Telecommunications Network Technologies

Technologies for establishing a base network infrastructure including optical networks, wireless and satellite, all of which are essential to guaranteed bandwidth and broadband telecommunication.

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Implementation of Internet Access via the FTTH Used for CATV

Optical fiber's most significant feature is its broadband capacity. FTTH\(^1\) has thus been initially developed and deployed, in many areas, for the CATV\(^2\) service. The upgrading of HFC\(^3\) to have a bi-directional capability allows broadband Internet access and this attracts consumers, so this feature is vital for the further deployment of FTTH.

Internet access via the CATV transmission system is currently quite common. This is based on the STM-PDS\(^4\) and SCM-PDS\(^5\) systems. In the STM-PDS system, a conventional phone service (PSTN\(^6\) or ISDN) is provided along with broadband IP connectivity by which Ethernet packets are carried between the homes and the CATV center. The bandwidth for IP connectivity can be configured in 64 kbit/s increments, up to 10Mbit/s, and is shared among customers. To stop customers setting up services that the CATV operator and ISP\(^7\) do not want, such as the sharing of files and printers among customers, packets from customers only travel to and from the CATV center, and not to and from other customers.

The SCM-PDS system provides unidirectional video-signal transmission over the wide frequency region from 90 to 770 MHz. By employing the FM-conversion technology, it is possible to avoid the deterioration in signal quality caused by the reflections at connectors and the chromatic dispersion of the optical fiber. A 1.3-\(\mu\)m optical signal is used in the STM-PDS system and a 1.5-\(\mu\)m signal is used in the SCM-PDS system. WDM\(^8\) technology allows both systems to be run independently on the same fiber.

The Access-Network Operations System (AcNOS), currently at version 5, has been developed for the management of this FTTH system. This system helps the operator to configure and maintain the system.

(NTT Access Network Service Systems Laboratories)

Photonic Transport Network System that Supports Broadband Access Services

As the Internet continues to penetrate every aspect of our daily lives, it is reshaping the way we do things, and bringing into existence a fully-evolved information distribution society. In a few short years we have seen the emergence of an environment where people can quickly and easily obtain all sorts of information by accessing the network from their personal computers and cell phones. Once broadband access becomes available, anyone will be able to download very-high-quality images and enjoy super-realistic networked games with players who are located on the other side of town or on the other side of the globe.

We are already witnessing a remarkable increase in data traffic to accommodate this growth and penetration of the Internet into our daily lives. The expansion of data traffic has exceeded all expectations, even outweighing Moore's Law, the notion that the number of transistors on integrated circuits has doubled every year since the integrated circuit was invented. A radical new kind of network system based on unprecedented technology is essential to meet the needs of this vast increase in data traffic that even exceeds the projections of Moore's Law.

It is clear that optical communications technologies—an area where NTT is preeminent—and IP technologies will be indispensable for next-generation network systems. NTT is an acknowledged leader in lightwave communications, with dramatic breakthrough achievements in everything from optical devices to photonic transport technology.

Photonic transport technology is evolving very rapidly, and was brought much closer to practical deployment with the implementation of optical cross-connect switching. Optical cross-connect switching permits light signals to be differentiated by wavelength and routed across the network to a destination as light, and not converted to electrical signals. Using the relatively simple mechanism of the optical cross-connect switch, vast amounts of bursty traffic can be bundled and sent over pre-set routes. NTT has now developed a fully-functioning network system based on optical cross-connect switching.

In another recent development, a high-speed photonic router that operates very efficiently was implemented by combining wavelength routing and IP routing technologies. Efforts are now underway to develop and deploy a photonic transport network system based on this rugged high-performance photonic router.

(Network Innovation Laboratories)
**Development of an OADM-Ring System**

This OADM*1-ring system was developed to operate as the backbone of optical communications networks for use in urban areas, where IP traffic is expected to increase enormously in the future. This system multiplexes 20 wavelengths in the 1550-nm band, each with a throughput of 2.4 Gbit/s, over an SMF*2. The system can be equipped with optical amplifiers to achieve long-distance transport, so this has made it possible, for the first time in Japan, to transport signals over 100 km without repeaters. The nodes in the ring consist of central nodes and local nodes. Central nodes can add and drop up to 20 wavelengths. Local nodes can add and drop up to four wavelengths. Each wavelength path can form a logical star network. NE-OpS*3 can operate the ring as a whole via a digital communications network.

The main attributes of the system are as follows.

(1) The system achieves a large cost reduction because of the reduction in the number of OS/OR*4 modules at each node and handling add/drop through processing of the optical signals.

(2) The ring transport system makes it possible to set up equipment easily to suit the demands of traffic.

(3) 1+1 path protection, which can change the path immediately in case of problems, provides the system with good characteristics in terms of maintenance and operability.

This OADM was built using components from NTT Green Procurement Guideline, so it also represents an eco-friendly communication network.

NTT West introduced the system as a backbone of the optical IP communications service in Osaka on 30 November 2000, and field trials began in December 2000. Field trials also began in Nagoya, Hiroshima and Fukuoka in March 2001. The OADM-ring system is a promising basic system because of its independence from the upper layer in the ever-changing IP-signal environment. Extensions for even higher transfer speeds, such as expansion of the number of multiplexed channels and a 10-Gbit/s interface are expected in the near future. These will make it possible to adapt to the expanded demand for communications that the expansion and addition of various IP services will bring. It is expected that OADM will make a strong contribution to the IP networks of the future.

(NTT Service Systems Laboratories)

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**Development of a Large-Capacity WDM Transmission System**

The dramatic rise in data traffic especially on the Internet in recent years has brought about an increasing demand for greater capacity and cost efficiency in the trunk network. To this end, the WDM transmission system has been promoted as a means of achieving a significant jump in the transmission capacity of the trunk network, and its deployment is now moving forward. Up to now, however, 1.3-μm SMF has been used as the transmission fiber in WDM transmission systems, and dealing with DSF*1 used in the long-haul network has been an issue.

NTT Laboratories have succeeded in developing WDM-2 transmission systems to achieve the world's first transmission system that can handle both SMF and DSF. In WDM transmission over DSF, crosstalk caused by FWM*2 occurring in the fiber must be suppressed. The developed system can overcome the distance limitations imposed by this FWM crosstalk through utilization of the following new technologies. The first is unequally spaced wavelength arrangement in the C-band (1530-1565 nm), the wavelength band normally used. Also, considering the variance in dispersion characteristics of laid DSF, the optical power level has been optimized and high-quality bit-error-rate characteristics have been achieved. The second new technology is use of the L-band (1570-1610 nm) as a new wavelength band to supplement the conventional C-band. The L-band features moderate dispersion, which enables the generation of FWM to be suppressed. These new technologies realize the transmission of more than 48 wavelengths over a maximum distance of 320 km (three repeaters). They also enable a transmission speed of 10 Gbit/s per wavelength in addition to existing speeds of 600 Mbit/s and 2.4 Gbit/s.

Deployment of this system in NTT Communications' backbone network began in 2000 and the deployment area is expanding throughout Japan.

(Network Service Systems Laboratories)

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Example of the structure of OADM

- **OADM**: Optical Add/Drop Multiplexer
- **SMF**: Single Mode Fiber
- **NE-OpS**: Network Element-Operation System
- **OS/OR**: Optical Sender/Receiver

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**Configuration of type-2 WDM transmission system**
Full-Mesh Photonic Network System (AWG-STAR)

Full-mesh network systems are attractive for use in future communication services because they can be used to achieve a flexible network architecture that allows such functions as simultaneous transmission and reception using different information protocols. We have established a full-mesh network system with a very simple structure by using WDM technology and a cyclic-frequency arrayed-waveguide-grating (AWG) router.

We use the cyclic-frequency AWG router to send WDM signals through an input port to an output port. Each input port sends its signal to predetermined output port corresponding to the signal wavelength, and no two signals of the same wavelength as one output port are sent from different input ports. Therefore, as the number of input and output ports is the same as the number of wavelengths, we can achieve a full-mesh connection.

The configuration of our full-mesh network with this cyclic-frequency AWG router (AWG-STAR) consists of one cyclic-frequency AWG connected to nodes with specific-wavelength light-transmission and reception modules arranged in the shape of a star. Using this single system enables us to install communication nodes that use operating signals with any protocol or frame by assigning wavelengths based on this principle, even when the signals are analog or when the transmission rates are different. We can also apply this system to a high-speed Internet and various mass network services such as supercomputer connections.

The system has the following additional features. It can raise wire speed between nodes by using WDM. It is capable of multicast connections for cyber-communities. It can be easily upgraded or extended. It can achieve high-speed routing without the limitation imposed by electronic devices, and it is suitable for real-time transmission of live TV broadcasts.

We will develop a wavelength-on-demand/bandwidth-on-demand AWG-STAR with a self-healing system.

Common Digital Data Broadcast and IP Communication System

One of the key features of the digital satellite broadcasting service launched in December 2000 is its ability to broadcast digital data. To ensure a low degree of reliability and offer users the convenience downloading data whenever they want, a carrousel transmission scheme was adopted that partitions data into blocks and repeatedly sends the data. Meanwhile, multimedia satellite communication systems employ an IP transmission scheme and are capable of highly reliable data delivery.

Now a new satellite communications system has been developed based on a digital satellite broadcasting technology that exploits the strengths of both IP and carrousel transmission schemes: IP transmission is used by multimedia satellite systems to provide dependable data delivery, while carrousel transmission is used to support a digital satellite broadcasting service to several million large-scale users that is reliable and has the added convenience of allowing users to download their data anytime they want.

Since the same hardware can support both transmission schemes, the system was largely implemented through software development. A carrousel conversion program was developed for the transmit side that converts data to the carrousel transmission format, while a tuner program was developed for the receive side that enables PCs to handle both transmission schemes.

In addition, the carrousel conversion program that was developed in implementing this system was also used to construct a contents verification system that can be applied to affordable digital satellite broadcasting. NTT Group have all expressed interest in adopting this new system.

Upcoming work will focus on developing and deploying new services that exploit the features and advantages of both the IP and carrousel transmission schemes.

(Photonics Laboratories)

Data delivery system based on Japanese BS digital transmission technique

Full-mesh WDM network (AWG-STAR)
Practical Deployment of MSTP

In order to accommodate the fast growing signalling traffic associated with more diversified and advanced communication services, there is pressing demand for greater capacity, faster throughput and improved cost effectiveness in common channel signalling networks. Anticipating these needs, NTT Laboratories developed a multi-protocol- STP (MSTP)*1 and new network elements operations support systems (NE-OSS), which were released in September 2000. These products have been working in the new common channel signalling networks of NTT East, NTT West and NTT Communications since February 2001.

Taking up to three cabinets, the MSTP accommodates 3,000 signalling links, 2,000 signalling link sets, and is capable of processing up 100,000 combined MTP*2 level-three and SCCP*3 signals per second. Compared to conventional SS7 signalling switches, the MSTP occupies only 1/10th the number of cabinets while at the same time boosting the number of signalling links that can be accommodated as well as the processing capacity by three fold, respectively. In addition to the 4.8-kbit/s and 48-kbit/s signals links that were supported by the old legacy system, the new system is able to accommodate high-speed 1.5-Mbit/s links based upon ATM technology. Transmission equipment costs have also been held down by replacing the old 64-kbit/s circuit interface with the much more efficient SDH*4 interface with multiplexing capability. Turning to NE-OSS, reliability of the new operation system has been significantly upgraded through distributed redundancy architecture.

Development of both the MSTP and NE-OSS was also achieved very cost effectively. We were able to utilize the S1 platform and much of the hardware from the already-developed MHN series, which meant that only the common channel signalling component had to be designed and developed from the ground up. The NE-OSS was also implemented economically by using existing software assets (compact OSS for MHN-A*5 , etc.) and adapting a commercial management platform.

NTT East, NTT West, and NTT Communications have already begun a phased migration over to the MSTP-based common channel signalling network systems from the legacy network system.

(Network Service Systems Laboratories)

*1 MSTP: Multi-protocol Signalling Transfer Point
*2 MTP: Message Transfer Protocol
*3 SCCP: Signalling Connection Control Part
*4 SDH: Synchronous Digital Hierarchy
*5 MHN-A: Multimedia Handling Node-Asynchronous Transfer Mode

Free Access, Navi Access, AP Navi Services, and e-Call Services Based on Advanced IN Technology

Following the company's restructuring, NTT's new regional companies face strong competitive challenges from local NCCs. Aside from differences in designated telecom facilities, the regional NTTs must try to capture more traffic by developing services that provide unique capabilities differentiating itself from other players. And now that the Internet has become such a pervasive presence in society, all sorts of new services will have widespread appeal. For example, these might include a service targeting ISPs enabling them to make more efficient use of multiple access points (AP) by combining the access points into one representative group, or services that merges personal telephony with the Internet.

In anticipation of these demands, NTT has developed the free access, the navi access and the AP navi services. The free access and the navi access services enable customers, for the purpose of accessing calling and called party charges, to specify and connect to an in-prefecture calling area using a UABO system unified number. AP navi services is a service that permits an ISP to combine all its phone numbers within the same CA and connect using that unified UABO number. This AP navi service is used also for AP selection in L-mode service.

Finally, the e-call service which is provided by NTT Communications enables one to receive messages (voice, fax, or email) at a designated terminal over the Internet, but a number of new capabilities have been added: a credit call option, a unified message center connection product, and voice mail delivery from the Web.

In the advanced IN*, services can be developed and deployed much faster than in the past using the SCE*. This economy is possible because the services are largely implemented using common platform functions and unique service-specific programs: service, management, and operation logic programs (SLP*, MLP*, OLP*). Adopting this new service architecture, the APP* is prescribed by the platform, while the SLP, MLP, and OLP are independently developed for each respective party. The free access, the navi access and AP navi services were developed by the regional R&D Centers of NTT East and NTT West. The additional functionality to provide the e-call service can be easily made available by just developing the SLP, MLP, and OLP, a process that takes only half the time of a comparable development in the past. Finally, the service control protocol between the MHN-SCP* and the switch is based on the INAP* which is standardized by the ITU-T and TTC, thus ensuring transparency and openness in the competition to provide advanced connection services.

Development of the plain-old telephony platform is largely complete. In the days and years ahead we will see further extension of the IP-based platform, and many new service offerings that exploit the convergence of telephony and the Internet, for example internet call-waiting service.

Free access, navi access, AP navi services
Roll-Out of Digital Access 6000 Service

In the market for digital leased lines, there is a growing demand for faster throughput service options for enterprise networks and ISP access lines to accommodate increasing Internet usage, while at the same time there is a pronounced shift toward lower cost services. A range of economical, always-on digital access services options are currently available —64, 128, and 1500 services— but now NTT East and NTT West are both requesting that a digital access 6000 service be added to the lineup of leased-line options that are available. In other words, they are calling for an economical, always-on service that supports throughputs up to 6 Mbit/s.

To meet this demand, NTT has upgraded the DSM*1, a system launched in August 1999, that is the hardware heart of the company’s leased-line network infrastructure. Essentially the development involved the creation of a new subscriber hardware module, a two-board OSU*2 interface, and an upgrade to the DSM NE-OpS software to control and monitor the new OSU interface.

We were able to implement the new service very quickly and cost-effectively to meet and exceed the expectations of NTT East and NTT West by taking full advantage of existing technology. The two-board OSU interface is based largely on the one-board OSU interface that is currently used to support the Digital Access 1500 service, and the scale of the software development was similarly kept to a minimum by reusing existing software as much as possible.

The architecture supporting the new service consists of a PDS that provides two-way communication over a single fiber, the two-board OSU interface is based largely on the one-board OSU interface that is currently used to support the Digital Access 1500 service, and the scale of the software development was similarly kept to a minimum by reusing existing software as much as possible.

The architecture supporting the new service consists of a PDS that provides two-way communication over a single fiber, the two-board OSU interface is based largely on the one-board OSU interface that is currently used to support the Digital Access 1500 service, and the scale of the software development was similarly kept to a minimum by reusing existing software as much as possible.

The architecture supporting the new service consists of a PDS that provides two-way communication over a single fiber, the two-board OSU interface is based largely on the one-board OSU interface that is currently used to support the Digital Access 1500 service, and the scale of the software development was similarly kept to a minimum by reusing existing software as much as possible.

Development of 99 Version MHN-S and MHN-S (IC)

During the on-going process of revamping the STM network architecture, excellent progress is being made on the node system — particularly, 99 Version MHN-S*1 and MHN-S (IC) — that can accommodate analog telephony in addition to PHS and ISDN.

Essentially, the 99 Version MHN-S system permits the sharing of system functions, so that resources and capabilities not available in a particular service — processing, switching, SDH interfacing, and so on — can be shared, or can be added onto a service as the need arises. This, for example, would allow a subscriber line line-card to share analog and ISDN service capabilities, thus enabling a subscriber’s service to be switched back and forth between analog and ISDN functionality from a remote location, and would permit new service capabilities to be added quickly and easily by simply downloading them.

Furthermore, a diverse range of interconnection configurations are supported by adopting the same SDH interface used on transmission equipment for the node-link interconnect function. This permits interconnections via transmission equipment as well as direct coupling of optical fiber, and facilitates seamless switching.

In addition, the switching capacities of both the ASM*2 and SBM*3 modules implementing the 99 Version MHN-S have been expanded. The ASM is implemented using a building-block approach, so the module can be flexibly scaled to accommodate any size system. To achieves its designed optimum capacity in terms of cost, the switching capacity of the SBM was doubled.

The MHN-S (IC) is a large-capacity node that not only supports prefeecture-wide trunk connections but also supports NTT Communications links and NCC gateway switching connections. The ASM of the MHN-S was adopted largely unchanged, and every effort was made in developing the MHN-S (IC) to utilize existing technology as much as possible. Trunk capacity was expanded by increasing switching capacity, increasing the number of shared line links, and by extending functional capabilities in other ways.

**Notes**

* DSM: Dedicated Service Handling Module
* OSU: Optical Subscriber Unit
* ONU: Optical Network Unit

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Hardware configuration of 99 Version MHN-S and MHN-S (IC)

**99 Version MHN-S**
- SBM: Subscriber Module
- ASM: Architectural STM Module
- ONU: Optical Network Unit
- NE-OpS: Network Service Systems Laboratories

**MHN-S (IC)**
- SBM: Subscriber Module
- ASM: Architectural STM Module
- ONU: Optical Network Unit
- NE-OpS: Network Service Systems Laboratories

**Added line card**
- Card sharing by ISDN and analog services
- Both direct connections by optical fiber and connections via transmission equipment and uninterruptible switchover
- Building-block configuration and expansion of switch capacity
- Addition of functions needed by analog services in a block-by-block manner
Failure-Resistant ATM Transport Method for the Transmission of High-Quality Real-Time Signals

When video is delivered over ATM networks, the required quality cannot always be satisfied by the transmission quality of the ATM network alone. It is also critically important that services for delivering broadcast programming over ATM networks are continuous, so it is desirable that no information is lost in the event of network failure or during switching.

One commonly used method of compensating for cell losses and coding errors in real-time signals is forward error correction (FEC) based on Reed-Solomon coding or some other technique. Although this method is fairly robust in dealing with cell losses and coding errors that occur randomly, it cannot effectively address interruptions on the order of seconds such as caused by network failures when there is really no way to avoid short interruptions of the transmission.

It is in this context that we have been investigating an uninterruptible ATM transmission scheme that will prevent information from being lost even if the network fails and will provide better quality correction in dealing with cell losses and coding errors.

The concept of the uninterruptible ATM scheme is shown in the figure. In the transmitter, the cell stream is duplicated and sent via two different virtual paths (VPs) or virtual circuits (VCs). The receiver monitors the two incoming cell streams, and selects the better of the two to output.

To ensure that the receiver selects the better stream, synchronizing cells are defined. Synchronizing cells are inserted in the VP cell stream by the transmitter at regular intervals, and the receiver uses the synchronizing cells to determine which stream is better to output.

In the transmission of real-time signals, delay variation must be kept below an allowable threshold, but in the uninterruptible scheme proposed here, the delay variation is automatically reconciled using arrival time data in the synchronization cells.

Based on a successful trial implementation of the proposed parallel VP transmission scheme, we see it being applied to high-quality STM over ATM networks, and to many other potential applications.

(Network Service Systems Laboratories)

Scalable Switch Architecture (HCS)

With the rapid spread of the Internet, more mass data traffic than voice traffic is starting to inundate communication networks. To effectively handle multimedia traffic, which is a combination of data and voice traffic, there is an increasing necessity for networks to incorporate packet integrated nodes that are equipped with multi QoS*1 guarantee functions based on IP and ATM technology, as well as a terabit-class switching capacity.

HCS*2 switch architecture can expand switch size through multi-stage connection of unit switches. It can guarantee QoS to both IP and ATM traffic, and has the following features.

(1) Scalability of a terabit or over.

Adopting distributed architecture whereby the time stamper, dynamic cell distributor and hierarchical guaranteed cell sequence sorter act independently, each function of HCS can be extended independently. Therefore the switch size can easily be extended in excess of a terabit. Cell sequence sorters located in the unit switches construct a hierarchical guaranteed cell sequence network by multi-staging, thereby guaranteeing a recursive cell sequence.

(2) Multi QoS guarantee functions for IP and ATM traffic.

A time stamp control algorithm for each QoS class provides for class-specific switching. It also realizes small switching characteristics of low-level delays and delayed distribution for high-priority traffic.

(3) Non-block.

HCS uses a dynamic cell distributor to achieve non-block characteristics through functions that distribute load by the destination of each cell. Moreover, each cell distributor can distribute load independently because the buffer of the cell sequence sorter in each unit switch absorbs burst vibrations.

Packet-integrated nodes that has terabit-class switching capacity and multi QoS switching capability is realized by applying HCS switch architecture equipped with the above features to a core switch. In the future, study will be advanced on technology to realize hardware for HCS architecture, with consideration to be given to the development of HCS for core nodes.

*1 QoS: Quality of Service

*2 HCS: Hierarchical Cell Sorting

Overview of failure-resistant ATM transport method

Scalable Switch Architecture (HCS)
Enhancement of ISDN (INS-Net 64 Service) Access Circuits for Long Distance Use

Though few in number, there are occasionally subscriber lines in rural areas that cannot be provided with INS-Net 64 Service due to limitations associated with the transmission characteristics of DSU*1/OCU*2. These include a loss limitation (no greater than 50 dB) and resistance limitation (no greater than 810 \( \Omega \)).

In the past, this problem was resolved by adding optical features to the subscriber line through RT*3 installed on telephone poles and RSBM*4. In the case of a resistance limitation only, however, the problem was solved through 4-wire provision.

The ISDN long-distance access circuit system is configured with 2-wire metallic repeaters (ISDN repeaters) and is applicable to circuits with the above problem except when resistance is the only limitation. These ISDN repeaters use existing copper cables (subscriber metallic cables) originally deployed for telephone use, and therefore make for reduced facility-investment costs and lower rates compared to opticalization.

At NTT Laboratories, we have used proprietary ISDN transmission technologies to develop ISDN repeaters and establish their specifications. Deploying these repeaters in subscriber lines makes it possible to terminate and regenerate ISDN AMI*5 signals and to relay communications between DSU/OCU with the result that services can be provided at up to twice the previous distance. In this system, subscribers are provided with the same user-network interface as that of the existing service (INS-Net 64 service). In addition, power does not present a problem since the repeaters employ low-power LSIs and operate by station feed (from OCU).

(Genesis Network Service Systems Laboratories)

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Gigabit Ethernet Network Interface Extension (GENIE)

GENIE has been developed to support native-Ethernet fiber-network operations by providing an exclusive signaling channel for media converter management. The signaling channel is added to the low-cost Gigabit Ethernet optical interface, and supports almost all the SDH/ATM link maintenance functions, such as multi-domain bit-error monitoring, remote defect indication, and automatic protection switching. This extension will allow us to construct a native-Ethernet fiber-network yet also provide SDH-grade link services with guaranteed link quality, fault localization facility, and higher service availability.

In the legacy fiber network, a WAN*1-specific SDH frame (the train in the figure) conveys the customer’s Ethernet data. The fiber network undergoes reliable operations by using transport overhead bytes (the train cockpit) reserved in the SDH frame. However, this means that the customer’s data must transit from the Ethernet frame (the car) to the SDH frame. Sometimes another container, the ATM cell, may also be handled.

GENIE, on the other hand, assumes that the customer’s Ethernet frames drive into WAN seamlessly, where the management signaling for WAN is conveyed by the mini-frame (the smaller car) during the inter-frame gap period. This allows us to operate a reliable fiber network even with the Gigabit Ethernet interface, where we will enjoy significantly reduced costs by leveraging its huge market volume.

The GENIE concept is now being standardized for the 10-Gbit/s Fibre Channel as the LSS*2. Since the Ethernet and Fibre Channel will be fully compatible in the 10-Gbit/s physical interface, it will be possible to apply GENIE to the 10-Gigabit Ethernet interface as well.

(Network Innovation Laboratories)

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*1 DSU: Digital Service Unit  
*2 OCU: Office Channel Unit  
*3 RT: Remote Terminal  
*4 RSBM: Remote Subscriber Module  
*5 AMI: Alternate Mark Inversion  
*1 WAN: Wide Area Network  
*2 LSS: Link Signaling Sublayer
Semantic Information-Oriented Network (SIONet)

Gnutella’s service announcement in March 2000 stirred worldwide interest by referring to a new P2P* model. Basically, the P2P model needs not the broker—the centralized management server—that until now has figured so importantly in prevailing business models, and offers a new approach that enables entities such as end terminals to discover out and locate other suitable entities on their own without going through an intermediary server. Indeed, Gnutella has now implemented this business model based on a P2P interaction approach.

In a parallel development, NTT Laboratories proposed a brokerless model (P2P model) back in 1998, based on SIONet as the implementing technology. Prototype version α of SIONet was developed in 1998, followed by prototype version β in 1999, and versions 1.0 and 1.1 of SIONet in the year 2000.

SIONet is essentially a meta network based on an autonomous decentralized collaboration scheme. In contrast to conventional networks that require a destination address for packets to reach their proper destinations, packets are delivered in SIONet based on semantic information. This enables entities to search for and zero in on other specific entities in the vast sea of distributed non-specific entities that are connected to the Internet.

In the SIONet-based approach, networks are constructed through autonomous decentralized interaction among distributed entities, including a number of functional SIONet configuration elements. There are a number of different types of these SIONet configuration elements—semantic information switches, semantic information routers, semantic information gateways, event places, sessions and so on—that work together as needed to build scalable and highly secure networks from the bottom up. We are now exploring the prospects of implementing community networks that are in the SIONet intelligent layer.  

(Network Innovation Laboratories)

* P2P: Peer-to-Peer

What is SIONet?

- Semantic Information-Oriented Network (SIONet)
  - A network that transmits events (packets) based on semantic information
  - Dynamically searches for, discovers and identifies destinations

SIONet Semantic information:

- Tokyo resident
- Classical music lover
- Someone walking along Mejiro Ave.
- Content on “travel”
- IP address

Event receiver

SIONet

Event sender

Terminals

Hybrid network type

- Conventional networks (e.g., IP network)
  - A network that transmits events (packets) based on destination address

IT System Architecture Planning Platform (ITAP)

A great range of IT systems are being developed and deployed by companies today as mission-critical business tools to support their corporate activities. Ironically, these initiatives can be counterproductive if IT systems are deployed without sufficient planning, for poorly conceived IT systems can cause corporate performance to actually decline, and it takes an enormous amount of time and effort to improve a company’s performance. In the fundamental planning stage of IT system deployment, it is important to first clarify the requirements of business processes executed by the IT system, then determine the performance of system elements needed to satisfy these requirements, and perform an end-to-end assessment of all the elements combined.

Awareness of these general requirements led us to develop the IT system architecture planning platform (ITAP), a system that provides systematic support for consultations regarding the deployment of IT systems. Essentially, the ITAP scrutinizes a target system on two levels—on a business process level and on a system (hardware, software, and network) level—, then analyzes and evaluates the relationship between the constituent elements and the system’s overall performance. The advantage of this approach is that the proposed IT system can be closely tailored to the company’s needs during the design stage by taking the company’s business processes into account from the beginning (how the IT system will be used and the nature of the business workflow in the company), and by analyzing business transactions and information flows between system elements (application traffic profiling, or ATP). A clear grasp of a company’s network and equipment configuration is also important for performing comprehensive assessment network simulations (taking protocol stacks into account) and business process-driven network simulations (BPDNs). The ITAP was designed to be applied during the stage of fundamental planning for IT systems.

On-going efforts are making the ITAP even more useful by extending its protocol coverage to such lower level protocols as WDM and MPLS* and newly standardized protocols, and by upgrading the system’s hybrid simulation techniques to support actual measured data and advanced analytical methods.

* Mpls: Multi-Protocol Label Switching

(Building blocks of the ITAP system)

IT System Architecture Planning Platform (ITAP)

- Business process profiling
  - Modeling the business workflow executed by the IT system, using UML
  - Analyzing and modeling business transactions and information flows between system elements

- Application traffic profiling
  - Simulating taking account of standard and/or customized protocol stacks
  - Creating new process models and customized node models

Network simulation

Feedback to business process profiling

Network structure and traffic analysis

Feedback to application traffic profiling

Feedback to network configuration (number of servers, the capacity, processing speed, and network structure)

Design, performance evaluation

- Business process
  - Application
  - Network

* UML: Unified Modeling Language
Development of VoIP Quality Evaluation Technologies

Advances in technologies like priority control and low-delay processing in packet transmission have generated expectations that voice over Internet protocol (VoIP) can be achieved at the same level of quality as that of fixed-telephone services. This possibility has created a need for quality-design and quality-control methods based on the measurement and analysis of network and voice quality.

In response to this need, NTT Laboratories have developed technologies that clarify the procedures for evaluating the quality of VoIP products, the relationship between network performance and voice quality, etc., based on studies performed for various requirements and conditions such as different conditions in the target network.

For example, there is a need for a method that can estimate degradation in voice quality caused by a drop in packets. For this purpose, we have proposed a method that considers the effects of a "fluctuation-absorption buffer for delayed packet arrival" on the receive side. The plot in figure (a) shows the relationship between packet loss probability on the network and subjective evaluation of voice quality (shown as mean opinion score: MOS). Examining the vertical axis, we see that MOS varies significantly even for the same value (0%) of packet loss probability. The reason for this is thought to be that the fluctuation-absorption buffer is not taken into account. Using the proposed method, however, we can quantify the effects of dropped packets in the fluctuation-absorption buffer, and define "ineffective packet rate" as these effects combined with packet loss on the network. The plot in figure (b) shows the relationship between ineffective packet rate and MOS values. Compared with figure (a), the correlation with MOS is high demonstrating the effectiveness of this method.

The development of such technologies is enabling efficient quality evaluations to be performed and guidelines to be obtained in the development and sale of various VoIP products. They are also clarifying quality-design and quality-control guidelines for networks that are to provide VoIP and the scope of VoIP in existing network services. These technologies are therefore contributing to the expansion of VoIP services from the aspect of quality.

(Service Integration Laboratories)

Relationship between packet erasure and MOS

(a) Relationship between packet loss probability and MOS

Variation decreases

(b) Relationship between "ineffective packet rate" and MOS

MOS increases

"ineffective packet rate" increases

Development Future ACEMOLE, Realizing All "NO-DIG" Operation with Underground Conduits Installation

Underground conduits installing work is deployed by regular open-trench method – digging a trench, laying the conduits, and backfilling — but this kind of excavation always creates enormous headaches: it is noisy; causes shaking and vibration and traffic snarls around the site, and usually involves miserable working conditions often at night. Open-trench method also has adverse environmental impacts on the social community (surplus soil, broken concrete and other debris, and backfilling soil for borrow pit), and involves substantial construction costs that are unavoidable.

The Future ACEMOLE system offers a fundamental solution to all the problems associated with open-trench method by implementing all NO-DIG* (trenchless method: for underground conduit installation with microtunneling technology) operation for deploying underground telecom conduits.

Featuring a host of new cutting-edge technologies, the Future ACEMOLE achieves a fundamental breakthrough over all the conventional microtunneling systems. Costs have been significantly reduced to about the same level as open-trench methods in rural towns, and the new system permits faster construction, smaller sized equipment, automation of control, and new remote control capabilities. The Future ACEMOLE enables a clean execution by anyone, anywhere, while at the same time minimizing facility investment and contributing to environmental protection.

The Future ACEMOLE is able to cut through hard soil, something that was never technologically feasible before, and can therefore penetrate most types of soil except gravel and boulder strata and bedrock. Linking the control cables and the drive pipes has also been automated and speeded up, so that this task done each day is two to three times faster than before. A key condition for conducting NO-DIG works in urban environments is reducing the size of the equipments. The shaft from which the driving is done takes less than half the space of conventional shafts, and construction term has been dramatically slashed by having the manholes serve double duty as shafts. These combination shafts/manholes are constructed out of a special, high-strength resin material developed exclusively by NTT, and are fully capable of withstanding the enormous loads during the actual driving work. The operating system that controls the driving machine also features for the first time in a comparable system a knowledge database and optimum control logic, so anyone can easily operate the system with precision accuracy and avoid potential pitfalls.

Exploiting the characteristics of the Future ACEMOLE system, we are planning to extend it to the deployment of other basic infrastructure networks such as water and sewer mains that can also benefit from the advantages of NO-DIG trenchless method.

* NO-DIG: NO-DIGging Method

(Infrastructure Service Systems Laboratories)