EPIC Symposium Programme

24 February 2010

14:30-15:45	**Session 1: FTTH Network Technologies** 14:30-14:55 **Dr. Jörg-Peter Elbers**, VP Advanced Technology, ADVA AG Optical Networking *"WDM-PON Technologies for FTTH Access"* Abstract: This presentation discusses WDM technologies as basis for next-generation optical access networks. It describes drivers and requirements. Challenges as well as possible solutions are outlined. 14:55-15:20 **Curt Badstieber**, Project Leader, Nokia Siemens Networks *"Ultra-dense Access Network Architecture Serving >1000 Clients, Including Coherent Technologies"* The access data rate is foreseen to continue its exponential growth for the next years. A ten-fold increase of the user-available access data rate has been observed every three to five years for the last two decades. Optical fibre is the only medium which can satisfy this future demand. Any terminal equipment (ONU) of the fibre access network will also need to undergo an evolution over time to keep pace with this need. This presentation focuses on NGOA (Next Generation Optical Access), a NSN proposed PON design currently in Research and Development, based on a coherent heterodyne resceiver design enabling ultra dense lambda spacing and avoiding some of the disadvantages of conventional WDM and TDM PON systems. The precise wavelength selectivity and high sensitivity of these receivers enables a completely filterless WDM design with long reach, high split rates and simplified logistics, promising an affordable 1Gbit/s sustained datarate for all users. The presentation will highlight the basic system building blocks and briefly describe the network architecture implications in practical field case examples, considering factors such as outside plant, open lambda optical unbundling, central and local office consolidation, coexistance as well as migration from other existing pon systems. 15:20-15:45 **Dr. Gerlas Van Den Hoven**, CEO, Genexis *"10 G PON and Point-to-Point PON"* After the first FTTH projects in Europe have now reached maturity, operators are preparing for the next step in large-scale roll-out of fiber to the home. It is clear that Gigabit per second bandwidth will be a requirement in the near-future in order to beat the competition from cable networks and to offer new compelling services to increase average revenue per user. To realize Gigabit to the home, several technologies are available ranging from shared 10G PON networks to dedicated 1G Ethernet networks. Clearly, each approach has its own technical merits and issues, which will be discussed in regards to the European FTTH initiatives. At the same time, Gigabit networks offer such a high bandwidth that the actual amount of bandwidth becomes irrelevant, and other factors come into play, such as network openness, security, and compatibility with next generation services. The role of the network equipment - central office and home gateway - will be key in enabling next generation services and taking full benefit of the Gigabit capacity.
15:45-16:30	Coffee Break
16:30-17:40	**Session 2: FTTH Network Technologies** 16:30-16:55 **Dr. Michael Robertson**, VP Research Programmes, CIP Technologies *"Energy Conservation Strategies for the FTTH Network"* The advent of FTTH networks offers an excellent opportunity to reduce carbon emissions through reduced business travel for example, through the use of videoconferencing and greater home working. However, this can only be effective if FTTH networks are energy efficient. Telecommunication networks are currently using increasing proportions of national energy consumption. In this talk, issues of energy usage in FTTH networks will be discussed. The relative usage of the different approaches will be described and comparisons made between different options. 16:55-17:10 **Dr. Roland Wessäly,** Managing Director, Atesio **(Sebastian Orlowski, Axel Werner,** Atesio, and **Maren Maartens**, Zuse Institute Berlin) *"Cost Optimal Design of FTTx Networks"* The Berlin-based research consortium fttx-plan (atesio GmbH, Heinrich-Hertz Institute, VPIsystems GmbH, Zuse Institute Berlin) aims at developing tools and methods for planning future FTTx networks. The consortium offers a unique combination of photonics modeling, technical expertise, network planning, and mathematical optimization know-how.

	The central goal of the project is to support the strategic decision process of city carriers and new local operators by performing an objective, quantitative analysis that considers varying boundary conditions. We will present methods and tools developed by the fttx-plan consortium in order to reduce planning uncertainties, to support a realistic forecast of costs, and to detect potential technological dead-ends early in the design process. Custom-built mathematical optimization methods build the core for our planning tool. We show how this approach can support city carriers and new local operators in answering fundamental design decisions such as: • What are the key decisions for the business case? • How to design an FTTx network which is both cost-efficient and easily extendible to new technologies without touching the passive infrastructure later? • What are the dependencies between total cost of ownership and the technical possibilities of the available system technologies? • What is the cost difference between G-PON and P2P-Ethernet solutions in a particular town or district? • Under which conditions is it possible to offer protection against equipment failures or cable cuts to valuable customers at little additional cost? A sound modeling of all planning ingredients is fundamental to automatically optimize FTTx networks using state-of-the-art mathematics. We present a detailed model of street, railway, and sewer networks, an existing duct and cable infrastructure, the installable passive and active components, the private and business customers to be served, CAPEX and OPEX cost incurred during the life-time of an FTTx network, and various other constraints which would be hard to take into account in a manual planning process. Based on this model we will show how abstraction combined with methods from mixed-integer linear programming can successfully be used to automatically compute cost-optimized FTTx networks. As a highlight we will present results from techno-economic studies using this unique approach. 17:10-17:25 **Dr. André Richter**, Director Product Management - VPIPhotonics, VPISystems *"FTTX-PLAN – Planning the Upgrade of Today's Passive Optical Networks"* Planning future access networks requires not only the optimization of capital and operational expenditures for the network infrastructure, but also the assessment of the *upgradeability* of the network. Since fiber infrastructures represent an investment over several decades, it should be ensured that deployed systems can easily be upgraded with existing or upcoming technologies in order to meet future requirements in terms of reach, services, total capacity and available bandwidth per user. After a short review of trends in PON technologies and activities related to the upgrade of current PON systems, we investigate a typical migration scenario for deployed GPON/EPON systems with respect to • *Extendibility*: Increase the reach or/and the number of users without changing the hardware at the OLT and ONUs. • *Interoperability*: Offer soon-to-be-standardized solutions without removing current services. • *Scalability*: Increase the bandwidth per user using current or future technologies. Using numerical simulations, we illustrate and quantify physical limitations related to this migration scenario. We demonstrate limitations in the upgrade process and identify possible solutions to enable a simple and low-cost update of current PON systems. The findings of our investigations on migration scenarios can be incorporated to the network planning process, and thus, influence the decision on network optimization results. Our activities are performed in frame of FTTX-PLAN – a research project and Berlin-based consortium aiming to develop tools and methods for planning future FTTx networks by combining photonics modeling and design expertise with network planning and optimization know-how. 17:25-17:40 **Rosie Cush**, Senior Research Scientist, Oclaro *"Low Cost Tuneable Lasers for High Performance, Flexible Access Networks"* Tuneable lasers offer maximum performance and flexibility for access networks but are perceived to be a high cost technology. However, developments in the design and operation of the DSDBR tuneable laser demonstrating athermal operation and remote wavelength control offer the prospect of a low cost tuneable product based on a proven high yielding manufacturing process. Devices of this type enable flexible access networks capable of evolution to higher data rates, longer reach and ultra-dense channel spacing.

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9:30-10:55	**Session 3: Component Technologies for FTTH**

	9:30-9:55 **Christophe Kazmierski**, Project Leader, Alcatel-Thales III-V Lab *"Remote Amplified Modulators: Key Components for 10Gb/s WDM PON"* Abstract: While single section RSOA devices are showing qualifying performance for applications in WDM PON working up to symmetrical 2.5Gb/s, a new reflective component class integrating low-chirp and large-bandwidth Electro-Absorption Modulators with SOA are progressively taking over as a realistic solution for the symmetrical 10 Gb/s. This is due to their ability to work over indoor temperature range while remaining simple enough for lowest cost TO-CAN package standards. Additional multi-function capabilities open a way for very simple all-monolithic duplexers in a single low-cost receptacle. Still, 10 Gb/s remote modulators must demonstrate improved power budget to qualify for the New Generation Access. 9:55-10:20 **Prof. Xing-Zhi Qiu**, Project Manager, IMEC/University of Gent *"10Gb/s Burst Mode Receivers"* Worldwide, passive optical networks (PONs) are a massively deployed fibre access technology, and a cost-effective optical solution to deliver high capacity services to end users for HDTV, IPTV, VOD, and digital home. Future PONs are evolving towards 10Gb/s symmetric operation, where 10Gb/s burst-mode receiver (BM-Rx) and burst-mode clock and data recovery (BM-CDR) circuits located at the optical line termination (OLT) are key physical medium dependent (PMD) components. This presentation will give an overview of 10Gb/s BM-Rx developments, and their design challenges associated with high performance TDMA PONs. Different configurations of 10Gb/s BM-Rx prototypes for IEEE 10G-EPON and potential ITU-T FSAN 10G-PON2 will be compared. A 10Gb/s ultra high capacity hybrid WDM / TDMA physical layer for high split long-reach PONs will be also introduced. Finally, recent research of 10Gb/s APD-based BM-Rx supporting shorter burst overhead will be discussed. This newly designed BM-Rx will meet the future capacity need with improved performance, taking efficient network transmission, good interoperability and reliable operation into account. 10:20-10:35 **Dr. Norbert Grote,** Deputy Dept. Head, **and Norbert Keil**, Fraunhofer Institute for Telecommunications, Heinrich-Hertz-Institut *"Polymer Based Integration Platform for Access Components"* The presentation addresses: - polymer based PLC technology - implementation of passive optical functions (filters; polarisation splitter; reflectors) by means of integrated thin film elements - passive pick-and-place fiber attachment - integration of photodiodes (up to 25 Gb/s capability) - integration of single-mode laser diodes - examples of integrated components for use in access networks 10:35-10:55 **Dr. Jonathan Schrauwen**, Caliopa *"Silicon Photonics Multichannel Transceivers Enable 100+ Channel Point-to-Point FTTH Central Office Linecards"* Point-to-point fiber networks offer the highest possible bandwidth and security to the end user. However, every end-user connection requires a separate transceiver in the central office, making these networks more expensive than PON architectures. At Caliopa - a startup spinning out of IMEC - we can integrate 12 transceivers in a single package by using silicon photonics. This approach greatly reduces the CO equipment cost as well as the power consumption of a point-to-point FTTH network, enabling FTTH networks with the bandwidth, security and flexibility of point-to-point at the cost of PON.
10:55-11:30	Coffee Break
11:30-12:45	**Session 4: Technologies and Applications for FTTH** 11:30-11:55 **Dr. Anthony Kelly**, Amphotonix "High Performance Polarisation Independent Reflective Semiconductor Optical Amplifiers in the S, C and L bands" Many types of WDM-PON architectures exist, including those which require operation in two wavelength bands; one for the upstream, the other in the downstream direction. Wavelength seeded RSOAs are compatible with these architectures harnessing the cyclic nature of array waveguide de-multiplexers (AWGs). Hence a broadband source can be used to seed several RSOAs covering the S-band such that they can be used as transmitters at the OLT. The adjacent free-spectral range of AWG multiplexers can be used in tandem with a C/L band broad band source to seed RSOA transmitters in the C/L band at the ONU. Thus the same AWG can be used at both the ONU and OLT. In this way, only two separate RSOA designs are required, one for the upstream and a second for the downstream path. This paper reports on the design, manufacture and test of such an RSOA pairing which covers the 120nm over the S, C and L band providing 25 dB path loss capability over this range with -20dBm seed power. Polarisation independent strained bulk RSOAs have been fabricated in the S band for the first time. In system tests at 1.25Gbit/s, the devices have been shown to operate over >60nm with large return path loss capabilities. With the use of a C/L band RSOA of similar design, contiguous operation over the S, C and L bands

using only 2 devices has been demonstrated. Each device is capable of providing >25dB PLC over a 60nm span and hence the combination of the RSOAs provides PLC of >25dB over a wavelength interval of >120nm (1470 nm to 1590 nm).
The temperature performance of the C/L band device has also been studied and a PLC of >20dB has been shown at 60°C. To our knowledge, this represents the largest PLC at 60°C for a polarization independent RSOA.

11:55-12:20 **Dr. Ioannis Tomkos**, Athens Information Technology

"Electronic Equalisation Technologies for FTTH Access Networks"

The use of fiber channel equalization techniques is emerging as a key technology to enable low-cost and hig-performance next generation optical access networks operating at 10 Gb/s and beyond, while reaching tranmission disctances of up to 100km. This presentation outlines the main technology solutions, discusses their limitations and presents results from extensive studies that have been contacted on this topic in the framework of EU project SARDANA.

12:20-12:45 **Dr. James Lott**, Chief Technology Officer, (co-authors Prof. Nikolay Ledentsov, CEO, and Jörg-R. Kropp), VI Systems GmbH

"Similarities in Datacenters, Local Area Networks, and Fiber-to-the-Home Systems: Trends, Bottlenecks, and Opportunities for Vertical Cavity Surface Emitting Lasers"

Datacenters, LANs, and Fiber-to-the-Home (FTTH) systems exhibit similar trends in signal aggregation and bottlenecking. Assemblies based on vertical cavity surface emitting lasers (VCSELs) will likely play a key role in facilitating future generations of FTTH networks, in concert with the rise of the use of VCSELs in datacenters and LANs.
Single mode fiber (SMF)-based passive optical networks (PONs) that share cable and systems costs via the use of splitters exist in a variety of configurations. The Ethernet in the First Mile (EFM) initiative led to an early PON standard that was soon further developed by the IEEE and the Metro Ethernet Forum into a completed 10 Gb/s Ethernet PON (10G EPON) standard. One of the network options specified in the 10G EPON is a LAN-like environment with an active node between a feeder and a group of end-users. This situation occurs in densely built residential areas and multiple dwelling units/buildings, and resembles the structure of the current business LAN environment where multimode fiber (MMF) is preferred for data transfer rates of 10 Gb/s and faster. This is due primarily to the low connectivity cost and the use of the inexpensive 850 nm VCSEL technology.
In the IEEE 802.3ba 40/100 GbE (Ethernet) standard, with ratification expected in June this year, the lowest speed in the system is defined by the electrical input/output (I/O) running at 10 Gb/s (G). These 10G serial links undergo bandwidth aggregation to 40 or 100 Gb/s within MMF ribbons (10G x 4 and 10G x 10). Signal aggregation over the installed base, however will require an even higher serial transmission speed per channel per wavelength. This is realized within the 100GbE by using 25G x 4 transmission over SMF. On the horizon is the need for 40 to 50 Gb/s serial transmission using the already installed duplex multimode fiber links, particularly those utilizing the "Structured Cabling" standard in opposition to a fiber ribbon approach. According to the IEEE Ethernet Roadmap by 2015 the I/O speed will reach 40 Gb/s while the signal aggregation will reach 400 Gb/s up to 1 Tb/s. These blazing data transfer rates may possibly be served both by ribbons (40G x 25) and by WDM-like approaches at much higher serial transmission speeds.
In the presentation we compare and contrast the critical issues of the power, performance, and cost of high speed serial data transmission in datacenters, LANs, and FTTH systems from the perspective of the VCSEL technology. We focus on potential short-reach optical link solutions based on multi-mode and single-mode ultrahigh-speed infrared VCSELs that use direct current and electro-optic modulation schemes for mainstream FTTH applications.