The expansion of broadband network services has led to the growing use of IP telephony and video streaming services. Since the quality of speech and video should be evaluated subjectively, the networks and connected terminals should be designed and managed taking into account the characteristics of subjective quality.

NTT Laboratories have developed methods for evaluating, designing, and managing the quality of IP telephony and video streaming services. These methods include:

1. Service value assessment that provides guidelines for setting competitive quality levels and prices,
2. Objective quality estimation for speech and video that enables quality to be assessed without conducting subjective evaluation experiments,
3. Overall quality estimation of IP telephony using the quality parameters of the networks and terminals, and
4. Quality management that enables end-to-end quality to be estimated based on the status of network devices and terminals.

We will continue researching and developing ways to assess speech and video quality and will expand our scope to include the evaluation of community and collaboration services.
Network configuration overview of VoIP service systems

- VoIP: Voice over Internet Protocol
- PSTN: Public Switched Telephone Network
- Type1CA: Type 1 Call Agent
- SS: Session Initiation Protocol
- SIP: Session Initiation Protocol
- ISUP: ISDN User Part
- GWSN: Gate Way Service Node
- MG: Media Gateways
- IP-IVR: IP Interactive Voice Response
- WDM: Wavelength Division Multiplexing
- xDSL: Digital Subscriber Line
- VoIP: Voice over Internet Protocol
- IAD: Integration Access Device
- ISUP: ISDN User Part
- ASR: Automatic Speech Recognition
- TTS: Text To Speech
- CS: Cable Service
- QAM: Quadrature Amplitude Modulation
- V-OLT: Video-Optical Line Terminal
- V-ONU: Video-Optical Network Unit
- DTV: Digital Television
- VOTV: Video On Demand
- B-PON: Broadband Passive Optical Network

Optical Multi-Channel Video Signal Transmission Employing B-PON System

The rapid growth of broadband users and the trend toward high-speed, broadband systems through optical fiber has attracted much notice of late. Against this background, NTT has developed a world-leading transmission system that uses the transmission capacity of optical fiber to the full, and has conducted a joint experiment with SKY Perfect Communications Inc. to test the system and associated technologies. This experiment, which was conducted at a condominium building in the Shinjuku district of Tokyo from March 2002 to January 2003, employed NTT’s B-PON*1 optical access system featuring a peak data rate of 100 Mbit/s and simultaneous transmission of up to 500 channels of video signals over a single optical fiber. The B-PON system provides a new world standard in optical access enabling cost-efficient provision of diverse broadband multimedia services to multiple customers.

At present, BS*2 and CS*3 broadcasting uses a total of five satellites to distribute video. In general, three coaxial-cable systems are required to enable all the channels in those broadcast signals to be viewed in condominium buildings or other residential complexes. The problem here is that most condominium buildings are constructed with only one coaxial system preventing the viewing of at least some channels. Video distribution using the B-PON system, however, can use the 64 QAM*4 modulation system known for its high spectrum efficiency enabling all channels of terrestrial, BS, and CS broadcasting to be viewed with only one coaxial system.

B-PON is expected to be used in FTTH*5 systems to provide high-speed communications and high-quality multi-channel broadcasting and as a means of improving the viewing of satellite broadcasts in residential complexes. It is also promising as a means of expanding service areas for soon-to-begin digital terrestrial broadcasting and of promoting the use of information systems in thinly populated areas.

Outline of B-PON system

- ETH: Ethernet
- ONU: Optical Network Unit
- TX: Transmitter for video signal
- B-OLT: Broadband Optical Line Terminal
- V-OLT: Video-Optical Line Terminal
- WDM: Wavelength Division Multiplexing
- ONU: Optical Network Unit
- STB: Set Top Box

Development and Release of VoIP Service Systems

NTT Network Service Systems Laboratories, NTT Information Sharing Platform Laboratories

Symbolizing the government’s e-Japan initiative, we are seeing a very rapid rollout of xDSL*, optical access, and other broadband services, and faced with ever fiercer competition, all kinds of service providers are getting hold of reports issued by Ministry of Public Management, Home Affairs, Posts and Telecommunications (MPHPT) research groups, and deploying fully functional IP based telephony services one after another.

NTT Laboratories have been devoting R&D resources to a next-generation IP core network platform since the beginning of 2000, and VoIP*2 was one of telephony services one after another.

Communications (MPHPT) research groups, and deploying fully functional IP based network systems since the beginning of 2000, and VoIP*2 was one of telephony services one after another.

Considering the voice service systems that businesses have in place, NTT has now developed and released a number of core systems needed to support IP-IP and IP-PSTN*3 voice services. These include: (1) a Type1CA*4(SS*5 function) with SIP*6 server function, (2) a GWSN*7 and trunking MG*8 that support SIP-ISUP*9 conversion and interworking between the legacy PSTN and IP networks (the Type1CA GW*7 function can also be used instead of the GWSN), (3) a VoIP network management system that supports the ordering of services and provides integrated management of CAs and MGs, (4) IP-IVR*11 featuring SIP-ISUP*9 conversion and interworking between the legacy PSTN and IP networks, and the IP network on a signaling level.

This system provides service ordering to VoIP Network Management System that manages IP service resources. This system has interface with PSTN and VoIP, and manages IP service resources. This system has interface with PSTN and VoIP, and manages IP service resources.

It can also control the trunking MG, and connect between PSTN and the IP network on a signaling level. This system controls the trunking MG, and connects between PSTN and the IP network on a signaling level.

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Establishment of Open Software Technologies for Next Generation Networks—Open APIs for Adapting 3rd Party Vendor Applications

NTT Network Service Systems Laboratories

In the past, most services provided by common carriers over networks were developed either by the carriers themselves or by network equipment vendors, an arrangement that tended to drive up the cost and prolong the time required to develop new services. Now open APIs*1 provide an alternative in the form of technology that enables third parties—i.e., companies other than the carriers—to develop and deploy network control applications.

Two well-known examples of open APIs are JAIN*2 and Parlay (The Parlay Group). The establishment of reliability verification procedures for assessing open API-based applications has greatly reduced the amount of time and work needed to verify new services before the services are offered to the public. By applying these verification procedures, network services can be developed quickly and cost-effectively based on applications developed by ISVs*3.

A series of field trials to evaluate this approach is now in progress in cooperation with seven software vendors—two from Japan and five from other countries—and once the results are in, we will present our findings in standards-making forums and telecom exhibitions. The ability of ASPs*4 and other independent software companies to provide services should open the way to a vast expansion of business in those areas that have always just relied on services provided by carriers.

Other projects we are now considering to encourage more third-party application development include the establishment of a forum just for application developers and an open tested environment or open laboratory for assessing third-party applications. We are also exploring the possibility of sharing applications through alliances with other overseas carriers.

*1 API: Application Programming Interface
*2 JAIN: Java APIs for Integrated Networks
*3 ISV: Independent Software Vendor
*4 ASP: Application Service Provider

JAIN is a registered trademark of SUN Microsystems, Inc. of USA.

Interactive Multimedia Communication Technologies

NTT Network Service Systems Laboratories

The number of Internet users is expanding, and then that of always-on broadband access users is rapidly growing. The Web-based download type services are already commonplace, and we are seeing many new IP-based start-ups offering interactive chat, voice over Internet, and various other real-time services. Interactive multimedia (IMM) technology is now being developed as a platform to provide the session control and presence functions, which make the two-way multimedia services between broadband users much simple, safe, and smart to use.

In this past year, we established a simple session control application technology for networks and user presence application technology, NAT*1 traversal technology (STUN*2), and an SIP*3 protocol stack. Also, by linking these advances with community/collaboration technologies of NTT Laboratories, we developed an integrated collaboration service platform including multipoint AV conferencing and user presence exchange. In addition, we participated in the SIPit*4, and made headway in verifying the interoperability of some of our new products with the leading-edge products of other companies.

Further efforts will be focused on providing practical technologies for implementing security and quality-of-service control for each session, which will be the important parts of core technologies for supporting next-generation end-to-end communication services.

*1 NAT: Network Address Translator
*2 STUN: Simple Traversal of UDP through NATs
*3 SIP: Session Initiation Protocol
*4 SIPit: SIP interoperability test event
Optical Access Distribution Technology for Rapid and Economical Response of Optical Services

NTT Access Network Service Systems Laboratories

With NTT’s launch of B-FLET’S, broadband IP communications services based on FTTH technology, power companies and other players have entered the broadband connection business one after another resulting in intense competition for a share of the broadband market. To accelerate the spread of FTTH services and compete effectively in this fierce business environment, NTT Laboratories have developed and implemented technologies for achieving “cost reductions” so that reasonable fees can be set, and “service responsiveness” so that customers can be provided with desired services quickly and reliably.

As a distribution technology in the aerial interval, we have recently deployed a non self-support aerial optical cable that requires no supporting wire. Up to now, we have been using bundled-fiber installation technology, which uses a helix-shaped hanger that facilitates construction of new optical facilities without limiting installation points. The addition of circular aerial cable to this technology makes installation work even more economical. We have also developed separation technology that improves optical fiber usage rate at aerial wiring points by switching from 4-fiber tape operation to single-fiber operation so that wiring can be dropped to households in units of single fiber.

At present, however, optical facilities are being constructed in an “overlay” configuration with metallic facilities. To make more efficient use of space when dropping optical fiber to customer, we have downsized the optical cabinet and limited installation points. The addition of circular aerial cable to this technology makes installation work even more economical. We have also developed separation technology that improves optical fiber usage rate at aerial wiring points by switching from 4-fiber tape operation to single-fiber operation so that wiring can be dropped to households in units of single fiber.

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NTT Laboratories plan to continue developing and deploying innovative products like the ones described above with the aim of spreading FTTH services even further and becoming a leader in this market.

Deployment technologies for rapid and economical response to optical-access service orders

IP Nomadic Service Technologies

NTT Network Service Systems Laboratories

IP nomadic service provides ubiquitous IP services that enable seamless connectivity over wired or wireless access from a wide variety of locations. IP nomadic service allows users to communicate anytime, anywhere and with anybody, providing a communications environment that feels just like your own home network. For example, introducing a nomadic service to an office intranet enables employees to continue to use the same IP addresses they are using in their home office when they are out on the road or away from the office: they could share electronic documents or participate in TV conferences just as if they were back at the office. Moreover, once these nomadic service capabilities are in the public-service network, users will be able to make continuous uninterrupted communications even as they move into totally different kinds of access networks by selecting automatically optimized communication technology dynamically in accordance with the mobile location and the access bandwidth.

To build a robust network service platform supporting IP nomadic services, NTT Laboratories are working on three key technologies: mobile IP technology, seamless access management technology, and nomadic presence technology. Mobile IP technology enables users to continue to receive communications and content delivery using their fixed IP addresses even when they move about, and receive home-network services at different roaming destinations. And, the seamless access management technology provides an authentication platform that supports multiple kinds of access, thus permitting roaming that cuts across different access networks (Inter-media handover). Finally, nomadic presence technology provides optimum service support tailored to a user’s particular circumstances including real time management of a terminal’s mobile location, access bandwidth, and terminal type.

By interworking more closely with ITS* and sensor networks, future R&D efforts will focus on developing and deploying ubiquitous services that support seamless communications not only with other people but with all sorts of agents and objects.

* ITS: Intelligent Transport System

IP nomadic services

- Broadband seamless access and always-on connectivity
- Mobility in the IP layer
- Secure virtual home environment services at any location

Seamless Connection Services
Content delivery is expected to be a killer application for broadband networks. Content delivery over a network requires the efficient delivery of information to multiple users. Although the multicasting technique used in current IP multicasting systems is remarkable, it is not sufficient for providing commercial services because neither user authentication nor accounting functions are provided.

We have developed a multicast group management protocol with user authentication and accounting called “IGAP” (IGMP with user authentication). IGAP enables user access to be controlled by using the user information in a content request message. A network node monitors the request messages sent by subscribers and sends user information to a management system. The management system provides subscriber behavior to content providers and creates accounting methods that match the properties of each provider’s content. IGAP enables the collection of user behavior information in near real time, so content providers can distribute content attractive to subscribers in a timely manner. IGAP also provides IGMP capabilities, so it is easy to deploy in existing networks. We are now working on the standardization of IGAP in the IETF.

We are also developing a content delivery platform based on IGAP. IGAP offers not only content delivery as a carrier service but also commercial-content delivery services over closed networks, such as VOD service in a hotel. We are researching and developing a similar protocol framework for the IPv6 network and also applying IGAP to other service areas.

* IGMP: Internet Group Management Protocol
* IGMP*: Internet Group Membership Authentication Protocol
* RADIUS*: Remote Authentication Dial-In User Service
* VOD: Video-On-Demand

**Extended IP Multicast Protocol (IGAP) for Content Delivery Systems**

**Many usage scenarios**

- Multicast delivery control system
  - Accounting function
  - EPG function
  - Management function

- Multipurpose protocol (HTTP, etc.)
  - Accounting method
  - Information service
  - Matches user/content

- Authentication server
  - AAA

- IGAP
  - User target report
  - User ID, program, location

- RADIUS
  - Secure/secure access control
  - Authentication (RADIUS, etc.)

- Content provider
  - Delivery of individual information

- Content delivery system using IGAP

**Multicast delivery control system**

- Accounting function
- EPG function
- Management function

**Multipurpose protocol**

- HTTP etc.
- Matching user content

- Authentication server
- AAA

- IGAP
- User ID, program, location

- RADIUS
- Secure access control

- Content provider
- Delivery of individual information

**Direct-Multicasting Satellite Communications System for Nationwide Digital Contents-Gathering and Distribution Service**

Satellites are often used for multicast communications due to their ability to distribute information to multiple receiving points simultaneously. The multicast satellite communications systems currently available commercially are mainly star-type systems composed of a center hub and very small aperture terminal (VSAT). Therefore individual dedicated terrestrial lines connected to the hub are needed for contents gathering, which increases the system cost.

We have developed a direct-multicasting satellite communications system for economical distribution of digital contents directly from the VSATs to all receiving points without relay by the hub. This system is based on the use of a group modem and a highly efficient channel-assignment control program. The group modem enables simultaneous communication of video signals, IP data, and audio data with multiple points at any data rate. The control program manages allocated bandwidth of the satellite transponder and distributes the necessary channel capacity to the transmitting VSAT automatically.

The system provides a full-mesh satellite network that enables real-time contents gathering from and distribution to multiple access points easily and cost-effectively. It realizes efficient use of the transponder bandwidth through dispersed assignment of the discontinuous bandwidth due to an ability of the group modem to integrate the discontinuous spectrum into one communications channel.

NTT will contribute to the creation of new business by pioneering new satellite communication markets through its economical direct multicasting satellite communications system using VSATs.
Wireless IP Access System (WIPAS)

NTT Access Network Service Systems Laboratories

High-speed Internet access over optical fiber, ADSL, CATV, and other networks has become rapidly available in recent years. Yet there are still many users who do not enjoy access to these broadband environments due to the difficulties posed by deploying fiber-optic cable or simply because services have not been made available in their areas due to cost considerations. With the goal of bringing high-speed Internet access to these neglected pockets of users, the Access Network Service Systems Laboratories has developed a wireless IP access system (STEP 1) that is a P-MP type FWA system using quasi-millimeter-waves in the 26-GHz band.

The STEP 1 system provides "best-effort" IP service at a wireless transmission rate of 40 Mbit/s, and a maximum Ethernet frame data delivery rate of 23 Mbit/s. One AP can manage 239 WTs. Services were made available over this STEP 1 system beginning in September 2002 when NTT East and NTT West added it to their menus of B-FLET’S service offerings.

Now a second generation of the wireless IP access system has been developed the STEP 2 system that doubles the transmission rate of the STEP 1 system and is implemented much more compactly. The maximum wireless transmission rate of the STEP 2 system is 80 Mbit/s, and the maximum Ethernet frame data delivery rate is 46 Mbit/s. In addition, the subscriber-side equipment has been significantly reduced in size and weight by combining the antenna/RF module (RFU) and base-band processing modules (IFU) that were implemented separately in the STEP 1 system, and by adopting a compact flat antenna. The IFU of AP was also substantially downscaled.

Services based on the Wireless IP Access System (STEP 2) will be made available beginning 2003. In the future, we will add QoS, and adaptive modulation functions, and develop a repeater for WIPAS.

Overview of Wireless IP Access System (STEP 2)

<table>
<thead>
<tr>
<th>Items</th>
<th>Specifications</th>
</tr>
</thead>
<tbody>
<tr>
<td>Frequency</td>
<td>26 GHz band</td>
</tr>
<tr>
<td>Tx/MOD scheme</td>
<td>TDMA/TDD, QPSK/16QAM</td>
</tr>
<tr>
<td>Radio capacity</td>
<td>Max. 80 Mbit/s</td>
</tr>
<tr>
<td>Tx power</td>
<td>14 dBm (QPSK), 11 dbm (16QAM)</td>
</tr>
<tr>
<td>User/NW IF</td>
<td>10/100BASE-TX, 100BASE-FX</td>
</tr>
<tr>
<td>Tx distance</td>
<td>Max. 700 m</td>
</tr>
<tr>
<td>Max number of WTs</td>
<td>Approx. 200 WT/AP</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>AP-RFU</th>
<th>Omni and sector-antenna-type</th>
</tr>
</thead>
<tbody>
<tr>
<td>Size: 150 x 100 x 300 mm</td>
<td>Weight: 7 kg</td>
</tr>
<tr>
<td>(Omniantenna-type)</td>
<td>Weight: 3 kg</td>
</tr>
</tbody>
</table>

Lightning damage risk map

Lightning surge simulation technology
Congestion-Aware Network Admission Control Based on Per-User Performance Statistics

When real-time applications such as video streaming are run on an IP network, network performance directly affects application performance. To maintain end-to-end video quality for all users, it is necessary to combine a TCP-like per-flow control scheme with a network-resource control scheme that analyses network congestion, performs network admission, and allocates the best delivery route for each user.

We have developed a network control scheme that estimates the video quality of each user based on the transport and application performance received by each user, estimates the degree of congestion for each network area by analyzing the user-level performance statistics, and admits new requests for video delivery based on the degree of network congestion. We clarified through software prototyping that the scheme can detect a sign of congestion accurately based on the performance parameters of the picture frame buffer, and that degradation in video quality can be predicted accurately based on the performance parameters of the picture frame handling layer. We also clarified that the scheme can maintain the video quality of all users by prohibiting new video delivery requests when it detects a sign of congestion.

The proposed scheme is applicable not only to the business model for end-to-end CDNs, but also to the model that for content distribution to the users of interconnected network providers. The video quality monitoring function is applicable to such value-added services as SLA monitoring and viewer rating surveys.

We plan to develop an autonomous algorithm for controlling network resources and maintaining delivery quality by combining the proposed scheme with a scheme for allocating routes and resources for individual users. The aim is to use network and server resources efficiently and to maintain application performance for all network users.

" TCP: Transmission Control Protocol
" ARQ: Automatic Repeat reQuest
" CDN: Contents Delivery Network
" SLA: Service Level Agreement

Development of Technology Permitting Denser Accommodation of Cables in Communication Tunnels

The communication tunnels in which optical cables are deployed are equipped with disaster prevention walls to prevent fire or flood waters from spreading to NTT buildings in the event that a fire or a flood should occur in a tunnel. These fire and water protection functions are essential, and the disaster prevention walls also limit the amount of cabling that can be accommodated in the tunnel. Due to the “dead space” that was created when the cables were initially deployed, the tunnels are already overcrowded thus creating an impasse. Today, some 30% of communication tunnels in central Tokyo already exceed 80% of their cable holding capacity. Furthermore, the trend toward greater congestion will only increase in the years ahead considering the need to accommodate FTTH and ADSL services and to provide obligatory services to business corporations based on interconnection agreements with other carriers.

The demand for a technology that would permit a denser concentration of cables in communication tunnels led to our development of the multi-waterproofing equipment, a device that will support growing future demand for cable without impairing the functions of the disaster prevention walls.

The key features of the multi-waterproofing equipment are summarized as follows:
(1) Maintains the waterproof pressure function corresponding to the communication tunnel environment (98 kPa).
(2) Capable of accommodating up to three maximum-diameter fiber cables (1000-fiber SM-type optical fiber WBB-FR cable).
(3) Permits all optical cables deployed in a communications tunnel in a multi-level configuration (6 levels) to be networked by an adapter.
(4) By adopting a partitioned structure, the equipment can be used not only in new ducts but also in ducts where cable was previously installed. The equipment can also be flexibly adapted to disaster prevention walls with a high cable accommodation rate.
(5) Can be applied to all disaster prevention walls.

The new waterproofing equipment permits more efficient use of the communication tunnel space. Also, the additional space created by denser concentration of cables in the tunnels can be used for all sorts of other purposes to increase profits for the company. The multi-waterproofing equipment began to be installed and put into service in the forth quarter of 2002.

" FTTH: Fiber To The Home
" SM: Single Mode
" WBB-FR: Water-blocking B-cable Flame Retardant

Disaster prevention wall in communication tunnel and multi-waterproofing equipment

Multi-waterproofing equipment
Overview of optical cross connect (OXC) system

- Optical fiber (Existing WDM line)
- Optical path
- IP router
- Existing SDH equipment
- OXC equipment
- Operation Support System

Optical cross connect (OXC) system

- Remote control and supervision
- DCN
- UNI
- Photonic Network

- Provide 10 Gbit/s optical path - Optical path network overlaid existing DWDM system

Condominium IT Kit: Transmission System for Providing Broadband Services in Closed Areas

An increasing number of local governments and companies are deploying optical fiber with the goal of implementing broadband Internet environments. However, the quality and performance of such environments are not more capable than those provided by the common carriers. To address this situation, it is necessary to investigate a scheme for building a new user-side network that improves user convenience and promotes the deployment of a broadband environment.

Recent work has culminated in the development of a condominium IT kit, a system for implementing fiber-optic-based user networks targeting specific areas. Deployed at user initiative, the system extends an optical fiber broadband environment into condominium complexes, school campuses, and other bases. The condominium IT kit also incorporates several key carrier-grade technologies developed by NTT Laboratories into user networks including optical video transmission technology, PDS transmission technology, enhanced robustness in poor reception environments, and advanced operations support.

By combining these technologies, we achieved three key functional components: a 100-Mbit/s throughput delivery function providing a high-speed communication environment, a broadband video transmission function across the 2.6-GHz band covering the entire frequency band from digital terrestrial broadcasting to satellite broadcasting, and a communication function providing lowest bandwidth guarantee for monitoring and control. In order for these various functions to be applied to different user network environments that vary widely in terms of network scale and functional requirements, we have adopted an architecture in which the functions are implemented as autonomous kits. This permits users to add, remove, modify or otherwise tailor the functions to their specific needs in block or package units. In addition, the functions all support optical wavelength division multiplexing transmission to take full advantage of user optical fiber facilities.

In the coming months we plan to implement speech communication, security, and other functions in kit form, and to promote the formation of optical user network platform communities by providing other application technologies that interwork with the high-speed communication environment.

Installation in condominium (Condominium IT Kit)

- PDS: Passive Double Star