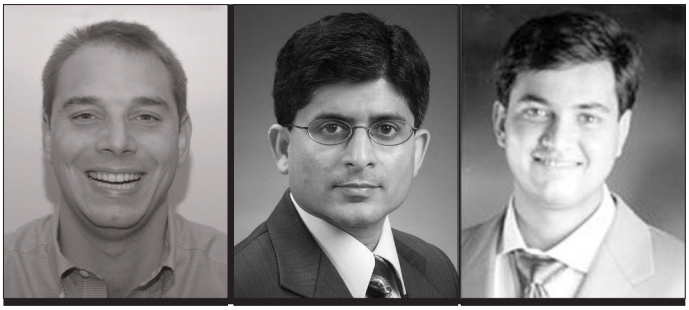

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NEXT-GENERATION CARRIER ETHERNET TRANSPORT TECHNOLOGIES

The share of packet-dominated network traffic has grown exponentially in networks worldwide. A majority of this traffic is now either encapsulated using Ethernet or the Internet Protocol (IP). Enterprises and residential customers familiar with Ethernet technology have and are demanding a simple, inexpensive and high-speed universal Ethernet service. Indeed, the Metro Ethernet Forum (MEF) has defined such a carrier Ethernet service as a ubiquitous, standardized, carrier-class service/application characterized by some key attributes: reliability, hard quality of service (QoS), service management, and scalability, which set it apart from the ubiquitously deployed LAN-based Ethernet. Service providers are responding to this demand in most areas of service delivery by offering various forms of carrier Ethernet services.

There are, however, several options for building the underlying transport infrastructure to deliver such a carrier Ethernet service. These include, for example, using IP/multiprotocol label switching (MPLS) technology to deliver point-to-point Ethernet circuits joined together with physical Ethernet bridges/switches; IP/MPLS with virtual private LAN service (VPLS) or hierarchical VPLS (H-VPLS), developed in the Internet Engineering Task Force (IETF); Ethernet directly over various optical technologies; transport MPLS (T-MPLS) being proposed by the International Telecommunication Union — Telecommunication Standardization Sector (ITU-T) and IETF; using modified Ethernet technology with provider backbone bridging (PBB) and provider backbone transport (PBT) as proposed by the IEEE; using a combination of a modified Ethernet data plane and a generalized MPLS (GMPLS)-based control plane with VLAN cross-connect (being proposed by several vendors and under consideration in the IETF) and even circuit emulation services (CES) over an Ethernet fabric to provision pseudowires (PWs).

The guest editors of this special issue have sought out articles that present and discuss the critical challenges in and options for delivering a carrier Ethernet service. Overall, the response to our CFP was very strong, totaling over two dozen submissions, leaving us with the hard task of choosing the final set of articles. All submissions were carefully reviewed by well qualified independent reviewers, and the selected articles were revised according to reviewer feedback. In the end five high-quality articles were selected, spanning key carrier Ethernet transport topics in standards and architectures, techniques and options, and real-world deployment experiences.

Our special issue begins with an article by Fang *et al.*, "The Evolution of Carrier Ethernet Services — Requirements and Deployment Case Studies," that first presents the various options for how carrier Ethernet services can be realized in modern networks. The article discusses requirements for a carrier Ethernet service, as well as requirements for the underlying network that will be needed to support such a service (or services). The article does a good job of explaining the difficulties of deploying carrier Ethernet services from the perspectives of several prominent service providers, and provides useful insights for those considering deploying these services.

Salam and Sajassi next present "Provider Backbone Bridging and MPLS: Complementing Technologies for Next Generation Carrier Ethernet Transport." This article presents one possible solution to the requirements presented in the first article based on a combination of the IEEE's PBB Ethernet, H-VPLS, and MPLS. The article first explains the key points of these technologies for those readers unfamiliar with them. It then goes on to show why the combination of PBB as an edge/access technology with H-VPLS coupled with MPLS as a core transport technology is a suitable and viable means for those wishing to provide carrier Ethernet services.

The next article, "Ethernet Provider Backbone Data Plane Evolution" by Fedyk and Allan, first explains the evolution and taxonomy of the current state of the IEEE's various Ethernet technologies. This complements the detailed explanations in the article by Samer and Sajassi. This includes a well written explanation of the key attributes and functions of PBB, and an extension to PBB called PBB traffic engineering (PBB-TE). Both of these technologies are at the forefront of the IEEE's work in the Ethernet space. The article then goes on to show how these technologies can be used as possible approaches to solving the aforementioned requirements.

The final two articles are concerned with highavailability, and operations, administration, and management (OAM), both of which are critical to the long-term operation of carrier-grade Ethernet services. The first article, by Boccie, Cowburn, and Guillet, is "Network High Availabil-

ity for Ethernet Services Using IP/MPLS Networks." This article first reviews existing protection mechanisms and approaches used in existing IP networks based on Ethernet or MPLS. The article then describes additional enhancements to both of these technologies that are useful when realizing highly available carrier Ethernet services. The final article, "OAM and Its Performance Monitoring Mechanisms for Carrier Ethernet Transport Networks" by Ryoo *et al.*, takes a look at the existing OAM mechanisms based on the IEEE, ITU-T, MEF, and IETF. It first introduces standards such as IEEE 802.1ag and ITU-T Y.1731. It then introduces the reader to the challenges of monitoring the performance of Ethernet networks and explains some solutions based on various available standards.

Challenges and hurdles clearly stand before those service providers wishing to offer highly available high-quality carrier Ethernet services. The good news, as some of the articles in this feature topic illustrate, is that a number of options exist allowing providers to surmount these challenges.

It was truly an honor for us to serve as guest editors, and we would like to thank all the authors who responded to our original call. It is this collective response that gave us such a strong pool of articles from which to choose. We would also like to thank the many experts who gave their invaluable time and effort to provide detailed reviews, many on very short notice. Finally, we are indebted to the previous Editor-in-Chief of *IEEE Communications Magazine*, Dr. Tom Chen, for facilitating this special issue, and for his guidance and advice during its preparation. We would also like to thank the IEEE publications staff, particularly Sue Lange, for their assistance and diligence with preparing the final articles for publication.

It is our hope that the selection of articles in this feature topic issue will give the readership sufficient flavor and a cross-section of some of the existing technical and operational challenges and solutions involved in delivering modern carrier Ethernet services. We hope you enjoy this reading, and welcome your feedback and comments.

BIOGRAPHIES

THOMAS D. NADEAU (tnadeau@lucidvision.com) works at BT Group, PLLC where he is responsible for BT's 21CN Advanced Cross-Platform Architecture. This includes the design of BT's 21CN access, aggregation, and core networks. Prior to BT, he worked at Cisco Systems, where he was a technical leader responsible for the leadership of network management development and architecture for MPLS-related components of Cisco's routing and switching platforms. He is an active participant in the IETF, ITU, and IEEE. He is co-author of 27 IETF RFCs in the areas of MPLS, PWE3, L3VPN, L2VPN, and GMPLS. He has filed several patents in the area of networking, and is co-inventor of U.S. Patent 7,099,947. He has been co-guest editor of feature topics in the October 2004 and June 2005 issues of *IEEE Communications Magazine*, as well as co-author of a number of articles published therein. He received his B.S.C.S. from the University of New Hampshire and an M.Sc. from the University of Massachusetts in Lowell, where he has been an adjunct professor of computer science since 2000 and teaches courses on the topic of data communications. He is also on the technical committees of several prominent networking conferences where he provides technical guidance on their content. He is the technical editor of *Enabling VPN Aware Networks with MPLS* (Prentice Hall, 2001) and author of *MPLS Network Management: MIBs, Tools, and Techniques* (Morgan-Kaufman, 2002).

VISHAL SHARMA [StM 93, M98, SM01] (v.sharma@ieee.org) has over 16+ years of diverse research, academic, industry, and consulting experience in networking and telecom technologies, with a focus on system architecture, protocol design, system analysis and optimization, software prototyping, and network planning. He is a core contributor to the generalized MPLS standards developed at the IETF with approximately 10 RFCs published and co-editor of the "MPLS Recovery Framework" (RFC3469), and has three patents awarded and over eight patents in process in MPLS recovery, optical routing, the IP control of SONET/SDH networks, and advanced switch architectures and switch scheduling. He is a Fellow of the IETE, and on the Scientific Committees of the MPLS World Congress and Wi-Max Summit. He is also on the advisory board for FutureNet and has served on the TPC of several international conferences, such as GLOBECOM, DRCN, IEEE LAN/MAN Workshop, and i-POP. He is a frequent chair, speaker, and invited panelist in industry and academia worldwide. Additionally, he has provided services in technology strategies, architecture and design trade-offs, product development, and knowledge enhancement to organizations ranging from large equipment manufacturers to premier optical and network planning tool startups to established component/semiconductor vendors on four continents. Currently, he serves as a principal consultant and technologist at Metanoia, Inc. and was also associated with the Indian Institute of Technology (IIT), Bombay (2004–2007). His current consulting and research interests are in metro/access wireline and wireless network and systems design, high-speed switch/router design, and QoS and traffic management in fixed-mobile networks and 3G cable networks. He earned a B.Tech. degree in electrical engineeringfrom IIT Kanpur, and M.S. (signals and systems), M.S. (computer engineering), and Ph.D. (electrical and computer engineering) degrees from the University of California at Santa Barbara.

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