ATM 망에서 Qos를 위한 시스템 관리의 모델

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요 약

본 논문에서는 QoS(Quality of Service)의 관리와 특히 이와 관련된 ATM 망의 관리를 위한 시스템 관리에 관하여 연구한다. QoS 관리는 감시 기능으로 고려된다. 따라서 자원 제어, 성능 관리를 위한 OAM(Operation and Maintenance) 기능, 그리고 감시 기능을 가지고 있는 제어와 정보 측면의 관리 모델을 설정한다. 특히, "QoSAlarm"으로 표현된 QoS 격하(degradation)의 지시로 야기되는 보고된 성능 정보의 효율적인 처리에 초점을 둔다. 이러한 관리 활동을 수행하기 위하여 관리자는 QoS 등급에 근거한 우선 순위 개념을 사용하여 제안된 방법으로 QoS 격하의 문제 보고를 처리할 수 있다. 이러한 상황하에서 장애와 성능 문제를 가진 피관리 객체를 위하여 미리 설정되고 제한된 시간 안에 회복 활동을 수행하는 것이 가능하다.

A Model of Systems Management for Quality of Service in ATM Networks

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ABSTRACT

In this paper, we study on the systems management for managing ATM network which is especially related to the management of Quality of Service(QoS). QoS management is considered as monitoring function. Therefore, we establish the management model of control and information aspects to manage ATM layer which has resource control, Operation and Maintenance(OAM) functions for performance management and monitoring functions. In particular, we focus on the effective processing of reported performance information caused by the indication of QoS degradation being represented as "QoSAlarm". In order to perform these management activities, the manager can process problem reports of QoS degradation in the proposed manner which uses the priority concepts based on QoS classes. In this circumstance, it is possible to take recovery actions in a predetermined and limited time for managed objcets with fault and performance problems.

1. Introduction

In this paper, we present the model of systems management for QoS in ATM network which is important to communication network to support the various applications developed in recent. For future applications, especially highly interactive applications and those relying on the transfer of multimedia information, it is essential that QoS is guaranteed system-wide, including the distributed system platform, the transport protocol and the multi-service network. Enhanced communications protocol supports such as end-to-end QoS negotiation, renegotiation, indication of QoS degradations and coordination over multiple related connections are required. In these applications, com-

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munication requirements are extremely diverse, and demand varying levels of service in terms of parameters such as latency, bandwidth and jitter. Network performance management is a critical part of a Telecommunications Management Network(TMN) that ensures that the network is operating efficiently and delivers the prescribed Grade of Service(GoS). The QoS is maintained by using a service evaluation process that starts with network characterization, allowed by setting performance objectives and measurements. Control of network parameters is then exercised to improve service and performance. An important aspect of QoS is that the time for service provisioning is becoming a QoS measure, thus intertwining the realm of configuration management and performance management[1, 2, 3, 4, 5, 8].

QoS standards are considered in the ISO's Reference Model for Open Systems Interconnection(OSI-RM) and the ITU's I-series recommendation for ATM networking. QoS characterization of ATM networks is applicable at three different levels. The call control and connection levels are concerned with the establishment and release of calls and the allocation of resources along a path of ATM switch nodes. The cell control level is concerned with the data transfer phase itself. In ATM recommendations, there is no consensus on how resources will be allocated and how requested QoS levels will be maintained, policied and renegotiated in both networks and end-systems.Performance measurements and control of QoS are the processes of monitoring and controlling conformance to the performance objectives and determining plans to rectify the situation if objectives are not met. The measured results are then compiled and categorized(e.g. high objective, low, unsatisfactory bands) and distributed through a management information system for local action. Local action quite often uses diagnostic aids to identify the source of the problem and generating means of correcting the problem[4].

Therefore, we use the threshold QoS semantic which is one of QoS semantics in transport. QoS indication is related to fault and performance alarm. A QoS alarm is informed from the agent to the manager, should the QoS degrade below the requested value. The violation of QoS is abstracted as QoSAlarm which is described as a managed object in ATM network. This is considered as an alarm reporting function which has previously been implemented in our pilot system with diagnosis and recovery system[2] and used to send the QoSAlarm to the manager from the real devices(i.e. ATM node, ATM switch). In the following section, we establish the environment of systems management which can be used in the OSI management or TMN and apply ATM layer management function from the perspectives of occurring of QoS degradation alarm. Also, We model the systems management based on the roles of manager and agent in section 3. In this situation, the QoSAlarm which is described as a cause of the degradation of QoS is processed effectively by the manager with priority concepts. And it is desirable to use the diagnosis and recovery for the managed object with the QoSAlarm of higher QoS class. In consequence, we use QoS classes to determine the criteria of priorities of the received QoSAlarms and compute the mean waiting time in terms of processing them.

2. Management Function and ATM Layer Management

The actual process of performance management can be grouped into performance monitoring, traffic and network management, QoS observation. QoS observations constitute determining a provisioning sequence to maximize long-term network flexibility and utilization and assessing statistical data trends to avoid overload and maintain QoS[1,3].

2.1 Systems Management Function

Systems Management Function Systems management interface is supported by the manager which provides a standard interface to monitor, control and manage end-systems. This approach is like TMN from the viewpoints of management activities and management information. In system-wide entities, the systems management agent is used in conjunction with OSI systems management protocols to enable system resources to be remotely managed. The local resource manager represents end-system control of resources. The system QoS control function combines two system-wide capabilities : to tune performance of protocol entities and to modify the capability of remote systems via systems management. The system policy control function interacts with each layer-specific policy control function to provide an overall selection of QoS functions and facilities.

Systems management function,Common Management Information Service Element(CMISE), Remote Operation Service Element(ROSE), and Association Control Service Element(ACSE) are represented as an application structure which is based on TMN and OSI management. Management functions in the agent can call ACSE to establish associations with the application entity of the manager to report the event. We use the operation services of CMISE for object management service and M-EVENT-REPORT service of CMISE for event reporting service. Namely, QoSAlarm could map to M-EVENT-REPORT service through CMISE-Interface in the agent which can translate the management information structure of ATM Management Informaion Base(MIB) to the Guidelines for the Definition of Managed Objects(GDMO) style. The records of event report are constructed from such operations as object creation, object deletion, change of attribute values, state chang-e, and occurrence of QoSAlarm. The function of event report management can schedule the distribution and logging of events. Also, it can select sending events and transfer them to the destinatination. Therefore, it can create, delete, suspend, and resume the construct of event forwarding discriminator to manage event reports like QoSAlarm. And the function of log control can manage the records of log[2, 5]. According to the Structure of Management Information (SMI) of OSI management, the syntax of qualityofServiceAlarm notification type is specified as following.

```
qualityofServiceAlarm
Notification
  BEHAVIOUR qualityofServiceAlarmBehaviour;
  WITH INFORMATION SYNTAX Notification-ASN1Module.
  AlarmInfo AND ATTRIBUTEIDS
  probableCause             probableCause,
  specificProblems          specificProblems,
  perceivedSeverity         perceivedSeverity,
  backedUpStatus            backedUpStatus,
  backUpObject              backUpObject,
  trendIndication           trendIndication,
  thresholdInfo             thresholdInfo,
  notificationIdentifier    notificationIdentifier,
  correlatedNotifications   correlatedNotifications,
  stateChangeDefinition     stateChangeDefinition,
  monitoredAttributes       monitoredAttributes,
  proposedRepairActions     proposedRepairActions,
  additionalText            additionalText,
  additionalInformation     additionalInformation;
  REGISTERED AS {smi2Notification 11};

qualityofServiceAlarmBehaviour
BEHAVIOUR
DEFINED AS
"This notification type is used to report a failure
in the quality of service of the managed object.";
```

As shown above description, the SMI is constructed from the managed object which is trying to send QoSAlarm. The alarm reporting function in the agent can construct the QoS-

Alarm message by constructing the object class, object instance, and etc.

2.2 ATM Layer Management

Unlike some existing telecommunications networks which dedicate a physical path to each connection, ATM networks operate by multiplexing fixed-size packets(known as cells) from different virtual connections over the same physical link[5]. The key requirement at the ATM layer is to achieve a high degree of resource utilization by statistically multiplexing traffic while simultaneously meeting the users resource traffic QoS requirements. The service commitment is partitioned into deterministic service, probablistic service, and best effort service. Especially, the probablistic service may suffer from the QoS degradation from time to time because of the statistical nature of the network service.

In BISDN management, ATM layer includes F4 and F5 as OAM cell. OAM function provides the information flow of OAM typed as F4 and F5 for Virtual Path Connection(VPC) and Virtual Channel Connection(VCC). These information flows are end-to-end F4/F5 information flow and segment F4/F5 information flow. The functions which are composed of performance monitoring, defect and failure detection, system protection, failure and performance information, and fault localization have been considered in specifying the OAM functions of the B-ISDN. Network performance is monitored on blocks of user cells[6]. A performance monitoring cell insertion request is initiated after every N(N=128, 256, 512 or 1024) user cells. The monitoring cell is inserted at the first free cell location after the request. Each OAM cell contains a count of the number of user information cells transmitted since the last OAM cell. The receiver keeps a running count of the number of user information cells transmitted(N_t) and received(N_r). Cell loss ratio can then be calculated as $(N_t-N_r)/N_t$ if N_t-N_r is positive. The manager can obtain N_t from sending end system and N_r from receiving end system from the perspectives of virtual connections. These informations are stored in the MIB(e.g. represented as DB) as attributes. To get the attributes of related performance information(e.g. N_r, N_t, etc), GET operations of mange-ment protocol is invoked for management activities.

A user of ATM virtual connection is provided with one of a number of QoS classes supported by the network. It should be noted that a VPC may carry VC links of various QoS classes. The QoS of the VPC must meet the most demanding QoS of the VC links. The QoS class associated with a given ATM connection is indicated to the network at the time of connection establishment and will not change for the duration of ATM connection. A QoS class can have specified performance parameters (Specified QoS class) or no specified performace parameters(Unspecified QoS class)[3, 5]. For each Specified QoS class, there is one specified objective value for each performace parameter. Initially, each network provider should define objective values for a subset of the ATM performance parameters for at least one of the following service classes from ITU recommendation I.362 in a reference configuration that may depend on mileage and other factors :

— Service Class A : Circuit Emulation, Constant Bit Rate Video-Service Class B : Variable Bit Rate Audio and Video-Service Class C : Connection-Oriented Data Transfer-Service Class D : Connectionless Data Transfer. The sources of QoS degradation are propagation delay, media error statistics, switch architecture, buffer capacity, number of nodes in tandem, resource allocation, failures, and etc. The performance parameters impacted from QoS degradation are Cell Error Ratio(CER), Cell Loss Ratio(CLR), Cell Misinsertion Rate(CMR), Mean Cell Transfer Delay(MCTD), Cell Delay Variation(CDV). The following table summarizes how various sources of degradation can impact the performance parameters[5].

(Table 1) Degradation of QoS parameters

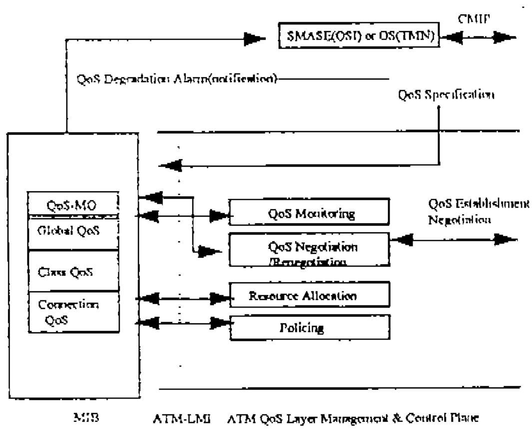
Attribute	CER	CLR	CMR	MCTD	CDV
Propagation Delay				×	
Media Error Statistics	×	×	×		
Switch Architecture		×		×	×
Buffer Capacity		×		×	×
Number of Tandem Nodes	×	×	×	×	×
Traffic Load		×	×	×	×
Failures		×			
Resource Allocation		×		×	×

3. Model of Systems Management

Systems management is initiated by monitoring the managed objects which are created by the system or remote management service and the notification of QoSAlarm is transferred to the manager. QoS must be monitored at all layers to ensure that the negotiated levels of QoS are being maintained. Each layer will collect statistical information associated with the on-going connection performance and make an assesment of the QoS measured against QoS requested. Monitors may then either attempt to take action to restore QoS levels themselves or they may choose simply to inform the upper layer that there is a problem. But it is efficient to use systems management in this circumstance. Therefore, we model systems management from the viewpoints of the manager and the agent.

3.1 Agent Role

QoS management is concerned with QoS specifications, QoS mapping or translation, QoS negotiation, resource allocation, admission control, QoS maintenance,QoS monitoring, QoS policing, and QoS renegotiation[8]. There is one method to measure each QoS performance parameter in either in-service or out-of-service mode. Other alternative measurement methods or estimates are possible. Either in-service or out-of-service method may be used to estimate values for the ATM cell transfer performance parameters.The model of agent role is depicted in Figure 1.



(Figure 1) The model of agent role

Management functions are end-to-end QoS negotiation including admission control for new connections, policing to ensure that users are not violating negotiated QoS parameters, and monitoring to ensure that negtiated QoS levels are being maintained by the service provider. Resource management strategies are required for all areas of operating system and memory management. This role is applied in the basis of QoS managed object class defined in this systems management. This managed object has the action, behaviour, operation and notification characteristics when the conditions are satisfied in the coded value or operation.QoS parameters in the ATM layer and their bounds may be established in the QoS managed object class.

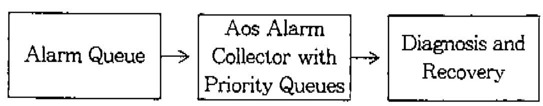
There are three kinds of managed objects such as connection QoS, class QoS, and global

QoS in MIBfor representing QoS management information. Connection QoS managed object is related to VCC or VPC and includes threshold, QoS-provisioned, QoS-delivered, QoS_translation, and send_notification. Class QoS managed object is a set of managed objects with the same QoS class. Global QoS includes network provisioning and is a set of all class QoS managed objects and includes threshold, QoS_demanded, QoS_translated, QoS_negotiated, QoS_delivered, QoS_translation, and send_notification. The Interim Local Management Interface(ILMI) uses SNMP for monitoring and control operations of ATM management information across the UNI. The types of management informattion which will be available in the ATM UNI MIB are physical layer, ATM layer, ATM layer statistics, VPC, VCC, and address registration information. The ATM UNI MIB may be extended over time to allow for the addition of new items without requiring any changes to the management protocol or framework[5]. Also, resource allocation and policing may be used for performance management. The manager is viewed as Systems Management Application Service Element(SMASE) in OSI or Operations System(OS) in TMN.

3.2 Manager Role

In current, we consider the following management operations from the perspective of the manager to manage QoS performance management in ATM networks. These services are performed by the support of CMISE services in wide area management or the SNMP services in local area management. These services activate performance management, reconfigure performance management, change the measurement method (in-service or out-of-service) and get the performance parameters from completed QoS negotiation. Once a connection has been successfully negotiated between two end points, the source must be policed at the edge of the network to ensure that it does not exceed the traffic profile declared at ATM call-setup time.In addition, a network level QoS.Indication which is transformed in the degradation of QoS in the agent will be generated indicating that bandwidth violation has been detected on the connection. In this point, we consider that the manager may perform the correlation of QoSAlarms notified from endpoints which are in logical connection path from standpoint of sender which monitors the current sending QoS and receiver which monitors the receiving QoS[2].

When the QoSAlarms caused by QoS degradation are occurred in the agent with ATM layer, the manger analyzes QoSAlarm messages. The manager model is shown in Figure 2. The manager receives QoSAlarms from alarm queue and distributes them to QoSAlarm collector with priority queues based on QoS classes and then passes them to the diagnosis and recovery system. The QoSAlarm collector is used to select alarms by scheduling them according to their priorities which are determined fromQoS classes. The diagnosis and recovery system have much work for determing proposed actions in accordance with symptoms caused from QoS degradations.



(Figure 2) The model of manager role

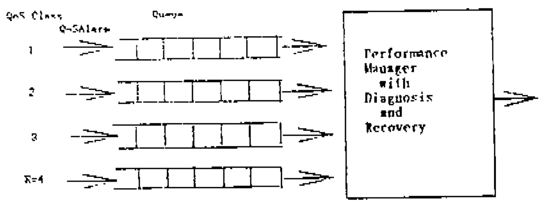
There are other possibilities in the negotiation process which may be of use at different layers. For example, rather than simply proposing a level of service, upper and lower bounds on acceptability could be proposed by the user and the provider could be permitted. Also renegotiation of QoS on a live connection could be permitted. In this case, the manager could specify the alternative path to be taken when commitments are not met by the provider. As an example of a hifi audio channel could be degraded to 64Kbps voice audio channel. At the same time, the system would inform the manager who would adjust the source and sink codec as appropriate. The actions taken from the manager are related to the set of QoS parameters in Table 1. Based on the knowledge processing on inference system, the description of diagnosis and recovery may be set up as follows.

IF(CI : The QoSAlarm caused from the degradation of QoS is occurred on a connection between two nodes)
THEN Ignore the situation
OR Reconfigure the QoS in the requested service
OR QoS renegotiation of QoS on a live connection.

3.3 An Operation of Systems Management

In this section, we exemplify the relationships between the actions of diagnosis and recovery and management operations in our system model. As it is difficult to adapt recovery actions according to all of occurrences of QoS degradations, we now concentrate on an example in which systems management can reconfigure VC path in the case of performance fault caused by the threshold of CLR. In general, this is mainly related to the overflow of buffer in switch of ATM networks. We assume that switch has one more input buffers and there is a buffer with reserved capcity in the case of one buffer with overflow state. Also, the values related to QoS are stored in the MIB for representing the QoS parameters in the agent hosts of ATM networks. Therefore, QoS managed object classes of VP and VC are created as managed object instances when new connections are established In this case, fault switch may send the message of QoS degradation to the manager and the manager should take the recovery actions by using management operations. The QoS degradation caused by CLR is mainly important to QoS class 1. This message may have the highest priority in this system. The following management operations can be performed to change the input buffer of VC in switch. In addition, this method can be applied in the fault link with the degradation of QoS.

(step 1) M-SET : update the value of VC in VC table of fault switch
(step 2) M-ACTION : test buffering status
(step 3) M-CREATION : create new connection
(step 4) M-ACTION : reconfigure connection onto new connection
(step 5) M-ACTION : recover fault switch
(step 6) M-SET : change in-use connection onto recovered connection



(Figure 3) The priority model based on QoS classes

4. Estimation of Systems Management Model

The basis of priorities of each QoS degradation message processed by the manager are postulated by QoS classes computed from performace parameters.The model for the estimation of systems management is depicted in Figure 3. The system model can use the non-preemptive and preemptive scheduling methodology for processing the diagnosis and recovery. The number of waiting queues may be increased in accordance with the number of QoS classes.

In order to estimate the proposed management model, we use the priority model which is appropriate to this system. In practice, priority is something given to certain class to improve the QoS over other classes. We compute the mean waiting time of QoSAlarm calls in the environment of the preemptive priority and non-preemptive priority model. In non-preemptive model, when all servers are busy, everytime a call in service terminates, the waiting call with the highest priority enters service. This means that a higher priority call does not interrupt a lower priority call in service. A model is called a preemptive priority model if an incoming higher priority call, finding a lower priority call being served, is served by interrupting the latter call.

Consider the single server system represented as performance manager, in which QoSAlarm calls of QoS class i, i=1, 2, ⋯, R(R=4), arrive at random at rate with the service time arbitrary distributed with mean and second moment $h_i^{(2)}$ A higher priority class is given a small i. Let $\rho_i = \lambda_i h_i$ and be the offered load and the mean waiting time, respectively, for QoS class QoSAlarm calls. Assume FIFO with infinite buffer in the same QoS class and the existence of steady state. In non-preemption model, the mean waiting time for QoS calss QoSAlarm calls is as follows[7]

$$W_i = \frac{\sum_{i=1}^{R} \lambda_i h_i^{(2)}}{2\left\{1-\sum_{j=1}^{i-1}\rho_j\right\}\left\{1-\sum_{j=1}^{i}\rho_j\right\}} \quad (1)$$

And we analyze the M/M/1 type preemptive priority model using the same assumption and notion of nonpreemption. We have the following mean waiting time for QoS class i QoSAlarm calls.

$$W_i = \frac{\sum_{j=1}^{i} \lambda_j h_j^{(2)}}{2\left\{1-\sum_{j=1}^{i-1}\rho_j\right\}\left\{1-\sum_{j=1}^{i}\rho_j\right\}} \quad (2)$$

Consider a priority model with R=4 and identical traffic conditions, $\lambda_i = \lambda$, $h_i = h$ and, $h_i^{(2)} = h^2$, i=1, 2, 3, 4(fixed service time : the execution time of management action for diagnosis and recovery), $\rho = \lambda h$ If $\lambda = 0.2$/sec, h=1sec, from above formula we have

Model/Mean Waiting Time	W_1	W_2	W_3	W_4
Non-preemptive priority	0.5	0.835	1.667	5
Preemptive priority	0.125	0.667	1.917	6.5

We conclude that the mean waiting time of QoS class 1 and 2 can be reduced by applying the proposed method. It means that the diagnosis and recovery of QoS degradation of services with more rapid demanding can be accomplished effectively, and so the reliability of systems can be increased.

5. Conclusion

We overviewed the integration of the model of systems management and the QoS management in ATM networks. We have established the management model which processes the QoSAlarm according to the QoSclass. It is desirable to postulate the priority of Qos class when the QoSAlarm is occurred from the agent. In current, we compute the mean waiting time in queues existed in the manager to apply the concepts that the QoSAlarm with higher class may be more urgent than the one with lower class. Though we consider QoS classes only, we can disseminate these classes in detail by adding the other characteristics related to the determination criteria of each QoS class.

And we are bound to consider the evolution of other services which will be developed and varified.

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