Considerations of Design Requirement for a Broadband ATM Network

Jun Kyun CHOI*, Mun Kee CHOI*, Tae Soo JEONG*, Kyoung Soo KIM*, Young Seok SHIN* *Regular Members*

正會員 崔 埈 均* 正會員 崔 文 基* 正會員 鄭 泰 洙* 正會員 金 敬 洙* 正會員 申 榮 錫*

ABSTRACT We investigate the considerations of design issues for a broadband ATM network. Three kinds of network design requirements are considered : user grade-of-service(GOS) requirements, network manager requirements, and system designer requirements. In this work, we are focusing on the balancing problems among performance measures. We suggest that design parameters for a broadband ATM exchange would be tuned within the acceptable sets by a layering concept on the performance objectives.

要 約 최근 사용자의 광대역 및 지능형 서비스의 요구로 협대역 ISDN에서 광대역 ISDN으로 발전되고 있다. 따라서 본 논문에서는 광대역 ATM(Asynchronous Transfer Mode) 망의 설계에 따른 여러 고려사항을 사용자의 GOS(Grade-Of-Service), 망관리 및 시스템 설계 요구사항의 3가지 관점에서 살펴 보았다. 특히 3가지의 고려사항을 광대역 통신망의 성능면에서 서로 형평에 따라 조명하였으며, 광대역 ATM 교환기의 설계를 위한 각종 파라메터들을 망운용 및 관리(OAM)와 성능면에서 계층 개념을 도입하여 제시하였다.

I. Introduction

Recently, the communication network is confronted with a new trend of changes, which widely is appeared from local area network to long-haul network. This trend is mainly caused by the emerging high-performance processing system and by the provision of network intelligence. There is an emerging demand for broadband services with more than 150 Mbits/s, which requires high speed switching and processing as well as high speed transmission. These changes would be realized by constructing the broadband integrated service digital network(B-ISDN). As it is known, asynchronous transfer mode(ATM) is adequate for both circuit-mode and packet-mode information transfer capabilities in B-ISDN[1].

Until now, it has been widely studied on the evolving network architectures for broadband video serviece and switched multi-megabit data service(SMDS) as well as the flexible multi-services such as multi-party conference service and bidirectional distribution service with subscriber control[2, 3]. The reference configurations and functionalities for B-ISDN are also proposed in and open architecture approach[4]. There are some approaches to construct B-ISDN infra-structure with a transport network using ATM cross-connect system based on a virual path concept[5, 6]. The switching network architectures and those implementation technologies are studied in depth. Also the investigations for bandwidth and resource allocation, ATM traffic control, signalling, and operation and maintenance in B-ISDN are actively done[8, 9].

Throughout the investigations, the network requitrments and functionalities for B-ISDN are studied partly on the topics of broadband service, .network and swithc architectures, swithching technologies, signallings, and operation and maintenance. Now we consider the

*韓國電子通信硏究所 광대역 통신방식 硏究室
ETRI
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overall network requirements and functionalities with three different views from a user, a network manager, and system designer. As it is noted, the network user is normally interested in how *fast* and how *good* in quality the informations is transferred. A network manager is mainly interested in how *efficiently* and *reliably* the network is provided. From the point of a system designer's view, the main interest is how *simply* and *well* the network elements are implemented and controlled. In addition, a user, a manager and a designer are commonly interested in implementing the network *easily* and *economically* while they are using, managing, and designing the network, respectively.

Here, we remind of the performance objectives for a telecommunication network in order to balance B-ISDN requirements. Network performance objectives are classified into a user oriented aspect, a network manager oriented aspect, and a system designer oriented aspect[10]. In a user oriented aspect, there is a variety of service attributes, qualities(e.g., connection types, priority classes, access types etc.) and the user network interfaces. In a network manager oriented aspect, there are bandwidth management(e.g., virtual path and virtual circuit management etc.), network performances(e.g., error, delay, throughput, and so forth. In a system designer oriented aspect, there are multiplexing and switching techniques, traffic control mechanism, virtual path identification / virtual circuit identification(VPI / VCI) translation, and so on.

Is this paper, we investigate the considerations of design requirements for a broadband ATM network with a hierarchical view of the network performance objectives mentioned above. Especially, we are focusing on balancing problems among different design views. Based on these classifications, we analyze design considerations implementations for a broadband ATM exchange.

II. Broadband ATM Network Requirements

In order to construct the broadband ATM network *optimally* and *efficiently*, three performance objectives are considered as shown in Fig. 1[10]. Those are user performance objectives, network manager objectives, and system designer objectives. User performance objectives would be considered as measures of quality,

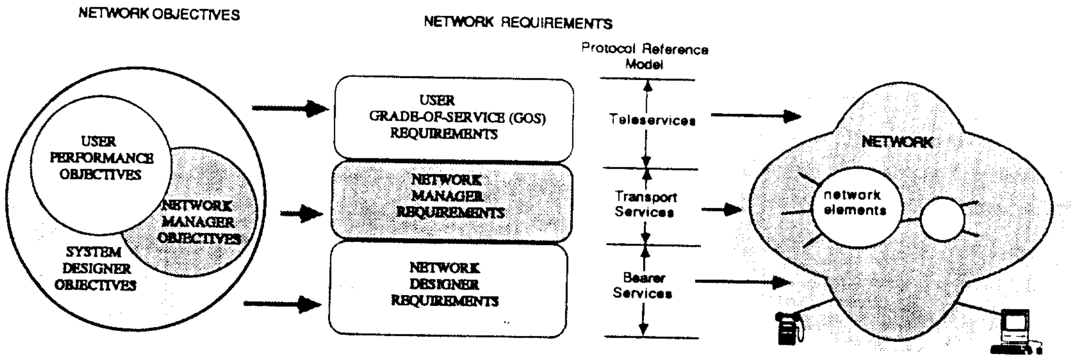

Fig. 1. Concept of network performance requirements.

delay, and availability, Network manager objectives are mainly focused on overall netw-ork efficiency and reliability while he is oper ating and managing the network. Designer objectives are primarily on a simplicity while he is designing and controlling the network elements. These objectives are dependent on each other.

Based on these performance objectives, we classify three kinds of network performance requirements as user grade-of service(GOS) requirements, network manager requirements, and system designer requirements as shown in Fig 1. These classifications are done on the user-network boundary based on a layered concept of reference model. The user GOS requirements, the network manager requirem ents, and the desiner requirements would be applied to area *outside, on,* and *insied* the network, respctively. In the viewpoint of U-plane, the user GOS requirements would be used for supporting *teleservices.* the network manager requirements for suppotıng network ***transport services*** and the system designer requirements for supporting *bearer-services.*

First, we consider the user GOS requitrments for broadband ATM network. In the user GOS aspect, there is a wide range of considerations as follows.

- Service attributes
  - service class : timing, bit-rate, connection mode(*)
  - priority class
  - direction : uni-directional, bi-directional symmetric and asymmetric
  - connection type : point-to-point, multi-point, and distribution
- Service qualities : loss, delay, throughput, efficiency, and availability

In addition, there is an increasing need for the user self controllability such as user self controlled bandwidth management and user-defined addressing / naming. Here, the user requirement means to access the network with a satisfactory grade of service level in terms of transmission quality, access delay, and availability. In Table I(a), we summarize the user grade-of service requirements.

Table I. Classifications of Network Requirements
(a) User Grade-Of-Service requirements

Requirements	Items
Error	Bit and cell loss ratio
	Transaction error ratio
Delay	Link transfer delay
	End to end delay
	Cell connection delay
Bandwidth	Cell transfer rate
	Call access rate
Availability	Call blocking ratio
	Access blocking ratio
Transparency	Timing transparency
	Semantic transparacy
Efficiency	Transmission overhead
	Processing overhead
Priority	Priority level
	Cell loss level
Direction	Uni-directional
	Bi-direction(symmetric and asymmetric)
Connection Mode	Connection oriented
	Connectionless
Connection Type	Point to point
	Multi-point, destribution
Interface Type	User network interface
	(R, S, T, U-interface)

Next, we consider the network manager requirements. Network manager would primarily support the user GOS levels by taking in charge of network operation and management. Network managements are classified as follows

- Network management
  network operation, administration and maintenance (OAM), fault management, resource management, configuration management
- Traffic management
  bandwidth management, routing, performance monitoring
- Subscriber management
  service management, addressing / naming, accounting, security management

The network management requirements would be considered as network elements, network itself, and their services. They are functioned by network / system operation control, traffic flow rate control, user access control, service class control, and network / system configuration control. In Table I(b), we summarize the network manager reqirements.

(b) Network manager requirements

Requirements	Items
Provisioning of User GOS level	Servcie Classes and types Service qualities User network interface
Subscriber Management	User addressing, service naming Accounting ans security
Bandwidth Management	Bandwidth allocation(statistical assigned, reserved, permanent) Performance monitoring
Traffic Management	Link level flow control Path level load control Routing and access control
Network OAM	System functional control Network operation control Rrsource and service control
Fault Tolerance	MTTR, MTTF Redundancy and reliability
Configuration	Subnetwork dimensioning Function, class, priority grouping

Finally, we consider the network designer requirements. Network designer objectives mainly provied the network management levels for network configuration, operation, and traffic control. The designer is also responsible for the provision of user GOS levels. The designer requirements are concerned with the following items ; in the following items :

System grouping and partitioning
System types and functional classes
Channel bandwidth control
Flow-rate and congestion control

(b) Network designer requirements

Requirements	Items
Provisioning of User GOS level	Timing, bit-rate, mode Cell loss, delay, priority Mylti-connection, direction
Provisioning of Network management level	Acess, bandwidth control System and circuit control Fault detection, by-pass VCI / VPI assignment
System dimensioning and types	Local and transit system Multiplexing / distribution Interface / interwokrking Database system
Multiplexing and Switching	SDM, FDM, TDM, WDM Circuti and pachet switching
Flow rate and Congestion control	Prioritized cell clipping Backward acknowledgement Admission control
Combinatorial Capability	Cell sorting or numbering Replication, masking, filtering Address / priority grouping

- Multiplexing and switching
- Combinatorial capability.

In Table I(c), we summarize the network designer requirements. As explained above, there exist relationships among these requirements. Hence, we illustrate overall relations among network requirements in Fig. 2.

Ⅲ. Design Considerations for a Broadband ATM Network

The target ATM network would be constructed by considering network requirements mentioned above. Here, we note that each item in Table I may have a number of selectable

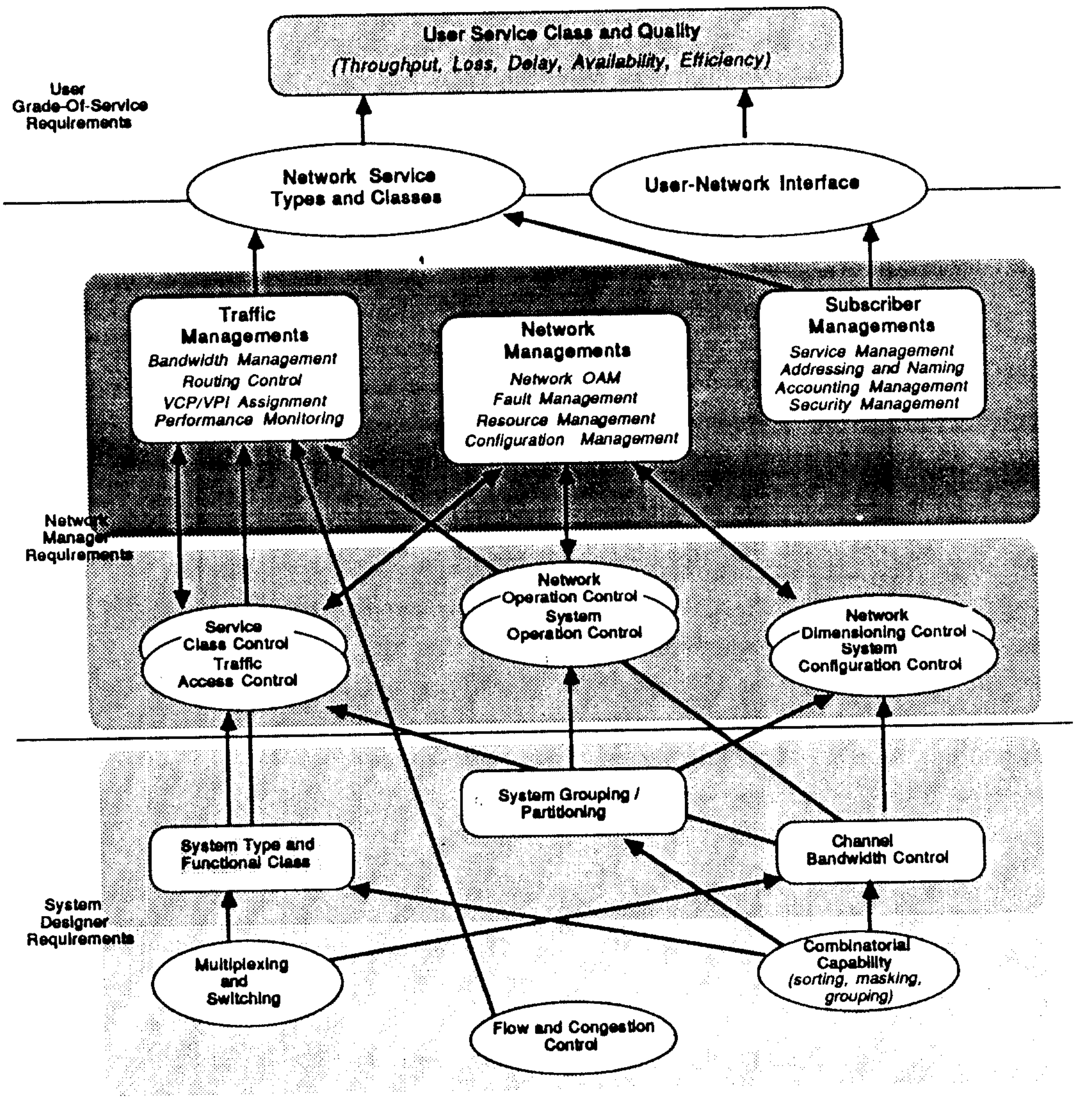

Fig. 2. Overall Relations of Network Requirements

parameters. A user may request one from various levels of requirements for his loss and delay performances. Also, the user may want to choose one from various connection types and modes, priority levels, and bandwidths. Network manager may want to choose one from various bandwidth management algorithms, traffic control mechanisms, priority controls, and routing mechanisms, etc. Ideally, the *target* broadband ATM network would be designed to support all the levels of network requirements whose numbers are normally given by the combination of the requested parameters in user performance, network management, and system design. Total network requirement levels might be approximately more than thousands.

On the other hand, there exists a need that the optimal performance parameters are tuned with the network objectives. Some performance measures may be sometimes negatively related with each other. For example, in the point of network manager's view, it widely requires an efficient use of the network elements such as transmission links, network terminating equipments, multiplexing / switching systems, and other processing systems. But the network efficiency might cause the system to be complex and unstable. In a case, it may cause the degradation of user service qualities(e.g., access complexity, loss, delay, etc.). Thus, the performance objectives for B-ISDN should be finely tuned with others.

Some examples for basic design considerations are followings.

Network efficiency

In a shared network, there is basically a trade-off relation between an efficiency and a loss / delay. A network efficiency would be degraded as the traffic becomes more loss-sensitive and delay sensitive. To provide a good efficiency, it is well recognized that the network would integrate the complementary types of traffics(that is, loss / delay sensitive traffice and lsss / delay insensitive traffics). It means that the network would provide at least two different classes and all the network elements woruld be designed for supporting more than two priority classes. In other word, the ATM transmission and exchange systems would be designed to provide at least two priority classes.

-Buffering overhead

Message buffering would provide good performances on loss and efficiency measures within an allowable delay. It also provides a good timing mechanism for transmission synchronization and source clock recovery. But it is only useful for the delay-insensitive traffic. As it is known, the delay variance in a real-time traffic brings complex synchronization algorithm. Also, it causes the complex flow control and congestion control problems inside the network. It can be said that the buffering technique requires much processing times for high-speed channel to provide the good loss and efficiency performances.

Reliability

Provision of better reliability would cause network inefficiency and complexity. There exists a balancing problem for the redundant network construction in networklevel, the stand by operation in system level, and the fault tolerant implementation in functional modules.

In a basic design principle for the ATM network, it is important to classify the performance objectives in a limited set. The set would be often taken by service classes, fun ctional grouping, and user grouping, etc., Also, a number of logical networks could be defined on the same physical network. Each network would support a limited set of the prioritized non blocking service, one way distribution service, low cost messaging service and so on. Eventually the target B-ISDN network to integrate all services would be realized when performance objectives reach in a unified set with the support of ATM technology. In addition, the target broadband ATM network would be competitively designed in comparison with other independent special purpose netw orks.

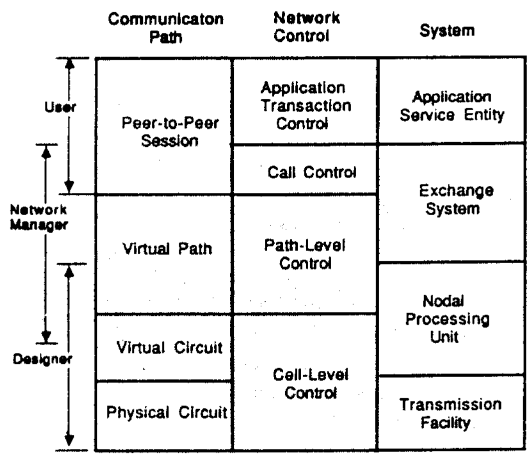

Fig. 3. Coverage of Network Implementation Level

Ⅳ. Implementation Considerations for a Broadband ATM Exchange

The optimal implementation of a broadband ATM exchange is performed by compromising the trade-off relations among the performance measures while technologies and algorithms are supported. Many studies have been taken for these performance balancing problem. Currently, the divide by conquer rule is very popular for accommodating performance obje ctives which are difficult to integrate in the same network. There is a well known modular implemntation in the design of an exchange system by using a number of functional modules such as circuit switching module, packet switching module, video switch module, video distribution module, and so forth, while each module has different performance objec tives and requirements partly due to the tec hnology and cost. This modular implementation may be sometimes done based on the service class and sometimes based on the technology.

Now, we suggest a systematic approach for the implementation of a broadband ATM exchange so that design parameters would be tuned within the acceptable sets. These para meters are separated by taking the layered concept on three performance objectives as shown in Fig. 1 Each design parameter would be independently chosen on that for other performance objectives. Here, the network manager has a role to compromise user obje ctives and designer objectives. Here, the net work manager has a role to compomise user objectives and designer objectives as well as his own objectives.

In Fig. 3, we show the coverage of hierar-chical implementation level a broadband ATM exchange, in which it can be classified into communication path level, network control level, and system level like U, C- and M plane. In this figure, user perspective is focused on the application service entity and the service -dependent system between peer-to peer communication sessions by using the application transaction control and call control. Network manager's interest is centered on the exchange system and the nodal processing unit to set

Table Ⅱ. Implementation for provisioning user GOS level

Items	User side	Manager side	Designer side
Error	Ignore Retransmission, recovery	Re routing Performance monitoring	Simple discard Buffer for overflow
Delay and timing	Source clock recovery algorithm	Priority assignment	Periodic transfer Constant latency Cell sequencing
Bandwidth	Bit rate compression Multiple channel	Multi link Access control Performance tunign	Module seperation based on cell type and control level
Availability	Access queueing Service scheduling	Multi path provisioning Fault diagnosis and monitoring	Changeover, by pass Module of function duplication Fault reportin
Efficiency	Simple protocol	Load sharing Call scheduling Network reconfiguration	Buffering Resource sharing Real time resource reconfiguration
Service Class and type	By using database	By using centralized or distributed database	Combinatoral capability (sorting, masking, grouping) Function seperation

up a virtual path and a circuit at the call, path and ceoo level control. The designer is primarily interested in the nodal processing unit and the transmission facility by controlling the virtual and physical circuit at the path and cell level. A simple example of this implementation approach is illustrated in Table Ⅱ. We show the implementation considerations for user GOS performance measures on a broadband ATM exchange, in which we consider user, network and system designer's views according to their implementation levels given by Fig. 3.

In this table, each design parameter for a user, a manager, and a designer is only confined within their implementation levels. First, in a loss performance, the user takes the peer to peer session control on the application service entity at transaction level and call level. In a variation of the loss performance, the network manager keeps trak of monitoring a loss and decides the change over or re routing of the network system and transmission facility to maintain the loss requirement. At the system designer side, error cell would be simply discarded and loss statistics are reported to the network manager. The design parameters for other GOS measures would be similarly separated according to the implementation level. Thus, the total network design parameters would be acceptably reduced.

As described in Table Ⅱ, we try to show the design balancing among user, network manager, and designer performance measures. It requires the harmony with implementation perspectives. In order to reduce the acceptable sets, for the network design parameters the implementation coverge for one side would be taken not to override with that of other sides, even though it is mainly dependent on the network objectives and a designer interest.

V. Conclusions

In this paper, we have investigated performance objectives for a broadband ATM network. Three kinds of design requirements have been considered whith a hierarchical layered concept : the user grade of service requirements, network manager tequirements, and system designer requirements. In this work, we have discussed the balancing problems of implementations of three performance objectives. By applying a layered concept to three performance objectives, we have suggested that network design parameters would be reduced with acceptable service to implementation perspectives. We have shown that a user grade of service level would be implemented in harmony with a user, a manager, and a designer view.

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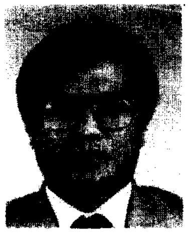
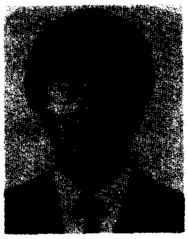
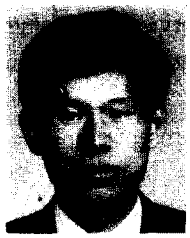
崔 埈 均(Jun Kyun CHOI) 正會員
1959年 10月 22日生
1982年 2月 : 서울大學校 電子工學科 卒業
1984年 2月 : 韓國科學技術院 電子工學科 卒業(碩士)
1988年 2月 : 韓國科學技術院 電子工學科 卒業(博士)
1990年 8月 ~ 1991年 8月 : Univ. of Toronto Post Doc.
1986年 6月 ~ 現在 : 韓國電子通信研究所 光대역 通信方式 研究室 先任 研究員



崔 文 基(Mun Kee CHOI) 正會員
1951年 4月 7日生
1974年 2月 : 서울大學校 應用數學科 卒業
1978年 2月 : 韓國科學技術院 産業工學科 卒業(碩士)
1989年 2月 : North Carolina State Univ. OR (博士)
1978年 8月 ~ 現在 : 韓國電子通信研究所 광대역 通信方式 研究室 責任 研究員



鄭 泰 洙(Tae Soo JEONG) 正會員
1957年 9月 23日生
1981年 2月 : 慶北大學校 電子工學科 卒業
1983年 2月 : 慶北大學校 大學院 電子工學科 卒業
1983年 3月 ~ 現在 : 韓國電子通信研究所 光대역 通信方式 研究室 專任 研究員
1991年 4月 ~ 現在 : Univ. of Lowell (美國) 派遣 研究員



金 敬 洙(Kyoung Soo KIM) 正會員
1964年 6月 3日生
1988年 2月 : 慶北大學校 電子工學科 卒業
1990年 2月 : 慶北大學校 大學院 電子工學科 卒業
1990年 ~ 現在 : 韓國電子通信研究所 光대역 通信方式 研究室 研究員

申 榮 錫(Young Seok SHIN) 正會員
1958年 10月 25日生
1982年 2月 : 全北大學校 電子工學科 卒業
1984年 2月 : 全北大學校 大學院 電子工學科 卒業
1989年 3月 ~ 現在 : 全北大學校 大學院 電子工學科 博士課程
1984年 3月 ~ 現在 : 韓國電子通信研究所 光대역 通信方式 研究室 先任 研究員