PRISM

VOL. 1 NO. 1

ONTC PRISM Newsletter

Dear ONTC Members,

A warm welcome from the Editorial desk of the ONTC's newsletter "Prism". The telecommunication world has seen significant development in the past few years. From the days of the dot-com bubble burst, followed by the so-called photonic winter, our industry has survived and succeeded to scale new heights. Emergence of new technologies and business cases in both the developed and the developing world has meant proliferation of optical networking solutions towards the end-user. It is this proliferation that we seek to cover and enhance through this newsletter. The focus of this newsletter is to bring together industry, academia and government as well as other stake holders of optical networking and high-speed telecommunications. To this end, we will send this newsletter to the ONTC mailing list as well as to other targeted readers on a quarterly basis. ONTC PRISM has a website at www.ontc-prism.org. Readers are welcome to email the Editor with information or articles or even observations that affect the telecommunication industry. We do ask though, that readers keep their messages relevant to the mandate of the ONTC. Prism has a unique *technical advisory board* or TAB. The TAB consists of distinguished folks from industry and academia across different continents giving Prism significant diversity and a broad coverage focus. TAB members are responsible along with the editor for content in Prism. Typically, we envisage a TAB member to be in-charge of a particular issue. We encourage ONTC members and others to send in articles of 2-3 page limit of relevance to the growth of telecommunications to us. Articles should be emailed to submissions@ontc-prism.org. A TAB member will be assigned to review the article, and typically will solicit 2-3 independent reviews. To begin with we will have a list of open topics soliciting articles. For example, the next issue (for Feb 2010), will have articles focused on data-centers.

In the first issue, we have invited articles that cover the exciting optical access market. The optical access market is particularly important as it has direct impact on the end-user. Passive Optical Networks (PONs) are being rapidly deployed in almost every major country. Gone are the days when there was some doubt about the business case of PON – it is now almost a necessity to meet the true needs of residential broadband. In fact, when compared with WiMax, PONs have certain OPEX advantages that are currently being researched upon by various groups in North America and Europe. The first article is by Marek Hadjuczenia and Henrique da Silva from ZTE. The article called Next-generation PON - a quick look at current status, focuses on next generation PON standards and discusses the happenings of the industry in detail. The second article is by Wang Bo from China Telecom – one of the largest deployers of PON in Asia. Wang Bo describes China Telecom's role in furthering PON technology as well as how the recently emerged 10 Gb/s GE PON standard (IEEE 802.3av) is being pursued.

We move from the access towards the metro, where we have an article by Abhay Karandikar and Vinod Kumar from IIT Bombay, where they describes the recent standardization effort in the Carrier Ethernet community. Carrier Ethernet is an increasingly important technology for metro and access networks – poised to replace SONET/SDH and become the de facto WDM overlay in the years to come. This article shows some of the opportunities that exist for academic and industry researchers. References at the end of the article will guide the interested reader to the various standardization bodies across the broad spectrum of Carrier Ethernet.

Talking of standardization, one cannot but appreciate the work done by the IEEE in making Ethernet such a prolific technology over the past many years. From Bob Metcalfe's invention to the present day, Ethernet has traversed a long and successful journey. As mentioned by Bob himself, in the OFC 2008 keynote, one of the key reasons behind the success of Ethernet is active standardization in the IEEE. To discuss the happenings in today's 802.3 and 802.1 standard bodies, we have an article from Wael Daib who is also the Vice-Chair of the 802.3 Ethernet working group within the IEEE. The article describes the multiple active bodies within the 802.3 standard group as well as gives an overview of the advances made by the working group. The last article is a letter written by Admela Jukan and myself – a letter to the community describing the challenges that we face in the next 1-5 years. The objective of the letter also coincides with the reasons as to why we do have this newsletter and we do encourage readers, especially from the academic community to identify challenges based on our observations.

Interested authors who would like to send in an article, are welcome to send a 3 page (single column, 10 point font, with all one-inch margins) to submissions@ontc-prism.org. The deadline for reception of articles is December 15, 2009. On behalf of the TAB we are thankful to the IEEE Communication Society as well as to the ONTC officers Jason, Byrav, Suresh and Dominic who have supported us in making this newsletter happen. It is our hope that the newsletter would bring the community together and identifying areas of growth and common interest. It is often said that the previous century was one of innovation – and if that is so, then this century is opined to be one of collaboration. It is hence our sincere hope that PRISM does become a vehicle of collaboration – of ideas and through processes in leading this fast moving industry.

Ashwin Gumaste, IIT Bombay.

Next-Generation PON – A Quick Look at Current Status

Marek Hajduczenia and Henrique J. A. da Silva

Introduction – the continued increase in bandwidth demand in the first mile, as observed in recent years, is a direct result of the growing number of residential and business customer applications relying on high speed IP-level connectivity, which forces service providers to increase the capacity of their access infrastructure, providing more bandwidth to end subscribers, making fibre-based access the technology of choice for many of forward-looking operators. Given the rapidly growing market penetration of existing, first-generation Passive Optical Network (PON) technologies, with more than 30 million customers connected worldwide using various xPON flavours (primarily EPON, BPON and G-PON, ordered decreasingly in terms of market adoption), it is commonly believed that in the next 2-3 years, current xPON deployments will have to be migrated to higher bandwidth solutions. That is why various Standard Development Organizations (SDOs) have already started working on extending existing PON solutions to meet the anticipated operator and customer requirements for nG-PON systems. The term 'nG-PON' is used here to collectively refer to IEEE 10G-EPON and ITU-T NG-PON systems, while the term 'NG-PON' is used to collectively refer to ITU-T NG-PON1 (including XG-PON1 operating at the nominal data rate of 10 Gb/s in downstream and 2.5 Gb/s in upstream, as well as XG-PON2 operating at 10 Gb/s in both downstream and upstream channels) and NG-PON2 systems to provide differentiation between both solutions.

10G-EPON status – IEEE 802.3 Working Group started development of 10G-EPON in 2006Q3, when first a Study Group and then the P802.3av Task Force were created after a very successful Call for Interest (CFI), supported by a large number of companies and several operators with and without existing 1G-EPON deployments. They are interested in the proliferating Ethernet-based access network architecture, representing a natural bridge between LAN and MAN networks also based primarily on Ethernet technology. The approval of IEEE 802.3av 10G-EPON standard on the 11th of September 2009, the numerous and geographically varied attendance of the meetings, the deep involvement of many companies and commercial availability of 10G-EPON equipment from the first system suppliers come as a result of more than three years' worth of continuous work of a dedicated group of experts. As the first Ethernet-based networking solution, 10G-EPON supports both symmetric and asymmetric line rate operations, where the symmetric option (10/10G-EPON) operates at 10 Gb/s in both downstream and upstream directions, while the asymmetric option (10/1G-EPON) operates at 10 Gb/s downstream and 1 Gb/s upstream, driven by the fact that IP video services create bandwidth pressure mostly in the downstream direction and taking advantage of low-cost and more mature 1G-EPON burst mode optics. The major technical features of the finalized 10G-EPON system include therefore:

- The downstream wavelength band ranges 1575 - 1580 nm, relying on high-power (cooled) laser sources, most likely in the form of post-amplified Externally Modulated Lasers (EMLs);
- The upstream wavelength for 10 Gbit/s data channel ranges from 1260 to 1280 nm (coexistence with 1G-EPON guaranteed by dual-rate TDMA scheme), relying on high-power (un-cooled) Directly Modulated Lasers (DMLs) already available on the market. 1 Gbit/s upstream links use the 1G-EPON band, i.e. from 1260 to 1360 nm, reusing exactly the same, cost-effective components without the need for requalification.
- Mandatory stream-based FEC in all 10 Gbit/s links, based on the RS(255,223) code, which has better error correction properties (optical gain around 4 dB compared with 3 dB of RS(255,239) FEC used in 1G-EPON) than FEC used in 1G-EPON (accepts raw BER of 2.2×10^{-3}), though has higher transmission overhead (approximately 12.9% compared with 6.7% for RS(255,239) used in 1G-EPON).
- Inherent support for coexistence with 1G-EPON on the same ODN, through careful redesign of MPCP functions (such as discovery process, registration, etc.), utilization of a common time-reference unit (time quantum of 16 ns), as well as technical issues in the PHY layer (dual-rate burst-mode receiver at OLT, etc.);
- More flexible upstream data burst timing, where ONU laser on/off times can be negotiated between an ONU and the OLT, depending on the quality of the burst-mode receiver at the OLT and on the design of the ONU laser driver. The fixed laser on/off time set in 1G-EPON was found too inefficient to be mandated in this next generation access system. Practical analysis of the PMD subcomponents indicate that there is no technical difference in terms of laser diode and laser driver design between 1.25 Gbit/s and 10.3125 Gbit/s devices, and thus it is expected that 10G-EPON PMDs will have similar parameter values. T
- Compatibility with mass produced 10 Gbit/s P2P Ethernet components (Ethernet switches, some elements of optics, etc.) means that the necessary supplier ecosystem is already in place at this time.

Mature 1G-EPON systems with 1 Gbit/s symmetric bandwidth have been in mass deployment worldwide since 2004, supporting all possible existing diverse applications, including TDM and mobile backhauling, known for their high QoS requirements. For this reason, IEEE 802.3av 10G-EPON standard was focused on enabling a seamless upgrade and simultaneous operation of all EPON flavours (10/1G-EPON, 10/10G-EPON and 1G-EPON) on the same ODN, providing operators a unique chance to extend the ROI for their newly deployed fibre networks. 10G-EPON can be rolled out without the need to replace any existing 1G-EPON ONUs, minimizing the truck rolls and lowering the cost of migration to higher data rate system. Providing 10 times more raw bandwidth than the current 1G-EPON, 10G-EPON will deliver the bandwidth required by the next-generation applications, following an evolutionary scenario rather than forcing operators to completely replace legacy 1G-EPON equipment.

It is also anticipated that 10G-EPON equipment will follow the path of 10–fold capacity increase at roughly 3 times the port price (expected to be achieved around 2011 under current deployment scenarios), so characteristic of all Ethernet equipment in the past, though prices for prototype equipment already available from several vendors may indeed exceed this threshold.

NG-PON1 status – ITU-T SG15 Q2 community took a much longer time to react to rapidly evolving market requirements, mainly due to the higher downstream channel capacity available in G-PON systems (series of ITU-T G.984 Recommendations). However, initial stages of work on NG-PON systems (specifically NG-PON1) as well as development of G.987 series draft with 2009Q4 – 2010Q3 approval period, are under way. Current discussions (as for September 2009) and the quantity of technical issues remaining to be resolved at the PMD layer cast some shadow of doubt over the planned consensus schedule, especially taking into consideration that more complex tasks are yet ahead of the community. Development of the NG-PON1 system started during the May 2009 meeting of ITU-T SG15 Q2 in Geneva, Switzerland, which is currently working towards consensus on initial draft versions of G.987 series, describing an XG-PON1 system. The XG-PON2 system was dropped out of the scope of G.987 series and may be added in the (uncertain) future, once operators' interest in this access technology becomes more mature.

Technically speaking, an XG-PON1 system is currently viewed as a higher-speed G-PON, operating at the nominal data rate of 10 Gb/s in the downstream and 2.5 Gb/s in the upstream. The bandwidth asymmetry of 1:2 in G-PON was increased to 1:4 in XG-PON1, taking into consideration arguments from operators, indicating that the upstream channel capacity in G-PON was too high when compared with the downstream channel. Additionally, it is expected that the cost of 2.5G burst-mode solutions will be somewhat lower than that of 5G or 10G solutions, which at this time remains yet to be verified on a commercial scale. For now, two power budgets have been defined and consented so far, i.e. Nominal1 (N1), with 29 dB insertion loss, and Nominal2 (N2), with 31 dB insertion loss. The Extended (E) power budget is yet under discussion, with the insertion loss ranging between 33 and 35 dB, depending on the target application and compatibility with the Nominal power budget of choice. Along with the definition of the power budgets, link specification was created, producing so far only N1 (with APD ONT) and N2 (with APD and PIN ONT) class downstream link and corresponding upstream link for both power budgets. The E class power budget is reserved for further study (FFS), considering the lack of consensus on this topic.

The TC layer framing is not expected to change much in XG-PON1 system and still relies on 125 μs framing, providing a precise 8 kHz clock signal for all connected ONTs. Despite multiple arguments brought to the attention of the community against the use of such strict framing format for transmission of variable size IP frames, which ultimately increases the system cost and limits the functional integration at the ONU and OLT devices, this specification of the G-PON system will most likely be reused with no changes at all. Likewise, the concept of GEM-like encapsulation will also be reused in XG-PON1 (called XGEM), with several minor changes which are still to be discussed in the future i.e. extension of the XGEM header, alignment of XGEM size to multiples of 4 bytes (32 bits) to facilitate underlying physical implementation, definition of new applications for certain fields inside of XGEM header, etc.. This means that the XGEM channel in XG-PON1 may play multiple functions, including transfer of encryption related information (key index). Likewise, proposals for redefinition of the PLOAM channel were also presented to the community, where PLOAM control messages would be carried over dedicated XGEM ports rather than in specialized structures inside of the 125 μs framing. Due to controversy of such a proposal and being a fundamental change in the PLOAM channel character, further discussion on this topic will be needed in the near future. XG-PON1 system security represents yet another area where extensive development is expected in the coming months. Some operators submitted proposals for extension of existing G-PON security models, where only the downstream data channel was subject to encryption. However, in face of the evolution of security threats and malicious activity on the networks, upstream channel encryption as well as mutual ONT – OLT authentication become pivotal for a successful access network.

FEC for XG-PON1 is also generating very hot discussions. Proponents of reusing existing solutions opt for RS(255,223) for the downstream link and RS(255,239) for the upstream link, while several companies show interest in modified or truncated FEC codes, which have not been used in any commercial equipment until now. Given that the problem of truncated FEC word support was already resolved in G-PON, it is not certain what the advantages of using brand new FEC codes really are. The majority of polled IC vendors prefer to reuse the existing FEC design blocks rather than having to redesign them and test implementation afterwards.

The XG-PON2 system was announced as out of focus or of no interest for the next few years, due primarily to the lack of interest in symmetric, 10 Gb/s access system, as publicized by some of the operators. It was originally planned to have the first two drafts approved by September 2009 (future G.987.1 and G.987.2 specifications), though the amount of discussion in the community on the characteristics of the XG-PON1 PMD sublayer created at the time a potential for delay of such a document. The XG-PON1 specifications for the TC layer (XTC) and OMCI control planes (G.987.3 and G.987.4, respectively) are planned for consensus in 2010Q3, though again this target date may be subject to fluctuations, depending on the quantity of changes introduced into the TC layer specifications. OMCI at this time is expected to remain pretty much unchanged, when compared with G-PON Rec. G.984.4.

NG-PON2 status – both 10G-EPON and NG-PON1 are TDMA PON systems, operating at a higher data rate though not changing dramatically anything in the existing PON architecture. NG-PON2, as the long-term target access architecture, the development of which is slated for the period after year 2015, represents a revolutionary rather than evolutionary approach to first mile connectivity. While 10G-EPON and NG-PON1 reuse much of the existing, first-generation xPON architecture, inherently including the Outside Distribution Network (ODN), NG-PON2 will require complete make-over of the deployed fibre, especially in terms of replacing passive optical combiners / splitters with e.g. wavelength routers (Arrayed Waveguide Gratings – AWG) or even more exotic solutions, currently under intensive academic research. The precise adoption and specification timeline depends on the actual market demand, which at this time is rather weak considering economic slow-down and decreased demand for new deployments and access technologies alike.

NG-PON2 at this time does not have any preferred technology, and therefore a plethora of possible access system implementations were submitted for community consideration, ranging from higher capacity multi-channel TDMA-PON (e.g. 40G PON, operating on a single wavelength though with different modulation formats, known only from long-haul or experimental trials), through WDM-PON, and ending with such exotic systems as (O/E)CDMA-PON with dynamic code allocation or even OFDMA-PON. Each of these architectures features a number of technical challenges which need yet to be addressed by industry and academia, in order to provide a cost-effective solution suitable for access network development:

- higher capacity TDMA-PON systems will have to combat dispersion effects and reduction in receiver sensitivity, which beyond 10 Gbit/s begin to challenge support for higher power budgets – targeted by carriers to guarantee higher port densities at the CO sites.
- WDM-PON will remain troubled by the use of wavelength selective devices at the ONU side. Despite rapid progress in colourless ONU transceivers (via the use of R-SOA devices or tuneable lasers), such solutions remain at this time prohibitively expensive when compared with existing TDMA-PON transceivers, thus failing to meet the test of cost-efficiency that so many technologies have already failed in the access domain.
- More exotic approaches, mainly in the form of (O/E)CDMA-PON systems, have the form of research projects at this time, with numerous technical and system-level challenges, struggling with basic research and material limitations, and imposing constraints that typical PON architectures have never faced before.

From the existing NG-PON2 technologies, at this time WDM-PON seems to have the brightest commercial future, provided that emerging customer applications demand provision of dedicated high capacity bandwidth pipes to each customer. A few commercial WDM-PON systems are already available for deployment, though their market share is very limited to small trials only and non-residential applications, mainly due to weak operator interest, high deployment and maintenance costs (running typically 6 – 10 times cost per bit for TDM-PON), as well as lack of residential user demand, except for business customers, who are nowadays typically served with P2P solutions.

Convergence of nG-PON standards – at this time, it is not clear how much convergence between both nG-PON systems (i.e. 10G-EPON and XG-PON1) will be achieved in practice, though efforts have been made to bring both standardization groups together in order to discuss potential alignment at both PHY and MAC levels. Both SDO groups held joint workshops and expressed interest in coordination of their work for the common benefit of future customers of nG-PON technology. Given that the 10G-EPON standard was approved in September 2009 and no technical changes can be introduced now, any convergence efforts are restricted at this time to XG-PON1 only.

Despite the aforementioned high-level intentions towards alignment of both standards, the current status of draft G.987.2 seems to indicate that the convergence between both said systems will not be achieved in practice, given such basic differences as data rate selection, FEC codes, XTC framing layer in XG-PON1, or even persistent support for 125μs framing, resulting in a number of specific differences in operation between both discussed systems. Given the rejection of multiple attempts to reuse 10G-EPON as a transport layer for the nG-PON converged access system, achieving a single standard seems very improbable as for today, and so we may witness one more chapter of the EPON versus G-PON marketing war, which we all have seen waged in mass media for several years.

Comparison table for ng-PON systems (various generations) is illustrated below:

	G-PON	1G-EPON	10G-EPON	NG-PON1	NG-PON2
LEVEL 1 (PHY) PARAMETERS					
Downstream [Gbit/s]	1.244/2.488	1.25	10.3125	9.952	~ 1 / customer
Upstream [Gbit/s]	0.155[1]/0.622[1]/1.244	1.25	1.25/10.3125	2.488 / TBD[10]	~ 1 / customer
Line Coding	Scrambled NRZ	8b/10b	64b/66b[2]	Scrambled NRZ	Unknown[10]
Channel Insertion Loss [dB]	A: 20, B: 25 B+: 28 C: 30, C+: 32	PX10: 20 PX20: 24 PX30: 29[3]	PR(X)10: 20 PR(X)20: 24 PR(X)30: 29	N1: 29dB N2: 31dB E: 33-35dB[9]	TBD[10]
Laser on/off	≈ 13 ns	512 ns	512 ns	TBD[9]	Unkown TBD[10]
AGC[4]	44 ns	< 400 ns	< 400 ns		
CDR[5]		< 400 ns	< 400 ns		
LEVEL 2 (MAC AND ABOVE) PARAMETERS					
Payload encapsulation	GEM	Ethernet + LLID	Ethernet + LLID	XGEM	Unknown[10]
Frame Fragmentation	Yes	No	No	Yes (? - TBD)[9]	Unknown[10]
Max Logical Reach [km]	60	unlimited	unlimited	60 (? – TBC)[9]	Unknown[10]
Max Logical Range [km]	20	unlimited	unlimited	20 (? – TBC)[9]	Unknown[10]
Max Logical Split	128[7]	32767[7]	32513[8]	> 128	> 128
STANDARD MATURITY AND MARKET SITUATION					
Maturity	G.984 under extension	released 09.2004	released 09.2009	2010/2011 (?)	2015 (?)
Market	US and Europe, trials in APAC (limited)	APAC, NA, East Europe	APAC, NA, East Europe	Target US and Europe, APAC (?)	Unknown

Legend:
[1] Deprecated.
[2] 64bit/66bit is used for 10.3125 Gbit/s links. 1.25 Gbit/s links use 8bit/10bit encoding of 1G-EPON.
[3] Never officially specified.
[4] Automatic Gain Control.
[5] Clock Data recovery.
[6] TC layer limited to 128 (127 ONU IDs can be used in practice).
[7] Limited by LLID address space of 215-1 (1 LLID reserved for broadcast).
[8] Limited by LLID address space of 215-255 (2 LLID reserved for broadcast, 253 LLIDs reserved for future system extensions).
[9] Partial consensus at this time or discussions are under way.
[10] Discussion to be started in 2010.

Marek Hajduczenia received his MSc and Engineer diplomas in electronics and telecommunication, specialization - optical transmission systems, from Technical University in Bialystok in 2003. In 2008 he received the Ph. D. degree in telecommunications from University of Coimbra, Department of Electrical and Computer Engineering.
Currently, he is working for ZTE Corporation at the position of xPON Standardization Director and is involved in research and development of next generation PON systems. His main research interests include self-similar stochastic processes, control management layer and security for optical access networks, IPv4/IPv6 transition problems, optical burst switching and many more.
He is involved in the IEEE 802.3 (assistant editor for former P802.3av 10G-EPON Task Force) as well as FSAN/ITU-T projects (NG-PON work group at FSAN, Q2/SG15 at ITU-T). He is also a member of the IEEE Communication Society (ComSoc).

Henrique J. A. da Silva received the Ph. D. degree in communication systems engineering from the University of Wales, United Kingdom, in 1988. Since then he has been with the Department of Electrical and Computer Engineering at the University of Coimbra, where he is now an associate professor.
He is the leader of the Optical Communications Group of the Institute of Telecommunications at Coimbra, Portugal, since 1992. His research interests include optical and mobile communication systems, with emphasis on photonic devices and optical networks.
He is a member of the Optical Society of America (OSA) and of the IEEE Communications and Photonics Societies.

China Telecom Views 10G-EPON as a Key to Innovation and Sustainable Development

Wang Bo

Upward of 50 million broadband subscribers, today China Telecom represents the largest broadband network in the world. And while the number of fixed-line telephone subscribers has declined in 2008 from 220 to 208 million, the number of broadband subscribers has been growing by approximately 8 million annually for the last 5 years. China Telecom expects this number to reach 75 million by 2011.

Understandably, China Telecom takes very seriously the choice of the broadband technology capable of sustaining such aggressive growth targets. In making its choice, China Telecom focuses on service capabilities, technology maturity, capital and operational costs, and future evolution. In most green field deployments, China Telecom has stopped deploying copper lines, instead preferring Passive Optical Network (PON) to the building, with regular Ethernet reaching the subscriber (FTTB + Ethernet). In high-end deployments, FTTH is used with fiber reaching individual subscribers. While retrofitting existing deployments, the preferred architecture includes PON to the building followed by DLS (FTTB + DSL).

China Telecom has started evaluating various PON technologies in summer of 2005. This work has focused on Ethernet Passive Optical Networks (EPON) standardized by the IEEE and on Gigabit Passive Optical Networks (GPON) standardized by the ITU-T.

To fully develop and evaluate EPON capabilities, China Telecom has formed and chaired a working group that included four EPON ASIC vendors and six EPON system vendors. This group has produced a comprehensive EPON system-level specification that included such features as security, protection, VLAN modes, multicast support, QoS mechanisms, and Multi-Point Control Protocol (MPCP) discovery enhancements. In parallel, interoperability tests events were conducted, first among the chip vendors and then among the system vendors. In the first half of 2007, China Telecom has become the first carrier in the world to demonstrate large-scale, comprehensive chip-level and system-level EPON interoperability. Correspondingly, encouraged by the emergence of a healthy EPON ecosystem, China Telecom and other Chinese carriers have begun mass-deployment of EPON technology. EPON is also deployed in large volumes in Korea and Japan.

The work has also continued on evaluating the capabilities and maturity of GPON equipment by carrying out GPON tests once per year since 2005. China Telecom is conducting a GPON field trial with about 3000 subscribers this year. While GPON vendors have made good progress over the last few years, the full potential of this technology has not been fully realized yet. There exist only few commercialized ASICs, especially for the Optical Line Terminal (OLT) side of the network, and the interoperability efforts have not been successful.
With 16 million Chinese subscribers expected to be served by EPON by the end of 2009, issues of sustainability and upgradability are becoming very important. One of the distinctive features of EPON and the recently-standardized 10G-EPON technologies is their ability to coexist on the same network and support for smooth upgrade without network-wide service interruption.

CTC engineers have tracked the progress of 10G-EPON standard in IEEE and in June 2009, China Telecom co-hosted the IEEE 802.3av task Force meeting in Shanghai.

In July 2009, China Telecom has conducted the 10G-EPON chip-level interoperability test, the first such event worldwide. The tests were performed with asymmetric version of 10G-EPON (10Gb/s downstream and 1 Gb/s upstream data rates) and covered interoperability at the physical and MAC layers, FEC, MPCP, normal and extended OAM discovery, remote management, coexistence with previous-generation EPON, and performance measurements. All four chip vendors have demonstrated satisfactory progress. The second round of the chip-level interoperability test is planned in November 2009, this time covering the symmetric 10G-EPON. China Telecom hopes to carry out the system-level test interoperability in the first quarter of 2010, trying to achieve full 10G-EPON interoperability in the first half of 2010. Commercial deployments of 10G-EPON are anticipated in the second half of 2010.

Increasing and changing service demands and increasing subscriber base require FTTx access networks to be robust and reliable, flexible, and evolvable. Through its consistent innovation and in collaboration with component and equipment vendors, China Telecom experts ensure the sustainable development of the FTTx technology.

Wang Bo graduated from the Department of Electronic Engineering of Tsinghua University, China in 1998 with a Masters Degree. In 2004, he studied in Coventry University, UK, receiving a Masters Degree of Communication Management. Since 1998 when he joined China Telecom, he has been engaged in the research and project management on DSL access, fiber access, wireless access and home network. He also organized and participated in specifications formulation, equipments evaluation, new technologies trial and formulation of technical strategies of China Telecom in the related fields. He has been assuming the vice director of Access Network Working Group of CCSA (China Communications Standards Association) since 2003.

Recent Advances in Carrier-Class Ethernet Transport

Abhay Karandikar and M Vinod Kumar

In the last decade, Ethernet has been upgraded with many carrier grade features like scalability, protection and restoration and operations, administration and maintenance (OAM) making it an ideal packet transport for core networks. In this article, we review these developments that have taken place in Ethernet standards.

IEEE 802.1ad Provider Bridges (PB) standardized in 2005 [1] was the first step towards applications of Ethernet Bridges in service providers' networks by separating the Customer virtual LAN (VLAN) from the service provider VLAN (S-VLAN). However, it still suffers from scalability problem. This problem was addressed in IEEE 802.1ah Provider Backbone Bridging (PBB) [2]. A PBB network comprises of Backbone Edge Bridges (BEB) and Backbone Core Bridges (BCB). Customer frames are encapsulated/de-capsulated at the BEB with Backbone Source MAC address (B-SA), Backbone Destination MAC address (B-DA), Backbone Service Identifier (BSI-ID or I-SID) and a Backbone VLAN ID (B-VID). While B-SA and B-DA are the MAC addresses of ingress and egress bridges within PBBN, 24 bit I-SID identifies the service in the PBB network. By separating the customer and provider MAC address space and separating service tag from forwarding tag, PBB leads to a scalable metro network design.

While PBB has addressed the issue of scalability, it does not have the capability of Traffic Engineering (TE). A new standard IEEE 802.1Qay [3] ratified recently in June 2009, addressed this problem by establishing traffic engineered paths called Ethernet Switched Paths (ESP). This is achieved by disabling source MAC address learning, discarding frames destined to unknown destination MAC address and disabling spanning tree for a range of B-VID (called ESP-VID) in PBB and configuring them by an external management plane or control plane. Along with Connectivity Fault Management (CFM) [4], PBB-TE provides a highly scalable architecture for deploying Ethernet in core network.

PBB-TE specifies only 1:1 end-to-end point to point (P2P) tunnel protection switching and does not take advantage of possibility of local repair. New ongoing IEEE project 802.1Qbf PBB-TE infrastructure protection switching [5,6] addresses the relatively high failure rate of particular links or bridges within a network in an efficient way by performing local repair. A sequence of LAN ports (called Infrastructure Segment) over which at-least one PBB-TE tunnel is configured are identified and monitored through continuity check messages (CCM) (Refer Figure 1). Upon absence of CCM, tunnels are diverted (without altering the end-to-end tunnel identifier) from working/primary infrastructure segment (WIS) to backup infrastructure segment (BIS) (Refer Figure 2). WIS and BIS together form a segment protection group (SPG). Infrastructure Protection is applicable for both P2P and branches of Point to Multipoint (P2MP).

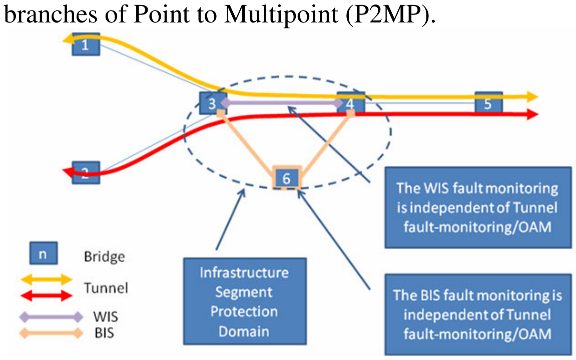

Figure 1: Before PBB-TE Infrastructure Segment Protection Switching

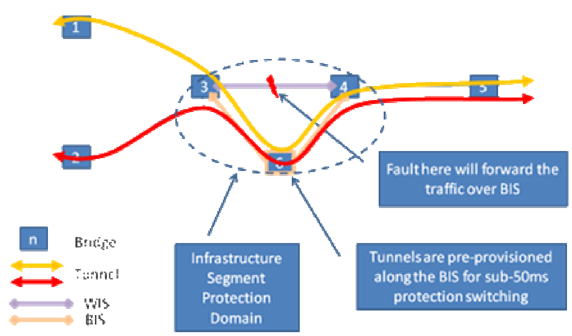

Figure 2: After PBB-TE Infrastructure Segment Protection Switching

IEEE 802.1Qbf will enable scalable and manageable backbone transport network. Service Provider can locally and cost-effectively protect a group of tunnels flowing over an infrastructure segment without modifying the tunnel identifier. Further, fault localization is still possible because tunnel identifier is not changed for customer frames and is globally unique thereby offering a true carrier class local-restoration functionality. Service Providers can perform maintenance activities in one infrastructure segment of a network without disabling protection in another infrastructure segment. IEEE 802.1Qbf (as of October 2009) is still work under progress and expected to be complete by 2010. In summary, these significant amendments to Ethernet will lead to a truly scalable carrier class Ethernet with protection and manageable transport network.

REFERENCES
[1] IEEE 802.1ad, “Local and Metropolitan Area Networks, Virtual Bridged Local Area Networks – Amendment 4: Provider Bridges”, 2005.
[2] IEEE 802.1ah, “Local and Metropolitan Area Networks, Virtual Bridged Local Area Networks – Amendment 6: Provider Backbone Bridges”, 2008.
[3] IEEE 802.1Qay, “Local and Metropolitan Area Networks, Virtual Bridged Local Area Networks – Amendment 10: Provider Backbone Bridging with Traffic Engineering”, 2009.
[4] IEEE 802.1ag, “Local and Metropolitan Area Networks, Virtual Bridged Local Area Networks – Amendment 5: Connectivity Fault Management”, 2007.
[5] PBB-TE Infrastructure Protection Proposed PAR, IEEE 802.1 May 2009 Interim Meeting, Pittsburgh, PA., USA, http://www.ieee802.org/1/files/public/docs2009/new-sultan-infrastructure-segprot-proposed-par-0509-v05.pdf, 2009.
[6] IEEE 802.1Qbf “Draft PAR for Local and Metropolitan Area Networks, Virtual Bridged Local Area Networks – Amendment: PBB-TE Infrastructure Segment Protection”, http://www.ieee802.org/1/files/public/docs2009/new-qbf-jeffree-draft-par-0609-v01.pdf, 2009.

Abhay Karandikar received his M.Tech. and Ph.D degrees in Electrical Engineering from the Indian Institute of Technology, Kanpur in 1988 and 1994, respectively. He is currently a Professor in the Department of Electrical Engineering, IIT Bombay. At IIT Bombay, he started many technology development projects, including the one on Open Source MPLS and Linux based MPLS emulator. He co-founded the venture backed company Eisodus Networks. He is currently leading TTSL-IIT Bombay Center for Excellence in Telecom. His research group at IIT Bombay is focused on resource allocation in wireless networks. He has made several contributions to IEEE 802.1 and 802.16m WiMAX standards. Dr Karandikar has lectured extensively in various international fora and given tutorials in IEEE GLOBECOM, MILCOM. He has consulted for industries in the area of communications and networking.

Vinod Kumar received his B.Tech degree in Electrical Engineering from the Indian Institute of Technology, Madras in 2003. Subsequently, he completed his post graduation in Telecommunication from the Indian Institute of Science, Bangalore in 2005. Since then he is with Tejas Networks Ltd. working in Standards and Technologies Team. His primary focus is Optical Transport systems, Protection Switching, Quality of Service, Traffic Engineering, Networking Algorithms, Wireless Backhaul for 2G, 3G, 4G, Wi-Fi and mobile-WiMax, L2-L3 interworking, IP/MPLS and Carrier-Ethernet. Towards this end, he has applied for several patents. Mr. Vinod Kumar has made several contributions towards IEEE 802.1Qbf. His other areas of interest are Synchronization, TDM-Ethernet Circuit Emulation Service, Data-Centre Bridging and Load-balancing.

IEEE 802.3 Ethernet Working Group: State of the Standard

Wael William Diab

The past decade has seen IEEE's Ethernet Working Group (802.3) expand into new areas, specify faster speeds and enable new application spaces.

Major Recent Milestones:

Before we get into the current active projects within 802.3, its helfpul to take stock in some of the major milestone projects that Ethernet has underdaken in the last few years.

Following the successful and widely deployed 10 Gigabit Ethernet interfaces, IEEE Std 802.3af-2003 was published in 2003 as an amendment to IEEE 802.3.* This project was revolutionary in that it enabled low-voltage DC power to be carried over the Ethernet infrastructure thereby enabling, what has become common place in today's Enterprise networks, converged VoIP (Voice over IP) telephony. The result of which has been a consolidation in infrastructure, and thus lower CapEx and OpEx costs for Enterprise IT networks. Moreover, it gave way to many revolutionary features in VoIP and video technology within the Enterprise.

Shortly after, IEEE Std 802.3ah-2004 published as an amendment to IEEE 802.3.* This was a major project that addressed a new space for Ethernet, namely the service provider access space by introducing a family of technologies that addressed the varied geographic and bandwidth needs; interfaces from high speed Ethernet over DSL copper links to point to point optical and point to multi-point optical links (EPON). In addition, the Ethernet in the First Mile amendment introduced an operations, administration and management technology (OAM) that aides deployers in managing and debugging their network deployments thereby bringing down the OpEx cost of their networks.

In 2006 and 2007, IEEE Std 802.3an-2006, IEEE Std 802.3aq-2006, IEEE Std 802.3as-2006 and IEEE Std 802.3ap-2007 were published. The first two introduced new interfaces for 10Gb/s Ethernet, specifically a 10GBASE-T interface over the widely popular twisted pair copper infrastructure and 10GBASE-LRM, a serial optical interface at 1310 nm over multi-mode fiber such as OM1, OM2 and OM3. .3as expanded the frame format of Ethernet to allow for additional extensions via an envelope frame that could be used by higher layer encapsulation protocols such as those defined by the IEEE 802.1 Working Group, ITU-T or IETF while retaining the same basic frame format for carrying Ethernet data. Finally, Ethernet entered another new area by specifying backplane connectivity technology with the publication of .3ap, some of which have been referenced by outside organizations for media connectivity such as SFP+.

Current Projects:

Today, IEEE's Ethernet Working Group (802.3) continues to be very busy with new exciting projects on the horizon.

At the time of publication of this article, three recently approved amendments to the current base document, IEEE Std 802.3-2008, are undergoing the publication process.

IEEE Std 802.3av-2009, also known as 10Gb/s PHY for EPON, adds a series of interfaces to the EFM family aimed at emerging applications such as higher definition content distribution for video on demand (VOD) in the consumer market, support for multi-dwelling unit deployments with a large number (64-128) of subs per ONU and wireless backhaul. The standard specifies new 10Gb/s interfaces that are defined for 3 optical power budgets supporting split ratios of 1:16 and 1:32, and distances of at least 10 km and 20 km. It is also noteworthy to mention that the 10GEPON project allows for an evolutionary upgrade path where 10GEPON systems can coexist with previous generation 1GEPON systems allowing mixed deployments as well as 10G/1G interfaces in addition to the 10G/10G interfaces.

IEEE Std 802.3at-2009, also know as DTE Power Enhancements and sometimes informally reffered to as "PoE Plus", enhances the popular power over Ethernet technology. The standard increases the available power to

25W, enabling a variety of new applications including feature rich wireless access points with multiple radio technologies.

IEEE Std 802.3bc-2009 contains the Ethernet Organizationally Specific Type, Length, Values (TLVs) used by IEEE 802.1's Link Layer Discovery protocol. IEEE 802.3bc enables IEEE 802.3at's enhanced power-management features such as dynamic power allocation and negotiation down to 1/10th of a Watt.

IEEE P802.3az™, which is currently in development and also known as Energy Efficient Ethernet, is targetted at saving energy in Ethernet networks on a select group of PHYs. The PHYs selected for work in this project include the popular 100BASE-TX and 1000BASE-T PHY as well as the emerging 10GBASE-T technology and the backplane interfaces. The method of power savings currently planes is a technique known as Low Power Idle (LPI), which takes advantage of low utilization (high idle time) that is characteristic of many Ethernet networks, while allowing for very rapid transitions back to the active state for data transmission. IEEE P802.3az is also currently planning to use 802.3bc for its enhanced power-saving modes that allow for power savings beyond the PHY layer. The enhanced capability has a dynamic aspect to it so that behaviors can be adjusted over the life of the link and for the specific application in use.

IEEE P802.3ba™, which is currently in development and also known as 40Gb/s and 100Gb/s Ethernet and sometimes informally referred to as "Higher Speed Ethernet", targets the next two speed increases for Ethernet. Emerging applications that have been demonstrated to need bandwidth beyond the existing capabilities such as data center, internet exchanges, high performance computing and video-on-demand delivery. The specification of two new rates rather than a single higher speed rate is in recognition that network aggregation and end-station bandwidth requirements are increasing at different rates. IEEE P802.3ba is currently planning on defining the following interfaces:

- 40GBASE-KR4 40 Gb/s PHY using 40GBASE-R encoding over four lanes of an electrical backplane.
- 40GBASE-CR4 40 Gb/s PHY using 40GBASE-R encoding over four lanes of shielded balanced copper cabling.
- 40GBASE-SR4 40 Gb/s PHY using 40GBASE-R encoding over four lanes of multimode fiber, with reach up to at least 100 m.
- 40GBASE-LR4 40 Gb/s PHY using 40GBASE-R encoding over four WDM lanes on single-mode fiber, with reach up to at least 10 km.
- 100GBASE-CR10 100 Gb/s PHY using 100GBASE-R encoding over ten lanes of shielded balanced copper cabling.
- 100GBASE-SR10 100 Gb/s PHY using 100GBASE-R encoding over ten lanes of multimode fiber, with reach up to at least 100 m.
- 100GBASE-LR4 100 Gb/s PHY using 100GBASE-R encoding over four WDM lanes on single-mode fiber, with reach up to at least 10 km.
- 100GBASE-ER4 100 Gb/s PHY using 100GBASE-R encoding over four WDM lanes on single-mode fiber, with reach up to at least 40 km.

The SR technologies are defined for operation over 50/125 µm multimode type A1a.2a (OM3) or OM4 fiber. The WDM based technology for planned use for 40G has center wavelengths as members of the CWDM wavelength grid defined in ITU-T G.694.2 and are spaced at 20 nm. For 100G, the WDM based technology currently planned have center frequencies as members of the frequency grid for 100 GHz spacing and above defined in ITU-T G.694.1 and are spaced at 800 GHz.

Recently, the IEEE 802.3 Working Group has chartered a study group to support the IEEE P802.1AS Time Synchronization Protocol. IEEE P802.1AS is part of a suite of standards under development by IEEE 802.1's Audio-Video Bridging Task Group that is working to allow Ethernet to be used in the home as the interconnect for all audio/video consumer electronic equipment, professional A/V equipment other markets where tight time synchronization is necessary such as SONET grade equipment and industrial applications.

Finally, at the time of publication of this article, a Call For Interest (CFI) in forming a Study Group to study the need for an amendment to the IEEE 802.3 standard to specify a 40Gb/s Ethernet Single-mode Fibre PMD has been announced. This motivation for the CFI is to study an interface optimized for client applications in the carrier environment. If approved, this study group will output (a) a recommendation to the IEEE 802.3 Working Group if such a amendment is required and (b) if so a Project Authorization (PAR) draft, 5 Criteria and Objectives in support of a project to develop the amendment.

Concluding Remarks:

There are a number of emerging Ethernet related technologies that will continue to expand the application space.

First, the demand on bandwidth requirements at lower cost structure will continue to increase both directly, via applications that require such interfaces, and indirectly, for application that drive the bandwidth in the backbone, aggregation or enable new spaces.

Secondly, convergence around Ethernet as the ubiquitous technology for wired Layer 2 connectivity is as strong as it has ever been. From the home to the core, convergence is occurring in the consumer, enterprise, service provider, backhaul, datacenter and high performance computing to name a few. This drives higher volumes and lower cost while eliminating unnecessary protocol conversions. Moreover conventional connections within the home migrating to Ethernet are on the horizon. Finally, the convergence trend has gone beyond connectivity, as the network architectures themselves have converged with different "types" of networks having increasingly more similarities than differences.

The emerging projects described above in conjunction with the work that is ongoing in the IEEE 802.1 Working Group, such as Audio-Video Bridging (AVB) and Data Center Bridging (DCB), represent an evolutionary snapshot of the ongoing trends and emerging applications that Ethernet will help enable.

Footnotes
* Now part of IEEE Std 802.3-2008
Views expressed in this article are those of Mr. Diab's and not the IEEE

Wael William Daeb is a Sr. Member of the IEEE, elected Vice-Chair of the IEEE 802.3 Ethernet Working Group and a member of IEEE-SA's Standards Board Committees. Wael is an IEEE published author for book "Ethernet in the First Mile: Access for Everyone" and holds BS and MS degrees in Electrical Engineering from Stanford University, a BA degree in Economics from Stanford, and an MBA with honors from the Wharton School of Business. He has numerous patents in the networking space.

The Role of Optical Networking for the Future Internet: Bright Prospects for our Community

Admela Jukan and Ashwin Gumaste

Editorial Letter to the Optical Networking Community

The development of next generation network architecture is fueled by the growing demands of upcoming applications requiring two new features: high bandwidth pipes with guaranteed service level agreements and flexible invocation of services irrespective of location, transmission and switching technologies. Towards meeting these demands, optical networking – encompassing Carrier Ethernet and WDM solutions, has been at the source of innovation in telecom in the last 10 years. Not only is it the key technology for the transformative wireline network design, but it has entered the wireless world addressing the capacity issues of the base station's "last mile". Ethernet over WDM has become a de facto standard solution for provisioning traffic in contemporary metro and access networks. It is further slated to dominate transport networks, which have traditionally been based on SONET/SDH systems. The replacement of SONET/SDH by Carrier Ethernet is a huge business opportunity in North America and Europe. In Asia, especially in China, India, Korea and Japan, Carrier Ethernet in conjunction with WDM is forming a bulk deployment.

Many future networking proposals not only suggest to route end-to-end at the lower layers instead of the IP layer, and but also assume participation of various players in the network evolution, including application developers, control platform operators, and transmission infrastructure owners. The trends to integrate the Internet into the carrier-grade infrastructure is not only attributed to the high CAPEX and OPEX of switching at the IP layer as compared to switching at the layers below, but also to the increasing demand to provide unified security and the control plane for both IP and carrier-grade world. There is no doubt that the next decade will see a mélange of Internet architectures embedded into high-bandwidth technologies and carrier-grade IT systems for control and management. This presents a big opportunity for our community to address and focus on.

The optical network community indeed is best equipped to lead the efforts towards the 21st century telecom architectural paradigm which can successfully address the issues pertaining to IP network evolution. Three major domains have emerged as distinctive areas of broad impact of the optical network technologies:

1) Data center networks, including the so-called Green Networking facilitated through the fiber based networks connecting remote locations close to the energy sources.

2) Global digital media networks, with the optical networks being the technology of choice for streaming of the high-definition media in the "cinema" quality

3) Convergence of IP and carrier-grade network infrastructure, where carriers are increasingly interested in understanding how these two networks can interoperate for leaner overall expenses, both in wireline and wireless worlds. Mobile backhaul and combined IP-Ethernet-optical video distribution are excellent examples of this major telecom domain.

We are seeing bright prospects for our community in making the true difference in the years to come. The optical network community has all reasons to be optimistic about this prospect, as we are witnessing a huge momentum in the industrial world, where integrated Ethernet/WDM boxes are coming out of age as reported by dozen of vendors; where carriers are consolidating their networks trying to find way to control and manage a converged "packet-circuit" world; where the research community is participating in the most exciting development in the wireline industry since the telecom boom in the nineties.

There is a note of caution though – which if left unchecked has the potential for our community to loose at the very business which defines us! Given the quantum of deployment and development that we expect, it is only natural that IP world communities will try to claim Ethernet switching as a mere extension of routing. It is here that the optical community has to display leadership in embracing Ethernet switching, Carrier Ethernet, multi-service transport, data-centers, and massive media distribution as our own efforts. And, indeed these are our efforts. High-speed Ethernet interfaces are optical! Energy efficiency is at its maximum when data continues in the optical domain. Highly virtualized data center cores are almost exclusively connected, controlled and created using photonic cross-connects. 4k/8k digital media streaming is only possible over optical networks. Etc. We have to hence as a community broaden our vision and absorb, assimilate these new areas of growth. We have to realize that if we continue to harp in the olden days for first and second generation optical networks – we will be left to face the depreciation of everything we have invented in our community to date. The time has come for us to turn a new leaf – one that promises a true revolution in telecommunications.

Admela Jukan is W3 Professor of Electrical and Computer Engineering at the Technical University Carolo-Wilhelmina of Brunswick (Braunschweig) in Germany. Prior to coming to Brunswick, she was research faculty at the Institut National de la Recherche Scientifique (INRS), University of Illinois at Urbana Champaign (UIUC) and Georgia Tech (GaTech). From 2002-2004, she served as Program Director in Computer and Networks System Research at the National Science Foundation (NSF) in Arlington, VA. While at NSF, she was responsible for funding and coordinating US-wide university research and education activities in the area of network technologies and systems. During her NSF tenure she initiated two research community activities and workshops: *Fundamental Research in Networking* and *Residential Broadband Revisited: Research Challenges in Residential Networks, Broadband Access, and Applications*. She received the M.Sc. degree in Information Technologies and Computer Science from the Polytechnic of Milan, Italy, and the Ph.D. degree (cum laude) in Electrical and Computer Engineering from the Vienna University of Technology (TU Wien) in Austria. She received her *B.Sc.* degree from Univ. of Zagreb (Croatia) and she also holds an habilitation degree (*venia legendi*) from the TU Wien. Dr. Jukan is the author of numerous papers in the field of networking, and she has authored and edited several books. She serves as a member of the External Advisory Board of the EU Network of Excellence BONE. Dr. Jukan has chaired and co-chaired several international conferences, including IFIP ONDM, IEEE ICC and IEEE GLOBECOM. She serves as Associate Technical Editor for IEEE Communications Surveys, IEEE Communications Magazine and IEEE Network. She is a Senior Member of the IEEE.

About PRISM (www.ontc-prism.org)

***Aim*:** To disseminate relevant content pertaining to optical networking and related growth areas across industry and academia. To promote the growth of optical networking activity by creation of a unified knowledge base. To create a communication bridge between industry and academia in terms of research frontiers and complementary strategies for future growth.

***Scope*:** The optical networking community stands at a point where its potential is not fully realized. The bandwidth offered by the fiber at price points that currently prevail is a fantastic business case for Internet services for providers the world over. Optical networking has transcended itself from a point-to-point communication service to a WDM based multi-point granular networking hierarchy. This journey was made possible through successful and important innovations in the optics and networking domain, bringing together a rich technology set for deployment in telecommunication networks. It would be fair to say that without optical networking, the scope of the Internet would not reach its global scale that it has presently reached. In the future, optical networking has the potential to impact the telecom world through new innovations in architecture, protocol and devices that would lead to new service offerings impacting human lives. Amongst these futuristic offerings are cloud computing, energy efficient systems, data-centers, 100 Gigabit Ethernet, WDM PON, multi-point communication systems, sub-wavelength grooming and transparent ROADM-based services. It is clear, and especially pronounced in Asia and parts of Europe that optical networking will play a very important role in the design of future networks. Whether it is the GENI project in the US or the Akari in Japan – optical networking finds a clear way into technological offerings for the future of the telecommunication industry. From a historical perspective, optical networking has offered significantly to the telecom industry – we distinctly note that after the telecommunication bubble burst, it was the area of metropolitan networks that led to the re-bounce of telecommunications the world over. It is always important to highlight such historical perspectives from industry leaders and pioneers to bring the optical community closer. We continue to exploit the latest advances in this area of telecommunications – delving on the research and development of optical networking solutions.

The scope of the newsletter is as follows:

- A forum that brings the optical networking community together, through leadership articles in technology and research.
- Bring to the fore issues that both industry and academia are working on, with the focus of being able to minimize this gap through interaction via the newsletter forum.
- Highlight important events related to the area of optical networking, in particular focus on consortiums, projects, awards, seminal breakthroughs, standards and industry related information.
- Research: Focus on research issues pertaining to optical networking. Showcase key growth areas (like data centers, metro ROADMs, 100GE, etc.).
- Consortiums and Projects: Focus on consortiums and projects relevant to optical networking, in which the primary entities are research focused (non-profit groups like universities etc.)
- Developing Economies: Focus on emerging economies and the networks there.
- Standardization activity: The newsletter will periodically discuss standard related activities especially when new drafts are circulated or a standard in form of an MSA is accepted. A standard pioneer will be invited to write about the standard. Our focus will be on the IEEE 802 working group, the ITU groups and FSAN groups in terms of coverage.
- Industry information: latest *technical* happenings will be reported from the industry. These will be critically based on demonstrations at international tradeshows such as OFC, ECOC and World Broadband Forum. Care will be taken not to report any company specific information and ensure vendor neutrality in the newsletter.
- Service provider focus: Since a key consumption point of our industry are service providers, it is most important to focus a section of the newsletter on them. We will in every newsletter focus on the latest happenings in the provider space – whether it is adoption of new technologies or new deployments or even network designs, we will cover these through neutral writings. In particular, we will ensure that no names are taken in the coverage, making it generic – for example, "a select provider in the North America has decided to deploy ROADM technology using WSS cross-connects [source]..".
- Periodically create a roadmap of technologies in different domains pertaining to optical networking. The roadmap would be a team effort by multiple experts in association with the editor.

- Optical Networking is Fun (ONiF): a section devoted to humor in optical networking – puzzles, crosswords and "did you know" for after-hours research.

Submit your article as a .pdf file to submissions@ontc-prism.org. Note that you must have a covering note that descibes the nature of the article from one of the above scope keywords. **The scope keywords are: consortiums, projects, growth areas, emerging economies, Standardization activity, Industry information, Service provider focus, roadmap of technologies and Optical Networking is Fun.**

Note to prospective authors: ONTC Prism follows strict policies mandated by the IEEE Code of Ethics. We will strongly enforce plagiarism and self-plagiarism as a review criteria. For more information visit:http://www.ieee.org/web/publications/rights/ID_Plagiarism.html.

Ashwin Gumaste, Ph. D.
James R. Isaac Chair,
Department of Computer Science and Engineering
Indian Institute of Technology Bombay,
Contact Information:
Room 208, Kanwal Rekhi Building, IIT Bombay, Powai, Mumbai, 400076
Email: ashwing@ieee.org, Web: www.ashwin.name.