.1f  
Protection mechanism with sub 50 ms fail-over  
Destination stripping of packets  
QoS differentiation (MAC protocol, different priority queues)  
Adoption of existing physical layer medium (SONET/SDH)

#### **xfpmsa 2004**

XPF multi-source agreement for small form factor pluggable optical transceiver<sup>68</sup>

<sup>64</sup> <http://www.itu.int/>

<sup>65</sup> <http://www.ieee802.org/>

<sup>66</sup> <http://www.ieee802.org/3/>

<sup>67</sup> <http://www.ieee802.org/17/>

#### ***A1.4.4 Grid Projects***

There are several groups working on grid development. Some of the more notable ones are:

- Grid Computing and Distributed Systems (GRIDS) Laboratory at the University of Melbourne developing the Gridbus project. All the elements required as described above are at some release status, and they have also developed a tool for modelling global grid operation
- Globus Alliance, a community of organisations and individuals who have released a toolkit for building grid systems and applications. The collaborators are primarily at European and American organisations. Coregrid, is a network of excellence funded by the EC under the 6<sup>th</sup> Framework program. It started in Sept 2004 and is due to last 4 years. The program of activities is based around 6 complementary research areas:
  - knowledge & data management;
  - programming models;
  - system architecture;
  - Grid information and monitoring services;
  - resource management and scheduling;
  - problem solving environments, tools and GRID systems.

Similarly there are several groups trying to organise large grid networks. These include:

- The Global Data-Intensive Grid Collaboration organised by the GRIDS laboratory. This is intended to demonstrate achievement of the two originating HPC challenges “Most Data-Intensive and Geographically Distributed Applications”.
- Teragrid<sup>69</sup> launched by the National Science Foundation in the US with multiple supercomputing sites connected. The components are linked by a 40Gbit/s network and can provide 20 Teraflops of processing power and over 1 Petabyte of storage. Stated applications for the Teragrid include:
  - the study of drug interactions with cancer cells, to thereby develop better cancer drugs
  - the study the human genome and how the brain works,
  - the analysis of weather data so quickly that they will be able to create real-time weather forecasts that can predict down to the kilometer where a tornado or other severe storm is likely to hit.
  - the design of better aircraft by allowing realistic simulations of new designs
  - the understanding the properties of our universe and how it formed.
- The Large Hadron Collider Computing grid (LCG). This is being built to deal with the anticipated computing needs of the Large Hadron Collider under construction at CERN. It includes more than 100 sites in 31 countries which contribute >10,000 CPUs and nearly 10,000,000 Gbytes of storage. The group claim this is the largest international scientific grid and they are achieving record breaking results for high speed data transfer. However the current processing capacity of this Grid is estimated to be just 5% of the long-term needs of the Large Hadron Collider. Therefore, the LCG will continue to grow rapidly.

Of these grids the first is the closest approximation of a flexible grid as described in the introduction. The other two examples are primarily under administrative control of one body for defined applications.

#### ***A1.4.5 Security***

##### ***A1.4.5.1 FP6 projects involved in security***

There are 15 projects active in the FP6 framework addressing the security issues. These being: BIOSEC, e-JUSTICE, INSPIRED, PRIME, SECOQC, SEINIT, ECRYPT, FIDIS, BioSecure, Digital Passport, MEDSI, POSITIF, SCARD, SECURE JUSTICE, SECURE PHONE. The details of the projects can be seen at their respective websites (available at [http://www.cordis.lu/ist/directorate\\_d/trust-security/projects.htm](http://www.cordis.lu/ist/directorate_d/trust-security/projects.htm)).

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<sup>68</sup> <http://www.xfpmsa.org>

<sup>69</sup> Strictly speaking the defined nature of the resources and their ownership by a collaborating group means that Teragrid should be considered a cluster network, rather than a grid network using definitions available in the literature.