Quality of Service Management in IBC: an OSI Management Based Prototype

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Abstract

As the Telecommunications Management Network (TMN) standard emerges, it becomes clear that Integrated Broadband Communications (IBC) management functions will make use of OSI management models and protocols. Service management functions will undoubtfully be of the most important ones in maintaining the negotiated Quality of Service (QoS) to service (and thus IBC) users. This paper presents the architecture of a QoS management prototype based entirely on the OSI management model, as being developed within the RACE NEMESYS project.

The modelling of services as managed objects at the different layers of the TMN hierarchy is presented. Intelligence is built into the service managed object classes, encapsulating most of the awareness and implementation functions of the NETMAN ADI model, while decision functions are left to the service management applications. In the absence of a real IBC environment, network and service functions are simulated but the actual QoS management functions are based on real OSI management services.

1. Introduction

In future integrated broadband communication networks (IBCN) [Kueh89] there will be complex provider and user schemes. Lower level service providers will sell their (lower level) services to higher level service providers, the latter being their users. At the top of this layered service hierarchy, end users will be using underlying services.

In the NEMESYS model, the so called network provider offers bearer i.e. pure transport services to its users, while service providers - using these - build up higher level services, so called teleservices:

- PCM telephone,
- TASI telephone,
- bulk file transfer,
- interactive data transfer,
- video broadcast,
- video conference,
- multimedia document transfer.

End users make use of these teleservices. Thus, we examine a layered service hierarchy consisting of three layers.

The RACE NEMESYS project [Del6] looks at Traffic and Quality of Service (QoS) management in IBC by building a management prototype over three work cycles.

In the first two cycles of this prototype, a management platform was developed based on a model of “shipping” managed objects instead of accessing them through a well defined management interface. Also the separation between the manageable entities and the associated managed objects, exhibiting a specified behaviour, was not clear. As the Telecommunications Management Network (TMN) standards [M30] emerge, it has become clear that IBC management functions will make use of OSI management models and protocols. We have thus decided to base the service management part of the NEMESYS prototype for its third cycle on real OSI management services [Del9], conforming closely to the emerging TMN management architecture and being in line with the RACE community [Guid4].

In this paper we explain our approach for the design of such a service management system for Quality of Service (QoS) management based on emerging standards. Its realisation gives insight into the problems of structuring TMN management applications. In particular, the modelling of services and profiles describing QoS delivered to end users as managed objects at different levels of abstraction at the various layers of the TMN hierarchy is presented. Intelligence is built into the service managed object classes, encapsulating most of the awareness and implementation functions of the NETMAN ADI model [Netm6], while decision functions are left to the service management applications. In the absence of a real IBC environment, network and service functions in the prototype are simulated but the actual QoS management functions are based on real OSI management services.

The rest of this paper has the following structure: a general view of service management requirements in IBC is presented first, followed by an overview of the OSI network management standards and the TMN architecture. The overall design of the service management system based on these principles is then presented, followed by our implementation decisions. Then, the managed object model at the different layers of the TMN hierarchy is described. Finally, the relationship to the generic Awareness, Decision, Implementation (ADI) model of the RACE NETMAN project is discussed.

2. Service Management

Service management functions will undoubtfully be of the most important ones in an IBC context in maintaining the negotiated Quality of Service (QoS) [E800] to IBC users. In general, many tasks will need to be tackled by a service management system [NeSt90]. In NEMESYS we concentrate on the following major functions:

- Service administration
- User administration
- Log and profile handling
- QoS verification
- QoS improvement
- Load evaluation

Service administration stores and updates information about services, providers offering these services, maximal QoS parameters that can be offered to users. We do not model services in such great detail as the ROSA project (R1068), nor do we look at trading aspects, e.g. which service provider offers the cheapest service given the user QoS requirements [HaTs91].

User administration functions cover all aspects of information about end users, e.g. names, addresses, service providers they have a contract with, QoS parameter values guaranteed by the provider. As such, user administration has very stringent security requirements.

Log and profile handling is the core of a service management system. Profiles store threshold values, describing any kind of performance characteristic (e.g. QoS parameters, usage parameters), that have to be met to deliver the agreed QoS specified in a contract. Logs store the history of events, thus including time aspects (e.g. QoS evolution, usage patters over some period of time). Data about QoS delivered to single users, user groups or all users is also stored.

This information is used by QoS verification functions to check if users get the QoS they subscribed to (and pay for) and by QoS improvement functions to derive effective countermeasures in the case of QoS degradation.

Load evaluation covers (short and long term) planning aspects. The service provider has to estimate the load users might generate at some point of time in order to plan its own resources required and to use lower level services efficiently e.g. it might be necessary to ask a network provider for more transmission capacity some time before it is actually needed.

3. OSI Network Management Standards

A great deal of work has been undertaken by standards bodies in the area of network management. Standardisation issues have been going on in ISO/OSI, OSI/NM forum, ETSI, CCITT, IEEE and last but not least RACE. All standardisation bodies have adopted an object oriented model. Real resources - physical ones such as links, nodes, users etc. and logical ones such as virtual paths, routing tables, services, profiles etc. - are modelled by so called managed objects (MOs) [I10040]. A managed object provides an abstract view of the resource, hiding local communication and realisation aspects. Management applications manipulate managed objects (create, delete, read, write, activate actions, receive notifications) in order to perform management tasks and it is the responsibility of the MOs to map these onto possible interactions to the real resource they represent (Figure 1).

Figure 1. Standard conformant management communication

Management applications in a manager role access managed objects via management applications in an agent role. The latter handle communication aspects, check access rights and select the right MOs to perform the requested management operation, applying scoping and filtering. The communication protocol for the manager/agent interaction, that is the communication of management information, has been standardised (Common Management Information Service/Protocol - CMIS/P [I9595; I9596]).

The interaction between the agent and MOs as well as the interaction between the MOs and the real resources they represent has been deliberately left outside standardisation as it is a matter of local implementation. Any method can be used, such as shared memory, local interprocess communication mechanisms, proprietary management protocols, the Simple Network Management Protocol (SNMP) etc. It should be noted that managed objects may well reside at a different network site from the actual real resource they represent: this is particularly necessary for small network devices that are not capable in supporting the full OSI stack functionality necessary for the operation of CMIS/P. This is known as proxy management.

The conceptual repository of all management information i.e. all managed objects is known as the Management Information Base (MIB) [I10040].

The OSI management model strongly encourages the implementation of event driven management applications. As MOs are able to emit event notifications concerning the operation of the real resource they represent, the interaction of management applications could be based principally on event reporting rather than polling. If MOs are defined carefully, almost every of interest for the purpose of management can be detected and forwarded to managers. This is one of the key differences between the OSI and the internet (SNMP) management model.

4. TMN Management Information Architecture

Telecommunications network management is a distributed processing application which requires the exchange of management information according to the management model described above. For communication purposes management applications take the role of managers, managed objects are accessed through agents. For organisational purposes, the overall management functionality is decomposed into layers restricting the scope of management activities. The management layers of the TMN architecture have been identified as the Network Element Management, Network Management, Service Management and Business Management Layers [M30]. The lowest layer, the Network Element Layer is the one to be managed.

The basic element of management activity is the Operations Systems Function (OSF). Management activity is decomposed into a series of nested OSFs[1], each providing its management information model i.e. objects to its upper OSF while accessing the management information models of its subordinate OSFs. This recursive relationship is terminated at the lowest layer of the hierarchy where only managed objects exist.

Each OSF can be conceived as consisted by a management application function accessing managed objects at subordinate or peer OSFs which provide an agent interface while it provides an agent interface itself to its superior OSF. Within one TMN all “vertical” and “horizontal” interactions take place at generic “q_3” reference points which are realised as “Q_3” interfaces on top of CMIS[2]. However, the interaction between OSFs of different TMNs, e.g. operated by different service providers, takes place at “x” reference points, realised as “X” interfaces.

Currently, [M30] envisages the realisation of “Q_3” using CMIS [I9595] and FTAM [I8571], while the realisation of “X” has not yet being considered.

5. NEMESYS Service Manager's Design

With our knowledge about the service management tasks discussed, the network management models presented above and our experience from the first two cycles of the NEMESYS experiment, we came up with the following design for the third cycle of the service management system shown in Figure 2.
As a real IBC environment does not yet exist, network, service and user functions are simulated. The user simulator represents user behaviour and characteristics, e.g. business and residential users differ in their service usage rate. The service simulator describes the load generated for specific services, e.g. different teleservices require different number of network connections. The actual instances of services are outside the scope of the TMN but the managed objects representing them belong to the TMN, enabling their management. Finally, the network simulator simulates a real network trying to deliver the load from a source to a destination.

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1 For simplicity we do not introduce here the concept of arenas, this is discussed in detail in [M30].

2 [M30] defines “q_x” and “Q_x” for lower level interfaces as well.

Figure 2. NEMESYS' third cycle service management architecture

At the network element layer (SSA - Service Simulator Agent) of the layered hierarchy there exist managed objects describing instances of service associations and network connections. Though these objects in a real IBC would be distributed accross the various service access points, in the NEMESYS experiment they are handled for simplicity by one agent. The SSA is split into two parts, the service simulator and the CMIS agent. This is, on one hand, because the service simulator was developed during the previous experimental cycles without CMIS based communication in mind. On the other hand, it is not clear if each service access point will be able to support standard conformant management communication in the future. Instead, a simple protocol may be used to exchange information with a mediation device [M30], the latter presenting a proper interface to the management system. This is the main reason behind our decision not to modify the service simulator but to select a proxy management approach.

At the network element management layer (NELSM - Network Element Level Service Manager) we envisage an Operations System Function which accesses the network element information model and creates its own, making it visible to the upper layer OSF (the service management layer OSF). While the SSA understands service associations and network connections, the NELSM manages these and aggregates them into service access point and node management information respectively.

At the service management layer (SLSM - Service Level Service Manager) we envisage another Operations System Function which in turn accesses the network element management information model (based on access points) to create its own based on services, service providers and network wide QoS, which it possibly presents to the business management OSF (foreseen, but not implemented in NEMESYS). The concept is exactly the same to that of the network element management layer.

In NEMESYS we implement no network management layer as this is of no meaning to service management. This violation of the layered hierarchy for that particular layer is envisaged in the TMN standard [M30; Guid4].

Via X interfaces (Figure 2) information from the service management TMN to the traffic management one is exchanged. At the network element management layer, Quality of Service complaints for specific network connection instances are sent if the network provider does not meet the QoS as agreed with the service provider for some teleservice. At the service management layer, aggregated general complaints and other information is generated as e.g. estimations about the expected load. Communication over these X interfaces is modelled as CMIS Event Reports emitted from managed objects at these layers.

We must note here that our approach having one OSF per layer for the service TMN is a simplified one, devised for the needs of the NEMESYS prototype. Despite that though, the principles of service management modelling and hierarchical OSF organisation realising Q_3 and X interfaces over CMIS as we have shown, are of direct relevance to a real TMN.

6. Implementation decisions

The management application function (MAF) (Figure 2) encapsulates the intelligence needed to perform a mapping from the lower level information model (e.g. service associations) to its own (e.g. service access points), though parts of it may be implemented in the managed objects themselves. This separation depends purely on the local OSF implementation, as the latter is one managed system, i.e. there is no management communication function between the MAF and the managed objects it provides for higher management layers.

In order to facilitate the development of the management application functions, we have introduced the notion of the Shadow Subordinate Information Model. To hide details of the Q_3 (CMIS) interface to the subordinate OSFs, an OSF holds managed object replicas, so called shadow managed object (SMOs). Thus, a MAF can operate on MOs of a lower layer as if they were local, the SMOs hiding all CMIS communication aspects and facilitating its implementation.

A lot of work has already being done in modelling the internal MAF to MO interface [KPWa91], this has been extended for the needs of the NEMESYS prototype. The MAF to SMO interface has also been modelled. Both interfaces are object-oriented and define an object-oriented structure for the generic managed system. Details on this work will be published in the future.

7. NEMESYS Service Managed Objects

Due to space limitations managed objects defined for QoS management in the context of NEMESYS can not be provided in detail. Instead, we give a list of the most important MOs used in the NEMESYS service manager:

- Service (subdivided into bearerservice, teleservice, etc.)
- Actor (subdivided into Provider, User)
- ServiceNetwork
- ServiceAccessNode
- ServiceAssociationAccessPoint
- ServiceAssociation
- Network
- NetworkNode
- NetworkConnectionAccessPoint
- NetworkConnection
- Address
- Profile (not further refined here)
- Log (not further refined here)
- Record (not further refined here)
- Discriminator

and give an idea how we selected them. Mainly four different sources can be identified:

1. Whenever possible, MOs were according to OSI management standards [I10164; I10165]. As these are still preliminary, it was mainly management support objects such as logs, records and discriminators that were used.
2. Otherwise, MOs are similar to the ones defined by RACE [CFSH550].
3. Another important input for MOs as well as for the relations defined between them is [Hark91]. A general approach is described of how to select appropriate MOs and structure a service management system.
4. Last but not least, the OSI NMF object library [NMF90] was also used for input.

The role of profiles and logs was discussed in section 2 briefly. A full description of all MOs is given in [Del9] using GDMO templates [I10165].

As the relations of MOs are very important, Figure 3 depicts them in relation to the management layer they belong to.
From this figure two concepts of the service management system can be derived. First, there is clear distinction between tele- and bearerservice related MOs e.g. service association as opposed to network connection. Generally speaking, there are MOs of the managed service and MOs representing resources of the underlying services used by the former [Hark91]. This is because a service provider has to monitor if the underlying services deliver the agreed QoS. If not, he has to complain in the correct terminology (via the appropriate MOs). It makes no sense for a multimedia service provider, say, to complain to a bearer service provider about multimedia associations. The bearer service provider knows about network connections only and has to be told which network connections failed for the multimedia association with poor QoS.

Second, there is a separation of MOs with respect to time issues [Qosm14; Hark91]. At the service management layer (SLSM) there are long term MOs, e.g. general information about services, providers, their contracts, etc. A service will be offered for a long period of time (several years). At the network element management layer (NELSM) there are mid term MOs, e.g. access points and related profiles. A service association access point is the representation of a contract between a service provider and a user. Such a contract exists much shorter than the service itself and must be updated more often, e.g. if the users QoS or load requirements change. At the lowest layer (SSA), there are short term MOs, e.g. service associations and network connections. Associations last for few minutes only but they are created and deleted often compared to an access point.

The two concepts described above help in structuring the overall management system and in designing the management information model for each layer.

8. Relationship to the ADI Model

In this section, we examine how the generic ADI network management model of RACE NETMAN project [Netm6] fits into the service management architecture described above.

The awareness function is split in two parts: one major part is implemented by intelligence built into the managed objects. Notifications are sent to (interested) managers according to events triggered by the function of the manageable entities they mirror, e.g. when the cell loss rate of some network connection increases above some threshold defined by the management application (e.g. as defined in a contract between teleservice and bearerservice provider). We remind here that the manageable entities may well be managed objects themselves belonging to the subordinate OSF's management information model. More complex events may need to be detected by the management applications, e.g. by the correlation of notifications from different managed objects. For example, long term QoS degradation may be discovered before actual QoS violation occurs. Advanced information processing techniques, such as knowledge based systems or neural networks, are investigated by NEMESYS for this task.

Figure 3. Visualisation of NEMESYS MOs and their relations

The decision function is primarily implemented in the management applications, that is by the MAFs. Sample decisions are updating of profiles, cancelling of ongoing service associations, complaining to the traffic management TMN, changing the number of network connections used for one service associations etc.

The implementation component is split again: one major part is handled by the managed objects themselves. Management directives sent by the management applications are realised performing special actions on the underlying resource. Other actions may be performed by the management applications e.g. informing a human service operator and asking for decision support.

The realisation of the ADI model within the object oriented management framework shows an important feature of management interaction: intelligence is "brought" down to the managed objects, relieving management applications and minimising network traffic. The careful modelling of managed objects at the various layers of the TMN hierarchy has a similar effect.

9. Conclusions

Using OSI and CCITT management standards as the basis for quality of service management in the context of IBC is very promising. The realisation of such a system in RACE NEMESYS is an excellent testbed to verify ideas published by RACE GUIDELINE [Guid4] and envisaged for its Integration Task Force (ITF) [ITF91]. In the current state of our development the architecture proposed in this paper is in line with standards. The framework provided is very helpful structuring the complex task of QoS management. As we have not yet fully implemented this service management functionality, our conclusions are preliminary.

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