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Abstract:

This document is the second deliverable of the WP23 “Topical Project on Optical communication networks in support of user mobility and Networks in Motion”. This report gives an overview of the WP23 activities during the first year of this topical project and the plans for the second year. During the first year of this topical project, six joint activities have been discussed. Details on the progress and plans for these activities are presented. Two (2) conference/workshop papers and one book under preparation are the dissemination outcome of these joint activities.

Keyword list:

Hybrid optical/wireless networks, optical networks for user mobility, Networks in Motion



Disclaimer

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2. Executive Summary

This document is the second deliverable of the topical project (TP) “Topical Project on Optical communication networks in support of user mobility and Networks in Motion”. This deliverable aims to provide the results and outcomes of the running joint activities (JAs) as well as to present the activities that are planned for the coming year. In total, 6 JAs are active in the framework of WP23. The current state and future plans of these JAs is presented.

3. Introduction

Playing the role of a Network of Excellence, the BONE project has brought together over several years of research activities in Europe in the field of Optical Networks and it intends to repeat and validate this effort by stimulating a more intensified collaboration, exchange of researchers and building on its centralized activities, Topical Projects (TP), and Virtual Centres of Excellence (VCE) that can serve to European industry with education and training, research tools and test-beds and eventually pave the way toward new technologies and architectures.

This work package, identified as a TP on ***Optical Communication Networks in Support of user mobility and Networks in Motions***, combines a large number of partners currently working on various research fields interoperable to each other.

3.1.1 TP Objectives

Within the next few years, networks in motion will play a central role in the people's lives, worldwide. An upcoming networking concept is emerging based mainly on the requirements of mobile working groups of people of various societal sectors that demand ubiquitous connectivity. The individual subscribers themselves will increasingly carry around their own short-range personal network which is constituted when networked personal devices interconnect and create a Personal Area Network (PAN).

Many groups of users exist who follow a slowly or a fast mobility pattern and therefore access on mobile vehicles (car, train, airplane) or just to people moving on foot becomes a necessity. The moving networks often need to communicate with each other or the outside world, resulting in a unique new form of network namely the "*network in motion*". Thus the surrounding infrastructure needs to be able to support a large amount of personal network connections. For such new application scenarios, it is critical that the next generation of networks employs intelligent components and devices that in a way sense the user needs and are able to provide guaranteed content delivery in an efficient and secure manner (while providing the privacy of the communication).

For such a system to run successfully, intensive research must be done. Particularly, the use of optical network solutions in the aggregation and core part of the network is essential and requires extensive research in the both the networking and technology areas.

The planned effort in this work package will be divided in three main activities according to the identified objectives, which will run in parallel for the duration of the project. The first activity is ***technology oriented*** and will focus on the investigation and development of novel approaches able to support networks of wireless users that require rapid handover characteristics and high bandwidth connectivity. The second activity focuses on the ***aggregation network*** that supports the wireless users and specifically on switching solutions with rapid reconfiguration characteristics. The third activity is ***network and control layer*** oriented and will study new MAC, routing and signalling protocols to support the characteristics of networks in motion.

The three activities cover research areas that can be initially developed independently but under the same general focus as this will be defined by the properties of networks in motion. Therefore, first, it is important to define a common knowledge platform about the possible solutions and the properties of these novel network approaches that support seamless connectivity of various wireless users in a rapidly reconfigurable environment. The purpose of this knowledge platform will be:

- *To provide the basic requirements and characteristics that novel technology and networking solutions should target in.*
- *To identify the limitations and challenges that require a possible solution and consequently push technology and networking towards these directions.*

Finally it is of interest in this work package to join together efforts that could possibly evaluate or even demonstrate complete solutions in support of the objectives.

More specifically this topical project is focusing on providing collaborative research towards three main directions identified in the following objectives:



- *To perform studies on intelligent technologies and design challenges for wireless access in networks in motion (e.g. based on radio over fibre (RoF), free-space optics (FSO), or conventional wireless solutions with optical fibre feed)*
- *To perform studies on networking properties and switching characteristics for the aggregation and core networks in support of networks in motion (e.g. Switched Ethernet based solutions or advance schemes like OBS/OPS),*
- *Development of control plane and signalling algorithms and protocols for networks in motion (e.g. MAC layer design or network layer approaches with QoS quarantines, resource reservation approaches etc.*

3.1.2 Deliverable goals

The main goal of this deliverable is to report the results and outcome of the performed activities within the framework of this TP and also to report the activities that are planned for the remaining time of this TP.

4. Participants

This section covers the interested partners and participants in this TP (WP23). According to the Annex I (Description of Work), there are (16) partners in total, which are collaborating in this WP. Besides, there are also some additional interested partners, who will collaborate in joint research activities. Table 1 (in alphabetic order of partners' short name) provides a list of participant and the code of joint activity(ies), in which they are involved. A detailed description of these joint activities is provided in the next section.

Table 1: Participating partners in joint activities of WP23

Partner Number	Short Name	PM Allocation	Joint Activity Code
P19	AIT	3.5	2, 3, 4, 5, 6
P08	COM	0.5	-
P49	Ericsson	0.5	1
P04	FRAUNHOFER	1.5	-
P01	IBBT	0.5	-
P20	ICCS/NTUA	1.0	-
P28	ISCOM	0.5	2
P37	IT	0.5	2
P30	POLITO	0.5	-
P35	TELENOR	1.0	-
P05	TUB	0.5	-
P36	TUE	0.5	5,6
P11	UAM	-	5,6
P45	UCAM	1.5	-
P46	UCL	-	3
P06	UDE	1.00	1
P47	UEssex	0.75	-
<i>Affiliate Partner</i>	<i>UH</i>	-	3
P15	UPVLC	0.5	4

5. Joint Activities

Based on common interests of partners the following joint activities were planned within this TP. Given the inventory of expertise, which is also circulated among the partners, it is possible to have more joint activities during the next year of this TP. The table of research topics is periodically circulated among the interested partners to make new collaborations/integrations possible. Table 2 contains the key information regarding the Joint Activities that are planned so far. In addition to the current planned activities, and given the inventory of partner expertise, it is possible for all participants in this TP (WP23) to plan other new activities during the term of this topical project. As it is shown in the following table, 6 joint activities with 3 mobility actions have been planned for this work package. These joint activities span till the end of the second year of this TP.

No.	JA Title	Contact Person	Participants	Mobility Action	Deadline
1	Hardware implications issues for networks in motion	Rebecca Chandy (rebeccachandy@gmail.com)	Ericsson, UDE	Yes	M36
2	State of the art definition for components supporting FSO networks in motion	Antonio Teixeira (Teixeria@ua.pt) Giorgio Maria Tosi Beleffi (giorgio.tosibeleffi@sviluppoeconomico.gov.it) Silvia Di Bartolo Gabriele Incerti	IT, ISCOM, AIT		M36
3	Converged MAC algorithms for unified optical wireless functionality	Pandelis Kourtessis (p.kourtessis@herts.ac.uk), Milos Milosavljevic (m.milosavljevic@herts.ac.uk)	UH, UCL, AIT		M36
4	UWB Radio-over-fibre transmission in indoor environments using different media	Roberto Llorente (rllorent@dcom.upv.es)	UPVLC, AIT	Yes	M24
5	Optimizing service delivery in a converged hybrid optical-wireless network	Bas Huiszoon (bas.huiszoon@uam.es), Ioannis Tomkos (itom@ait.edu.gr), Christos Tsekrekos (tsek@ait.edu.gr) Ton Koonen (a.m.j.koonen@tue.nl)	UAM, TUE, AIT	Yes	M36
6	All-optical Routing Architecture of Radio Signals using Label Processing Technique for In-building Optical Networks	Ton Koonen (a.m.j.koonen@tue.nl), Bas Huiszoon (bas.huiszoon@uam.es), Ioannis Tomkos (itom@ait.edu.gr)	TUE, UAM, AIT		M36

Table 2: Summary list of the planned joint activities



5.1 *Hardware implications issues for Networks in motion {Ericsson, UDE}*

5.1.1 *Motivation and objectives*

This JA will study reliability of components and hardware implications issues for networks in motion with respect to sensor applications.

5.1.2 *Main outcomes and results*

The expected outcome concerns theoretical and experimental work on improved design and reliability of hardware for networks in motion. Three telephone conferences have taken place between UDE and Ericsson in March, June and End of October 2009, respectively, organizing the mobility actions that are planned to take place in early 2010.

5.1.3 *Next steps*

The next steps within this JA are soon expected to be described.

5.2 *State of the art definition for components supporting FSO networks in motion {IT, ISCOM}*

5.2.1 *Motivation and objectives*

In the last decades, many new technologies have been proposed and discussed to solve the last mile bottleneck of telecommunication networks. Thanks to its high bandwidth, free-space optics (FSO) represent a good candidate for short reach, hundreds of meters, connection becoming an alternative solution to fibre based and/or existing RF network-user interfaces. Taking care of the atmospheric conditions and carefully controlling the beam misalignments, FSO could be suitable to temporary high data communications in motion network scenarios [1].

The main advantages of FSO are the bandwidth connectivity, in the order of Gb/s, the immunity to electromagnetic interference and the intrinsic security (difficult interception); for these reasons FSO is a widely used technology in military operations, as surveillance, or civil missions, as monitoring in disaster recovery scenarios.

As it is well known, atmospheric conditions can heavy impair the QoS in such transmissions for two more important reasons:

- Fog: due to its comparable size with the adopted wavelengths, there is a great induced laser beam scattering that introduces an optical attenuation ranging from 30dB/km up to 300dB/km (sea fog).
- Scintillation: small fluctuations of the atmosphere refractive index induce a signal fading at the receiver.

The rain, instead, is not a problem as for microwave links, because of the bigger dimension of raindrops (few mm) in comparison to the wavelength of optical signal [2]. Last but not least, the need of a line of sight (LOS) connection, between the two terminals, Tx/Rx, involved in the communication link. As a consequence, pointing, acquisition and tracking (PAT) operations are needed.

The different impact of weather conditions on FSO as well as on RF links creates the possibility to generate hybrid systems able to guarantee the maximum service availability.

A generic FSO system, as reported in Figure 1, is simply composed, on the transmitter side, by a light source and a collimating lens; on the receiver side, it is necessary a lens and a photodiode (Figure 1).

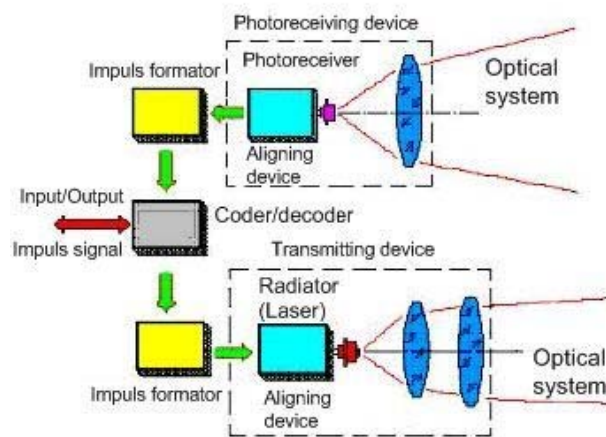


Figure 1. FSO system components [5]

It can be outlined that both a coarse alignment, pointing operation, and a fine alignment, acquisition phase, are strictly needed. Tracking operation is necessary to maintain the two systems aligned [3]. In a stationary case, in which both terminals are fixed, after a first set up of the optical link a tracking is not needed. When only a station is mobile and the other one is fixed, pointing, acquisition, and tracking (PAT) are already simplified, because information of fixed terminal position can be used by mobile terminal for a pre-determined tracking function. If both terminals are in motion, PAT operations are done repeatedly [4]. Wireless communications, in motion scenarios, present different challenges to be solved, which will be analyzed in the following subsection.

5.2.2 Main outcomes and results

ISCOM and IT carried out an exercise analyzing all the aspects of FSO interlinks in nomadic or mobile situations. The report covers mobile FSO terrestrial applications, airborne communications, Space Communications, Mobile FSO Maritime applications. We also report that in the framework of BONE and in collaboration with, COST ICO802 and WP13 on access, we are going through the publication of an on-line book by Intech on FSO technologies.

A. Mobile FSO terrestrial application

In wireless optical mobile communications, the main critical point is represented by PAT due to runtime change in the alignment and distance of two linked terminals. Distance influences many aspects of the RX design such as, for instance, receiver area or power level at the receiver [1]. It is possible to realize manual or automatic systems for PAT. Human operator simplifies PAT systems but in mobile scenario it is difficult to accomplish for fine alignment and tracking towards the other terminal manually due to fast acceleration and direction changes. It is possible to decide for a partial automation in which pointing is realized by human or a complete automation with sensors able to calculate position and orientation of the other terminal.

Pointing error has different sources: atmospheric turbulences that degrade optical signal quality and/or used hardware in terms of delay or inaccuracies, error information on terminal position and/or orientation. Accuracy position information depends on the quality of sensor, update rate and loss of information especially in fast mobile context [4]. In active FSO, the two principal applications are airborne and ground-space applications.

B. Airborne communication

Surveillance in military context or monitoring for civil aims are often realized using Unmanned Aerial Vehicles (UAV). UAV fly in a lower altitude than High Altitude Platform (HAP); the possibility to use them in a swarm configuration gives the chance to serve a wide area and to be robust against system failures. In swarm scenario, UAVs have to be connected at high data rate. As said, PAT operations are necessary to maintain alive

the connection between terminals. So it is necessary to know pitch, roll and yaw angle (Figure 2) of each UAV and the velocity between the UAVs.

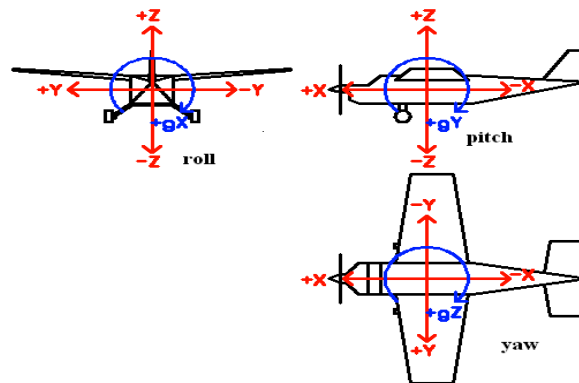


Figure 2. Position and orientation of UAV [6].

Flight behavior generates pointing uncertainties and some problems based on the vehicle vibrations. NASA/JPL Telecommunication and Mission Operations developed, for example, an Angular Vibration Test Fixture (AVTF) with three sensors, three accelerometers and a temperature sensor [3]. To realize an automatic PAT operation it is necessary to incorporate some reflective motorized components in the transceiver system. As shown in Figure 3, transmitter laser direction is controlled through the motor rotation angles of the mirror 1. This operation put laser beam in the direction of the receiver. To perform a fine alignment on the optical axis receiver, a second motored mirror is necessary. In the end, some sensing components are inserted in the system to calculate and correctly control mirror angle adjustments.

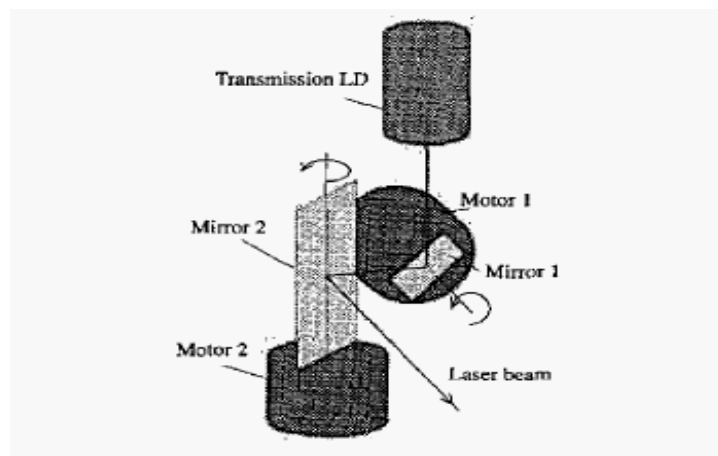


Figure 3. Figure 3. Active transmitter [7].

C. Space Communications

In space communications, optical wireless technology was implemented in ground-space or space-space up to simulating planet to planet scenarios. It was used in inter-satellite communications to realize high capacity extremely long transmissions. There is no atmosphere degradation or physical obstacle in optical channel, but the long distance to cover creates the need to use high power laser with small divergence angle to provide high energy density. To point laser beam with μrad precision on millions of kilometers becomes very difficult.

In space contest, flight behavior is influenced by space environment too, as radiation and vacuum. But the main obstacle is traveling through atmospheric turbulence [8].



D. Mobile FSO maritime applications

As previously mentioned, with respect to the static FSO system case, mobile systems require continuous update regarding the position of the mobile station in a permanent way. In order to maintain the connection between two ships, this can be done by using, other than the data wavelength transmitted, RF signals which can be used to transmit in broadcasting the actual position of each ship. The critical point for RF solution is that this kind of frequency is easy to discover, thus also the position of the ship can be easily detected.

Another aspect of the optical termination is the pointing, acquisition and tracking (PAT) between the optical heads; these operations cannot be fully manual because acceleration and direction of ships change. An automated mobile terminal is able to operate without human interaction using sensors to detect the position of the ship, its acceleration and its movements. Also the update rate data position exchange becomes important in order to better predict the future status of the ship, especially if the ships are in a fast moving contest.

An example of real maritime scenario [9] considers as distance between two ships, a variable length from 1 up to 25 km. Thus the system must be able to maintain the connection during the movement of the ships. A 1.5 Gb/s signal over a system characterized by an accuracy of 0.1 mrad with a probability of 95% has been demonstrated.

In the maritime scenario, the ship length must be considered too. This is because the beacon laser must be able to illuminate in case all the ship that can reach the length of 330 m. To cover all the ship length, at a distance of 25 km from the laser source, the beacon laser will have a divergence of 13.2 mrad plus 17.5 mrad considering the azimuthal error in radar measurements. Besides, the ship velocity can be assumed (as medium value) equal to 33 knots (about 60 km/h) inducing a maximum pointing error of 5.3 mrad considering a distance between two ships of 25 km. Using filtering techniques like, for example, Kalman filtering, it is possible to predict the future position of the ship considering its movement; thus the pointing error will result minimum.

Another problem regarding the laser used for pointing and information exchanges is the power emitted. In fact, the value of the laser divergence obtained above of 30.7 mrad (13.2 mrad + 17.5 mrad) is the minimum divergence for the beacon laser and this value has a fast increase with the short distance. Instead of using dangerous high power lasers, it is preferable to use a zoom-optic system. Generally, different wavelengths are used for transmitters and for receivers because if the same wavelength is used for both operations, the optical head could be blind due to reflections and scattering.

Often, the electronic antennas used for the data transmission are placed on a tower near or on the top of the ship bridge. This place is selected because can be easily reached by a human operator or by an automatic camera called Wide Field of View (WFOV). Most of the ship is below the tower, including the crew, thus do not exist part of the boat that interfere with the laser beacon. In marine scenario, several parameters must be considered; regarding the laser propagation over the water, it can be assumed that the local refractivity field within the atmospheric surface is horizontally homogeneous. The other parameter that can change the performances of the laser beam and then the features of the FSO system is the vertical temperature profile. This profile can change very fast over the sea surface, but generally, over the sea is more stable with respect to the rural scenario. Scattering and absorption represent the greater impairments in marine scenarios by means of the presence of marine aerosol, whose concentration depends on the wind speed. The aerosol, especially if the optical head is near the sea level, offers a great attenuation to the propagating optical beam. This is another reason that obliges to place the optical termination not lower than 10 m. Normally for this kind of set-up, the environment offer an attenuation of 0.2 dB/km at 1550 nm but in case of presence of relative humidity or sea salt the attenuation is about 0.8 dB/km and in case of fog or dense fog the optical beam is dramatically attenuated. Anyway, apart from the extreme or particular situation like fog or heavy rain, it is possible to assume 1 dB/km as attenuation offered by aerosol, absorption and scattering. At this kind of losses we must add the losses offered by the pointing, with a value around 3 dB.

Besides, the transmitted signal that travels along a horizontal sea surface, will encounter some perturbations and some fluctuations in its intensity and phase mainly due to wind speed and ASTD (Air to Sea Temperature Difference).

A different kind of maritime FSO application is the undersea scenario where FSO technique is used to transport information from fixed or mobile sea platforms to other stations without deploying any optical cable. Using a particular wavelength it is possible to convey the optical signals under sea level for small distances (around 100 m) using transmission rate around 10 Mb/s. The disadvantage of the undersea link is that the sea offers an attenuation and absorption greater than the values offered by the air. Submarine Laser Communications



(SLC) exploiting FSO technique is used to achieve high data rate transmissions also in case of emergency between two platforms or between a sea platform and an airborne system. SLC is used for communication with deeply submerged submarine using an optical head with a laser source placed at a particular wavelength. Green or blue wavelengths are used, placing the optical radiation in the visible spectrum.

For undersea applications, the adopted lasers can be for example based on Xenon Chloride (XeCl) technology shifted in the visible band. Each submarine receiver has an ad-hoc detector able to capture the optical laser beam. The performance of undersea laser link is under study and also aircraft to submarine transmission system has been tested. An aircraft flying at 40.000 feet was connected with a submarine using a double wavelength: blue wavelength for uplink and green wavelength for downlink stream.

5.2.3 Next steps

Next activities, such as possible new publications, book publications, collection of material, will be carried out in conjunction with the new agreement set between BONE and COST ICO802 and in collaboration with WP13 on Access Networks, WP02 on Teaching and WP01 on dissemination.

5.3 Converged MAC algorithms for unified optical wireless functionality {UH}

5.3.1 Motivation and objectives

The motivation behind the research and development of integrated wireless-optical networks becomes evident when considering the multifaceted advantages of such a solution for broadband access. The interoperability of wireless terminations and optical network termination units offers the flexibility and robustness, inherent in wireless access technologies. Such flexibility pertains to user mobility, users' peer communication, and multi-hopping capability, while the robustness can be introduced by implementing wireless mesh topologies, in which the users can be served through a multitude of paths. Further converged architectures offer the high capacity and dynamic bandwidth allocation schemes offered by next generation optical networking schemes. This offers significant advantages in the load-balancing issue, since dynamic ONU selection schemes can monitor the network status and offer solutions in congestion problems on-the-fly.

The combination of these traits renders the overall architecture more self-sustained, since the effective integration of flexible resource allocation, multi-path wireless access and sophisticated broadband media delivery protocols in the network layer creates a more sophisticated platform that minimizes the necessity for monitoring and corrective interventions. The cost effectiveness of such schemes creates new opportunities for service and network providers, since futuristic services can be provided over a more reconfigurable, easily deployable and profitable networking framework.

Towards the technical evolution of wireless-optical access networks, this joined activity presents important solutions to problems relating to this direction. QoS by means of service differentiation, service level agreement and buffer queuing status for individual subscribers is in the focus by seeking the development of dynamic bandwidth and wavelength allocation algorithms in a new MAC suite that would allow centralised management of ONU requirements on demand in addition to extended time frames associated with resource assignment and packet propagation.

The following objectives have been identified to measure this joint activity's scientific achievements:

1. Network Planning and Processing Management for Integrated Wireless-Optical Networks

This first objective will investigate primarily the MAC layer requirements (e.g. efficient distribution of bandwidth resources and end-to-end service delivery). In addition, network dimensioning studies will be performed resulting in detailed specifications regarding the network capacity and reach, number of served users, maximum guaranteed bandwidth per user etc. The basic outcomes are expected to provide network requirements with respect to the convergence of existing PON technologies like GPONs or EPONs, their possible updates (e.g. 10G GPON) and the originally proposed wired/wireless advanced PONs.

2. *Novel Dynamic Bandwidth Allocation Schemes*

This objective aims at developing and demonstrating a dynamic MAC protocol suite for legacy and radio-enabled PON link spans that would enable extended wavelength band overlay integration of mobile end-users. The protocol development would initially include bandwidth to wavelength scalability in view of novel algorithms, extensively accounting for wireless functionality to increase the MAC efficiency for legacy and radio ONUs.

3. *Innovative Routing protocols adapted to Hybrid Networking*

Issues pertaining to routing protocols that will be designed and deployed over the proposed hybrid network are of major importance to the success of the overall venture. The expected research outcome in regard to the specific topic relates to the design of novel strategies able to cope with the idiosyncrasies of such topologies, e.g. the asymmetric nature of both the optical backhaul and the wireless mesh topology, the dynamic and unpredictable nature of the wireless medium. Furthermore application awareness should be looked at to enhance QoS support through a cross-layer approach, in which routing decisions will take into consideration the type of traffic that needs to be routed. Our approaches will be compared with state-of-the-art routing mechanisms for optical networks, wireless mesh topologies and hybrid architectures.

5.3.1.1 *Topology*

Broadband wireless technologies, e.g. WiMAX [10] and Long Term Evolution (LTE) [11], would be employed to supply wireless terminations at selected ONUs. This could be implemented as a fibre termination to basestation (BS) ONUs. The architecture could consist of a legacy PON with novel wireless-enabled OLT and ONUs where the OLT controls the bandwidth allocation for all ONUs centrally. In particular to allow multiple wireless channel propagation in a typical sectorised approach over a legacy PON infrastructure, the wireless channels could be transmitted through the optical fibre after they have been downconverted to baseband NRZ and mapped to typical PON standard services (T-CONT in case of GPON).

In addition, the application of WDM to assign each ONU base station a unique P2P logical connection with the OLT provides the undisputable solution for increased capacity and improved network efficiency. In view of the proposed topology, extended wavelength band overlay [12] could support dynamic reconfiguration of wireless and wireline radio networking with low cost components employed in the OLT and ONU/BSs. This could be achieved by coarse wavelength propagation over the currently deployed splitter-based PONs. Consequently any wavelength in the operating spectrum could be partly or exclusively assigned to different ONU/BSs, providing in the later service level similar to WDM-PONs.

The topology would benefit from a flat control plane and seamless convergence by which signaling and control messages are directly exchanged between the OLT and end users. On-demand bandwidth provisioning to further enhance the wireless users capacity for example can be provided by dynamically distributing traffic over the mesh network. Significantly, the presented topology provides an advanced networking solution in the form of resilience since the application of wireless mesh allows channels from neighboring ONU/BSs to access users in the coverage area of a failing base station.

To that effect the control layer should adhere to service level agreement (SLA) and TCONT differentiation in the case of a GPON for instance. However, the classical DBA schemes employed in GPONs are not suitable for converged GPON and LTE networks for example due to the distinct transmission, bandwidth management methodologies and packet formats. To enable more efficient integration, an effective mapping mechanism is required between GPON priority queues and LTE service connections. Also since multiwavelength operation is in the focus, extra fields should be incorporated to the GPON frame format for each radio ONU during registration. Information such as the “wavelength sharing priority” needs to be included in the report message by adjusting the gate and the report packets used to establish communication between the OLT and ONUs.

5.3.2 Main outcomes and results

Towards the development of algorithms mapping the packets from wireless users to appropriate PON classes, preliminary work should be contacted aiming at providing all the requirements and optimal solutions for the optical backhaul network to efficiently support wireless routing. This is expected to be achieved by defining at a first stage and subsequently enhancing the preferred options at the PON MAC layer.

Dynamic Multi-Wavelength operation (DMW) over PON (GPON, EPON) infrastructures can be applied either by upgrading the existing single-wavelength PON, or by introducing a completely new Dynamic multi-wavelength PON topology and MAC protocol. To that effect a GPON upstream map frame format enhancement has been developed to support DMW operation over splitter-based GPONs, together with an algorithm to manage the bandwidth allocation among the supported wavelengths. OPNET modelling of the performance characteristics of a DMW-GPON Fibre-to-the-Home (FTTH) topology has demonstrated a minimum 100 Mb/s bandwidth provision for each of 32 ONUs with a maximum 0.09 s packet delay for the lower service level agreement (SLA) ONUs.

The application of extended band overlay has been previously demonstrated over a standard GPON topology and has been shown to provide an ideal interim solution for smooth, dynamic and on-demand capacity upgrade [13]. This was achieved by reviewing the upstream and downstream frame format maps and consequently developing a new protocol based on the dynamic bandwidth allocation (DBA) algorithms previously developed for single-wavelength GPONs as explained in [13]. To adapt and extend these algorithms for coarse WDM operation, extra fields were incorporated into the GPON frame format [14]. Both the grant and the report packets used to establish communication between the OLT and ONUs were reconfigured to support dynamic multi-wavelength operation. Out of the twelve bits, in the Flags-field of the GPON upstream map frame format, the six unused reserved bits were utilized by assigning four bits to express the ONU's operating wavelength for proceeding cycles and two bits to specify the packet type, e.g. whether it is a control packet or data packet as shown in Figure. The same bits will be used to provide wireless connectivity over the specified wavelengths in proceeding protocols.

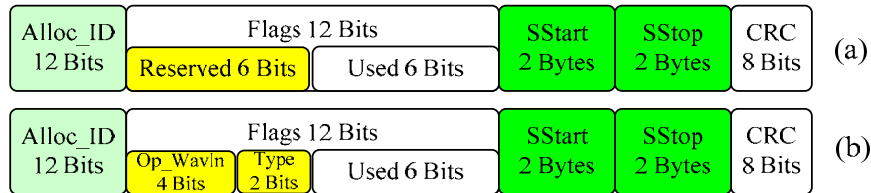


Figure 4. GPON upstream map frame format, (a) Single-wavelength, (b) DMW.

The wavelengths utilised by each ONU for data transfer can be defined during the ONU's registration stage by means of each ONU reporting its supported wavelengths to the OLT [13]. To demonstrate the maximum transmission time-slot utilisation for each operating wavelength and consequently provide reduced packet delay, a scheduling algorithm was developed that prioritises user transmission according to traffic status.

5.3.2.1 The Dynamic Multi-Wavelength Protocol

The aim of the DMW protocol is to increase the upstream bit-rate by introducing dynamic allocation of bandwidth concurrently in the wavelength and time domains. This has been initially achieved by developing the DMB algorithm [15] and modifying the GPON frame format to support multi-wavelength operation. The DMB algorithm facilitates three SLAs to assign each ONU with a guaranteed minimum bandwidth, to satisfy their basic service requirements, plus an additional allocation of extra bandwidth on demand, based on the assigned SLA. In the DMW algorithm presented here, a fourth service level is introduced to comply with modern service level provisioning [16] and to provide greater user experience and network flexibility. In addition, an extra upstream wavelength, bringing the total to five, is introduced with respect to previous DMW developments [13] to scale-up wavelength assignment in view of the ITU-T G.984.5 standard [12].

During ONU registration the OLT puts a request for each ONU to confirm the supported wavelengths. This is crucial to distinguish between different network sectors and bandwidth provision status among ONUs. Consequently, the OLT assigns the upstream bandwidth available in every polling-cycle in three stages. In the first stage, and after having received the requested bandwidth from each ONU, the OLT calculates a safety margin to refine the maximum cycle time for bandwidth allocation independently for each wavelength, allowing for more accurate population of the polling cycles with considerable decrease in idle time slots. The safety margin is determined by considering the overall ONU minimum bandwidth requirement and the ONU SLA contracts. In that manner the OLT allocates ONU bandwidth by means of the individual total network capacity depending on the time and wavelength measures ($BW_{total\ available}$), minus the safety margin as seen in equation (1).

$$BW_{total\ available}(\text{multi - wavelength}) = BW_{total\ network}(\text{multi - wavelength}) - \text{safety margin} \quad (1)$$

The maximum allocated bandwidth for ONU_i ($ONU_{Allocated_BW}$) is then assigned according to the DMB algorithm [14] as seen in equation (2).

$$ONU_{Allocated_BW} = \begin{cases} BW_{ONU_Requested} & \text{if } BW_{total\ requested} < BW_{total\ available} \\ BW_{ONU_Max.allowed} & \text{if } BW_{total\ requested} > BW_{total\ available} \end{cases} \quad (2)$$

After the first stage is completed, the second stage is introduced to manage the network bandwidth allocation process in an more efficient manner by excluding random distribution of ONU traffic among the different wavelengths that in cases could result in exceeding the maximum available cycle-time, as shown in Figure 5. To that extent the OLT specifies the highest ONU allocated bandwidth, positions it at the end of the cycle, expecting to increase the network throughput, and distributes the remaining ONU allocated bandwidths in order from high to low. In the third and last stage, the OLT commences assignment of the ONU time-slots to different wavelengths in sequence, starting by λ_{up0} to reach λ_{up2} . This process allows the OLT to guarantee that the last ONU time-slot in λ_{up2} can fit within the safety margin as shown in Figure 5. Only three wavelengths and 16 ONUs are shown in Figure 5 for algorithm demonstration purposes. This approach potentially produces a shorter polling cycle length, a reduction in the ONU upstream packet waiting-time in proceeding cycles, and hence increased network utilization.

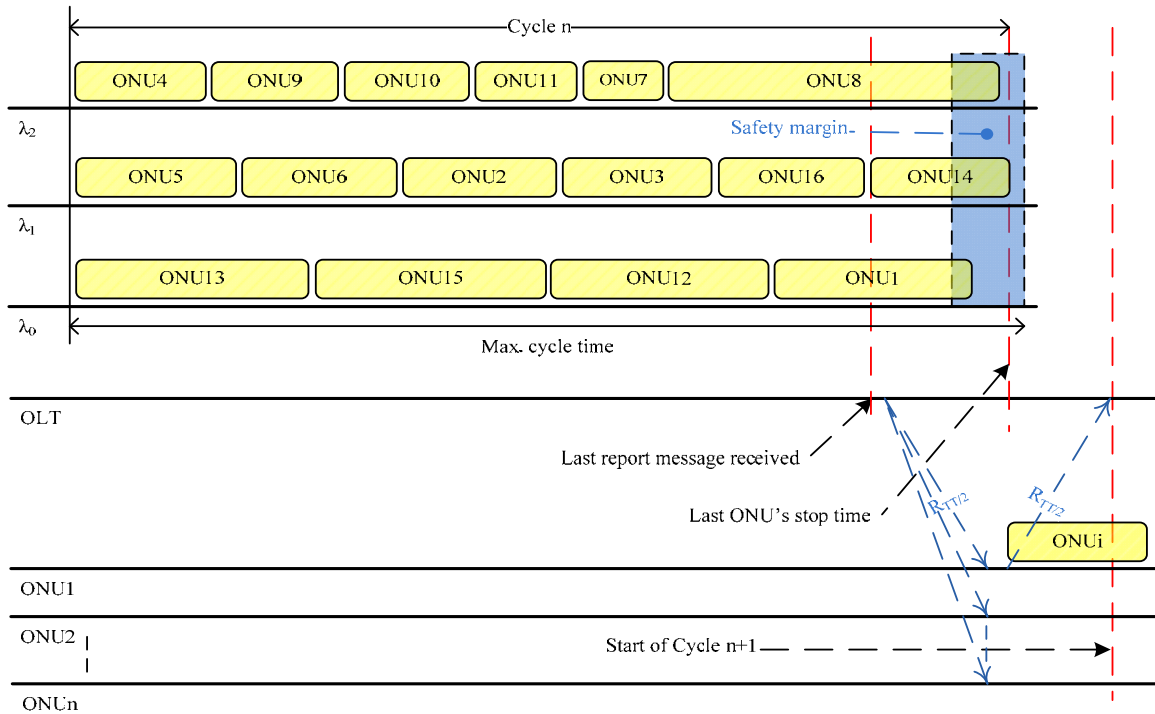


Figure 5. Principles of the DMW-GPON bandwidth assignment.

5.3.2.2 OPNET performance analysis

To investigate the performance of the DMW protocol a FTTH-based GPON network was modelled using the OPNET v.14.5 platform with pareto self-similar traffic with typical Hurst parameter of 0.8, 1.24416 Gbit/s upstream data-rate, 2.488 Gbit/s downstream data-rate, and 32 ONUs, assigned in manner of 4 ONUs SLA_0 , 4 ONUs SLA_1 , 8 ONUs SLA_2 , and 16 ONUs SLA_3 to comply with a typical current network and the near future end-users. Each ONU was connected with an end-user under a 100 Mbit/s line speed fibre cable, moreover, a 196 bits GPON guard-time between the ONU traffic, a 1.5 ms maximum cycle time, and is stated before 3% safety margin was used.

The single-wavelength GPON can achieve higher basic bandwidth per ONU by reducing the number of the ONUs in the network, it shows in Figure. It can provide each of the 32 network ONUs with a basic bandwidth of 30 Mbit/s, while DMW provides a minimum bandwidth of 100 Mbit/s for each ONU by using only three wavelength signals. Furthermore, it clearly indicated that, the channel throughput performance for each wavelength signal has the same throughput even by using a safety margin of 3% of the total network capacity.

It can be observed, while the maximum throughput of each wavelength of DMW-GPON is equal to the single-wavelength DMB-GPON, the total network throughput of DMW-GPON is three time the DMB-GPON.

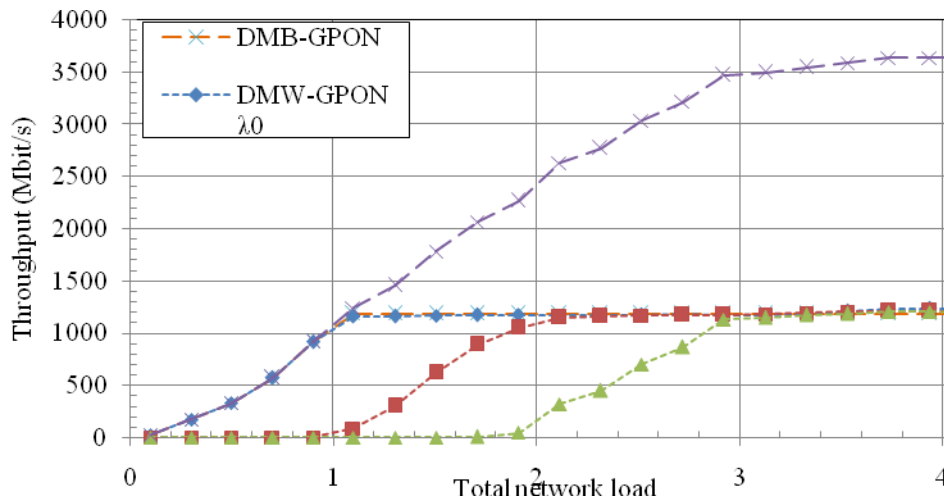


Figure 6. Throughput against total network load for single-wavelength and DMW-GPON.

While the mean packet delay for deferent SLAs of single-wavelength DMB-GPON overcomes 0.1 s when the total network load achieves one wavelength capacity, the DMW provide much reduced mean packet delay performance stays low at 0.03 s (which is satisfy the recommended one-way delay requirement of the interactive applications defined by the ITU-T recommendation G.1010 [17]) until the total network load reaches three wavelengths capacity as seen in Figure 7 which makes it a good candidate to support the real-time service (such as conversational voice and videophone). This gain or reduction in the delay came as a result of increasing the basic bandwidth of each ONU to 100 Mbit/s compared to 30 Mbit/s in case of single-wavelength protocols.

Even at higher network load for DMW-GPON, the lower service level ONUs (highest delay) delay stays below 0.1 s (which is below the boundary-limit of 0.4 s of the one-way delay of the interactive applications defined by the ITU-T recommendation G.1010 [17]).

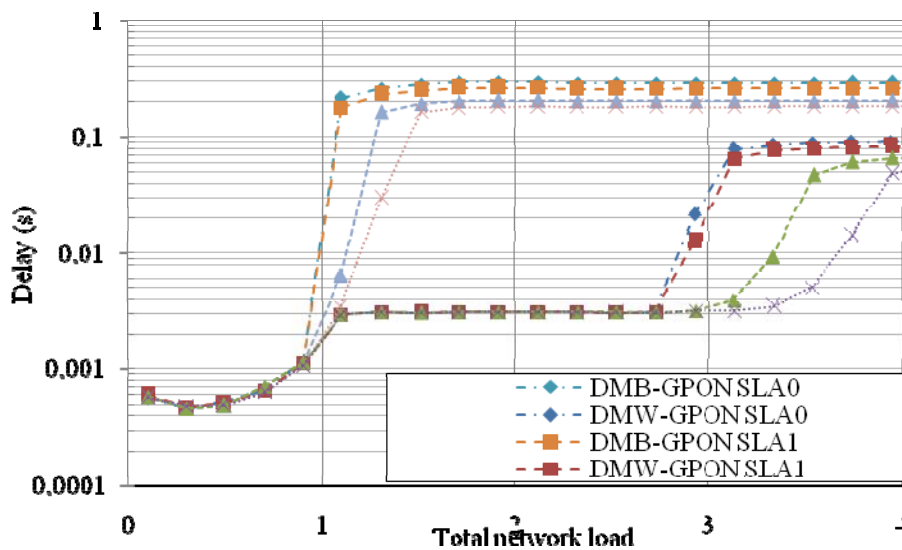


Figure 7. Mean packet delay against total network load for single-wavelength and DMW –PON.

5.3.3 Next steps

The DMW protocol methodology and the corresponding enhancements in the GPON upstream format map have been presented to accommodate multi-wavelength operation by means of smoothly upgrading the existing single-wavelength GPON infrastructure. This upgrade has been achieved by utilising additional bits in the frame fields to define the operating wavelength and packet type transfer for each ONU. The performance benefits of the multi-wavelength operation providing an aggregate transmission bit-rate of 3.7 Gb/s if only three wavelengths are utilised with 32 network ONUs served with a minimum bandwidth per ONU of 100 Mbit/s are demonstrated using OPNET. A reduction gain in the mean packet delay in comparison with the single-wavelength GPON was achieved. In summary, the DMW approach could enable an upgraded-GPON to be a good candidate to support the next generation access (NGA) network providing both sufficient bandwidth and appropriate QoS to deliver future FTTH.

Following steps should include further developing and evaluating algorithms that will be able to allocate optical network resources in a dynamic manner, exhibiting not only QoS but also the QoE requirements of different types of services, alongside congestion levels in the ONU. This could involve solutions, whereby each wavelength could be shared by many different ONUs in time but also where the number of wavelengths assigned to each ONU as a whole could change based on the temporal bandwidth demands.

Progressing to the joint activity's aim produced algorithms should be enhanced by also mapping the packets from wireless users to appropriate PON classes and wavelengths. In that direction user mobility should be taken into account as it is expected to critically affect the dynamicity of traffic that must eventually be carried by the backhaul. Moreover, the exact services carried by mobile users are a very important aspect.

Therefore the model topology should change to account for the wireless architecture to be integrated to the current optical model. The parameters affecting the allocation of network resources and hence data transfer would have to be assigned in a manner similar to GPON FTTH topologies although consisting physically of a FTT-Building or Curb optical network connected to a wireless infrastructure. Each ONU/BS could be divided into sectors in order to make corresponding cells more efficient in terms of reduced co-channel interference and increased capacity. As already mentioned the received packets (travelling over multiple hops in the mesh network) from wireless users in upstream will be mapped to appropriate PON classes inside an ONU prior to upstream transmission back to the OLT. On the radio side the resource scheduling over a PON would be in the focus by means of accessing the remote ONUs by conventional NRZ signaling eliminating the effects of non linear impairments that could be introduced by alternatively using radio over fibre transmission. Therefore the demonstration of end-to-end, vertical network connectivity of diverse radio and fibre technologies over a backbone PON infrastructure will be considered by moderately addressing the physical but primarily the MAC and network layer functionalities.



To enable more efficient integration, an effective mapping mechanism is required between GPON priority queues and LTE service connections. Specifically, the mapping needs to know which LTE flow should be stored in which GPON priority queue for equivalent QoS. In addition, GPON supports QoS in a DiffServ mode, under which packets are classified and stored in different priority queues. In contrast, although the services of LTE are classified to support different levels of QoS, LTE like WiMAX and WiFi is a connection-oriented technology, which essentially follows an integrated service (IntServ) mode. Thus, for integration, an interesting problem is how to make efficient conversions between Diff-Serv and IntServ services. In addition, it is also interesting to see how the end-to-end QoS can be supported after these two systems are integrated.

5.4 UWB Radio-over-fibre transmission in indoor environments using different media {UPVLC}

5.4.1 Motivation and objectives

Ultra-Wide Band (UWB) technology for wireless multiple access communications are receiving great interest for the last years due to its unique features such as spectrum coexistence with other wireless services, RF front-end simplicity (enabling potential low cost terminals), good radio wave propagation (robustness against multi-path fading, material penetration) and high bitrate. Several applications can be found ofr UWB radio-over-fibre in user mobility networks or networks in motion. One example is the optical fibre in-car distribution that can be used for providing multimedia connectivity and even car-safety functionalities.

Two main UWB implementations are being further developed nowadays. From one side, WiMedia-defined signals which are based on multi-band orthogonal frequency division multiplexing (MB OFDM) modulation that has been adopted in the standard ECMA-368 specification. From the other side, impulse radio (IR) technology signals increases the accuracy as employs short radio pulses, typically in the picoseconds range. IR-UWB is able to provide high-speed communications, localization and ranging simultaneously.

The proposed work comprises the radio-over-fibre transmission of both OFDM and IR UWB signals for in-building applications, e.g. offices or home environments, over different media as standard single mode fibre (SSMF) or multimode fibre (MMF).

The objective of this joint activity is to study (experimentally and by simulation) the performance of UWB signals in radio-over-fibre transmission for in-building applications in terms of quality of signal, bitrate, spectral efficiency, fibre maximum reach and others, considering, if possible, the effects of the fibre transmission on the UWB radio path.

5.4.2 Main outcomes and results

A comparison of the in-building transmission performance of the two main ultra-wideband (UWB) implementations, OFDM-based (OFDM-UWB) and impulse-radio UWB has been done experimentally and by simulation during this period. Both UWB implementations providing similar spectral efficiency are analyzed when transmitted over 300 m of standard single mode fibre (SSMF) or multimode fibre (MMF) link. The experimental results indicate that OFDM-UWB transmission is feasible for optical launch power levels of 2 dBm for both SSMF and MMF distribution. The impulse-radio UWB implementation achieves error-free SSMF transmission from -4 dBm launched power. Successful MMF transmission can be only achieved for impulse-radio UWB at 3 dBm launched power level.

Figure 8 shows the setups implemented to evaluate the performance of the distribution of OFDM UWB and impulse-radio UWB over SSMF and MMF.

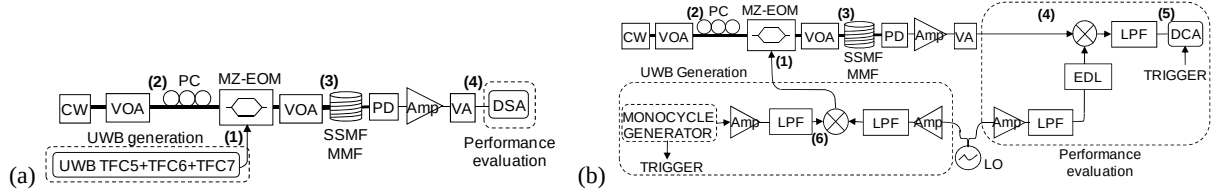


Figure 8. Experimental setup for performance evaluation of (a) OFDM UWB and (b) impulse-radio UWB distribution over fibre for indoor range. CW: Continuous-wave laser, VOA: Variable optical attenuator, PC: Polarization controller, PD: Photodetector, Amp: Electrical amplifier, VA: Variable electrical attenuator.

The UWB signal under study is externally modulated with a continuous-wave optical carrier at 1555.75 nm by a Mach-Zehnder electro-optical modulator (MZ-EOM) ($V\pi=1.46$ V_{DC}) working as a conventional double-sideband modulator. A variable optical attenuator is employed before the MZ-EOM to adjust the power launched to the fibre by adjusting the power at point (2) in Figure 8 (from now referred as P2) emulating the central office. The modulated signal is transmitted over fibre (SSMF or MMF) and the optical power launched to the fibre at point (3) in Figure 8 (from now referred as P3) is adjusted with a second attenuator in order to analyze the link budget. After fibre transmission, the signal is photo detected properly depending on the optical media: A 40 GHz PIN photodiode is employed for SSMF and a 7 GHz photo receiver consisting in a PIN photodiode with 50 μ m MMF pigtail and an integrated transimpedance amplifier is employed for MMF transmission. Subsequently, the power spectral density (PSD) of the photo detected signal is adjusted with an electrical amplifier (26 dB gain and 5 dB noise figure) followed by a variable electrical attenuator to accomplish, at point (4) in Figure 8, the UWB spectral mask defined in current regulation with a maximum PSD of -41.3 dBm/MHz [20], [21].

In order to evaluate the performance of OFDM UWB in optical fibre in-building distribution, the measurement setup shown in Figure 8(a) has been implemented. A multi-channel MB-OFDM UWB signal is generated combining the UWB signals from three transmitters (Wisair DV9110). Each UWB transmitter is located at frequency band #1, #2 and #3 respectively from UWB band group #1, performing a non hopping time frequency code (TFC5, TFC6 and TFC7), which enables a multi-channel MB-OFDM UWB transmission. The OFDM signal comprises 3 channels of 528 MHz bearing 200 Mbit/s each with QPSK modulation (as specified by ECMA-368 standard). This provides an aggregated bitrate of 600 Mbit/s and 0.378 bit/s/Hz spectral efficiency (10 dB frequency range of 3.168-4.752 GHz). The maximum PSD of the generated OFDM-UWB signal is -42 dBm/MHz. In Figure 9, EVM results for OFDM-UWB over 300 m SSMF (a) and MMF 50 μ m (b) transmission are presented and compared with B2B configuration for the MMF photoreceiver at a P2 of 13.9 dBm. The received spectrum after both kind of media are shown in Figure 9(c) and (d).

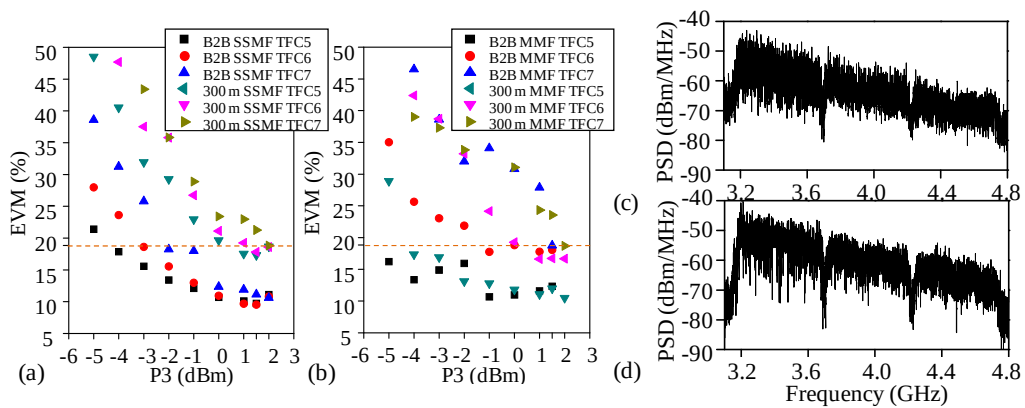


Figure 9. Measured EVM for OFDM UWB performance after 300 m (a) SSMF and (b) MMF distribution with P2=13.9 dBm. ECMA threshold in dashed line. Measured received spectrum at P3=2 dBm after 300 m (c) SSMF and (d) MMF distribution

These results have been checked by simulation using Photonics VPI software. The device specifications of the modules correspond to the ones available at the laboratory and the setup is the same as shown in Figure 8(a). The power levels along the system are adjusted with the ones measured experimentally for a fair comparison. Simulated and experimental results are in very good agreement as shown in Figure 10.

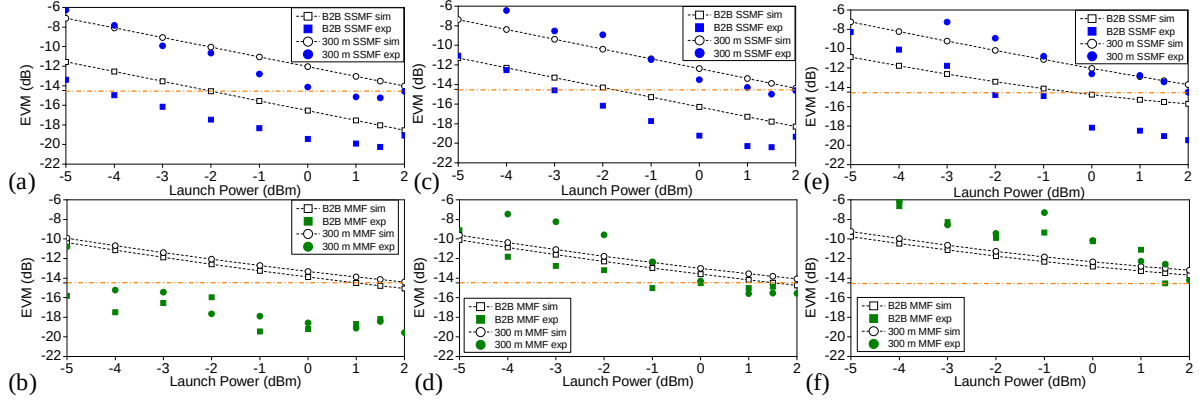


Figure 10. Simulated EVM for OFDM UWB performance for (a)(b) TFC5, (c)(d) TFC6, (e)(f) TFC7 after 300 m SSMF and MMF distribution respectively

For the MMF case, TFC6 (channel at 3.96 GHz) is the one that fits most the simulation results. For MMF propagation, simulation results (in dashed line in Figure 10) are worse than experimental, due to the phase lock used in simulation that does not correct the whole constellation rotation. The experimental data measured with DSA solve better this phase shift. From the simulations we observed that symbol mapped constellations present less dispersion in MMF than in SSMF. For this reason, in most of the cases the experimental EVM results are better in MMF than in SSMF. This is due higher power losses in the connectors of SSMF compared with the low-losses imposed by the transmission in 300 m SSMF. This effect can be seen in the difference in SSMF between B2B measurements and 300 m propagation results. This difference is much lower in the MMF case. If longer optical fibre distances were used (in the range of km), SSMF could lead to better results than MMF, but for short range communications MMF exhibits better performance.

Simulation and experimental results agree on that a typical range for in building distribution of 300 m can be reached using both SSMF and MMF media with launch power ranging from 1 to 2 dBm.

The second part of this activity evaluates the performance of impulse-radio UWB over fibre in-building distribution. The experimental setup implemented was shown in Figure 8(b). The generated monocycles after amplification and low-pass filtering (3.3 GHz bandwidth) to remove noise are shown in Figure 11(a) and (b). This signal corresponds to that measured at point (6) in Figure 8(b). Figure 11(c) and (d) show the detected impulse-radio UWB pulses at point (4) in Figure 8(b) after 300 m SSMF distribution with $P_2 = 13.7$ dBm and $P_3 = -3$ dBm.

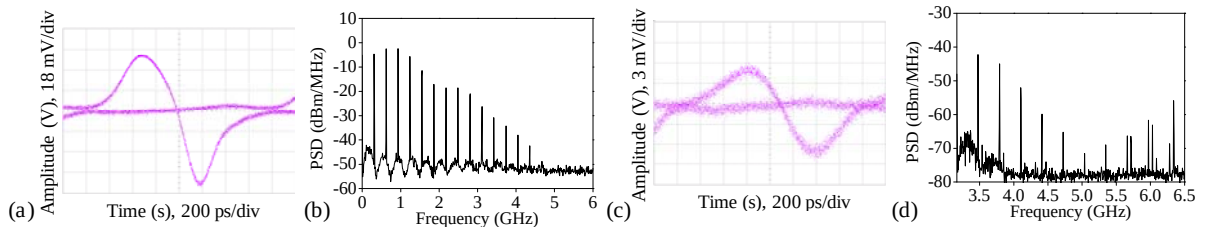


Figure 11. Generated baseband monocycle at point (6) in Figure 8(b): (a) eye diagram and (b) spectrum. Received impulse-radio UWB signal at point (4) in Figure 8(b) with $P_2 = 13.7$ dBm and $P_3 = -3$ dBm: (c) eye diagram, (b) spectrum

Figure 12 shows BER results for impulse-radio UWB over 300 m SSMF and MMF transmission compared with the corresponding optical B2B configuration as a function of P_2 . For SSMF distribution (Figure 12(a)), error-free transmission is achieved in the range of P_3 from -4 to 4.7 dBm. It can be observed that BER values maintain at P_3 in the range from -3 to 2 dBm while the higher P_3 the better BER at P_3 higher than 2 dBm and the lower P_3 the worse BER at P_3 lower than -3 dBm. In this case, BER is independent on P_2 . The results for MMF distribution shown in Figure 12(b) indicate that the best BER is achieved at P_3 about 3 dBm for all P_2 from 12 dBm to 13.7 dBm, but error-free transmission is only achieved at a P_2 of 12 dBm. Comparing with B2B case, the performance with MMF transmission is always worse.

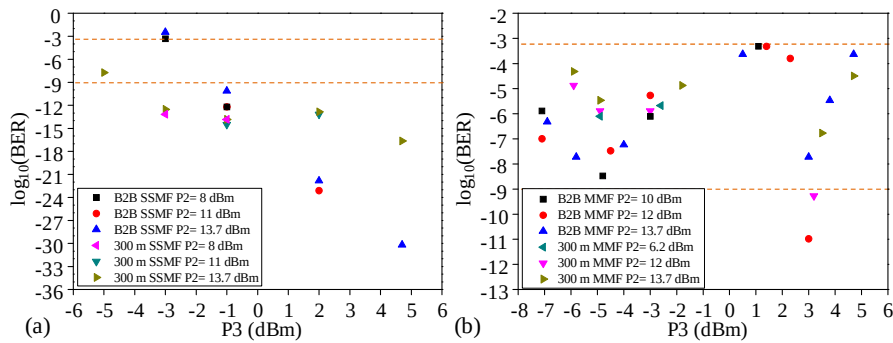


Figure 12. Impulse-radio UWB performance compared with optical back to back configuration for (a) SSMF and (b) MMF distribution. BER limits in dashed lines.

In conclusion, from the experimental results, impulse-radio UWB requires less optical launched power than its OFDM-UWB counterpart for successful SSMF transmission over a distance of 300 m. In the case of MMF, the experimental results exhibit a large variance and successful transmission over 300 m can only be achieved at a launched power of 2 dBm for complete OFDM-UWB or 3 dBm for impulse-radio UWB.

This activity has produced the following publications:

- Marta Beltran, Maria Morant, Joaquin Perez, and Roberto Llorente, “Performance Evaluation of OFDM and Impulse-Radio Ultra-Wideband over Fibre Distribution for In-Building Networks”, IEEE International Conference on Ultra-Wideband, Vancouver, Canada, 9-11 September 2009.
- Maria Morant, Joaquin Pérez, Marta Beltrán and Roberto Llorente, “Performance Evaluation of In-Building Radio-over-Fibre Distribution of Multi-Band OFDM UWB Signals”, 2009 IEEE International Topical Meeting on Microwave photonics, Valencia, Spain, 14-16 October 2009.

5.4.3 Next steps

Further investigation of the UWB performance over other optical media could be investigated in the future. This activity probably will lead to a mobility action by next year.



5.5 *Optimizing service delivery in a converged hybrid optical-wireless network {UAM}*

5.5.1 *Motivation and objectives*

The main motivation behind the JA5 is to support next-generation wireless networking with an optical access network, to apply novel concepts that increase its reconfigurability and that improve its resource usage, and to evaluate the performance considering different metrics. The topology is also taken as subject of study.

The main objective of JA5 is to propose a flexible and fast-reconfigurable network architecture that is optimized for high-bandwidth mobile networking. Non-mobile users are also considered and the network should be easily overlaid in existing access solutions, e.g. current fibre-to-the-home solutions.

As expected outcome, the JA5 considers to demonstrate the feasibility of its architecture for horizontal and vertical handovers between different kinds of next-generation wireless networks by means of physical-layer simulations and small-scale lab experiments. Several joint publications are planned.

5.5.2 *Main outcomes and results*

The JA5 has defined the network architecture that is based on key knowledge and equipment readily available. Accordingly, it is expected to quickly obtain results using the existing resources of its members. The work done on the basic operational principles can not be presented in this *public* deliverable of WP23 since the design has not been published yet in literature.

Regarding the outcome up to this point, the JA5 has defined a work plan, milestones and a time line for 2010 (second year of this topical project). These should be finalized before the end of 2009 in order to intensify the cooperation in 2010.

5.5.3 *Next steps*

With the intention not to compromise the original research done in JA5, the planned activities generally are:

- Jan.-Mar. 2010: Design, requirements, and mobility scenarios of hybrid optical-wireless architecture
- Apr.-Sep. 2010: Physical-layer simulation and possible network-level considerations
- Jul.-Dec. 2010: Lab experiments

The intention is to have a mobility action in the last part of the JA5. The next meeting is a teleconference in December 2009 where the detailed description of the work plan will be discussed.

5.6 All-optical Routing Architecture of Radio Signals using Label Processing Technique for In-building Optical Networks {TUE}

5.6.1 Motivation and objectives

The growing demand of broadband services among residential and business customers has fuelled the research and development of numerous wired and wireless technologies to satisfy those demands. Radio-over-fibre (RoF) technology is considered as a key enabler for merging of broadband wired and wireless services in an integrated full service access and in-building networks [1]. In addition, RoF distributed antenna systems are identified as a flexible option for the access architecture of current and emerging wireless access in-building networks as it reduces infrastructure costs and antenna site complexity.

Figure 13 shows an example of in-building access architecture. In this architecture, the main device is the home communication controller (HCC), which arranges communications between rooms and routes signals to the proper rooms according to the label information attached to the data signals. Optical routing based on label information will improve the flexibility and the efficiency of the network resources.

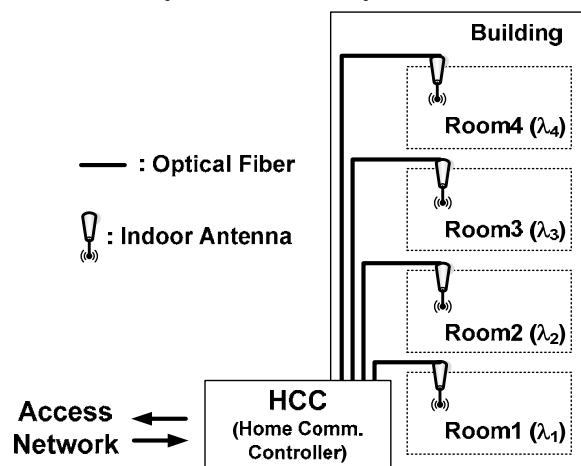


Figure 13. In-building network architecture.

In this joint activity a new all-optical HCC architecture that forwards the radio signal to the specific rooms based on the label information will be investigated.

5.6.2 Main outcomes and results

This JA is expected to experimentally investigate a new all-optical HCC architecture for routing of RoF signals with label-processing technique.

5.6.3 Next steps

This JA has not been active during the first year. It is expected that it will take place in the second year. It is of major concern to investigate HCC architectures that take into account user mobility.

6. Conclusions and future plans

Summary of Joint Activities and current status

The following table summarizes the 6 JAs in the framework of WP23 as well as their current status.

No.	JA Title	Current status
1	Hardware implications issues for networks in motion	Phone conferences to organize the activities/mobility actions of the second year.
2	State of the art definition for components supporting FSO networks in motion	A thorough analysis on all the aspects of FSO interlinks in nomadic or mobile situation has been carried out. Publication of an on-line book by Intech has been initiated.
3	Converged MAC algorithms for unified optical wireless functionality	Technology challenges have been analyzed and the performance of the DMW protocol a FTTH-based GPON network has been modelled using OPNET.
4	UWB Radio-over-fibre transmission in indoor environments using different media	Comparison of the in-building transmission performance of the OFDM-based (OFDM-UWB) and impulse-radio UWB implementations has been done via experiments and simulations.
5	Optimizing service delivery in a converged hybrid optical-wireless network	Requirements on architecture, relevant technology and equipment have been discussed. A detailed workplan has been agreed.
6	All-optical Routing Architecture of Radio Signals using Label Processing Technique for In-building Optical Networks	Activities will start in the second year.

Table 3: Summary of Joint Activities and their current status

Publications

The following publications have been presented during the first year of this topical project:

- In the framework of BONE and in collaboration with COST ICO802 and WP13 on access, the publication of an on-line book by Intech on FSO technologies is under preparation. (JA2)
- Marta Beltran, Maria Morant, Joaquin Perez, and Roberto Llorente, "Performance Evaluation of OFDM and Impulse-Radio Ultra-Wideband over Fibre Distribution for In-Building Networks", IEEE International Conference on Ultra-Wideband, Vancouver, Canada, 9-11 September 2009. (JA4)
- Maria Morant, Joaquin Pérez, Marta Beltrán and Roberto Llorente, "Performance Evaluation of In-Building Radio-over-Fibre Distribution of Multi-Band OFDM UWB Signals", 2009 IEEE International Topical Meeting on Microwave photonics, Valencia, Spain, 14-16 October 2009. (JA4)

Motilities (performed/planned)

The mobility plans for the second year are currently the following ones:

- JA1: mobility actions are expected to take place in early 2010.
- JA4: mobility action is expected to take place in 2010.
- JA5: mobility action is foreseen at the end of 2010.

Future plans (summary from JAs)

1. JA1: The future plans for this JA are soon expected to be described.
2. JA2: Next activities, such as possible new publications, book publications, collection of material, will be carried out in conjunction with the new agreement set between BONE and COST ICO802 and in collaboration with WP13 on Access Networks, WP02 on Teaching and WP01 on dissemination.
3. JA3: Further developing and evaluating algorithms that will be able to allocate optical network resources in a dynamic manner, enhancing the produced algorithms to enable mapping the packets from wireless users to appropriate PON classes and wavelengths, changing the model topology to account for the wireless architecture to be integrated to the current optical model, as well as enabling more efficient integration using an effective mapping mechanism between GPON priority queues and LTE service connections.
4. JA4: Further investigation of the UWB performance over other optical media could be investigated in the future.
5. JA5: With the intention not to compromise the original research done in JA5, the planned activities generally include the design, requirements, and mobility scenarios of hybrid optical-wireless architecture, physical-layer simulations and lab experiments.
6. JA6: This activity is expected to run during the second year.

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