Method for User Network Resource Management

Nobuhide Nishiyama†, Yasuhiro Suzuki†† and Fumihiko Ito†

NTT Access Network Service Systems Laboratories, NTT Corporation
†1-7-1 Hanabatake, Tsukuba-city, Ibaraki, 305-0805 Japan
Telephone +81 29 868 6119
††1-6 Nakase, Mihama-ku, Chiba-city, Chiba, 261-0023 Japan
Telephone +81 43 211 2473
Email: {nisiyama, ysuzuki, f.ito}@ansl.ntt.co.jp
http://www.ansl.ntt.co.jp/

Abstract

Home networks are attracting attention as a result of the increasing availability of PCs in homes and the appearance of new information appliances. Premises networks are also now being constructed in condominiums and schools. To achieve End-to-End service quality management in these environments, it is necessary to manage user network resources. However, network systems are constructed to match the individual needs of these networks. Therefore, network protocols (such as Ethernet, wireless LAN, Bluetooth and IEEE1394) or the vendors of network equipment for each user network may differ. Moreover, in user networks, the users usually reconstruct the network systems.

We propose a method whereby a user network manager (UNM) is installed in each user network to manage its network resources. Each UNM acquires proprietary network resource attributes, manages the common attributes of network services, and provides common management interfaces.

By using this method, users can employ network services without the need to consider the network protocols, equipment vendors or network reconstruction.

Keywords: user network, network resource management, network service, common management attribute, common management interface

Introduction

- Broadband network infrastructures are spreading rapidly
- Home networks attract attention through the spread of domestic PCs and the appearance of information appliances, and premises networks are being constructed.
- Broadband services are being provided.

User network resource management is needed to achieve End-to-End service quality management.

Expected user network conditions

The protocols and vendors of network equipment will differ among user networks.
(e.g. Ethernet, wireless LAN, Bluetooth, IEEE1394, …)
→ Attributes and interfaces for managing network equipment differ.

Users reconstruct user networks (alter topologies, add new equipment).

NTT APNOMS 2003 (2) ANSL

1. Introduction

Recently, broadband access network infrastructures, such as asymmetric digital subscriber lines (ADSL) and fiber to the home (FTTH), have spread rapidly to user areas. Moreover, due to the rapid spread of PCs and the appearance of information appliances, home networks have been attracting attention. Premises networks are also now being constructed in locations such as condominiums, schools and developing metropolitan areas [1]. This progress has generated a variety of network services, including the delivery of high quality movies and music, and real-time audio-visual communication services.

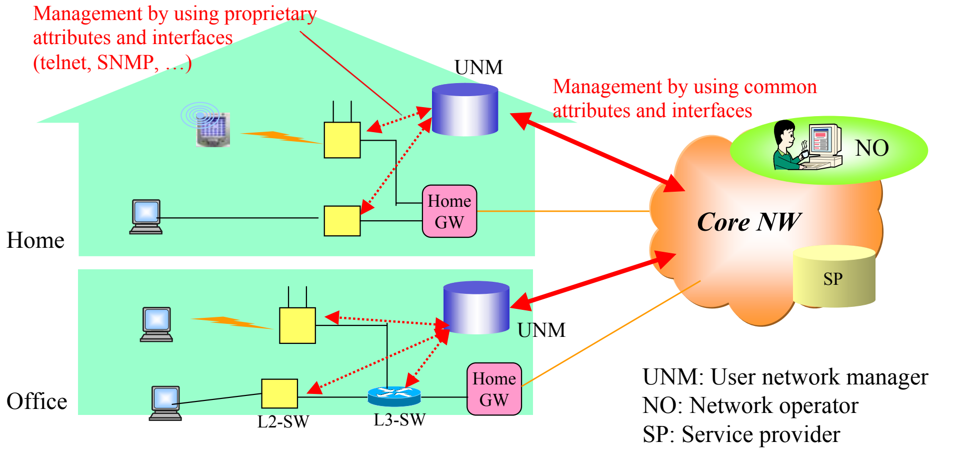
To achieve End-to-End service quality management in these environments, it is necessary to manage user network resources. We expect user networks to operate under the following conditions.

- User networks usually have different network protocols (such as Ethernet, Wireless LAN, Bluetooth [2], and IEEE1394) and the network equipment is often provided by different vendors. This is because the protocol and vendor will be selected independently for each user network, according to the purpose of the network.

- Users usually reconstruct user networks by altering the network topology and by adding equipment with new protocols or from new vendors.

Purpose of Study

- Management of user networks independent of protocols and vendors, by using common resource attributes and control interfaces
- Management of user networks without the need to consider network reconstruction (alteration of topologies, addition of new equipment)



Ethernet, Wireless LAN(802.11/HiSWAN), Bluetooth, IEEE1394, etc.

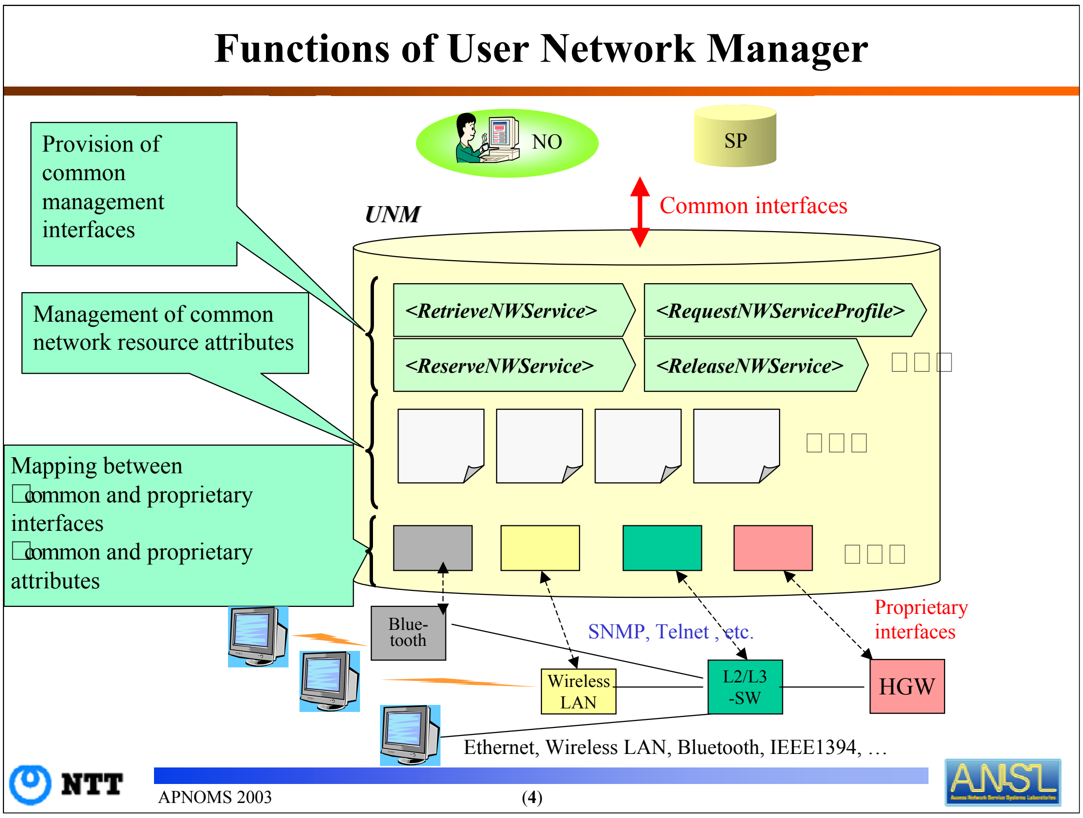
NTT APNOMS 2003 (3)

To achieve user network management that is independent of protocols and vendors, and without the need to take network reconstruction such as the alteration of topologies, or the addition of new equipment into account, we studied the method for managing user network resources described below.

- A method for abstracting the attributes of user network resources, abstracting interfaces for resource management, and providing such common attributes and interfaces to service providers (SP) or network operators (NO).

- A method for managing user network resources without the need to consider the reconstruction of user networks.

We have already proposed an information model for managing the resources of access networks that consist of a variety of network elements [3]. We have also proposed a method for managing user network resources [4][5]. In this paper, based on these studies, we propose common attributes for user network resources and common management interfaces, taking account of a variety of network elements and network reconstruction.



2. Functions of User Network Manager

To make it possible to manage user networks, we propose that a user network manager (UNM) is installed in each user network. Each UNM provides the functions described below.

- Management of common network resource attributes

The UNM manages abstract common network resource attributes, which represent, for example, performance, quality, states.

- Provision of common management interfaces

The UNM provides common interfaces to retrieve resources, obtain common attributes, and control resources for SPs or NOs.

- Mapping between common and proprietary attributes, and between common and proprietary control interfaces

The UNM obtains proprietary attribute values of network resources (e.g. MIB-2, private MIB) using proprietary interfaces (e.g. SNMP, telnet). And it abstracts them as common resource attribute values. It also converts common control interfaces to proprietary control interfaces. And software modules providing this function are downloadable as a result of the addition of new protocols or equipment from new vendors.

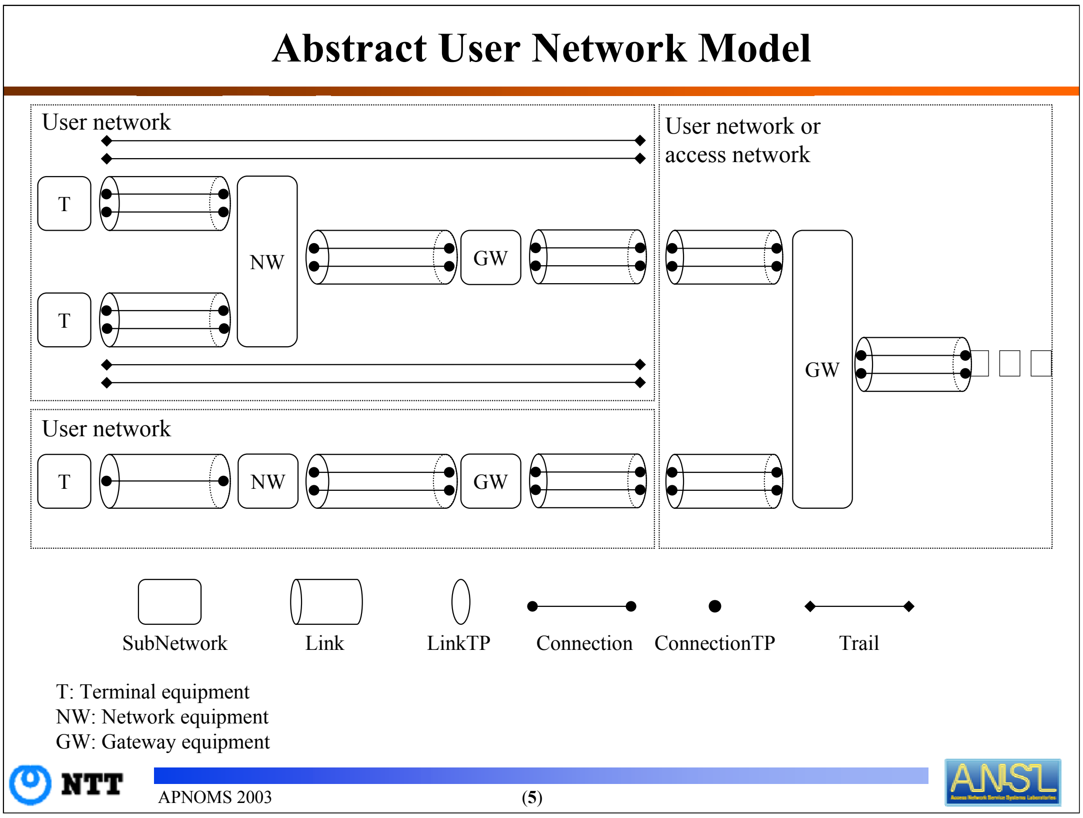
These functions bring the following benefits.

- SPs can describe services that require the service quality needed for each service in common languages without the need to consider protocols, the vendors of network equipment or network reconstruction.

- SPs or NOs can manage and control user network resources using common interfaces without the need to consider protocols, vendors or network reconstruction.

- Users can construct or reconstruct their network systems for their own purposes, and can receive services without the need to consider protocols, vendors, or network reconstruction.

The UNM can also provide such functions as authentication management, security management, log management, and accounting management.



3. Abstraction of user networks

3.1. Abstract user network model

User networks are composed of several network elements, including terminal equipment, network equipment, gateway equipment, links and connections, and termination points for each link and connection. Each user network is ended with a piece of terminal or gateway equipment. Terminal equipment terminates the user network, and gateway equipment connects each user network with other user or access networks.

We have already proposed an abstract model of access networks [3] with reference to the modeling of ITU-T [6][7][8]. We propose an abstract model for user networks, with reference to this access network model.

- Terminal/gateway/network equipment elements

SubNetwork represents an equipment entity. That is, it represents terminal equipment (such as a PC, or an information appliance), network equipment (such as an L2-SW, an L3-SW, bridging equipment between Ethernet and Bluetooth, or Ethernet and wireless LAN) or gateway equipment. Each SubNetwork includes several Link Termination Points (LinkTPs).

- Termination point elements

LinkTP represents a physical termination point entity and terminates a Link. Each LinkTP includes several Connection Termination Points (ConnectionTPs).

ConnectionTP represents a logical termination point entity and terminates a Connection.

- Link and connection elements

Link represents a physical link entity. Each Link has a LinkTP at each end, and includes several Connections.

Connection represents a logical link connection entity. Each Connection transports one or more packet flows with the same quality control method. Each Connection has a ConnectionTP at each end.

Trail represents a serial connection of Connection entities, such as the connection between gateway equipment and terminal equipment, gateway equipment and gateway equipment, or terminal equipment and terminal equipment.

By defining each type of equipment, termination point, link and connection as elements of user networks as described above, these networks can be managed flexibly even when users reconstruct them.

Common Network Service Attributes

	Common NW service attributes		Definition
	UserNWID		ID of user network
	NWServiceID		ID of NW service
Performance and quality of forwarding	InputSubNW		Information about input edge equipment
		InputSubNWID	ID of input edge equipment
		InputSubNWIPAddress	IP address of input edge equipment
	OutputSubNW		Information about output edge equipment
		OutputSubNWID	ID of output edge equipment
		OutputSubNWIPAddres	IP address of output edge equipment
	BandControl		Information about bandwidth control
		BandControlMethod	Bandwidth control method
		ClassifyField	Field name and its value based on which each flow is classified
		MaxBand	Maximum available bandwidth that cannot be assured
		AssuredBand	Maximum available bandwidth that can be assured
	PriorityControl		Information about priority control
		PriorityClass	Available priority class
		ClassifyField	Field name and its value based on which each flow is classified
	MaxDelay		Maximum delay
	MaxBufferSize		Maximum buffer size
	RequiredCondition		Information about required conditions
		Field	Field name and its required value
Information related to marking	MarkingField		Information about marking
		Field	Field name and its value that is marked when packets exit from the NW service

APNOMS 2003 (6)

3.2. Common network service attributes

Assuming that SPs or NOs control network resources in order to assure service quality for each service, the attributes of each network resource between gateway-terminal, gateway-gateway or terminal-terminal are more important than the attributes of each network element. Each UNM should manage the trail attributes, which represent abstract attributes of each network resource between gateway-terminal, gateway-gateway or terminal-terminal in user networks, and provide SPs or NOs with capability of each trail as a service. We call this a "network service".

The transport of packets through each network service is achieved as follows. The input edge of the service classifies the packets based on fields characterizing each packet flow, and forwards each flow according to the particular performance and quality. So the attributes listed below should be described in common network service attributes.

●Attributes that represent performance and quality of forwarding

□"InputSubNW" and "OutputSubNW" represent information of the input edge equipment and output edge equipment, respectively.

□"BandControl" attributes represent information related to bandwidth control, as described below.

-"BandControlMethod" attribute represents the type of bandwidth control method. The identification representing such as "ConstantBandAssured", "MinimumBandAssured" and "None" is assumed to be described. "ConstantBandAssured" means packets are forwarded at a required assured rate. "MinimumBandAssured" means packets are forwarded at a rate between the minimum assured rate and the maximum available rate.

-"ClassifyField" attribute includes information of fields based upon which the input edge of the service classifies each flow (such as IP addresses and port numbers).

-"MaxBand" attribute represents the maximum available bandwidth that cannot be assured.

-"AssuredBand" represents the maximum available bandwidth that can be assured.

□"PriorityControl" attributes represent information related to priority control, as described below.

-"PriorityClass" attribute represents the ability of priority control for forwarding. Available priority classes are described.

-"ClassifyField" attribute includes information of fields based upon which the input edge of the service classifies each flow (such as 802.1p priority).

□"MaxDelay" attribute represents the maximum delay of each flow.

□"MaxBufferSize" attribute represents the maximum buffer size for each flow. This size restricts the maximum burst length of each flow.

□"RequiredCondition" attribute represents the required conditions for each flow. In IP networks, the route is decided due to the destination IP addresses. In this attribute, the destination NW IP addresses to which the service can transport packets are described, according to routing information obtained from MIB-2 or OSPF MIB.

●Attributes that represent information related to marking

□"MarkingField" attribute includes information of the fields that are marked when packets exit from the network service. This attribute is necessary for combining network services among several user networks.

Moreover, the attributes which represent the composition of each network service should be also described.

Common Interfaces

Common interfaces	Common arguments
RetrieveNWService	Conditions for each common attribute value of network services (such as “InputSubNW”, “OutputSubNW”, “BandControlMethod”, “MaxBand”, “AssuredBand”, “PriorityClass”, “MaxDelay”)
RequestNWServiceProfile	UserNetworkID
	NWServiceID
ReserveNWService	UserNetworkID
	NWServiceID
	Values of fields based upon which each flow is classified (such as source/destination IP address (“FromIP” / “ToIP”) and port number (“FromPort” / “ToPort”))
	Values of fields that should be marked when packets exit from the network service (such as DSCP)
	Required bandwidth (“RequiredBand”)
	Required priority (“RequiredPriority”)
ReleaseNWService	Values of fields based upon which each flow is classified （such as source/destination IP address, port number）

3.3. Common interfaces

The required conditions for abstracting management interfaces for user network services are described below.

- Network services should be retrieved with the required conditions for each service or their attributes should be acquired.

- Network services should be controlled with common arguments.

We define the common interfaces described below in accordance with these required conditions.

- “RetrieveNWService” interface

This interface is used to retrieve network services with the required conditions for each network service attribute value, such as “InputSubNW”, “OutputSubNW”, “BandControlMethod”, “MaxBand”, “AssuredBand”, “PriorityClass”, and “MaxDelay”.

- “RequestNWServiceProfile” interface

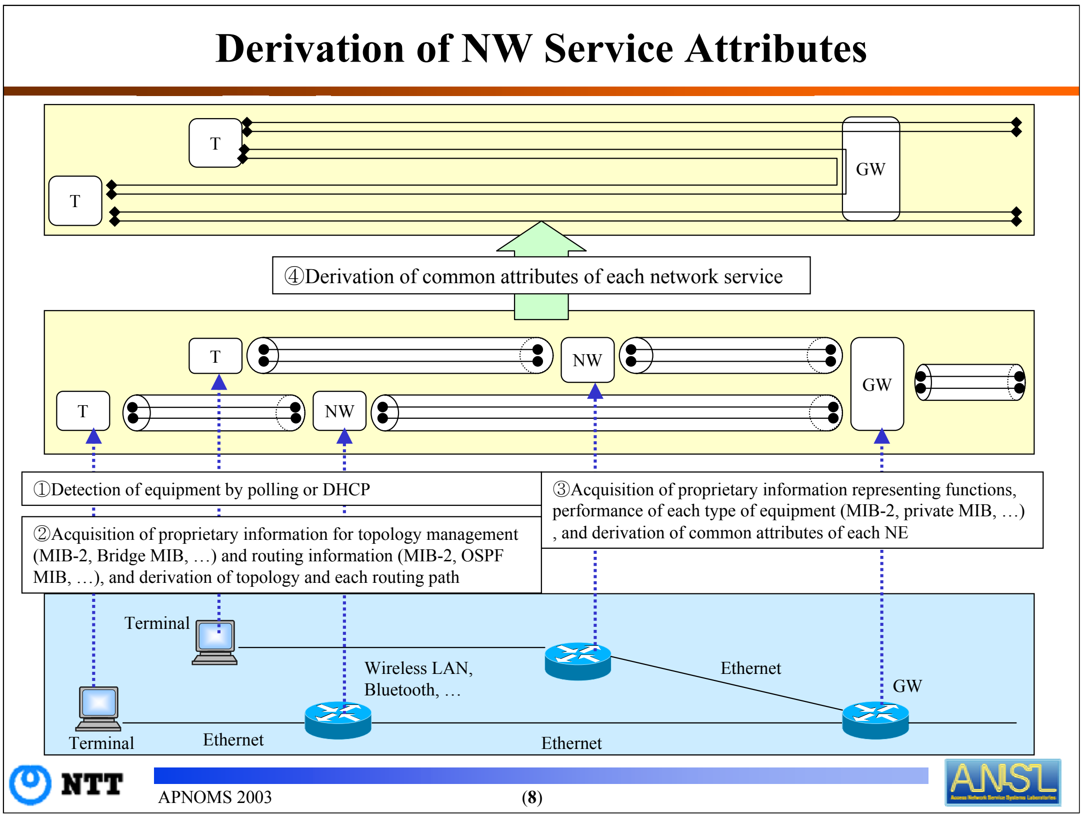
This interface is used to obtain the values of common network service attributes. For example, SPs or NOs can obtain values of available assured bandwidth and available priorities.

- “ReserveNWService” interface

This interface is used to reserve network services. Arguments are the values of “UserNetworkID”, “NWServiceID”, values of fields based upon which each flow is classified, such as source / destination IP address (“FromIP” / “ToIP”) and port number (“FromPort” / “ToPort”), values of fields that should be marked when packets exit from the network service, such as DSCP, the values of the required bandwidth (“RequiredBand”) and priority (“RequiredPriority”).

- “ReleaseNWService” interface

This interface is used to release services. Arguments are values of fields based upon which each flow is classified.



4. Methods of management and control resources

4.1. Derivation of network service attributes

The UNM obtains each common network service attribute as described below.

(1) The UNM detects equipment by polling or DHCP.

(2) The UNM acquires proprietary information for topology management (such as MIB-2 and Bridge MIB), and routing information (such as MIB-2 and OSPF MIB). Based on this information, it derives the topology of the network and each routing path.

(3) The UNM acquires proprietary information representing the functions or performance of each type of equipment (such as MIB-2 and private MIB). Moreover, it derives the common attributes of each network element, namely SubNetwork, Link, LinkTP, Connection, and ConnectionTP, from the acquired proprietary attribute values.

(4) The UNM derives common network service attribute values from the common attribute values of each NE, according to a particular logic.

Derivation of NW Service Attributes

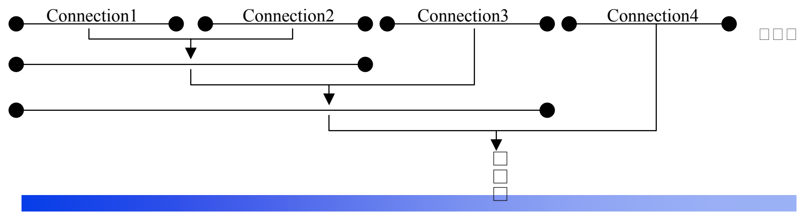
Derivation of attributes about bandwidth control

Connection1	Connection2	Connections			
BandControlMethod	BandControlMethod	Condition	BandControlMethod	MaxBand	AssuredBand
ConstantBandAssured	ConstantBandAssured	-	ConstantBandAssured	-	min(B_1, B_2)
ConstantBandAssured	MinimumBandAssured	B_1>B_2	MinimumBandAssured	min(B_1, A_2)	B_2
		B_2>B_1	ConstantBandAssured	B_1	B_1
MinimumBandAssured	MinimumBandAssured	-	MinimumBandAssured	min(A_1, A_2)	min(B_1, B_2)
None	(Any)	-	None	min(A_1, A_2)	-

A_1, B_1: "MaxBand" and "AssuredBand" value of Connection1, respectively
A_2, B_2: "MaxBand" and "AssuredBand" value of Connection2, respectively
"ConstantBandAssured" : The "MaxBand" value is equal to the "AssuredBand" value.
"MinimumBandAssured" : The "MaxBand" value is larger than the "AssuredBand" value.

Derivation of attributes about priority control

Connection1	Connection2	Connections
PriorityClass	PriorityClass	PriorityClass
(Not null)	(Not null)	common values between two Connections
(Null)	(Any)	(Null)

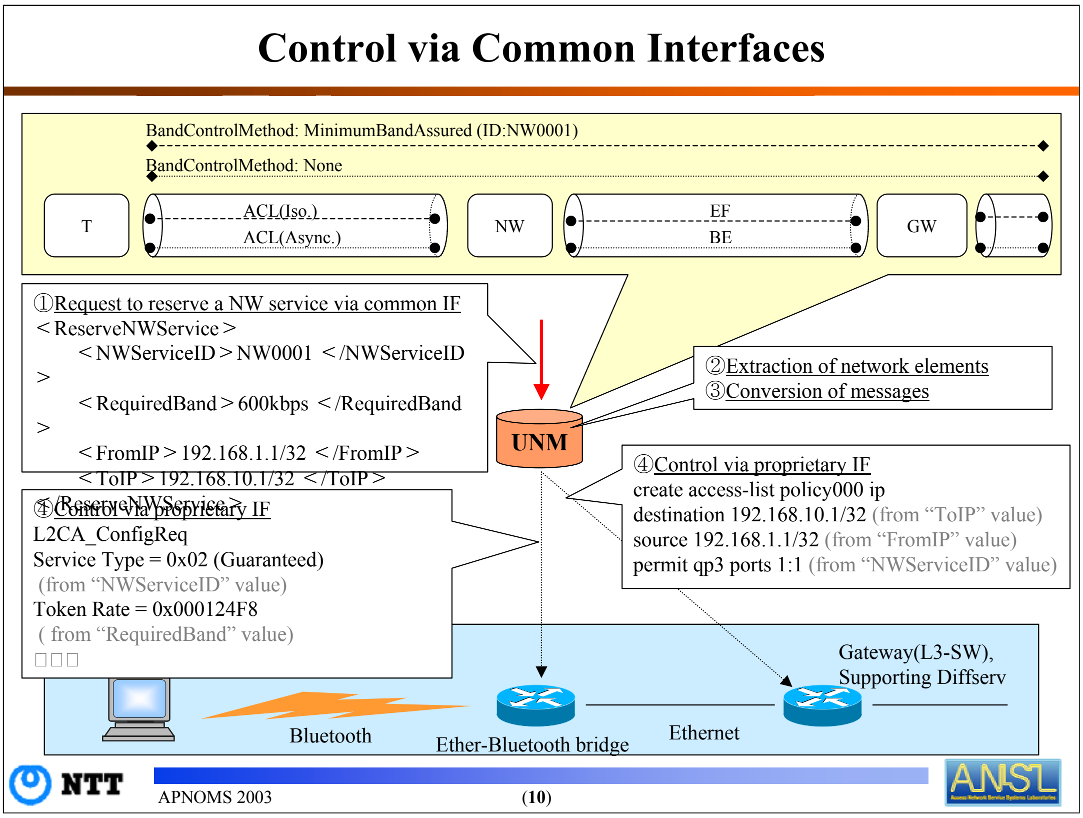


The derivations of some network service attribute values are described below.

"BandControlMethod", "MaxBand", "AssuredBand" and "PriorityClass" attribute values of each network service are derived from the attribute values of Connections composing each service. First, attribute values are derived from the values of two of the Connections. As regards the "BandCotrolMethod" values, if one of two Connections has the identification "None" as a value, the identification "None" is derived. Otherwise the identification "ConstantBandAssured" or "MinimumBandAssured" is derived according to the combination of the "BandControlMethod" and "AssuredBand" values. As regards the "PriorityClass" values, if both Connections have one or more attribute values, their common values are derived. And after that, considering the combination of two Connections as one Connection, attribute values are derived from it and the other Connection in the same way. By continuing this process, we finally derive the attribute values of the network service.

"MaxBufferSize" and "MaxDelay" attribute values are derived from the attribute values of the Connections composing each service. The "MaxBufferSize" value is the minimum value among the "MaxBufferSize" values of the Connections. The "MaxDelay" value is the sum of the "MaxDelay" values of the Connections. The "MaxDelay" value of each Connection can be derived from such parameters as the type of scheduling algorithm, service rate, maximum packet length of each flow, and bandwidth [9].

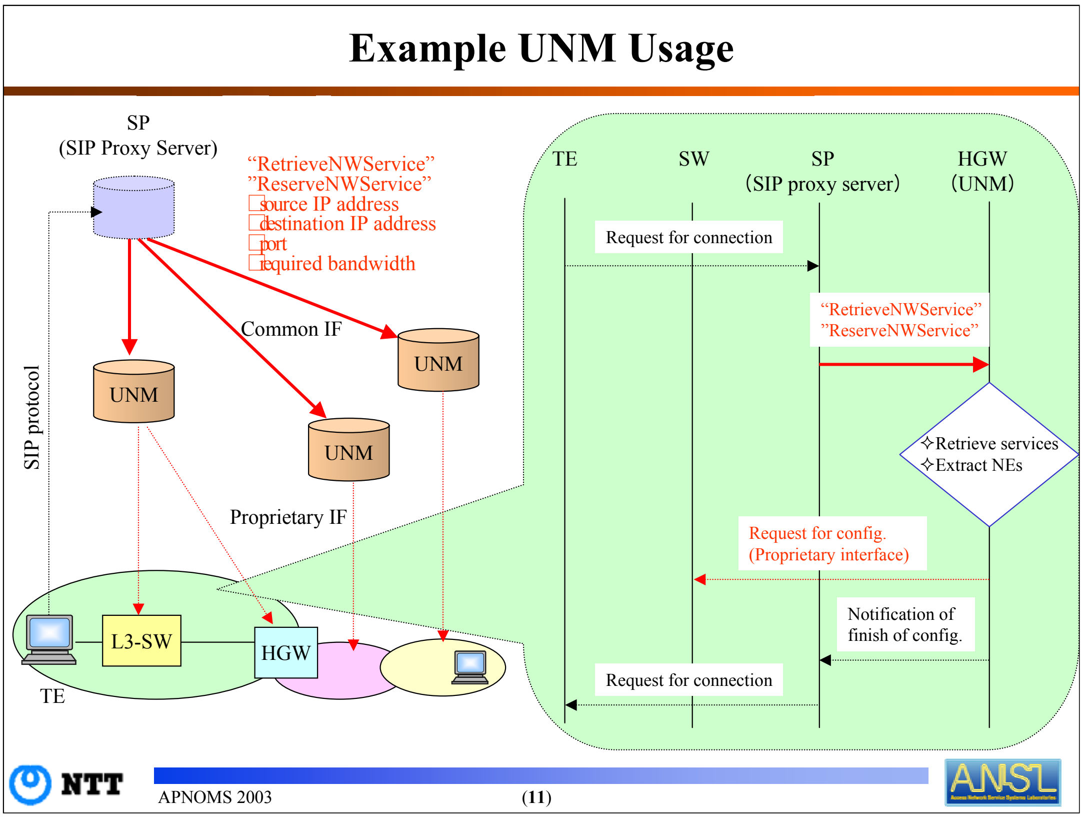
In this way, each UNM can manage common network service attribute values.



4.2. Control via common interfaces

When the UNM accepts requests for controlling network services via common control interfaces, it converts them to proprietary control messages, and controls each piece of network equipment via proprietary control interfaces. For example, we assume the case where one piece of equipment is an Ethernet-Bluetooth bridge and the other is an L3-SW supporting Diffserv, and the UNM accepts a request to reserve a network service, whose "BandControlMethod", "InputSubNWID" and "OutputSubNWID" values are "MinimumBandAssured", the ID of GW and the ID of Terminal, respectively, via common control interfaces (e.g. XML/SOAP). First, the UNM extracts network elements that compose the network service. It then converts the request and arguments into a proprietary control message and arguments for each piece of network equipment, and sends it using proprietary protocols (e.g. telnet). It sends the bridge a proprietary message of Bluetooth to create an ACL (Isochronous) connection with the "Service Type" and "Token Rate" values, which are derived from "NWServiceID" and "RequiredBand" values, respectively. It also sends the L3-SW a proprietary message to classify the flow into the EF class with the "QoS profile name", "destination" and "source" values, which are derived from "NWServiceID", "ToIP" and "FromIP" values, respectively.

Thus, SPs or NOs can control each network service via common control interfaces.



5. Example UNM usage

We propose one example of the use of the UNM. In the example proposed here, a UNM is installed in each home gateway. The SP includes the function of a SIP proxy server, and each PC is implemented with the SIP protocol. The sequences for beginning a real-time visual communication service are as described below.

(1) One of PCs contacts the SP and asks to communicate with another PC outside the user network, using the SIP protocol.

(2) The SP extracts the UNMs that are managing each user network on the routing path and sends them common messages of “RetrieveNWService” and “ReserveNWService” via common interfaces.

(3) Each UNM retrieves the network service that satisfies the required conditions, and extracts the network elements that compose the service.

(4) Each UNM sends proprietary control messages to the extracted network elements.

(5) After finishing the sequences described above in each user network, the SP sends a request for connection to each PC using the SIP protocol.

Thus, each PC can begin a real-time visual communication service with a required service quality.

Conclusion & Future Work

Conclusion

- We proposed functions for the User Network Manager
  - -mapping between common and proprietary interfaces and attributes
  - -management of common network resource attributes
  - -provision of common management interfaces
- We proposed a common network model and defined an network resource between gateway-terminal, gateway-gateway or terminal-terminal as a “network service”
- We proposed common interfaces and attributes of network services
- We provided an example of the use of this method.

Future Work

- Further study of the common management attributes and interfaces
- Applying this architecture to various protocols and equipment vendors
- Study the UNM functions such as authentication, security, log and accounting management
- Study the UNM software architecture (including software extension)
- Study cooperation between UNMs, access network manager and core network manager
- Implementation, verification and evaluation of UNMs

NTT APNOMS 2003 (12) ANSL

6. Conclusion and future work

We proposed a method for managing user network resources. We defined an network resource between gateway-terminal, gateway-gateway or terminal-terminal as a “network service”. The UNM abstracts proprietary network resource attributes as common network service attributes, and provides a common interface for retrieving, monitoring and controlling each network service without depending on protocols, equipment vendors or topology. Thus, service providers or network operators can provide services with the required qualities without the need to consider protocols, network equipment vendors or network reconstruction. We also described an example of the use of this method.

Future work is described below.

- Further study of the common management attributes and interfaces
- Applying this method to various protocols and equipment vendors
- Study the UNM functions such as authentication, security, log, and accounting management
- Study the UNM software architecture (including software extension) (with reference to OSGi [10], etc.)
- Study cooperation between UNMs, access network manager and core network manager
- Implementation, verification and evaluation of UNMs

References

[1] N. Tamaki, R. Miwa, H. Watanabe and N. Nishiyama, “A Study on the Formation of Communities Using Broadband Networks,” NTT Technical Review, Vol. 1 No. 1 Apr. 2003.

[2] Bluetooth, “Specification of the Bluetooth System Version 1.1,” Feb. 22, 2001.

[3] Y. Suzuki and I. Takahashi, ”A Method for Access Network Resource Management,” 2003 Technical Report of IEICE, TM2002-95, pp. 47-52, Mar. 2003.

[4] N. Nishiyama, K. Katayama, F. Ito and N. Tamaki, “A Study of Operation and Management Methods for Area-based User Networks,” 2002 Communications Society Conference of IEICE, Vol. B-14-9, p. 471, Sept. 2002.

[5] K. Katayama, N. Nishiyama, F. Ito and N. Tamaki, “A Study of Resource Management for Interaction and Cooperation Between Area Communities,” 2002 Technical Report of IEICE, Vol. 102, No. 497, IN2002-141, pp. 7–12.

[6] ITU-T Recommendation M.3100 Amendment 1, “Generic Network Information Model Amendment 1,” 1999.

[7] ITU-T Recommendation G.853.1, “Common Elements of the Information Viewpoint for the Management of a Transport Network,” 1999.

[8] ITU-T Recommendation G.852.2, “Enterprise Viewpoint Description of Transport Network Resource Model,” 1999.

[9] H. Zhang, “Virtual Clock a New Traffic Control Algorithm for Packet Switching Networks,” Proc. IEEE vol. 83 pp. 1374-1396, Oct-95.

[10] OSGi, “OSGi Service Platform, Release 3,” Mar. 2003.