Discussion

Wataru Imajuku

Q: You talked about switched circuits and QoS, can you talk a little bit about the bandwidth efficiency of circuit switching ?

A: About 70% of the transit traffic is pre-groomed.

Q: What applications are driving an increase in demand for bandwidth?

A: Many Japanese customers have started to use broadband services such as ADSL and Fiber-to-the home service. This is the main reason of traffic growth. And, future driving force will be HDTV services because Japanese people started to buy large displays such as liquid crystal displays in the home.

Q: Can you tell me how network costs scale for WDM networks?

A: In the conventional high-speed TDM system, so-called 2 to 4 rule, this means 2 times in cost for 4 times bandwidth, has been empirically proved. This comes mainly from the cost gain of high-speed LSIs. But, the cost reduction in WDM systems comes from mass production effect of LSIs. From the view point of cost reduction of optical devices, the realization of wavelength tunable laser device has become important issue.

Q: Would I be paying more for my telecommunication services if the optical amplifier had not been invented ?

A: I think so. The invention of optical fiber amplifier realized 80-kms repeater spacing even for 10 Gbit/sec system in Japan. Also, this technology made the WDM system reasonable. This resulted in low-cost deployment of internet infrastructure today.

Q: Can you comment on the switching power consumed in optical switches?

A: I'm sorry I cannot comment on the switching power exactly. But the amount of energy is of the order of hundred-milliwatts per switching point.

Jeffrey C. Livas

Q: What do you think about modulation speeds increasing to 40 Gb/s and even 160 Gb/s?

A: Technically it is feasible to communicate at higher speeds, but from a practical viewpoint at present there are issues with both availability of parts and also performance of parts that operate at those rates. Historically, the price per bit of communications decreases as the bit-rate increase, so higher data rates will be introduced when they are economically viable or where they are needed for a specific application when nothing else will work. It is likely that the next high speed data rate that is introduced will be motivated by the demand for high speed data and will be at a rate of 100 Gb/s using an Ethernet standard rather than a 40 Gb/s SONET/SDH standard

Q: How do people plan for network failures and survivability?

A: Today survivability is guaranteed mostly by redundancy in both equipment and signal path. Redundancy is not very efficient, so newer protocols such as GMPLS are being implemented to discover other potential routes through the network. Network topologies such as mesh allow a single signal path to be the potential protection path for more than one route at a time under the assumption that it is extremely unlikely for two independent routes to fail at the same time. This reduces cost and increase efficiency because less spare capacity needs to be built than for simple redundancy.

Q: How do you distribute power to nodes along an undersea cable?

A: Electrical wides are embedded in the undersea cable and +10,000 VDC is applied at one end of the link and –10,000 VDC at the other. A high voltage is used to keep the current low for a fixed power dissipation.

Q: Can you have continuous amplification along the fiber?

A: Not really. In order to have amplification it is necessary to optically “pump” the fiber with light at a higher energy (shorter wavelength) than the wavelength used for signaling. The pump light gets absorbed as it propagates down the fiber, so the amplification per unit length is not constant. It is possible to closely approach the continuous amplification ideal with Raman amplification. The Raman effect exploits an energy transfer mechanism between a high energy photon and the rotational energy states in glass. Distributed amplification has been demonstrated and although not continuous, still gives some of the same advantages in terms of better noise performance and lower non-linearity

Q: How do you guarantee privacy and security in optical networks?
A: It is not really possible to completely guarantee security and privacy in an optical network today, but in practice people do very well with a variety of encryption schemes. The most common scheme uses a public and a private key that are multiplied together to get a codeword that is used to encrypt data. Breaking the code is equivalent to factoring a large number, and the size of the keys is chosen to put the factorization problem beyond the reach of modern computing resources. A variety of quantum encryption key distribution schemes are being developed, and these are in principle impossible to break. The idea is to us a one-time key – that is, a codeword known only to the sender and receiver that is used eto encrypt the data in one specific message and then discarded. The one-time keys are distributed using quantum techniques that make it possible to tell if someone has eavesdropped on the message Rudimentary versions of this distribution scheme are available commercially, but they are not yet practical for use in a Wide Area Network (WAN) – just a local network (LAN).

Connie J. Chang-Hasnain

Q: What is the application of 'laser on silicon'?
A: This technology replaces the discrete laser devices. One of the merits is the improvement of power efficiency. The new integrated device will be applied to optical computing etc.

Q: How about the MEMS reliability. Some MEMS devices have an aging problem.
A: Since the MEMS includes moving parts, careful design, fabrication and packaging is necessary. However, I think there is no fundamental reason to fail.

Q: There are some proposal and development on fibers to expand the bandwidth for optical communication. How do you think about them?

A: Those technology such as hollow fiber are interesting but present available bandwidth, 50THz, is enormous. Innovations on the other parts of the network, switching devices, optical buffers, etc. are needed to use the bandwidth efficiently.

Q: I understand optical communication technology will be able to support enormous data transmission. Will the capacity be really used in the next ten years with reasonable costs?
A: I agree the importance to propose cost-effective services to users. From device-side, it is necessary to realize efficient operation with the fixed fiber network infrastructure. Dense Wavelength-Division Multiplexing and more intelligent network technologies will be applied to achieve least cost.

Q: Please give us additional comments about the control mechanism of your spatially-divided selection technique of single-wavelength data channel. Is the micro-mirror actively stabilized?
A: In this case, the MEMS is operated with a reference light and sensor device for feed-back servo-loop.

Q: Please comment about the trade-off in your optical-buffer between band-width, delay time and other factors.
A: There are a fundamental trade-off depend on the physical process that applied to and a design trade-off. Due to a fundamental trade-off of Electromagnetically-Induced Transparency (EIT) process, if the available band-width is spread, slow-down factor is reduced. In addition, for an optical device, we have to use quantum-dots made with semi-conductors, which is just like a human-made atom. And therefore its characteristics, such as bandwidth, can be designed but also its quality is dependent of our fabrication technology.

Q: Considering the extension of the existing application, the data-transmission will not so drastically increase in future. How do you think about it?
A: New application with acceptable cost can change our life-style. For example, I think 3-D imaging application for simulator use.

Shigeru Nakamura

Q: In your 160Gbps de-multiplexing experiments, why do you set your dividing factor to be 16?

A: This is just a decision in our first trial. We fabricated the necessary devices for 1/16 de-multiplexing on a chip. The serial data in 160Gbps is divided to 16 channels of 10Gbps data.

Q: In your talk, several types of 10-632Gbps time-domain technique including wavelength conversion has presented. How do they relate with each other?

A: It may be not practical in a network system to treat near-1Tbps data in a single channel. But, I hoped to show our Symmetric Mach-Zender (SMZ) device has sufficient flexibility to support a near-future system including wavelength-multiplexing.

Q: What kind of users did you imagine when you develop this technology?

A: For 10-40Gbps time-domain signal processing, our device can be applied to optical network use. The 160Gbps time-domain processing has same possible advantages in future optical communication in spite of remaining problems, too. Faster 632Gbps technique will be used by researchers.

Q: Have you any idea of innovation to expand people's needs for data-transmission bandwidth? I suppose a remote surgery system will need a wider communication network.

A: For example, the optical communication network has a potential to distribute a heavy computation work in a local area to many places. Such an application will need much more capacitance of data-transmission. I think it is necessary to prepare sufficient capacitance for future use.