Workshop on Modeling and Simulation of Next Generation Optical Communication and Networks (WNGOCN-2017) & Inauguration of SRM-OSA Student Chapter

December 01-02, 2017

In association with

OSA, OSI, IETE, LumericalInc

Fiber Optic Services, Supreme Scientific Corporation

DEPARTMENT OF ECE

Faculty of Engineering and Technology, SRM University

Kattankulathur – 603203, Kancheepuram Dt., Tamilnadu, India

Ph: 044-27417777 Fax: 044-27453903

Website: www.srmuniv.ac.in

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Together everyone achieves more.

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About SRM University

SRM Institute of Science and Technology (SRM University) is one of the top ranked universities in India with over 51,000 students and 2,800 faculty members, offering a wide range of Undergraduate, Postgraduate and Doctoral Programs in Engineering, Medicine & Health Sciences, Management, Science & Humanities and Law.

Over the last three decades, it has set standards in experiential learning and knowledge creation across various fields. It has reached beyond borders to universities and corporate across India and around the World. There are 4 sprawling campuses in Chennai and one near New Delhi spread across 250 acres with all facility.

It had conducted 98th Indian Science Congress in January, 2011 which was attended by 7,000 delegates from India and abroad, including six Nobel Laureates and several eminent scientists. SRM University is the first private university in India to launch a nano-satellite, named SRMSAT, into space, on board the PSLV-C18 from Sriharikota on October 12, 2011.

SRM University is accredited by NAAC with 'A' Grade in 2013. QS, the world renowned international ranking agency, has rated SRM as a '4-Star' university with '5- Star Ratings' in Teaching, Employability and Inclusiveness.

About the Department

The Department of Electronics and Communication Engineering (ECE) was established in 1991 under the affiliation of University of Madras. It offers one UG Program, three PG programs and Doctoral Program. It has 18 well equipped labs. It has ample resources in computing equipment, including personal computers running the full suite of CADENCE, OrCAD, MATLAB and Network Simulation softwares. It has USRP-RIO SDR hardware, Vector Signal Generator & Analyzer, Network Analyzer and ADS & HFSS tools.

The department has strong collaboration with industries such as Central Electronics Engineering Research Institute (CEERI) Chennai, Nuvoton Technology Corporation, Taiwan, National Instruments and ALTERA. It received research grants from Department of Science and Technology (DST) under Funds for Improvement of Science and Technology (FIST), in the area of MIMO-OFDM. Recently, it has received research grants for 3 projects from Defence Research and Development Organization (DRDO) and Indian Space Research Organization (ISRO). The B.Tech (ECE) program of Kattankulathur campus of SRM University is accredited by EAC of ABET. www.abet.org

About the Workshop

To meet the computing and communications needs which are growing multi-folds, a 'tera-era' vision is proposed for the future of information technology which demands high speed and high capacity communication. Central advances towards the tera-era will involve optical technologies.

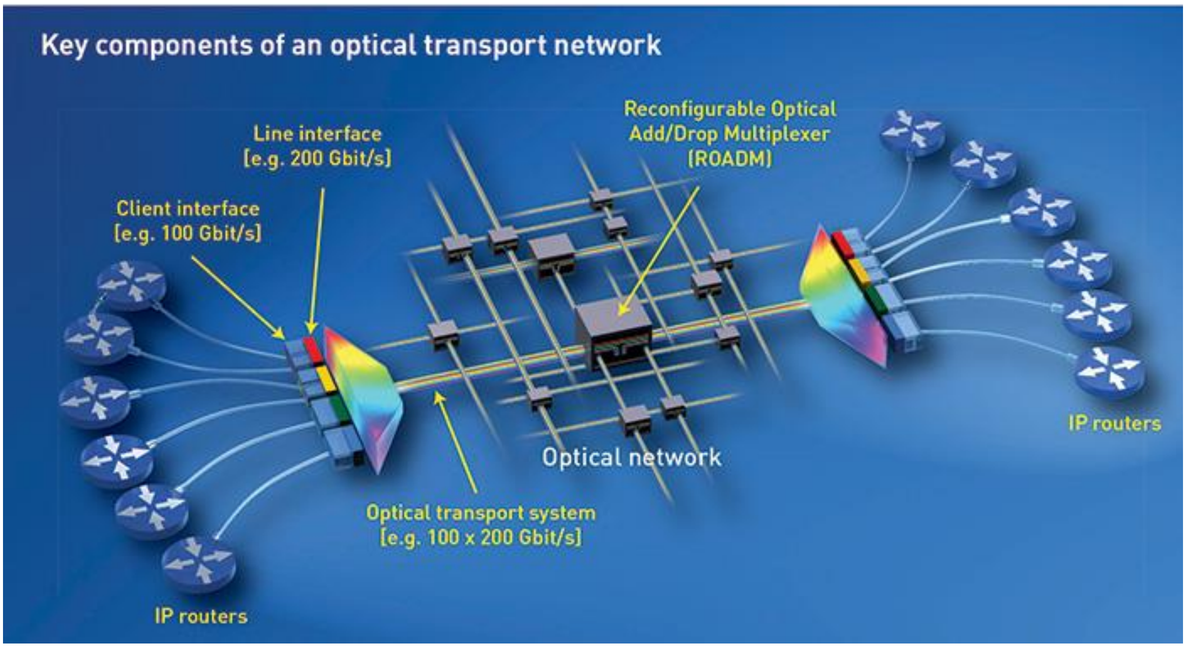
All elements of information transport are likely to require optical fibers and lasers, including 100-gigabit-per-second access networks, 10-gigabit-per-second local area networks, and even 1 gigabit per second to the desktop. It will also "future-proof" the network against the bandwidth needs of future services that do not even exist yet but that recent history indicates are sure to emerge.

The purpose of the workshop is to enlighten the need of optical technologies for next generation communication and networks and kindle the interest of participants towards this pervasive and primordial technology.

Theme of the Workshop

The aim of this workshop is to serve as a forum for effective exchange of scientific knowledge and experience among experts, researchers active in the field of optical communications, discuss various challenges posed by the next generation optical technologies and propose ideas and solutions to transform the current scenario of optical communication technologies. The workshop is also intended to provide a platform to access next generation optical communication technologies available to researchers in India. This workshop will provide an introductory overview of

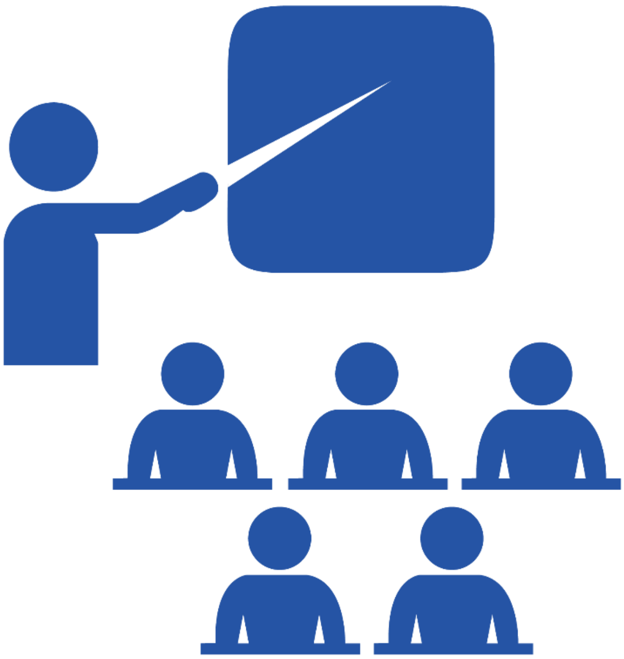
- *Need for next generation optical communication and networks.*
- *Various network topologies which can provide a viable solution in next generation systems.*
- *Research areas which can be exploited so that potential problems in the related fields can be addressed.*
- *Hands-on session guiding the attendees through the design of various network and system topologies for next generation optical communication.*



Resource Persons

Invited lectures are delivered by experts in this area on the basic aspects and recent advancements in the area of optical wireless communication and Networks. Speakers will include:

1. **Dr. Srinivas Talabattula,** Associate Professor, Electrical & Commn. Engg, IISc, Bangalore
2. **Dr. Varun Raghunathan,** Assistant Professor, Electrical & Commn. Engg, IISc, Bangalore
3. **Dr. M. Ganesh Madhan,** Professor, Dept. of Electronics Engg, MIT, Chromepet, Chennai
4. **Dr. D. Sriram Kumar,** Associate Professor, Department of ECE, NIT Trichy.
5. **Mr. N. Vedachalam,** Scientist-F, National Institute of Ocean Technology, Chennai.
6. **Mr. K. Sripadaraja,** Product Manager, SriDutt Technologies Pvt. Ltd., Bangalore.
7. **Mr. Arul Prakash,** Product Engineer, Supreme Scientific Corporation Ltd., Madurai.



AGENDA

Friday, December 01, 2017

08.30 Registration

09.00 Inauguration of WNGOCN-2017 and SRM-OSA Student Chapter

09.30 Keynote address on **Photonics for Quantum Commns. & Quantum Computing**
Dr. Srinivas Talabattula, Associate Professor, Electrical & Commn. Engg., IISc

10.30 Tea Break

10.45 Keynote address on **Radio Over Fiber Communication**
Dr. M. Ganesh Madhan, Professor, Electronics Engineering, MIT, Chennai

11.45 Keynote address on **Needs & Challenges in Underwater Wireless Communication**
Mr. N. Vedachalam, Scientist-F, Project Director, NIOT, Chennai

12.45 Lunch Break

13.45 Overview of **Lumerial Tool**
Mr. Sripadaraja, Applications Engineer, SriDutt Technologies Pvt. Ltd., Bangalore

14.30 Hands-on session on **FDTD using Lumerical Tools**

16.00 Tea break

16.15 Tech Talk on **Introduction to Converged Packet-Optical SDN**
Mr. Ruturaj Kadikar, Senior Research Associate, Dept. of CSE, SRM University

17.00 End of Day-1

Saturday, December 02, 2017

09.00 Keynote address on **Nonlinear Silicon Photonic Devices for High Speed Optical Commn.**
Dr. Varun Raghunathan, Assistant Professor, Electrical Communication Engineering, IISc

10.00 Tech Talk on **Free Space Optics: An Opportunity to Move Beyond Radio**
Mr. Rahul Bosu, Research Scholar, Department of ECE, SRM University

10.45 Tea Break

11.00 Keynote address on **Wireless Optical Communication**
Dr. D. Sriram Kumar, Professor & Head, Department of ECE, NIT-Trichy

12.00 Tech Talk on **Challenges of Optical Network and Opportunities In India**
Mr. Vivek Kachhatiya, Research Scholar, Department of ECE, SRM University

12.45 Lunch Break

13.45 Hands-on training on **OptSIM V2017**
Mr. Arul Prakash, Product Engineer, Supreme Scientific Corporation, Madurai

15.15 Tea Break

16.30 Valedictory Ceremony

17.00 End of Day-2 & Workshop

AGENDA

Inaugural Ceremony @ 09.00 Hours on Friday, December 01, 2017

Host: Mr. E. Elamaran & Mrs. A. Vinnarasi, Assistant Professors (OG), ECE

Invocation	
Welcome Address	Dr. Shanthi Prince, Convener, WNGOCN'17
Overview of the Workshop and Activities	Mrs. R. Manohari, Coordinator, WNGOCN'17
Overview of OSA - The Optical Society & The Student Chapter	Mr. Rohan Katti, President of Student Chapter Research Scholar, ECE, SRM University
Introduction of the Chief Guest	Mrs. M. Valarmathi, Asst. Prof. (SG), ECE
Memento Presentation to the Chief Guest	Dr. T. Rama Rao, Prof. & Head, ECE
Inauguration of SRM-OSA Student Chapter	Dr. Srinivas Talabattula, Assoc. Prof., IISc
Introduction of Guest of Honor	Mrs. Diana Emerald Aasha, Asst. Prof., ECE
Memento Presentation to Guest of Honor	Dr. T. Rama Rao, Prof. & Head, ECE
Release of the Souvenir	Dr. M. Ganesh Madhan, Professor, MIT
Presidential Address	Dr. T. Rama Rao, Prof. & Head, ECE
Inaugural Address / Keynote address	Dr. Srinivas Talabattula, Assoc. Prof., IISc

Valedictory Ceremony @ 16.30 Hours on Saturday, December 02, 2017

Host: Mr. E. Elamaran & Mrs. A. Vinnarasi, Assistant Professors (OG), ECE

Feedback by Participants	Mrs. Anilet Bala, Asst. Prof. (OG), ECE
Closing Remarks	Mr. Manikandan AVM, Asst. Prof. (SG), ECE
Distribution of Certificates	Dr. Shanthi Prince, Professor, ECE Dr. T. Rama Rao, Prof. & Head, ECE
Vote of Thanks	Mr. S. Nivash, Asst. Prof. (OG), ECE
National Anthem	
Group Photograph	

The Optical Society (originally established as The Optical Society of America, OSA) is a scientific society dedicated to advancing the study of light - optics and photonics - in theory and application, by means of publishing, organizing conferences and exhibitions, partnership with industry, and education. Headquartered in Washington, USA, the Optical Society is the leading global professional association in optics and photonics. Through world-renowned publications, meetings, and membership programs, The Optical Society provides quality information and inspiring interactions that power achievements in the science of light to a global network. OSA was founded in 1916, under the leadership of Perley G. Nutting, with 30 optical scientists and instrument makers based in Rochester, New York. OSA soon began publication of its first journal of research results and established an annual meeting. It was founded as the "Optical Society of America" and has evolved into a global enterprise with a worldwide constituency. In recognition of this, the society was renamed in 2008 as The Optical Society (OSA).

The Optical Society's (OSA) mission is to promote the generation, application and archiving of knowledge in optics and photonics and to disseminate this knowledge worldwide. The purposes of the Society are scientific, technical and educational. OSA's commitment to excellence and long-term learning is the driving force behind all its initiatives. To support this mission, the Society is committed to a set of core values known as "i4" which are Innovation, Integrity, Inclusivity and Impact.

OSA can count more than 19,000 members from more than 100 countries, a global network of 358 student chapters, 21 local sections and management of 45 conferences and meetings including some of the most important meetings and events in optics and photonics, 17 peer reviewed journals providing 40 % citations and 35 % of published articles in optics and photonics.

Membership benefits

An OSA Membership provides exclusive access to an unparalleled professional network, cutting-edge information and valuable resources to enhance your career and business.

OSA membership allows subscriptions to Optical and Photonics News magazines and Physics Today magazine, 50 downloads from OSA journals, 5 technical group affiliations, grants, leadership and award opportunities.

For more details, visit www.osa.org

OSA supports an extensive global network of more than 350 Student Chapters. These chapters, managed for and by students, create valuable opportunities for professional development and foster lasting relationships between peers and mentors.

OSA student chapters support your academic studies, power your research and provide opportunities that will propel your career in optics and photonics. In addition to their benefits for members, many chapters are heavily involved with community and youth education outreach to provide both a service to their community and work to disseminate the knowledge of optics and photonics worldwide. OSA Student Chapters receive many benefits including: activity and travel grants, guest lecture resources, networking opportunities, and much more!

Having being inspired from the mission of OSA and to contribute its part in the field of Optics and Photonics, Department of ECE, SRM University has taken the lead to start the OSA student chapter. SRM - OSA Student chapter will be inaugurated on 01/12/2017 along with Workshop on Modelling and Simulation of Next Generation Optical Communication and Networks to be conducted by the Department of ECE, SRM University during 01-02, December 2017. The SRM - OSA Student chapter currently has 6 members. The office bearers are

Faculty Advisor	Dr. Shanthi Prince, Professor, Department of ECE
President	Mr. Rohan Katti, Research Scholar, Department of ECE
Vice–President	Mr. Vivek Kachhatiya, Research Scholar, Department of ECE
Secretary	Mr. Ruturaj Kadikar, Research Associate, Department of CSE
Treasurer	Mr. Rahul Bosu, Research Scholar, Department of ECE

The tentative schedule of programs for the session January to April, 2018 is given below

January 2018	Photography contest on optics based phenomenon in SRM campus
February 2018	Community outreach program to a nearby school
March 2018	Tech Talk
April 2018	Challenge for optical innovation

Keynote Address-1

Photonics for Quantum Communications and Quantum Computing

Dr. Srinivas Talabattula, Associate Professor, Electrical & Commn. Engg, IISc, Bangalore

Quantum Communications and computing involves dealing with information represented by quantum states of objects like photons. The key feature is that '0' and '1' levels are not deterministic, but expectations of wave functions. Information is represented as superposition of these quantum states. Quantum information theory presents several strange results, such as no cloning, entanglement, and discord. Quantum approach provides enormous possibilities, such as super dense representation and storage of classical information, perfect security, and enormous computing possibility.

Implementation is a challenge due to requirement of devices. Photonics promises to provide solutions to many of these challenges. Recently several implementations of quantum information systems have been successfully demonstrated. For example Tokyo QKD network (2010) and World's first quantum computer (as claimed by China, Aug 2016). In this presentation, after a brief description of basics of quantum communication, we present the representation of quantum information using optical waveguide modes. Then a few examples of implementation will be discussed, namely, directional coupler output as an analog of superposition state, quantum Hadamard gate using photonic bandgap structures, etc. Finally we examine a higher dimensional representation of quantum information using Qubits and the corresponding BB84 protocol for highly secure quantum communication.

Biosketch

Dr. Srinivas Talabattula has graduated from New Science College, Hyderabad, with B Sc(Hons) in physics. He did his Integrated-M.E. and PhD from IISc, Bangalore. His Ph.D. was primarily focused on: Application of coupled mode theory to fiber and integrated optic waveguide structures. Later, he worked in Toyohashi University of Technology, Japan, during 1992-98 as a Post-Doctoral Research Fellow on tapered optical waveguide couplers and integrated optical amplifiers. Currently, he is an Associate Professor in the ECE department at Indian Institute of Science (IISc), Bangalore.

Dr. Srinivas Talabattula has been active in the research field since 2003 and has major research interests in the areas of Photonics integrated Circuits with application to optical communication, optical sensors and quantum photonics. His overall research work has got 661 citations with h-index of 12. His research paper entitled: "Investigation of ring resonators in photonic crystal circuits" has got the highest number of citations, till date.

Besides this, he has been acting as a reviewer to several peer-reviewed journals and conferences, notably IEEE PTL, Journal of modern optics, Journal of Optical Society of America, Current Science to name a few. Furthermore, he has been involved in sponsored research projects like, national program on smart structures (NPMASS) & systems, national program on micro-optics and nano photonics (NPMN). He is the secretary of IEEE Photonics Society Chapter, Bangalore Section and has supported several IEEE society chapters and many IEEE student Branches in Bangalore Section.

Keynote Address-2

Radio Over Fiber Communication

Dr. M. Ganesh Madhan, Professor, Electronics Engineering, MIT, Anna University, Chennai

Radio over Fiber (RoF) communication encompasses the technologies involved in delivery of high quality analog, digital modulated high frequency signals over the fiber to the intended area. The applications of this technology are wide spread in cellular mobile communications, phased array radar and antenna remoting. In the case of mobile communications, providing access to basements, tunnels and signal shadow regions have been realized. The optical fiber based CATV transmission is a well-known application for providing QPSK and QAM based digital TV signals for the subscribers. Recently, Ultra-wide band signals (UWB) have also be transported through fiber for enhanced coverage. However, the diverse requirements of different applications impose stringent requirements on the laser diodes and the transmitter circuits. One of the techniques to improve the modulation depth in directly modulated laser diodes for RoF applications is the gain levering mechanism. This can be realized by slightly modifying the structure of the laser diode and biasing it appropriately. Signal to Noise ratio (SNR) of the link depends on the modulation depth provided by the laser diode. The details of the Radio over fiber technology, gain lever mechanism and challenges involved will be discussed in the presentation.

Biosketch

M.Ganesh Madhan, received his B.E degree in Electronics and Communication Engineering from Madurai Kamaraj University, India, M.E degree in Optical Communications from College of Engg, Guindy, Anna University. He was a CSIR junior research fellow at Anna University for a short period and subsequently joined as a lecturer in the same institute. He worked for his Ph.D in the area of Optical bistability in Semiconductor laser diodes, under the joint supervision of Prof..P.R.Vaya, Head, Semiconductor Device research laboratory, IIT,Madras and Prof. N.Gunasekaran, Anna University, and obtained his Ph.D in 2001. Currently he is a Professor of Electronics Engineering in the Madras Institute of Technology campus of Anna University.

He has about 50 International Journal papers and 100 conference papers to his credit. His current research interests include design, modeling of opto - electronic devices, RF and optical communication systems. Two scholars have obtained their Ph.D degrees under his guidance. Currently he is guiding 8 candidates for Doctoral research in the above areas. He has guided a number of M.E and B.E students in the area of optical and RF communications. He has also carried out a number of consultancy and testing projects in the area of RF and optical communications. He has successfully completed a research project for CVRDE, DRDO with a grant of 9.8 Lakhs. He is serving as a reviewer for International Journals and conferences in the areas of optical and RF communication systems. He also organizes a number of short term continuing education programmes at Anna University. He is also serving as the Professor – In charge of University Library at M.I.T.Campus. He has also served as the invited, technical committee member in the Tamil Nadu Govt. Initiative on Solar energy based streets and home lighting project during 2012 - 2013.

Keynote Address-3

Needs and Challenges in Underwater Wireless Communication

N. Vedachalam, Scientist-F/Project Director, NIOT, Chennai

Oceans covering 72% of the Earth's surface houses immense living and non-living resources and plays a key role in regulating the planet's climate. At the same time, Oceans create environmental threats to the coastline in the form of cyclones and tsunamis. The future of the humanity is dependent on the health of the Oceans, and the goods and services provided by it. To date, Blue economy, is the 7th largest economy in the world accounting to US$ 2.5 trillion, and the total GDP of the global oceans is estimated to be ~ US$24 trillion. Oceans are a source of water, minerals, hydrocarbons and food. Technology is the key for carrying out effective exploration and safe exploitation of the ocean resources, ocean monitoring for advance warning, and for studying the planet right from the world's deep hydrothermal vents till the Polar ice shelves. Effective underwater communication and precise position determination are essential for advancing the Ocean activities. Terrestrial GPS and satellites could not be used for underwater positioning and communications as the radio frequency signals experience attenuation in the saline sea water medium. Till date, acoustic communications are used and their use is limited by the bandwidth, Doppler spread and multipath reflection, thus limiting the data rate up to 10 kbps at longer distances. Based on this underwater multi-hop sensor networks, which are event-based systems are under realization.

Wireless optical communication, (OWC) is one of the emerging effective techniques for high bandwidth underwater data transfers involving shorter distances. The limitation in range is due to the absorption and scattering of the light by the suspended particles in water medium. However, blue-green wavelength of the visible spectrum, having lower attenuation is capable of reaching increased distances. Even though lasers are used for high data rate transfers, they require very precise physical alignments which is challenging in the hydrodynamic environment. Light emitting diodes are used for achieving moderate data rates at increased distances. Hence they are effective in collecting in-situ data from stand-alone subsea observatories using autonomous vehicles when in the line of sight, dispensing the need for recovering the system to ship or using costly ROV-enabled wet mate interfaces. However the ultimate effectiveness of the OWC depends on the transmitter power, receiver sensitivity, modulation technique adopted, ambient light levels, electronic system noise, aiming and tracking strategies.

Biosketch

N. Vedachalam is a Senior Scientist at the National Institute of Technology (NIOT), an Autonomous institution under the Ministry of Earth Sciences, Chennai, India. His work areas include subsea robotics, gas hydrate production technologies, and reliability centered system engineering. His 22 years of experience covers industrial power, process, offshore, and subsea domains. The technical exposure includes development of multi-megawatt power electronic converters, control systems, and energy storage for the long step out deep-water enhanced hydrocarbon recovery systems; ocean renewable energy systems including ocean thermal energy conversion (OTEC), wave energy systems and subsea grids for tidal energy farms; subsea intervention systems including deep-water work class remotely operated vehicles; and industrial power generation, utilization and boiler control systems. He is the Secretary of IEEE Ocean Engineering Society- India Chapter, Executive Member of Marine Technology Society- India Section and Senior Member- Bureau of Indian Standards. He has about 40 publications in science citation indexed international journals, holds one international and two national patents in the areas of subsea robotics, subsea process and gas hydrates production.

Keynote Address-4

Nonlinear Silicon Photonic Devices For High Speed Optical Communication

Varun Raghunathan, Assistant Professor, Electrical Communication Engineering, IISc, Bangalore

The explosion in bandwidth requirement for data and communication needs in recent times is resulting in exploration of new revolutionary technologies for the physical layers to support the high data rates. Silicon photonics in one such revolutionary technology that deals with high density integration of photonic and electronic components on the same silicon chip to support high data rate datacom needs. Nonlinear silicon photonics is an allied area that deals with the use of silicon as a nonlinear optical material to realize light amplification, wavelength conversion, frequency mixing etc., for optical communication applications. In this talk I will give an overview of nonlinear silicon photonics and some of the different active photonic functionalities that have been realized by various groups around the world. Next, some of the research work from my group on dispersion engineering silicon waveguides to achieve enhanced optical pulse compression and super-continuum generation will be discussed. The applications of pulse compression to optical time domain multiplexing (OTDM) systems and super-continuum to spectrally agile light sources will also be discussed.

Biosketch

Varun Raghunathan received his Ph.D. in Electrical Engineering from University of California Los Angles (UCLA), in 2008, working with in the area of Silicon photonics. Then he worked at Ostendo Technologies, a start-up company based out of San Diego, CA USA in the area of III-Nitride LED arrays for pico-projector applications until 2009. He later worked as a postdoctoral researcher at the Chemistry department at University of California Irvine from 2009-2012 in the area of nonlinear optical microscopy. From 2012-2016 he worked as a research scientist at Agilent Research labs in Santa Clara, CA USA working on laser based infrared microscopy, developing optical imaging techniques for anatomic pathology and its clinical translation.

He joined IISc as an Assistant Professor in 2016. His research interests are in integrated photonics for applications in nonlinear optics and spectroscopy and nonlinear microscopy. He has published over 20 journal papers with more than 2000 citations, 5 book chapters and 6 applied patents. He received the Best PhD award in 2008 for his doctoral thesis work from the Electrical Engineering department at UCLA.

Keynote Address-5

Wireless Optical Communication

Dr. D. Sriram Kumar, Professor & Head, Department of ECE, NIT-Trichy

Free-space optics (FSO) communication has attractive features compared to radio-frequency (RF) communication which includes cost-effectiveness, high data rate, simple deployment, high security, license–free operation and free from interference. Due to the inherent features, the FSO has recently received significant attention and commercial interest for various applications including last mile network connectivity, fiber optic back-up, cellular backhaul and temporary connectivity for applications such as voice and data, video services and medical imaging. However, the link range, reliability and data rate of FSO communication systems are affected by various atmospheric phenomena viz. rain, haze, fog, snow, scintillation, and pointing errors. The major challenges in FSO communications are the atmospheric turbulences induced fading and misalignment induced fading. That is FSO links suffer from atmospheric turbulences and pointing errors.

Visible light communication is the indoor and outdoor wireless optical communication using visible light spectrum. The application of VLC is enormous in recent days. Particularly it is focused more towards automobile and medical applications.

The complete talk is going to introduce FSO and VLC in recent applications.

Biosketch

Dr. Sriram Kumar has graduated from Thiagarajar College of Engineering, Madurai, with B.E. in in Electronics and Communication Engineering in 1991. He did his M.E. from Alagappa Chettiar College of Engineering and Technology, Karaikudi in 1993. Later on, he completed his Ph.D. on Microwave Integrated Circuits in 2009 from Bharathidasan University, Tiruchirappalli. Currently, he is the HOD in the ECE department at National Institute of Technology Tiruchirappalli.

Dr. Sriram Kumar has been active in the research field since 2010 and has major research interests in the areas of Microwave integrated circuits, Carbon Nanotube Antennas, Smart Antennas, Flexible electronics, Free Space Optics and Optical Networks His overall research work has got 174 citations with h-index of 8. His research paper entitled: "Graphene nano-ribbon based terahertz antenna on polyimide substrate" has got the highest number of citations, till date.

Besides this, he is a member of Institution of Engineers, Society of Automotive Engineers, IETE and ISTE. Furthermore, he is involved in MHRD funded research project on RF MEMS Component (Reconfigurable antenna). Besides this, he is a member in the Centre of Excellence (CoE) in (i) Electronic packaging, (ii) Smart structures, and (iii) Social network computing, and Secretary and Treasurer of ISTE-NITT chapter.

Technical Talk-1

Introduction to Converged Packet-Optical SDN

Mr. Ruturaj Kadikar, Senior Research Associate, CSE, SRM University

Demand for bandwidth has continued to grow dramatically driven by video, cloud, and data center interconnect. In addition, mobile backhaul has migrated from TDM and ATM to Ethernet and IP interfaces with backhaul speeds set to evolve from 1 Gbps per cell site with 4G to 10 Gbps per cell site with 5G. These trends are driving network operators to complement WDM optical transport with packet transport technology, primarily in the metro and more recently in long haul networks. These trends include the demand for more bandwidth and greater agility with key applications including Ethernet and cloud connect services, fixed broadband aggregation, mobile backhaul, and SONET/SDH migration.

While the cases for both packet transport and WDM technologies are compelling, there is constant need for developing and deploying converged platforms that integrate both technologies into a single network element as an alternative to independent platforms. A converged packet optical platform is one that at a minimum integrates packet transport switching technology with full featured WDM interfaces and a WDM optical layer including ROADM technology. The key benefits achieved by this convergence includes reduced CapEx, reduced OpEx, and the potential for increased revenues through faster installation and provisioning.

Agility has also become a key enabler of competitiveness with faster service development, installation, and service provisioning all key requirements. Network management has also evolved with Software-defined networking (SDN) providing an architecture for multi-domain, multi-layer control with open APIs enabling new services and new levels of agility. SDN is an umbrella term consisting of several kinds of network technologies incorporated together to make the network as agile and flexible as possible enabling quicker response to the changing business and technical requirements.

Open Network Operating System (ONOS) is an open source project providing a multi-layer control plane for a Software-Defined Network thereby simplifying the management, configuration, and deployment of new softwares, hardwares and services. ONOS can also run as a distributed system across multiple systems, allowing it to use the processor and memory resources of multiple systems while providing fault tolerance in case of system failure without interrupting traffic.

Service Provider Networks are complex and multi-layer in nature. Each of these layers, including packet and optical, is provisioned and managed independently. Often times, the provisioning of capacity or new services can take weeks if not months. A converged SDN control plane for packet and optical networks can help address these inefficiencies. Service providers can optimize across both the packet and optical layers in real-time for availability and economics, thereby reducing over-provisioning. Operators can add capacity based on traffic and other considerations in minutes instead of days or months.

ONOS is purposely built for service providers who typically operate large and complex multi-layer networks. ONOS has native support for the most common type of multi-layer network, namely the packet/optical network. It does so by offering an innovative converged topology view, allowing rapid introduction of new services and unprecedented optimization in an environment which has been dominated by a legacy mindset.

References

1. https://onosproject.org
2. www.coriant.com

Biosketch

Ruturaj Kadikar received the M.Tech degree in Communication Systems from SRM University, Chennai, India, in 2016. Currently, he is working as Senior Research Associate in Software Defined Communications Research/Testbed Lab, Dept. of Computer Science Engineering, SRM University. His research interests include, Software-Defined Optical Networks, Software-Defined Networks and Cloud Networking.

Technical Talk-2

Free Space Optics: An Opportunity to Move Beyond Radio

Mr. Rahul Bosu, Research Scholar, ECE, SRM University

Free-space optical communication (FSOC) networks make use of free space as a transmission medium to deliver optical data signals at high bit rates. FSOC systems using lasers offer the promise of breaking through the RF bottleneck faced in the ubiquitous wireless networks. Laser transmitters, at wavelengths some 10,000 times shorter than RF waves, result in beams that are far narrower for the same unit aperture size—providing more concentrated communications power at the receiver with lower required transmitted power from smaller, lighter apertures. Right from the start of 1960s, the NASA plunged itself in deep space wireless optical communication project for implementing a deep space optical transceiver and ground receiver that will enable greater than 10 times the data rate of a state-of-the-art deep space RF system (Ka-band) for similar spacecraft mass and power [1]. The European Space Agency (ESA) started funding various FSO projects since the summer of 1977, aiming to develop high-data-rate laser links in space. NASA demonstrated its first laser communication system in space in 2013, with the Lunar Laser Communications Demonstration (LLCD) [2] mission, aboard the Lunar Atmosphere Dust and Environment Explorer (LADEE). LLCD demonstrated error-free data downlink rates of up to 622 Mb/s from the moon at a distance of some 400,000 km. More recently, the researchers at the German Aerospace Center demonstrated terrestrial FSO data transmissions at 1.72 terabits per second across a distance of 10.45 km [3].

With the leaps and bound increase in number of mobile devices, wireless communication services are now indispensable to many people just like water and electricity supplies. The recent developments in the optics and communication devices, has rejuvenated an interest in analyzing and enhancing wireless optical links and adopting FSO technology for wireless access networks. The FSO network could become a viable candidate for use in the broadband wireless networks of the next generation as there exists commercial transceivers that support Gbps data rates.

FSO networks are roughly classified into three types [3]: (i) Optical Wireless Terrestrial Networks (OWTNs), (ii) Optical Wireless Home Networks (OWHNs), and (iii) Optical Wireless Satellite Networks (OWSNs), according to the locations of optical transmitters and receivers and network range. OWTNs, a.k.a., "the outdoor FSO networks" are effective solutions for the "last-mile" or "first-mile" problems and can be incorporated for disaster recovery scenarios as the communication assets can be quickly deployed with ease. This telecommunication paradigm is extensively used to bridge existing high-data-rate networks, especially for ship-to-ship, building-to-building, or community-to-community communications.

OWHNs, also known as indoor FSO networks, are desirable for constructing a LAN comprised of multiple cells. Usually each cell is one of the divided spaces in the building and has a base station to which several terminals are connected with short-range optical wireless links such as infrared and light emitting diodes (LEDs). The optical sources with the same specifications can be reused in different rooms of the same building since light beams cannot penetrate walls, resulting in negligible mutual interference.

OWSNs are designed to provide high-bandwidth optical wireless network access to end-users by making use of satellites that can support any terrestrial residents regardless of topographical limitations. However, the extremely narrow divergence of the beams introduces challenges for their pointing, acquisition and tracking across the vast distances of space. In lieu of this, and the ground breaking success of (LLCD) mission has encouraged the NASA to team up programs for developing a prototype unit fully ground-tested to space environmental levels, as a precursor to flight of a working laser communication system on the upcoming Discovery mission scheduled for 2020. If the promise of integrated photonics can truly be realized to drive the costs of FSOC to well below those of RF systems, then commercial networks of "fiber-in-the-sky" may soon follow, and lead to yet another communications revolution in the very near future.

Biosketch

Rahul Bosu is currently a research scholar in the department of ECE, SRM University and is pursuing research in the area of wireless optics since 2014. His research interests include: optical fiber communication,free-space optics and statistical optics.

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2. https://www.osa-opn.org/home/articles/volume_27/may_2016/features/space-based_laser_communications_break_threshold
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Technical Talk-3
Challenges of Optical Network and Opportunities in India

Mr. Vivek Kachhatiya, Research Scholar, ECE, SRM University

The global IP traffic and global mobile data traffic are expected to increase three-fold and eleven-fold respectively from 2013 to 2018 as per the cisco statistics. Hence, in order to meet the rapidly growing bandwidth requirements for high-speed data transmission and the constant exponential need for even greater connectivity of consumer applications, it is necessary to further upgrade the optical network. Digital population in India as of January 2017 is nearly 46 crore users (460 Million users). India is the second largest online market, ranked only behind China. By 2021, there will be about 635.8 million internet users in India. So understanding the challenges of optical network is vital for Indian engineers to grab emerging opportunities in India.

The optical network is classified as the core network, metro network, and access network. In some scenarios depending on the location and terrain condition, services of core and metro network are merged together and metro and access network are merged together. Challenges in optical signal propagation/ deployment of the optical fiber are common for all three classified optical networks. Impairments in optical transmitter and receiver also plays a vital role to provide error-free performance of the optical network.

Some challenges are particular for a given network and need a technical and engineering assistance to enable the services. Following are the challenges involved in core network that need to be understood and resolved. End-to-end Ethernet, Mixed-line-rate network design, Dynamic optical circuit switching, Hybrid dynamic circuit/packet switched network, Robust network design, Excess capacity management, Energy-efficient network design, Data-center network design, Broadband access network design.

Metro network requires special attention on, Gridless/Elastic Networking, Sleep-Mode for Energy Efficiency, Space Division Multiplexing, Software Defined Networking, Mixed-Line-Rate Networks. The access network is all about providing a reliable connection to the users, providing high throughput and a wide range of services.

The Indian government approved a cabinet note on the scheme to create the National Optical Fiber Network (NOFN) dated 25 October 2011. The implementation framework, budget, technology architecture and other issues related to NOFN were worked out by the Department of Telecom (DoT) under the chairmanship of an adviser to the Prime Minister and Chairman UIDAI (constituted on 26 April 2011). The Special-Purpose Vehicle Bharat Broadband Network Limited (BBNL) was incorporated to execute the project, implemented by three prominent Public Sector Undertakings (PSUs), namely BSNL, RailTel, and Power Grid.

A committee constituted in January 2015 reviewed the earlier project (NOFN) and proposed a modified project called BharatNet, in a report submitted on 31 March 2015. The project was rolled out as a collaboration between the Union Government (to provide broadband connectivity at sub-district Block-level), state governments (optical fiber to gram panchayat level) and private sector companies (wifi hotspots in each village and connections to the individual homes). The revision (BharatNet) included almost three times the fiber length, a mix of infrastructure technologies, at twice the capex but with a significantly reduced opex, so that it works out to be a lower total project lifecycle cost. NOFN had not incorporated any revenue model but in BharatNet, content provisioning for the end user is envisaged by different competitive private service providers (PSPs). This reduces opex, where it has been assumed that 75% of the costs would be recovered through auction revenue.

BioSketch

Vivek Kachhatiya received the M.Tech. degree in Communication System from from SRM University, India, in 2014. Presently he is a Research scholar in the Department of Electronics and Communication Engineering, SRM University, India. His research interests include Passive Optical Network, Radio Over Fiber, Next Generation Unified all Optical Architecture and Software Defined Optical Network. He has published articles in recognized international conference and journal.

THE FINITE-DIFFERENCE TIME-DOMAIN (FDTD)

Introduction

The Finite-Difference Time-Domain (FDTD) method 1,2,3 is a state-of-the-art method for solving Maxwell's equations in complex geometries. Being a direct time and space solution, it offers the user a unique insight into all types of problems in electromagnetics and photonics. In addition, FDTD can also obtain the frequency solution by exploiting Fourier transforms, thus a full range of useful quantities can be calculated, such as the complex Poynting vector and the transmission / reflection of light.

Solver physics

This section will introduce the basic mathematical and physics formalism behind the FDTD algorithm. FDTD solves Maxwell's curl equations in non-magnetic materials:

$$\frac{\partial \vec{D}}{\partial t} = \nabla \times \vec{H}$$

$$\vec{D}(\omega) = \varepsilon_0 \varepsilon_r(\omega) \vec{E}(\omega)$$

$$\frac{\partial \vec{H}}{\partial t} = -\frac{1}{\mu_0} \nabla \times \vec{E}$$

where H, E, and D are the magnetic, electric, and displacement fields, respectively, while $\varepsilon_r(\omega)$ is the complex relative dielectric constant ($\varepsilon_r(\omega) = n^2$, where n is the refractive index).

In three dimensions, Maxwell equations have six electromagnetic field components: Ex, Ey, Ez and Hx, Hy, and Hz. If we assume that the structure is infinite in the z dimension and that the fields are independent of z, specifically that

$$\varepsilon_r(\omega, x, y, z) = \varepsilon_r(\omega, x, y)$$

$$\frac{\partial \vec{E}}{\partial z} = \frac{\partial \vec{H}}{\partial z} = 0$$

then Maxwell's equations split into two independent sets of equations composed of three vector quantities each which can be solved in the x-y plane only. These are termed the TE (transverse electric), and TM (transverse magnetic) equations. We can solve both sets of equations with the following components:

TE: Ex, Ey, Hz

TM: Hx, Hy, Ez

For example, in the TM case, Maxwell's equations reduce to:

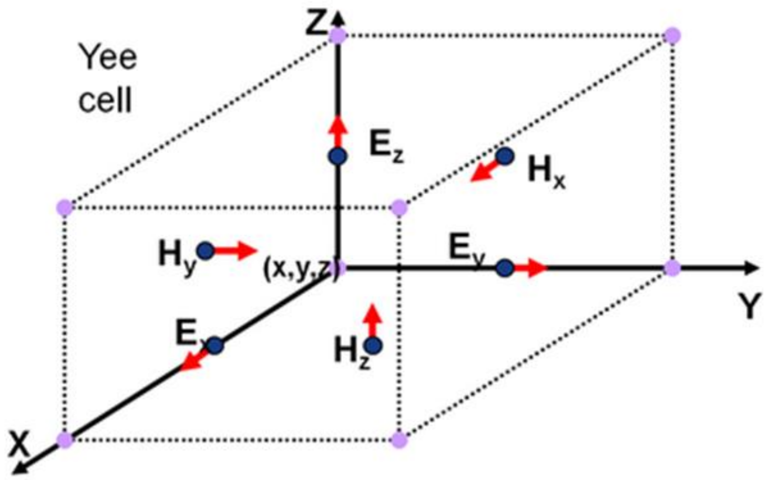
$$\frac{\partial D_z}{\partial t} = \frac{\partial H_y}{\partial x} - \frac{\partial H_x}{\partial y}$$

$$D_z(\omega) = \varepsilon_0 \varepsilon_r(\omega) E_z(\omega)$$

$$\frac{\partial H_x}{\partial t} = -\frac{1}{\mu_0} \frac{\partial E_z}{\partial y}$$

$$\frac{\partial H_y}{\partial t} = \frac{1}{\mu_0}\frac{\partial E_z}{\partial x}$$

The FDTD method solves these equations on a discrete spatial and temporal grid. Each field component is solved at a slightly different location within the grid cell (Yee cell), as shown below. By default, data collected from the FDTD solver is automatically interpolated to the origin of each grid point, so the end user does not have to deal with this issue in their analysis.



Dispersive materials with tabulated refractive index (n,k) data as a function of wavelength can be incorporated by using the multi-coefficient material models that automatically generates a material model based on the tabulated data. Alternatively, specific models such as Plasma (Drude), Debye or Lorentz can be used. The FDTD solver supports a range of boundary conditions, such as PML, periodic, and Bloch. The FDTD solver supports a number of different types of sources such as point dipoles, beams, plane waves, a total-field scattered-field (TFSF) source, a guided-mode source for integrated optical components, and an imported source to interface with external photonic design software.

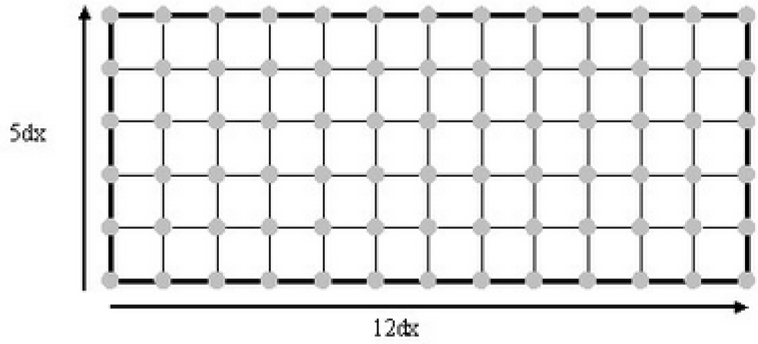
Meshing

FDTD Solutions uses a rectangular, Cartesian style mesh, like the one shown in the following screenshot. It's important to understand that of the fundamental simulation quantities (material properties and geometrical information, electric and magnetic fields) are calculated at each mesh point. Obviously, using a smaller mesh allows for a more accurate representation of the device, but at a substantial cost. As the mesh becomes smaller, the simulation time and memory requirements will increase. The FDTD solver provides a number of features, including the conformal mesh algorithm that allow you to obtain accurate results, even when using a relatively coarse mesh.

By default, the simulation mesh is automatically generated. To maintain accuracy, the meshing algorithm will create a smaller mesh in high index (to maintain a constant number of mesh points per wavelength) and highly absorbing (resolve penetration depths) materials. In some cases, it is also necessary to manually add additional meshing constraints. Usually, this involves forcing the mesh to be smaller near complex structures (often metal) where the fields are changing very rapidly.

Integrating over lines, surfaces and volumes

The electric and magnetic fields are recorded on the finite-difference mesh, as shown below for a 2D monitor, where the grey dots represent the positions where the fields are recorded. The thick black outline shows the limits of the surface monitor as seen in the Layout Editor. This monitor has an x-span of 12dx and a y-span of 5dy. This monitor records a total of 13x6 data points.



A typical calculation with this monitor might be to integrate the total power flow across the surface of the monitor, or

$$Power(\omega) = \frac{1}{2}\int real\left(\vec{P}(\omega)\right)\cdot d\vec{S}$$

In order to calculate this quantity, we provide the scripting function integrate. If Pz is a variable of dimension 13x6x1, and x and y are the corresponding position vectors, then the desired quantity is:

```
power = 0.5*integrate(real(Pz),1:2,x,y);
```

The integrate script command can be used to integrate over spatial dimensions even when several frequency points have been recorded. For example, if Pz is a variable of dimension 13x6x1x10, representing 10 frequency points, then the following can be used to integrate over y (ie dimension 2) and then x (ie dimension 1)

```
power = 0.5*integrate(real(Pz),1:2,x,y);
```

power will be a matrix of dimension 10x1.

References

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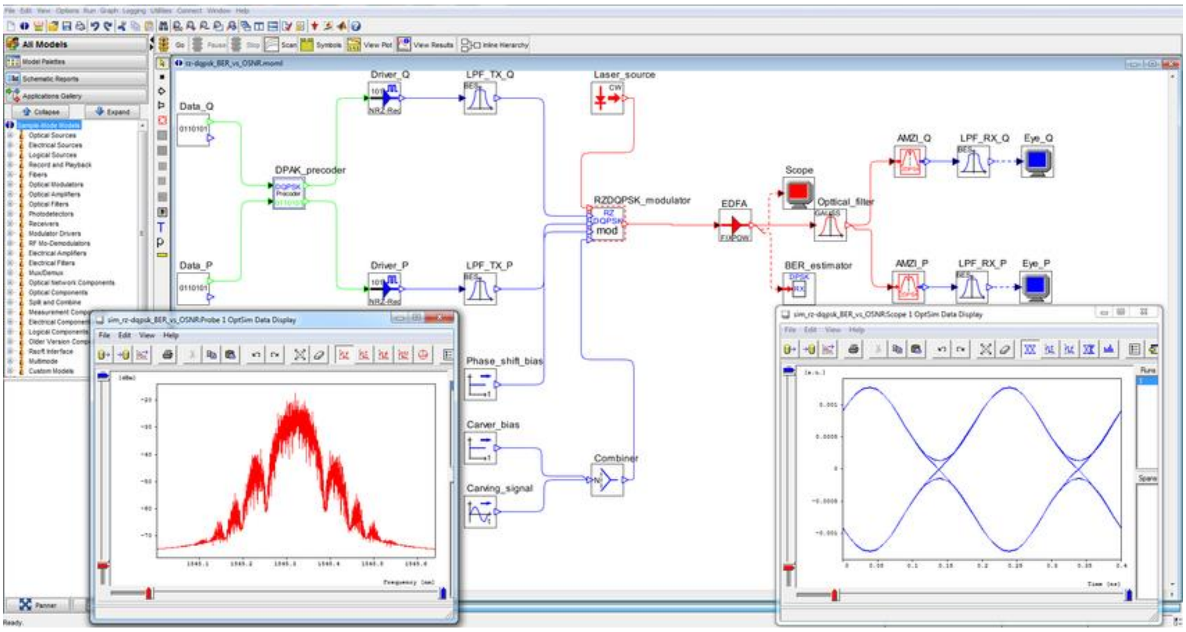
2. Dennis M. Sullivan, Electromagnetic simulation using the FDTD method. New York: IEEE Press Series, (2000).
3. Allen Taflove, Computational Electromagnetics: The Finite-Difference Time-Domain Method. Boston: Artech House, (2005).
4. Stephen D. Gedney, Introduction to the Finite-Difference Time-Domain (FDTD) Method for Electromagnetics. Morgan & Claypool publishers, (2011).

COMPREHENSIVE DESIGN ENVIRONMENT FOR OPTICAL COMPONENTS, SYSTEMS, AND NETWORKS

I. OPTSIM PRODUCT OVERVIEW

RSoft OptSim™ is an award-winning software tool for the design and simulation of optical communication systems at the signal propagation level. With state-of-the-art simulation techniques, an easy-to-use graphical user interface and lab-like measurement instruments, OptSim provides unmatched accuracy and usability. The software has been commercially available since 1998 and is in use by leading engineers in both academic and industrial organizations worldwide.



Layout of a 111 Gbps dual-polarized QPSK system with coherent reception

Benefits

- Virtual prototyping of optical communication systems for increased productivity and reduced time to market.
- Design optimization for enhanced performance and reduced costs.
- Interfaces with third-party tools such as MATLAB and the Luna Optical Vector Analyzer.
- Advanced electrical modeling with embedded SPICE engine.

Applications

OptSim is ideally suited for computer-aided design of optical communication systems including, but not limited to:

- Coherent optical communication systems, such as PM-QPSK, PM-BPSK, PM-QAM, OFDM
- Advanced modulation formats, such as D(Q)PSK, Duobinary, BPSK, m-PAM, m-QAM, etc.
- DWDM/CWDM system with optical amplification, such as EDFA, Raman, SOA, OPA
- FTTx/PON, including BPON, G(E)PON, WDM-PON, coherent PON, RSOA-based bi-directional PON
- Analog and digital CATV, radio-over-fiber, and microwave photonic links
- OCDMA/OTDM
- Electronic Dispersion Compensation (EDC)

- Interferometric Fiber Optic Gyroscope (iFoG)
- Free Space Optics (FSO)
- Optical interconnects
- Soliton transmission

Features

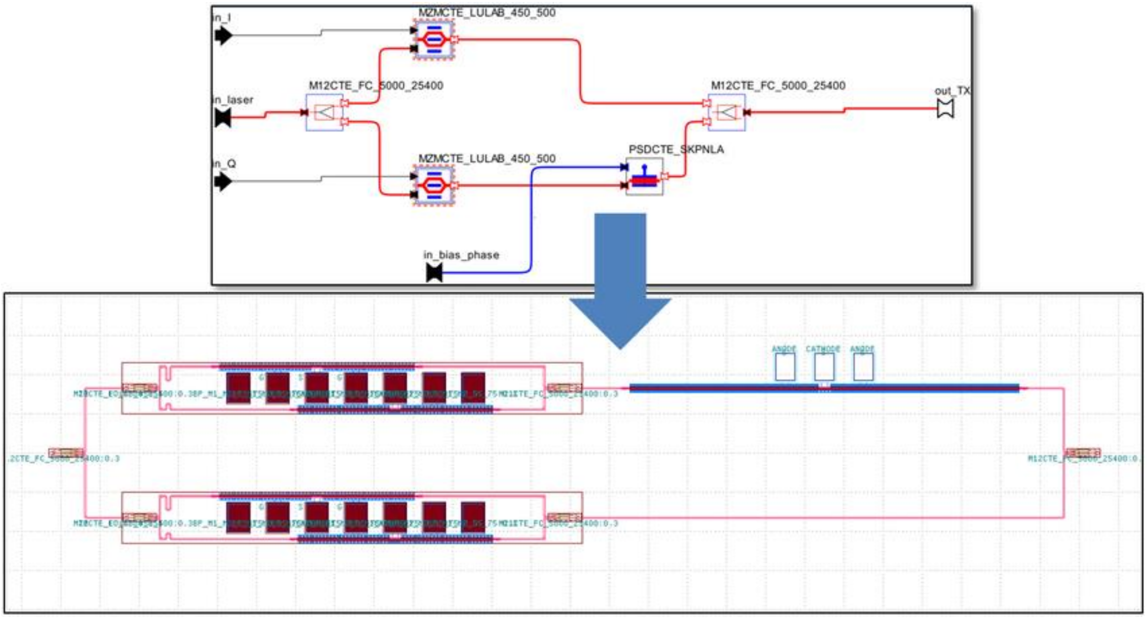
- Support for multiple parameter-scans-based optimization.
- Only design tool with multiple engines implementing both the Time Domain Split Step and the Frequency Domain Split Step for the most accurate and efficient simulation of any optical link architecture.
- MATLAB interface makes it easy to develop custom user models using the m-file language and/or the Simulink modeling environment.
- Interfaces with laboratory test equipment such as Agilent and Luna to merge simulation with experiment.
- Interfaces with device-level design tools such as BeamPROP and LaserMOD provide a powerful mixed-level design flow for optoelectronic circuits and systems.
- Co-simulation with embedded SPICE engine, and interfaces with EDA tools such as Synopsys HSPICE for a mixed-domain electrical and optical simulation.
- Application Programming Interface (API) for programming languages such as C/C++ for the development of custom user models.
- Best Fit Laser Toolkit™ makes customizing powerful rate-equation laser model parameters to fit desired performance characteristics easily.
- Extensive library of predefined manufacturer components makes it easy to model commercially available devices.
- Intuitive and flexible measurement post-processing graphical interface acts like a virtual laboratory instrument.

Reference

https://www.synopsys.com/optical-solutions/rsoft/system-network-optsim.html

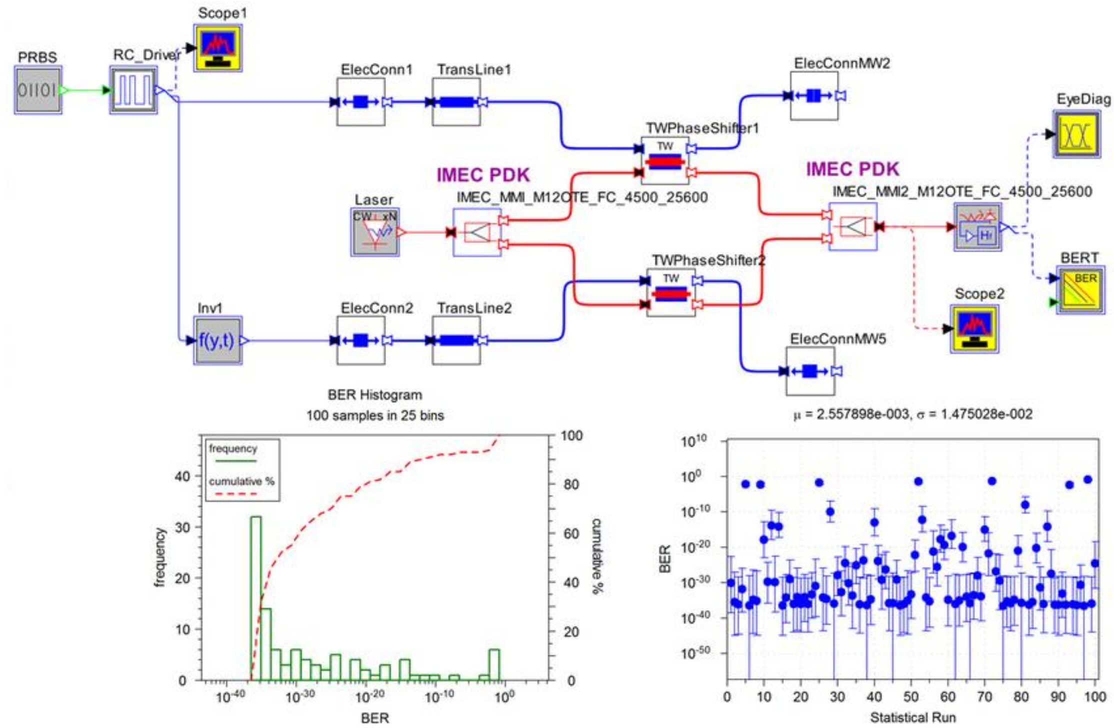
II. OPTSIM CIRCUIT PRODUCT OVERVIEW

OptSim Circuit provides an ideal platform for modeling optical systems and PICs that operate with coupling and feedback of different optical and electrical signal paths. The graphical user interface (GUI) stored with our award-winning OptSim tool offers a more natural user experience to test and optimize performance of PICs at the system level.



Foundry PDK-based schematic in OptSim Circuit to generation of mask for fabrication

OptSim Circuit comes with a rich library of PIC elements including, but not limited to, bidirectional waveguides, bidirectional couplers and connectors, modulators, optical sources (lasers and VCSEL), and photodiodes (PIN and APD). Measurement and plotting tools are supplied, such as optical and electrical scopes, signal, spectrum and eye diagram analyzers, Q-factor and BER estimators, power meters, etc. OptSim Circuit's intuitive representation of repeating and hierarchical elements provides brevity and efficiency to the layouts. For example, you can create custom components and organize and reuse them in the PIC layout.



Estimating performance bounds in OptSim Circuit due to wafer-to-wafer (WTW) and run-to-run (RTR) foundry process variations

OptSim Circuit takes into account bidirectional propagation of both optical and electrical signals. This makes it possible to model complex signal interactions such as reflections and resonance in PICs that otherwise are impossible to model in conventional systems modeling tools.

OptSim Circuit's extensive documentation includes an installation guide, user guide, models reference guide and application notes. The product also includes a number of pre-supplied PIC layouts such as single- and multi-stage micro-ring resonators, a micro-ring modulator, a gratings-based optical notch filter, and more.

Benefits

- Offers a comprehensive pathway to PIC ecosystems, starting from the development of concepts to foundry PDK-based schematics, and leading to the creation of masks ready for fabrication
- Provides a unified platform to evaluate and optimize the impact of PIC performance on the overall system when used with the OptSim tool
- Delivers powerful options for design setup, data visualization, plotting and management of project resources

Applications

- Single- and multi-stage Photonic Integrated Circuits (PICs)
- Silicon photonics
- Transceivers for coherent and non-coherent fiber optic communication systems
- Photonic systems with multipath interference (MPI), reflections and resonances
- Ring resonators, ring modulators, traveling-wave Mach-Zehnder modulators (TW-MZM), optical filters
- Photonic sensor circuits

Features

- Extends OptSim's system modeling capabilities to include PICs
- Models bidirectional propagation for both optical and electrical signals
- Models forward and backward propagating reflections and resonance
- Models single- and multi-stage bidirectional PICs
- Models multipath Interference (MPI) from network and PIC elements
- Includes library of PIC elements such as bidirectional waveguides, bidirectional couplers and connectors, light sources, modulators and photo diodes
- Includes a library of PDK elements for the commercial IMEC foundry
- Supports mask layout via an interface to Luceda IPKISS
- Supports reusable user-defined components and compound components
- Offers flexibility to create custom models using MATLAB cosimulations
- Provides a number of options for exporting data and for co-simulation with external tools
- Provides an intuitive graphical user interface
- Comes with powerful options for data visualization, plotting and management of project resources

Reference

https://www.synopsys.com/optical-solutions/rsoft/optsim-circuit.html

III. Hands-on Practice

1. Introduction to OptSIM V2017 – Twin Simulation Engine
2. Introduction to Block Mode simulation Engine
3. Block Mode:
    - Design & Simulation of simple optical communication system
    - Parameter sweep while simulation

- Creation of compound system in Block Mode.
- Use of HOC feature in Block Mode
- Design of Optical communication system design such as FSO, Radio over fiber, PON, FTTH etc

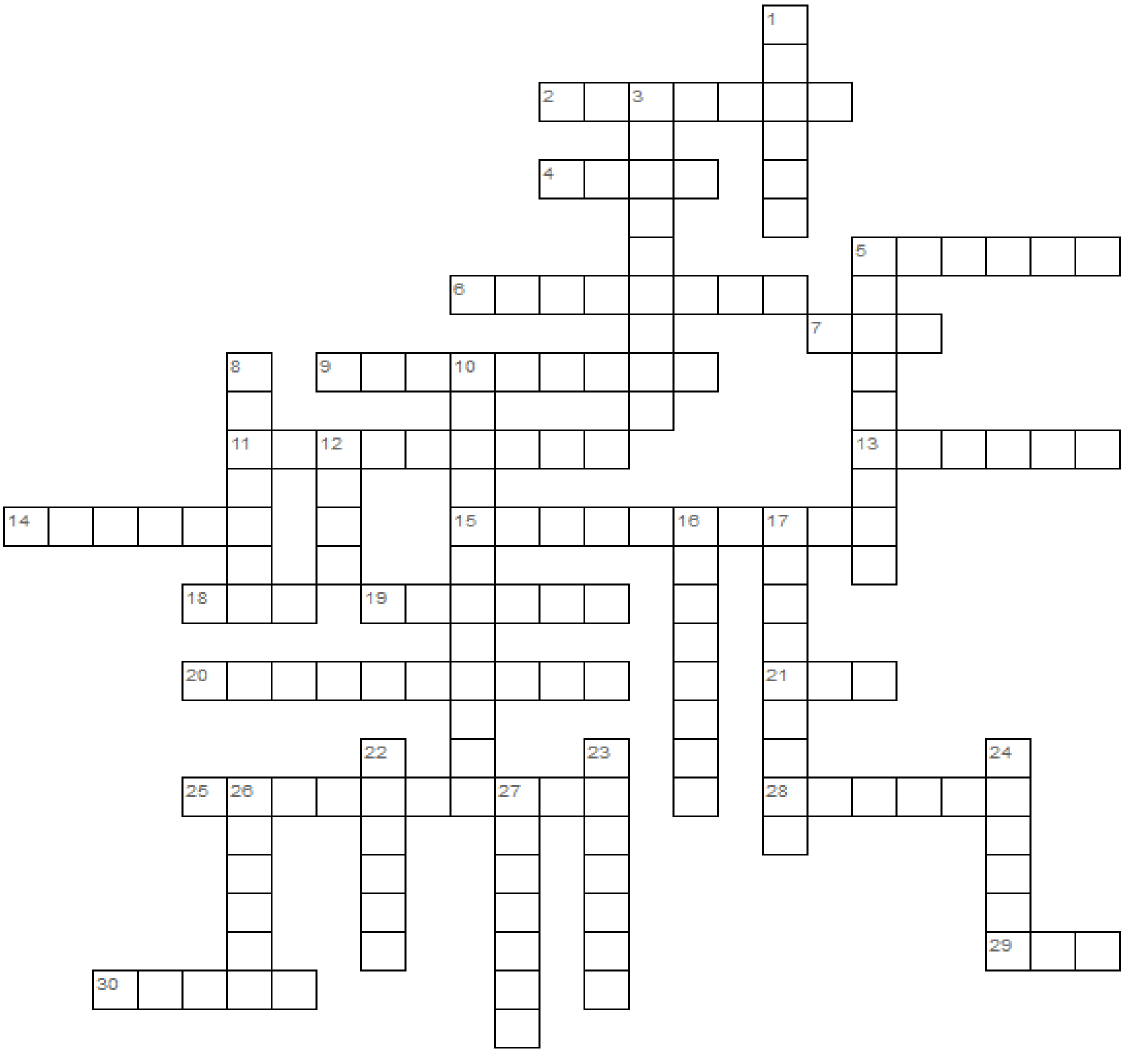
4. Sample Mode:
    - Introduction to OptSIM – Sample Mode
    - Introduction to Sample Mode simulation Engine
    - Design & Simulation of Optical communication system in Sample mode
    - Integration of Matlab with OptSIM
    - Integration of SPICE with OptSIM
    - Features of Best Fit Laser tool kit
    - Integration of RSoft Component Design Suite + OptSIM
5. Introduction to OptSIM Circuit
6. Design and integration of PIC in OptSIM using OptSIM circuit

Trainer

Mr. Arul Prakash, Product Engineer, Supreme Scientific Corporation, Madurai

CROSS WORD PUZZLE

Rohan Katti, Research Scholar, Department of ECE



Across

2 A type of cable consist of a single tightly buffered fiber
4 A device that measures the scattered reflected light returning from the pulse of transmitted light
5 What mode is used for long haul telecommunications
6 The portion that contains fiber optic transmission wavelengths
7 Unit that is use to measure power readings in optical fibers
9 When an atom has only one electron, it is a perfect?
11 One kind of cable consisting of electrical conductors and fiber
13 Composed of 12 fibers held together by a plastic tape
14 The fundamental unit of light and electromagnetic energy
15 When the light bounces off a medium, it is called
18 The process that includes quantizing, sampling and encoding
19 Cable containing Single mode and Multi mode fibers
20 It is the bending of light through the intersection of two medium
21 There are two most common types of light source used in fiber optic communication, one is laser diode and the one is?
25 The distance light travels to complete one cycle is called
28 Standard color for 62.5/125nm fiber cordage
29 It is the fiber optic communication common method of mudulation
30 Short for Synchronous Optical Network

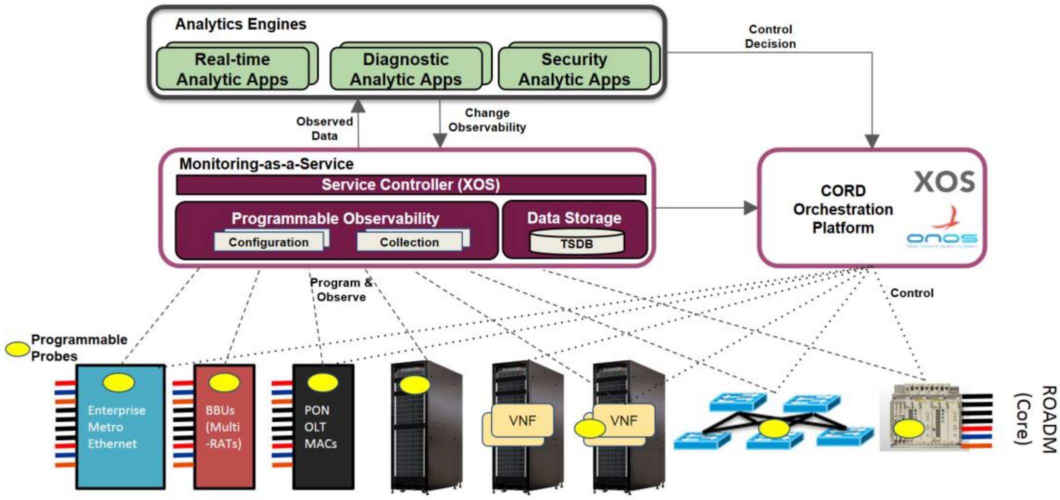
Down

1 How many different fibers does the standard fiber color codes accounts for
3 A device that converts a voice or data into a transmittable form
5 Cables that can handle high pressure and moisture associated with great depths
8 Fiber connector still being used on older systems
10 A non-breakout, tight buffered and used indoor is called
12 Reference guide that should always be available whenever chemicals and solvents are being used for splicing
16 The three components of optical fibers are core, jacket and
17 An atom that has eight valence electrons is a good
22 Cables used inside buildings and fire resistant are called
23 An analog sample rate must be atleast two times the highest frequency is called ____ sampling criteria
24 Standard color for 8.3/125nm fiber cordage
26 A coupler that provides no insertion loss
27 Cable ratings OFNG and OFCG, the G stands for

Article-1

CORD at a glance

Ruturaj Kadikar, Senior Research Associate, Department of CSE, SRM University



CORD Architecture

CORD (Central Office Re-architected as a Data-Center) combines NFV, SDN, and the elasticity of commodity clouds to bring datacenter economics and cloud agility to the Telco Central Office. An open reference implementation of CORD uses commodity servers and white-box switches, coupled with open source software that includes OpenStack, Docker, ONOS, and XOS.

- Openstack provides a base IaaS capability, and is responsible for creating and provisioning virtual machines (VMs) and virtual networks (VNs). CORD uses OpenStack's Nova, Neutron, Keystone, Ceilometer and Glance subsystems.
- ONOS is the network operating system that manages the white-box switches and software switches (OvS) in each server. It hosts control programs that implement services and it is responsible for embedding virtual networks in the underlying network.
- XOS is a framework for assembling and composing services. It unifies data plane services supported by OpenStack and Docker, and the control plane services running on ONOS.

The CORD Technical Steering Team (TST) has established the following projects under the CORD umbrella. Each has it's own community, roadmap, and software components, but they all come together into an integrated whole for each release of the CORD reference implementation.

- Residential CORD (R-CORD)
- Enterprise CORD (E-CORD)
- Mobile CORD (M-CORD)
- Analytics for CORD (A-CORD)
- Trellis: CORD Network Infrastructure
- XOS: The CORD Controller
- VOLTHA: Virtual OLT Hardware Abstraction

Residential CORD (R-CORD) includes services that leverage wireline access technologies like GPON, G.Fast, 10GPON, and DOCSIS. The initial release includes a disaggregated and virtualized OLT device for GPON, called vOLT. R-CORD also includes a virtual Subscriber

Gateway (vSG) and leverages a core networking service - virtual Router (vRouter); the former is implemented by a container that is bound to each subscriber and the latter is an ONOS control application. Design notes for each can be found here:

- Virtual OLT (vOLT)
- Virtual Subscriber Gateway (vSG)
- Virtual Router (vRouter)

E-CORD builds on the CORD infrastructure to support enterprise customers, and allows service providers to offer enterprise connectivity services (L2 and L3VPN). It can go far beyond these simple connectivity services, as it includes virtual network functions (VNFs) and service composition capabilities to support disruptive cloud-based enterprise services.

In turn, enterprise customers can use E-CORD to rapidly create on-demand networks between any number of endpoints or company branches. These networks are dynamically configurable, implying connection attributes and SLAs can be specified and provisioned on the fly. Furthermore, enterprise customers may choose to run network functions such as firewalls, WAN accelerators, traffic analytic tools, virtual routers, etc. as on-demand services that are provisioned and maintained inside the service provider network.

M-CORD is an open source reference solution built on the pillars of SDN, NFV and cloud technologies. It leverages open source software, disaggregationand virtualization of RAN and core functions of mobile wireless networks. M-CORD enables mobile edge applications and in novative services using micro-services architecture.

Key features of A-CORD

- Provides deep observability of both physical network elements and software element inside CORD: Dis-aggregated access devices (GPON OLT), dis-aggregated core devices (ROADMs), Fabric whitebox switches, Compute/Storage hardware, Software virtual switches (OVS), Software virtualized services running on the infrastructure
- Provides not only infrastructure level monitoring but also service level monitoring thereby enables end-to-end observability
- Programmatic interfaces to control level of observability
- Decouples Analytics applications from underlying probes thereby enabling true multi-vendor environments
- Allow multiple applications to consume the same collected data. i.e. collect once and use by many
- Applications can be data publishers too such that aggregated events can be fed into the system that can be consumed by other applications

Trellis is a unique combination of an underlay leaf-spine fabric, overlay virtual networking and unified SDN control over both underlay and overlay. In the current implementation, there are actually two sets of ONOS controllers with different responsibilities. The first ONOS cluster (onos-cord) is responsible for the overlay infrastructure (virtual networking and service composition) and the access infrastructure. This cluster hosts the VTN and vOLT applications, respectively.

The second ONOS cluster (onos-fabric) is responsible for controlling the fabric and interfacing with conventional upstream routers. This cluster hosts the Fabric Control and vRouter applications, respectively.

XOS brings the Everything-as-a-Service (XaaS) organizing principle to the CORD architecture. In doing so, it addresses several of CORD's high-level design requirements, including a means to seamlessly integrate control plane (SDN) and data plane (NFV) based services; the ability to support both access services and conventional cloud services; support for multiple security domains; and the "end-to-end glue" needed to make CORD both extensible and controllable.
VOLTHA introduces the next-generation optical access system architecture, based on SDN/NFV technologies. Disaggregating PON functions to functional modules with open interfaces supports the CORD vision for open source reference implementations to service "Access-as-a-Service" use cases. VOLTHA is a vOLT hardware abstraction component that supports the CORD Project objective of multi-vendor, multi-domain "any broadband access as a service" reference implementation for the Central Office. VOLTHA provides isolation between an abstract (vendor agnostic) PON management system, and a set of vendor-specific PON hardware devices. On its north-bound interface, VOLTHA provides a set of abstract APIs which north-bound systems can interact with the PON networks. On its south-bound side, VOLTHA communicates with PON hardware devices using vendor-specific protocols and protocol extensions through adapters.

Reference

https://wiki.opencord.org

Article-2
Finally, SDN's Time Come for Optical Network

Vivek Kachhatiya, Research Scholar, Department of ECE, SRM University

The optical system's market has been shockingly and surprisingly progressed in the recent years because of the rise of programmable optical modules by utilizing digital signal processors (DSPs) capable of modulating the data in multiple modulation schemes and also delivers the high data rate link in flexible combinations of reach and capacity. The optical line card adopted DSPs only for two significant reasons, first it inexpensive when compared with another component, in fact, DSP is a relatively cheaper component of the complete line card. Second, it enables re-configurability and reusability of the expensive optical modules and radio frequency (RF) components.

The industry is looking forward to time, the principles and standards of programmability of optical line cards apply to the broad area of the optical network. The programmability is an essential element of intelligent optical communication systems across most applications. As service provider/ operator/ administrators converged their fixed and mobile access networks and centralized (cloudify) their radio access systems (RANs), such programmability will be significant to provide multiple services, flexible services and dynamic/ adaptable data rate for broad/ various user application or demands. So absolutely DSP can be deployed for an access network segment, metro network as well as long-haul applications. As the mobility and data rate of the electronic gadgets increases, FEC algorithms enhances and systems capacity and reach capability increases.

It is all extremely well-having adaptability and programmability at the line card level, but there is an issue to be managed before this can happen and the problem is management and administration of new optical network since traditionally static optical networks management approach cannot enable us to the most efficient utilization of optical resources. Next-Generation optical networking management and administration demand the orchestration and software-defined networking (SDN) approaches that have been making a significant impact on the areas of optical carriers, network operation and stretches out it reach up to the optical transport network regarding administrative process management and system management. Some vendors are reacting to this with the presentation of new management systems and administrative frameworks that provide the more excellent visibility of the optical network that will be needed to empower more powerful and computerized administration, expected to enable more dynamic and automated management. The management system, an administration framework, and programming applications that guarantee real-time visibility into network performance, organize execution, less demanding wavelength provisioning, and more prominent computerization, as well as higher automation - like path restoration, are needed. Currently, the management system has open application programming interfaces (APIs) and standard data models to tailor the demand of service provider as well as expand in future.

In a parallel vein, pulling optical performance data from the network (including from coherent receivers) and analyses it in real time with any appropriate Processing Engine to survey the signal quality parameter per channel is another approach of empowering faster and less complicated wavelength provisioning. It is expected to see different vendors patching up their management systems and administration frameworks along similar lines within a couple of months from each other. For an, e.g., Ciena's Liquid Spectrum approach, introduced in March 2017, encompasses a management system (Blue Planet MCP). In a parallel vein, Coriant's Aware system demonstrated in March 2017.

The Heavy Reading report Telco Optical Systems Beyond 100G, takes an overview of change in the demand for optical transport, development of coherent optics and what is the future of this evolving dynamic technology along with presently established technology. It analyzes the electronic devices (gadgets) concerning high speed and high data rate capability and comprehends the results for the standard optical network spacing. Further, it also analyzes the methodologies and portfolios of 11 vendors of telco-centered optical systems. It also provides standardization efforts from both user side as well as service provider side.

Article-3

Do you know?

Rohan Katti, Research Scholar, Department of ECE, SRM University

- The sun is actually white when seen from space, because its light is not scattered by our atmosphere. From Venus, we wouldn't see the sun at all, because the atmosphere is too thick.
- In a double rainbow, light is reflected twice inside each water droplet and the colours in the outer arc appear in the reverse order.
- Some animals can see light which we cannot, bees can see ultraviolet light, pit vipers can see infrared.
- Light has momentum, researchers are developing ways to harness that energy to power space travel.
- Frogs eyes are so sensitive to to light that researchers in Singapore have used them to

develop, extremely precise photon detectors.

- Despite the name, black holes are the brightest objects in the universe, even though we cannot see past the event horizon, they can generate more energy than the galaxies in which they are housed.
- Light can make some people sneeze – photic sneeze reflex.
- A perfectly monochromatic light beam is always perfectly polarized but a perfectly polarized beam does not have to be perfectly monochromatic
- If a photon has a watch on its hand, it will always see it not ticking.
- Despite some lasers being hotter than the surface of the sun, they can be used to cool atoms when combined with a magnetic field.
- Humans are bioluminescent. However, the light emitted by our body is 1000 times weaker than our eyes can pick up.
- A 'jiffy' is an actual unit of time. It is the time it takes for light to travel one cm in a vacuum, which is about 33.3564 picoseconds.
- The world's longest lasting light bulb in California has been burning since 1901, with a few interruptions during power failures.

Article-4
Bio-Organic Optoelectronic Devices using DNA

S. Diana Emerald Aasha

Introduction

Biomolecular DNA, as a marine waste product from salmon processing, has been exploited as biodegradable polymeric material for photonics and electronics. For preparing high optical quality thin films of DNA, a method using DNA with cationic surfactants such as DNA–CetylTriMethylAmmonium, CTMA has been applied. This process enhances solubility and processing for thin film fabrication. These DNA–CTMA complexes resulted in the formation of self-assembled supramolecular films. Additionally, the molecular weight can be tailored to suit the application through sonication. It revealed that DNA–CTMA complexes were thermostable up to 230°C. UV–VIS absorption shows that these thin films have high transparency from 350 to about 1,700 nm. Due to its nature of large band gap and large dielectric constant, thin films of DNA–CTMA has been successfully used in multiple applications such as organic light emitting diodes (OLED), a cladding and host material in nonlinear optical devices, and organic field-effect transistors (OFET).

Using this DNA based biopolymers as a gate dielectric layer, OFET devices are fabricated that exhibits current–voltage characteristics with low voltages as compared with using other polymer-based dielectrics. Using a thin film of DNA–CTMA based biopolymer as the gate insulator and pentacene as the organic semiconductor, it has been demonstrated that a bio-organic FET or BioFET in which the current can be modulated over three orders of magnitude using gate voltages less than 10 V. Given the possibility to functionalise the DNA film customised for specific purposes viz. biosensing, DNA–CTMA with its unique structural, optical and electronic properties results in many applications that are extremely interesting.

DNA–CTMA as Optoelectronic Material The DNA used for research in optoelectronic devices is purified DNA. The starting point is marine-based DNA, which is first isolated from frozen salmon milt and roe sacs through a homogenisation process. It then went through an enzymatic treatment to degrade the proteins by protease. Resulting freeze dried purified DNA has molecular weight ranging from 500,000 to 8,000,000 Da with purity as high as 96% and protein content of 1–2%. The average molecular weight of DNA is, on average, greater than 8,000,000 Da. It was found that the purified DNA was soluble only in water, the resulting films are too water sensitive and have insufficient mechanical strength, so are not compatible with typically fabrication processes used for polymer based devices. It has also been observed that many particulates are present in the DNA films. Therefore, additional processing steps are performed to render DNA more suitable for device fabrication with better film quality. This DNA–CTMA films can be cast by standard methods like spin coating, doctor blading, dip coating, drop casting, etc. and exhibit excellent transmission over a broad wavelength range.

DNA–CTMA in Organic Light Emitting Diodes

DNA can also play a vital role in enhancing light emission in OLEDs. This stems from the fact that DNA–CTMA has large band gap of 4.7 eV for potential use as electron blocking layer (EBL). Hagen et al. have reported that incorporating DNA–CTMA as an EBL into fluorescent type OLEDs. resulted in BioLEDs that are as much as 10 times more efficient and 30 times brighter than their OLED counterparts. The light emission from green and blue-emitting conventional OLEDs is compared to DNA-containing BioLEDs operated under the same bias conditions and processing conditions including active area. The role of blocking electron flow is to enhance the probability of radiative electron-hole recombination, leading to increased device efficiency and luminance. Reference OLEDs are fabricated which are identical to the BioLEDs except that the DNA–CTMA EBL layer was replaced with organic EBL materials (PMMA – polymethylmethacrylate or PVK – polyvinyl carbazole). The reason for increases in the device efficiency and luminance are primarily due to the low DNA–CTMA LUMO level (0.9 eV) that allows for more efficient electron-hole recombination in the emitting layer of the device by reducing electron flow into the anode region.

Summary and Outlook

Optoelectronic devices, employing DNA-based biopolymers as either EBL or dielectric layers, can significantly enhance the performance of these devices, compared to their counterparts. Additionally, the molecular weight of DNA can be tailored, with the help of a sonication procedure, to realise molecular weights ranging from 200,000 to 8,000,000 Da, which correspond to 220–12,000 base pairs, respectively. DNA-surfactant complexes render excellent thin films using common organic solvents. This process also enhances the mechanical properties of the resulting thin films and neutralises the charge of DNA. Large band gap, dielectric constant (7.8), fully transparent through the visible regime of the spectrum, tunable electrical resistivity and thermal stability (up to 230°C) make DNA–CTMA suitable for numerous electronic and optoelectronic devices. Although the mechanisms are not yet completely understood, it is proposed that charged species, present in bulk of DNA–CTMA and at the interface of DNA–CTMA and the organic semiconductor layer, are likely to be responsible for the hysteresis in the transistor characteristics. Another possible explanation is related to the formation of an electrical double layer between DNA–CTMA and the semiconductor layer, which is reflected in the measurement of an unusually high capacitance at low frequency. Furthermore, due to the compatibility of carbon/hydrogen-based organic semiconductors with organic biomolecules, there can be a great opportunity to integrate such bio-organic semiconductor devices with living organisms. In general the largely independent bio/lifesciences and information technologies of today can thus be bridged in an advanced cybernetic approach using organic semiconductor devices . This field of bio-organic electronic devices is proposed to be the future mission of organic semiconductor devices.

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Article-5

Terahertz Photonics

Rohan Katti, Research Scholar, Department of ECE, SRM University

It is evident from the current scenario that data traffic is increasing exponentially with Internet Protocol (IP) traffic and is expected to reach over 130 exabytes per month by 2018. The impact of such a humongous increase in data traffic will be on wireless channels, as mobile users make the most use of online services. This increase in the ultra-high network capacity calls for the requirement of much higher wireless transmission rates in different connection links between each base station, between a base station and an end-user device, between each end-user device, etc. The prospective data rate for wireless communications in the market place will be 100 Gbps within 10 years. The total allocated bandwidth which is around 7 GHz~9 GHz for current technologies such as millimeter wave communications will limit the total throughput of the channel to an insufficient level for the increasing demand. This calls for a new frequency band called terahertz frequency band (0.1 THz – 10 THz) when the bandwidth requirement is few tens of GHz. The lack of readily available THz sources and detectors has led to this relatively unexplored region of the electromagnetic spectrum being termed the "THz gap".

It can be inferred from Shannon's formula that the information capacity or the data rate is associated with the bandwidth and the signal to noise ratio. Higher data rate terahertz communication can be possible due to the availability of large bandwidth even though the signal power tends to decrease with carrier frequency. One of big obstacles in terahertz communications is the atmospheric attenuation which increases with the increase in frequency.

Due to the limitation of attenuation, transmission distance is limited. Several frequency bands have been designated for particular applications based on the transmission distance, some of which are 100 GHz~150 GHz for long distance (1 km~10km), < 350 GHz for medium distance (100 m~1 km), < 500 GHz for in-door (10~100 m). Above 600 GHz, there are two windows for in-door communications; 625 GHz~725 GHz, and 780 GHz~910 GHz. When the frequency exceeds 1 THz, the radio wave undergoes a significant absorption by water vapour and oxygen molecules in the atmosphere, and is attenuated by less than one tenth at only 1-m propagation distance, which is still useful for near-field communications. The effect of rainfall should also be taken into consideration for outdoor applications.

Based upon the link distance criteria, THz communications have promising applications such as front- and back-hauling of base stations in femto cells, wireless local area networks in smart offices, wireless personal area networks in smart homes, near-field communications (NFCs) such as wireless connections in data centers, device-to-device communications (D2D), etc. In these applications, one of the important factor which plays a major role is the power consumption, which is directly related to transmitter and receiver architectures, and has a strong impact on the real THz link scenario.

To explore undeveloped THz-wave regions for wireless communications, photonic signal generation is considered to be one of the most powerful technique, and particularly, the approach with use of telecom- based components is not only a technology driver in the wireless communications, but also makes it easy to combine the wireless link with fiber-optic networks seamlessly. In the THz communications research, photonics technologies have been intensively employed for the transmitter rather than the receiver. It is the easiest way to generate signals at higher data rates with use of photonic components, which have inherently larger bandwidths because of their higher carrier frequency of over 100 THz.

One of the key features enabled by THz photonics technologies is the possibility to take benefit of the very low losses of optical fibers in order to remotely feed the THz emission circuits, which is useful in the case of backhaul applications. Other key advantage of photonic-based solutions is the ability to handle multi-carrier and multi-format THz channels as well as carrier switching, which has no equivalence in electronics-based solutions. This can be achieved by adding optical laser lines to the optical driving signals. This unique feature of photonics-based transceivers is in phase with optical network evolution towards 'flexgrids' that will expand core networks bandwidth beyond traditional WDM (wavelength division multiplex) systems. By essence, photonics could play a major as a convenient 'optical-to high speed radio' interface in mixed network technologies context.

Photonic technologies can help in term of link efficiency, generating high data rate and coherence, the system still needs more output power at the transmitter in particular for applications such as backhaul where the distance will have to reach a kilometre. To tackle the power limitation of photonic devices, the future of photonics-based THz systems may be based on the combination of power amplifiers associated to photomixers, but performances would require a monolithic association of the two devices, which has not been achieved in the THz range.

The primary technology that could improve both the power at the transmitter and the overall efficiency of the system is 'photonic integration'. Photonic integration will reduce coupling losses, such as the loss from fibre to chip and in particular the loss between the laser and the photomixer. It should also enable the use of multiple antenna system that would lead to advanced active array antennas to compensate the path loss and allow for some tracking. There is also a need for amplification at both the transmitter and receiver, thus low-noise and wide bandwidth THz amplifiers for both transmitters and receivers are also a key priority.

Photonics industry has taken a great leap in the advancements in generation and detection of THz signals in recent years. The primary goal is to obtain a high-quality signal with the high output power necessary for radio communication and other THz applications. This goal can be achieved electronically or photonically. Various electronics-based approaches to THz generation include schemes using Schottky diodes, gallium arsenide and indium phosphide integrated circuits and resonant tunnel diodes. A photonic approach, on the other hand, has a numerous advantages. First and foremost, it can generate THz signals that are compatible "out of the box" with wireless-over-fiber distribution, and that can be directly integrated into existing, low-loss optical-fiber networks. This approach also allows amplitude and phase modulation with high-speed data.

With the advancements in compact, high-power, spectrally pure THz sources, researchers have developed wireless-over-fiber communication setups in the W-band (75- 95 GHz) and for frequencies above 100 GHz. A typical experimental system for single-carrier, one-way wireless-over-single-mode-fiber (SMF) transmission, involving heterodyne detection of the combined output of two lasers through digital processing at the receiver is shown in figure 1.

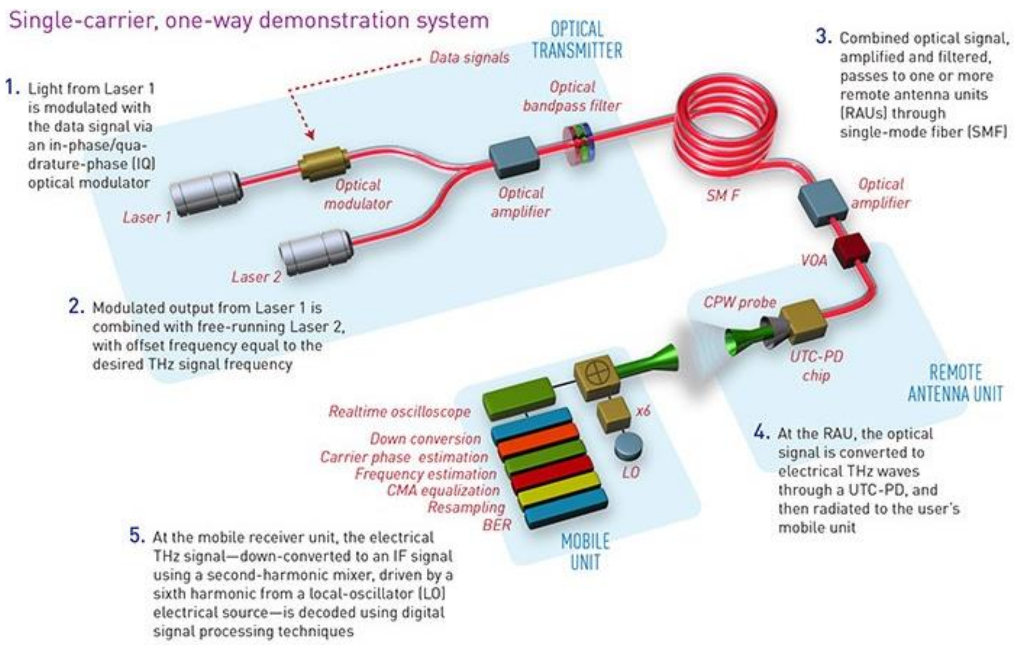

Figure 1: Terahertz wireless over fiber: A schematic view [4]

With the recent progress in THz photonics technology and integration, THz wireless links could provide part of the solution for ultra-broadband wireless in the scenario where the demand for data delivery is continually increasing. There are still many challenges to be addressed for complete development of THz-based wireless links. The combination of integrated solutions and receivers of lower noise figure should enable THz wireless links with throughputs matching optical communication systems—and help move forward the next generation of wireless data.

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Article-6

Industrial Advances in SDN Oriented Optical Networks

Ruturaj Kadikar, Senior Research Associate, Department of CSE, SRM University

Cisco is adding Automation and SDN control to Telecom Italia's Metro optical network which can esase the development towards software-controlled next-generation services. This will be done by deploying Cisco's latest Aggregation services Router (ASR) technology across TIM's Optical Packet Metro (OPM) network.Cisco is claiming the ability to provision 100 Gb/s IP connectivity to metropolitan areas after this installation.

SDN control over optical networks can allow operators to manage port speeds, protocols, and wavelengths; support more advanced modulation and detection schemes; and provide for flexible wavelength routing via dynamic reconfigurable optical add-drop multiplexers (ROADM). These enhancements will provide greater operational efficiency and control, including the ability to launch new business models that can facilitate the adoption of 5G technology.

Verizon is evolving its passive optical networking infrastructure using NG-PON2 technology, which the carrier plans to control using its software-defined networking (SDN) architecture. A phased approach for the evolution of NG-PON2 deployment toward [software-defined networking]- and [network functions virtualization]-based architecture using a common SDN and NFV infrastructure is being deployed in Verizon's network.

Voyager is a first step toward unbundling the hardware and software in today's proprietary packet-optical transport systems, which include transponders, filters, line systems, and control and management software goal. Facebook refers to Voyager as a "white box transponder and routing solution." It is based on an open source system that combines packet technology for switching and routing, along with dense wavelength division multiplexing (DWDM) transport technology.


Voyager transponder with 12 QSFP28 ports and 4 x200G DWDM line ports

ECI is now offering its Lambda on Demand, which gives the functionality to layer 1 and the optical layer which is similar to bandwidth on demand for data traffic in layers 2 and 3 of the network. The app provides bandwidth on demand for dynamic services and bursty applications when demand for data spikes. For example, with the data center interconnection backup process needs a lot of bandwidth for a very short time. The Lambda on demand capability allocates the necessary number of wavelengths at the designated time. This will reduce service turn up time on both packet and optical networks, allowing networks to respond to real-time needs within minutes.

Polatis' DirectLight optical matrix switch technology enables SDN users to move toward dynamic fiber cross-connect fabrics that can scale incrementally to tens of thousands of ports with the lowest loss. Ideal for SDN applications, Polatis all-optical switching can help where connection loss, stability, and reproducibility are critical. DirectLight connects fibers without needing light to be present on the fiber, empowering data center operators to pre-provision paths, and monitor the network. With an embedded OpenFlow agent and SDN support, all-optical circuit switches from Polatis enable data center operators to enhance performance and scalability to meet growing bandwidth demands.

Ciena launched the 8700 Packetwave, an important new line of optical networking boxes aimed at solving the challenges of handling the boom in cloud applications. The 8700 focuses on a couple of things and does them well, in this case Ethernet and DWDM (Dense Wave Division Multiplexing). Indeed, the 8700 offers scale, with 2 terabits of total Ethernet over DWDM switching capacity. It also supports MPLS-TP, with up to 200 10 gigabit Ethernet (GigE) ports or 20 100 GigE ports. It will solve some of the data-center network's biggest problems: The ability to move large amounts of Ethernet at lost cost, with low-energy consumption. One key to the 8700 is that it is coupled with some of Ciena's newer management tools, which look a lot like SDN.

As an initial step towards automating the optical layer, Infinera announced its Automated Capacity Engineering (ACE) concept that can automate the capacity of the optical layer. This ability to provide software-defined capacity is based on its Photonic integrated Circuit (PIC) hardware developed by Infinera. ACE takes previously manual offline route and capacity planning processes and implements algorithms in a micro services-based path computation element (PCE). ACE also understands optical impairments and computes optimal Layer 0 routes between nodes across multiple paths, including automatic routing and wavelength assignment with multiple path constraints such as traffic engineering cost, distance, and latency.

ADVA Optical Networking has introduced the FSP Network Hypervisor with the goal of bringing software-defined networking (SDN) to legacy optical networks. This Network Hypervisor creates an abstracted view of the physical infrastructure, which makes it easier to manage the photonic transmission systems and at the same time provides better network automation and optimization. A key element to the technology is that the hypervisor can act as a domain controller for the optical layer. This means that service providers can move away from static networks toward responsive architectures more suitable for a cloud-driven world. The FSP Network Hypervisor has been engineered to work with all open source and commercial SDN controllers — including those from Juniper Networks, NEC/NetCracker, ONOS, and OpenDaylight.

Reference

www.sdxcentral.com

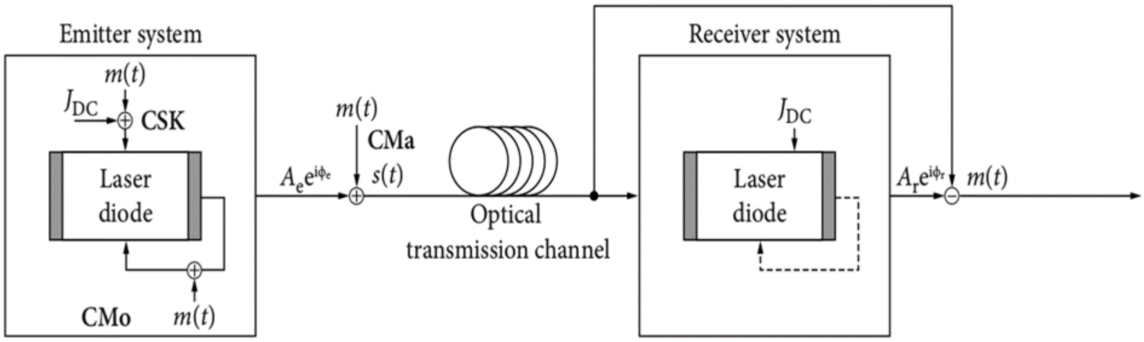
Article-7

All-Optical Cryptography

M. Valarmathi, Assistant Professor (SG), Department of ECE, SRM University

Information security is one of the major issues for present communication systems and should be carefully considered in various situations. For instance, lack of communication confidentiality in military, government and financial sectors could cause enormous damages and severely affect society. A common way to minimize data security problems is to encrypt information. This is usually performed in the presentation layer of the OSI model. However, presently most of the core networks rely on optical fiber communication systems that are safer than other transmission technologies but are vulnerable to intrusive and non-intrusive fiber tapping. For this reason, security issues and attack management in Transparent Optical Networks (TON) became a key point to Network operators.

In this scenario, various proposals for encryption in the physical and optical layers are available. Chaotic communication is a well-known hybrid secure communication method, where a chaotic carrier is generated through laser oscillation by all optical system. Several techniques using Optical CDMA (OCDMA) and spectral encoding approach can be utilized to protect the confidentiality of user data in access networks. In secure communication, another non-linear technique utilizes SOA in optical circuits that perform EX-OR operation between signal and a delayed version of it to enable optical encryption. Nonlinear effects are used to distort the amplitude and phase of optical signals and to encrypt them. The advantage of this method is that the secured signal can travel more than 200Km at 40Gbps without any drop. Optical systems are also capable of encrypting real world 3D objects.



Schematic representation of a laser-diode-based cryptosystem

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Article-8

Buy Lumens, Not Watts

G. Kalaimagal, Assistant Professor (OG), Department of ECE, SRM University

The Indian markets are flooded with cheap LED products of less-than-standard quality. Buying the wrong product leads to losses in the long run. Here are a few pointers to ensure you choose the right LED bulbs. The age old assumption is that the higher the consumption wattage marked on a bulb, the higher is its output. Well, that might have been true for the old incandescent but for LEDs that concept is history. In reality, higher lumens output and lower consumption wattage is the ideal combination to look for in a bulb. Thus, a bulb marked to produce a certain lumens output by consuming, for example 7 watts, is better than a bulb producing the same lumens consuming 10 watts of power. Good quality LED bulbs come with a warranty period of at least three years. Anything less than that should raise concerns about the fairness of the deal. In the Indian market a 9W LED bulb costs around ₹150 to the end users.

Note: An LED bulb consists of an LED chipset and a driver, which is the main power management system that drives the input voltage and current to the LED chip in utilisable form.

Reference

Paromik Chakraborty, EFY Magazine

Article-9

Benefits of Incorporating SDN in Optical NWs

Ruturaj Kadikar, Senior Research Associate, Department of CSE, SRM University

Service providers need a dynamic, application-aware network infrastructure that suits today's cloud and mobility needs. Software-defined networking (SDN) and network functions virtualization (NFV) have great potential to improve the flexibility and responsiveness of networks, decrease both operating and capital expenses, and add new and innovative features to many different types of communications networks.

SDN concepts were first applied to the packet portion of the network, since optical transport couldn't be programmed. However, new advances in optical technology can allow network operators to program the optical layer. A few examples are:

- Software-defined optical port speeds, protocols, and wavelengths
- Advanced modulation and detection schemes, especially at 100 Gb/s and higher speeds
- A flexible wavelength grid rather than a fixed 50 GHz grid
- Flexible wavelength routing via dynamic ROADMs
- OTN grooming and switching

These technologies open the gate for SDN in the optical transport layer. Employing these programming capabilities, the optical transport layer can be abstracted to a set of shared, common resources that can be used dynamically and on-demand. The main reason to adopt SDN in the optical layer is to reach a unified, multilayer control. In such an environment, packet and optical networks are not managed separately. A global, central control is aware of the entire complex of packet and optical resources and is able to use them efficiently for flexible service creation. Having a unified control results in better resource utilization, simpler end-to-end orchestration, and rapid and dynamic service turn-up.

The OIF, in its document "OIF Carrier WG Requirements on Transport Networks in SDN Architectures ," offers two models for SDN-controlled transport networks. In the first model, the SDN controller directly controls each node in the network, including the optical nodes. In this model:

- Each network element needs to support a transport programming interface, such as OpenFlow or Netconf
- The SDN controller communicates with each network element to provision an end-to-end service
- The SDN controller must be aware of the detailed topology and optical switch technology

In the other model, the controller controls a multidomain network and offers an integrated network view. The multi-domain network is abstracted and appears as a single, flat network for applications. Each domain exercises internally a choice of control – dynamic routing, GMPLS, or SDN.

The second model represents a more evolutionary road toward optical SDN. The ONF work on OpenFlow extensions for transport networks is still underway. In addition, service providers tend to implement SDN in a staged approach to avoid network instability. As a result, SDN is deployed alongside existing network control protocols.

We can identify a few building blocks that are necessary for multilayer control:

- Automatic discovery of the network topology, providing updates when the topology changes
- PCE (Path Computation Engine) – computation of paths based on routing and optical domain constraints

- Allocating resources and provisioning circuits based on the computed path
- Automatically restoring service on a network failure by providing an alternate path

An important element of the multilayer SDN control is the domain gateway controller. This controller is able to mediate between a legacy optical domain and a higher, multidomain SDN controller, translating the controller's commands to the domain protocol and relaying the detailed optical information to the controller via a standard northbound interface. The domain controller gateway holds both standard SDN northbound and southbound interfaces, such as OpenFlow, Netconf, and REST, as well as legacy interfaces such as SNMP. It also functions as a gateway for a domain controlled by distributed protocols such as GMPLS.
Reference: www.sdxcentral.com

Article-10
Visible Light Communication (VLC)

A. Ramya, Assistant Professor (OG), Department of ECE, SRM University

Overview
Implementation and applications of optical communications are changing very rapidly. It is surprising that the technology which was thought impossible few decades back has emerged with unbelievable and amusing advancements. Few emerging technologies in fiber-optic technologies are visible light communication, wireless optical communication, software defined optical networking, etc.

The Radio Frequency (RF) communication suffers from various issues such as (a) Interference mainly from use of mobile phones (b) more latency due to bandwidth limitations (c) As RF waves easily penetrate the walls, they suffer from security issues. (d) The increase in RF waves, transmission power beyond a certain limit results in risks to human health (e) RF communication suffers from power inefficiency because we require a separate setup for communication of the RF waves. Overcoming the above limitations, Visible Light Communication (VLC) is a preferred communication technique because of its high bandwidth and immunity to interference from electromagnetic sources. The revolution in the field of solid state lighting leads to the replacement of florescent lamps by Light Emitting Diodes (LEDs) which further motivates the usage of VLC.

Introduction
VLC is a data communication variant which uses visible light between 400 and 800 THz (780–375 nm). VLC is a subset of optical wireless communications technologies. The technology uses fluorescent lamps (ordinary lamps, not special communications devices) to transmit signals at 10 kbit/s, or LEDs for up to 500 Mbit/s. It uses electronic devices generally containing a photodiode to receive signals from light sources. Now-a-days cell phone camera or a digital camera can be used. The image sensor used in these devices is in fact an array of photodiodes (pixels) and in some applications its use may be preferred over a single photodiode.

History
Though the concept of using light for communication started in 1880's, the recent development started in Japan in 2003. In 2006, researchers from CICTR at Penn State proposed a

combination of power line communication (PLC) and white light LED to provide broadband access for indoor applications. In January 2010 a team of researchers from Siemens and Fraunhofer Institute for Telecommunications, Heinrich Hertz Institute in Berlin demonstrated transmission at 500 Mbit/s with a white LED over a distance of 5 metres (16 ft), and 100 Mbit/s over longer distance using five LEDs. In December 2010 St. Cloud, Minnesota, signed a contract with LVX Minnesota and became the first to commercially deploy this technology. In July 2011 a live demonstration of high-definition video being transmitted from a standard LED lamp was shown at TED Global.

Applications

Potential applications of VLC include Li-Fi, vehicle to vehicle communication, robots in hospitals, underwater communication, information displayed on sign boards and WLAN. VLC can be used in Li-Fi to provide high speed internet up to 10Gbits/s and in vehicular communication for lane change warning, pre-crash sensing and traffic signal violation warning to avoid accidents as these applications require communication with low latency which is provided by VLC because of its high bandwidth and easier installation due to the existing presence of vehicle lights and traffic signals. VLC also has applications in areas that are sensitive to electromagnetic waves, such as aircrafts and hospitals where the radio signals interfere with the waves of other machines. Visible light is used to provide both lighting and information using VLC techniques.

Advantages

- Unregulated 200 THz bandwidth in the range of 455-700nm wavelengths.
- No licensing fee requirement.
- Optical signals cannot pass through walls like radio waves penetrate. Line-of-Sight (LoS) is essential, that is, the sender and the receiver must see each other directly. Any intervening situation or barrier can be easily recognized. So it is preferred in the military and state mechanisms that require high information privacy and security.
- Stay of signals in the room or office, eliminates the possibility of any interference in adjacent rooms or offices.
- The equipment used is cheaper when compared with RF devices.
- Optical signals are not as detrimental as RF signals to the human health.
- VLC requires lower energy consumption than RF systems.

Standards

The standardization of VLC has been performed by the Visible Light Communication Consortium (VLCC) in Japan and IEEE. The Japan Electronics and Information Technology Industries Association (JEITA) CP-1221, JEITA Cp-1222 and JEITA Cp-1223 are published by the VLCC. The 802.15.7 is the standard completed by the IEEE for physical and MAC layer.

Modulation Techniques

Modulation in VLC is achieved using variations in the intensity of the light corresponding to the information in the message signal. Two factors to be considered in the design of the modulation scheme for VLC include (a) dimming and (b) flickering. The various modulation schemes used in VLC are

- On–Off Keying (OOK)
- Pulse modulation techniques
- Color Shift Keying (CSK)

References

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Article-11

All-Optical Signal Processing

R. Manohari, Assistant Professor (SG), Department of ECE, SRM University

All-optical signal processing is a powerful tool for the processing of communication signals and optical network applications have been routinely considered since the inception of optical communication. There are many successful optical devices deployed in today's communication networks, including optical amplification, dispersion compensation, optical cross connects and reconfigurable add drop multiplexers. However, despite record breaking performance, all-optical signal processing devices have struggled to find a viable market niche. This has been mainly due to competition from electro-optic alternatives, either from detailed performance analysis or more usually due to the limited market opportunity for a mid-link device.

Optical signal processing brings together various fields of optics and signal processing—namely, nonlinear devices and processes, analog and digital signals, and advanced data modulation formats—to achieve high-speed signal processing functions that can potentially operate at the line rate of fiber optic communications. Information can be encoded in amplitude, phase, wavelength, polarization and spatial features of an optical wave to achieve high-capacity transmission.

Optical or photonic computing uses photons produced by lasers for computation. Photons promise to allow a higher bandwidth than the electrons used in conventional computers. Most research projects focus on replacing current computer components with optical equivalents, resulting in an optical digital computer system processing binary data. This approach offer prospects for commercial optical computing, since optical components could be integrated into traditional computers to produce an optical-electronic hybrid.
Future optical communication depends on integrated optical processing. Integrated optical processing will improve Performance, provide security and provide switching and routing functions. The key to achieving all-optical processing functions is to use a nonlinear optical material where different light beams can interact. An SOA is made from semiconductor opto-electronic material (Indium Phosphide-based). The design of SOAs developed in two directions: as a linear amplifier and as a nonlinear medium. The nonlinear effects should be exploited for use in variety of applications such as all optical signal processing.The main practical physical mechanisms used for optical nonlinearity in SOAs are cross-gain modulation (XGM), cross-phase modulation (XPM), four-wave mixing (FWM) and nonlinear polarization rotation.

Reference

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Solution for Crossword Puzzle

Across	
2	Simplex
4	OTDR
5	Single
6	Infrared
7	dBm
9	Conductor
11	Composite
13	Ribbon
14	Photon
15	Reflection
18	PCM
19	Hybrid
20	Refraction
21	LED
25	Wavelength
28	Orange
29	WDM
30	SONET

Down	
1	Twelve
3	Modulator
5	Submarine
8	Biconic
10	Distribution
12	MSDS
16	Cladding
17	Insulator
22	Plenum
23	Shannon
24	Yellow
26	Active
27	General