Viewpoints on Traffic and Quality of Service Management in Telecommunication Management Networks

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ABSTRACT

The work described in this paper was carried out as part of the development of the NEMESYS experiment (RACE NEMESYS Project [11]).

This paper describes the modelling of an experimental Traffic and Quality of Service (QoS) Telecommunications Management Network (TMN) system that manages a simulated Integrated Broadband Communications (IBC) network based on Asynchronous Transfer Mode (ATM) technology. The TMN system of the IBC network is based on the emerging TMN standards [1] and TMN Architecture [2].

The modelling techniques used in the NEMESYS experiment are based on the emerging Open Distributed Processing (ODP) [3] viewpoints and the OSI/Network Management Forum (OSI/NMF)[4] perspectives.

The entire NEMESYS experimental system, from the IBC network (a simulator) to the TMN system was modelled using the ODP viewpoints, while the OSI/NMF perspectives were used to model and implement the QoS management functions of the TMN system.

Our conclusions on this subject are outlined.

1.0 INTRODUCTION

IBC networks of the future will offer a multitude of end user services ranging from existing voice and data services to new services such as video telephony. Traffic and QoS management functions are an important part of TMN as attempts are made to get the maximum throughput from the networks whilst maintaining the QoS provided to the end users. The Traffic and QoS management functions of these networks will be very complex. The complexity arises from distribution of the network, services and management and the different types of services offered on the same network.

The NEMESYS experiment implements a subset of the issues involved in Traffic and QoS management for IBC networks. The experiment consists of a number of TMN emulators which interact with a simulated IBC Network.

To understand the system being modelled, a knowledge of the issues involved in the Traffic and Quality of Service management is a prerequisite [6].

TMN systems are very large and complex distributed systems to which ODP and OSI/NM viewpoints are applicable. OSI/NM perspectives are specific to management systems and could be mapped directly onto the ODP viewpoints [2].

Chapter 2 is a short introduction to the NEMESYS experiment. Chapter 3 is an introduction to the ODP viewpoints and OSI/NMF perspectives. Chapter 4 and chapter 5 are describing the use of ODP viewpoints and OSI/NMF perspectives in the NEMESYS experiment.

Our conclusions on this subject are outlined in chapter 6.

2.0 NEMESYS EXPERIMENT

A description of Traffic and QoS management for IBC networks was introduced in [6] and expanded in [TMN6/I/9]. These issues have also been addressed by the CCITT in the M and I recommendations [7]. The functions are detailed in [8] and RACE Common Functional Specifications [10]. The experiment case study and design are documented in [5] and [9]. The following are the main subsystems of the experiment (Figure 2):

IBC Network Simulators

The simulated IBC network consists of a user simulator, a service simulator and a network simulator. The network simulator establishes and simulates ATM connections across the simulated network.

The network simulator supplies the management system with information about the state of the connections and calls made in the network. The service simulator informs the management of any QoS degradation and user call profiles. The simulators implement management decisions.

Traffic Management System

This manages the network simulator. The traffic management system controls the routing and bandwidth allocated to virtual paths (VP). The Call Acceptance Function (CAF) parameters are computed by the traffic manager. These are required by the network simulator for the acceptance of a new connection onto the network. The CAF parameters are computed by the Call Acceptance Management (CAM).

Service Management System

This monitors the service simulator. From the simulator data it computes the QoS as perceived by the users and computes the traffic load predictions for the network. The bad QoS reports and the load predictions are send to the traffic manager for action on the network simulator.

3.0 MODELLING TECHNIQUES

The modelling techniques used in the NEMESYS experiment are the ODP viewpoints[3] and OSI/NMF perspectives [4]. The OSI/NMF perspectives are directly mappable into the ODP viewpoints and are specific to management systems [2]. The ODP viewpoints are applicable to any distributed system.

3.1 ODP Viewpoints

ODP addresses the underlying architecture for the development, management and operation of distributed information systems. To this end, the ISO ODP group have generated a Basic Reference model of ODP in five parts: Overview, Descriptive model, Prescriptive model, User model and the Architectural semantics [3].

In an attempt to deal with the full complexity of a distributed system, the ODP standards consider a system from different viewpoints, each of which is chosen to reflect one set of design concerns. Each viewpoint represents a different abstraction of the original distributed system, and is only concerned with the issues from that particular viewpoint, all other issues being ignored. The viewpoints are Enterprise, Computational, Information, Engineering and Technology. Each of these viewpoints has aspects, these being Process, Storage, User, Communications, Identification, Management and Security.

3.2 OSI/NMF Perspectives

The OSI/NMF is specific to distributed network management systems. It has a general architectural framework for addressing interoperable issues and a number of different perspectives are used for modelling the entire distributed management system. Each perspective describes a different abstraction of some aspects of the general model, its major components and their interactions. Collectively, the different perspectives address the total problem of interoperable network management. The five perspectives are Enterprise, Single Managed Object, Managed Object Relationships, Logical Distribution and Physical Distribution Perspectives. These have been defined in the OSI/NMF Forum Architecture document [4].

4.0 THE USE OF OPEN DISTRIBUTED PROCESSING VIEWPOINTS IN THE NEMESYS EXPERIMENT

4.1 Approach

The experiment was implemented in three stages. The first stage involved an understanding and decomposing of the complete experimental system using the ODP viewpoints. The second stage involved the analysis of the experiment components using traditional analysis and design techniques and the emerging object oriented analysis and design methods. The third stage involved the development of the system.

The approach undertaken for the first stage was a pictorial analysis of the experiment using ODP viewpoints. A number of diagrams represented each ODP viewpoint. These diagrams were further refined to reduce the level of abstraction and put more detail into the design of the experiment. These viewpoints were revisited after the second stage to reflect the accuracy of the experiment. In all cases the viewpoint models are compliant with the TMN implementation architecture defined in [2].

4.2 Enterprise Viewpoint

This addresses the legal, administrative, legislative and business concerns of an enterprise. The enterprise being modelled is an IBC network and its management. The derived model mainly addresses the administrative and ownership concerns. However this viewpoint is vital and necessary for development of the other viewpoints since it forms the basis from which other viewpoints develop.The experiment based on an IBC network and its management is modelled from three views in the enterprise viewpoint:

- The Network Enterprise model: This shows administrative and business concerns of the network and its management.
- The Organisation Enterprise model: This shows the experiment components are organized in relation to the network enterprise and is derived from the Network Enterprise model.
- The Human Interfaces model: In any human enterprise, the involvement of the people is of vital concerns to the operation of the enterprise. This model shows the relationship of the IBC network enterprise to human users.

The Telecommunications Network Enterprise Model

Figure 1 represents the ATM Network Enterprise model mapped onto the experiment. The successive stages required to arrive at this model are described in the NEMESYS Experiment design [9]. The physical network is derived from the work of the CCITT study group XVIII [7].

The role of providers, suppliers, ownership and administrators is still under review by the legislative bodies in most countries. For example, in a deregulated telecommunications market the virtual network would most likely be controlled by value added suppliers, whilst in a regulated market all the control is by the public telecommunication supplier. This conflict was resolved by the Network Enterprise being owned by one organisation but the control and management of segments of the IBC network being done by departments within the organisation.

Figure 1 also shows the system interactions with the human user.

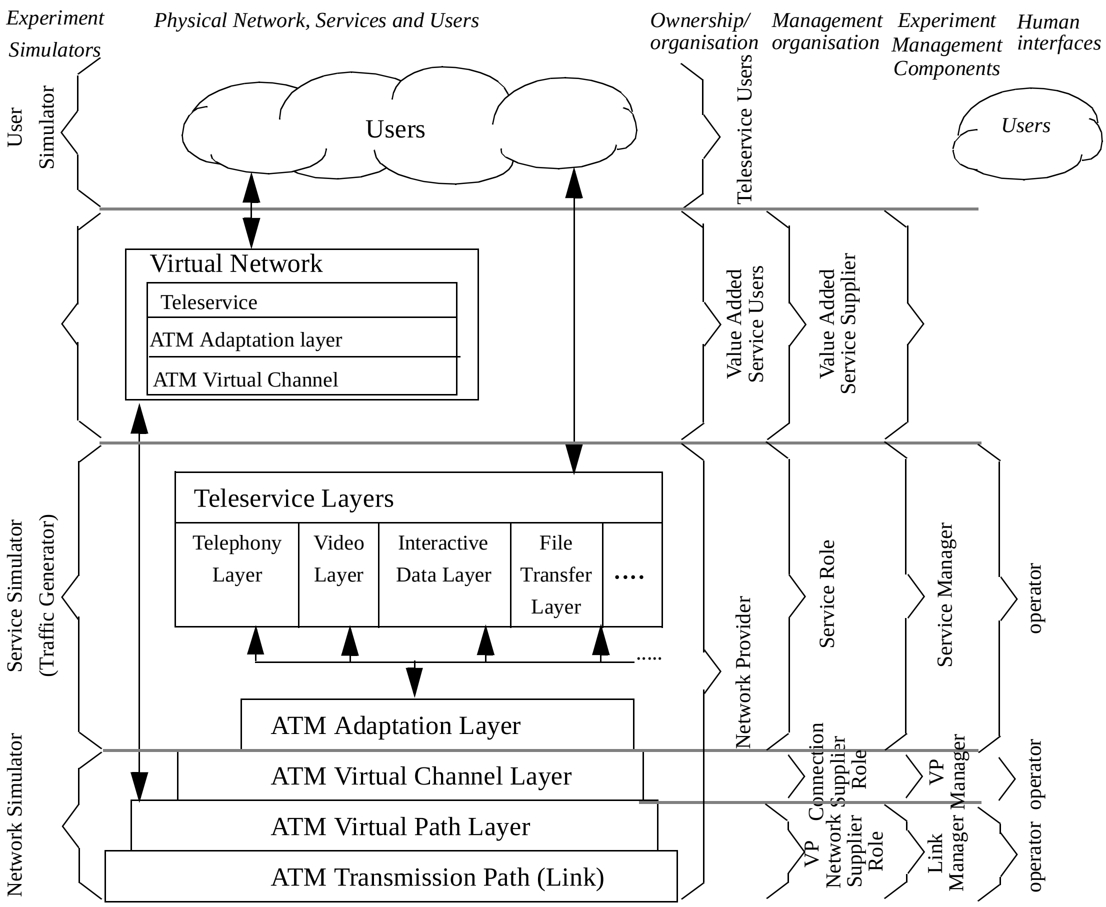

FIGURE 1. Telecommunications Network Enterprise model mapped onto NEMESYS Experiment

4.2 Information Viewpoint

Information is interpreted as data flows between the components of the system. It is created and stored at various places. This includes the Management Information Base (MIB) as defined in [2] and flow of information as events which may/may not trigger management activity and/or network reconfiguration. The location of the information is necessary in this viewpoint. The figures for this viewpoint reflect these by showing the logical level in which the information is stored. This complies with the CNA-M levels defines in [2]. The information viewpoint is modelled from the following areas of concern:

- Event Interfaces: This is information exchange between functional components. The standards bodies have stressed the importance of the interfaces between TMN Operational Systems [1], this viewpoint shows compliance with the q and x reference points of the TMN architecture[2].
- Management Information Base (MIB): The Manager Information Base (MIB) is based on the CMIS standard [14]. This is the repository of all management information in the TMN system.
- Data files. Since there are on-line and off-line components in this experiment, the interfaces between these are through files.

The Event Interfaces model

The event interfaces of the information viewpoint are shown in Figure 2. This displays potential event interfaces between the simulators and the Management Applications (MAs) and inter-MA event flows. A MA is the smallest amount of TMN functionality that can be assigned to an operating system process. In practice, several MAs are assigned to each process. This shows one TMN system composed of three components which interact with each other via the q_3 reference points. The interface between the network (simulators) and the TMN systems is via the q_x reference point.

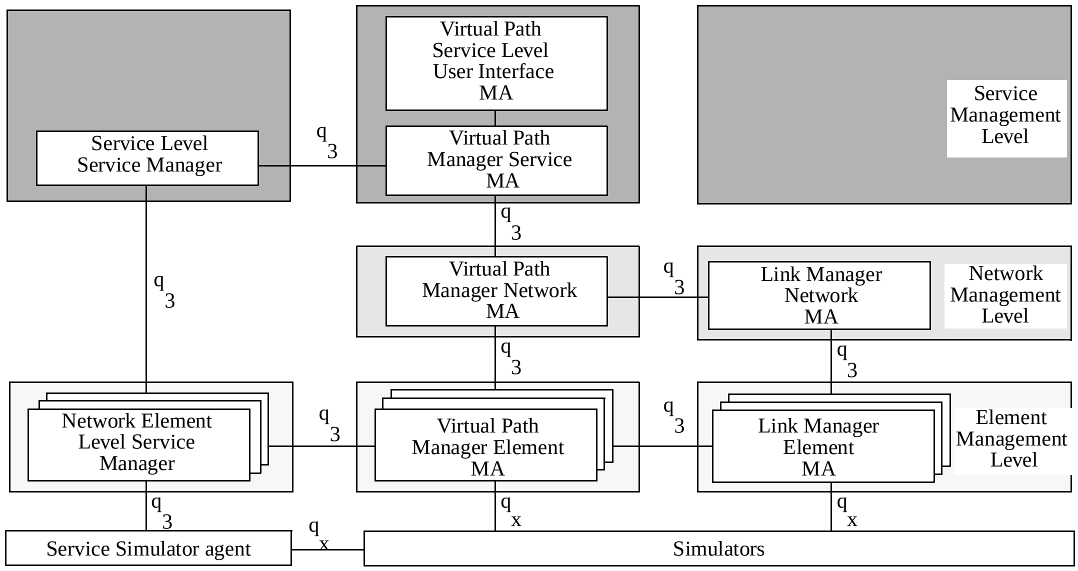

FIGURE 2. Reference Configuration for the NEMESYS Experiment

Management Information Base (MIB) model

Figure 3 shows the MIB of the NEMESYS experiment. Details of the Managed Objects (MO) can be obtained from [5]. This figure shows the structure and types of MO that have been implemented in the experiment. Each level has shadow MOs of the level below except for the Service Simulator agent (SSA). The SSA is a mediation function which translates simulator events into managed objects and management actions on the managed objects into events for the service simulator. Details of the managed objects are depicted in [9].

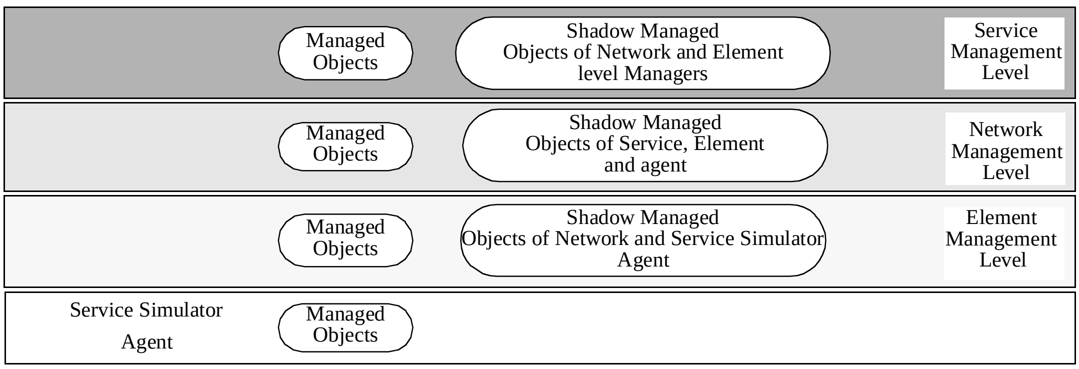

FIGURE 3. Management Information Base (MIB) model

4.3 Computational Viewpoint

This viewpoint lays the foundation for the development of the system. The experiment has a number of functional blocks:

- Simulators Functional blocks: These are the components of the simulator and the functional performed in these blocks.

- Experiment Platform Functional blocks: These are the components of the experiment control which provides the distribution framework for the other components.
- Service and Traffic Management Functional blocks

Figure 4 shows the experiment computational model; it also shows logical interaction of the events and the information flow.

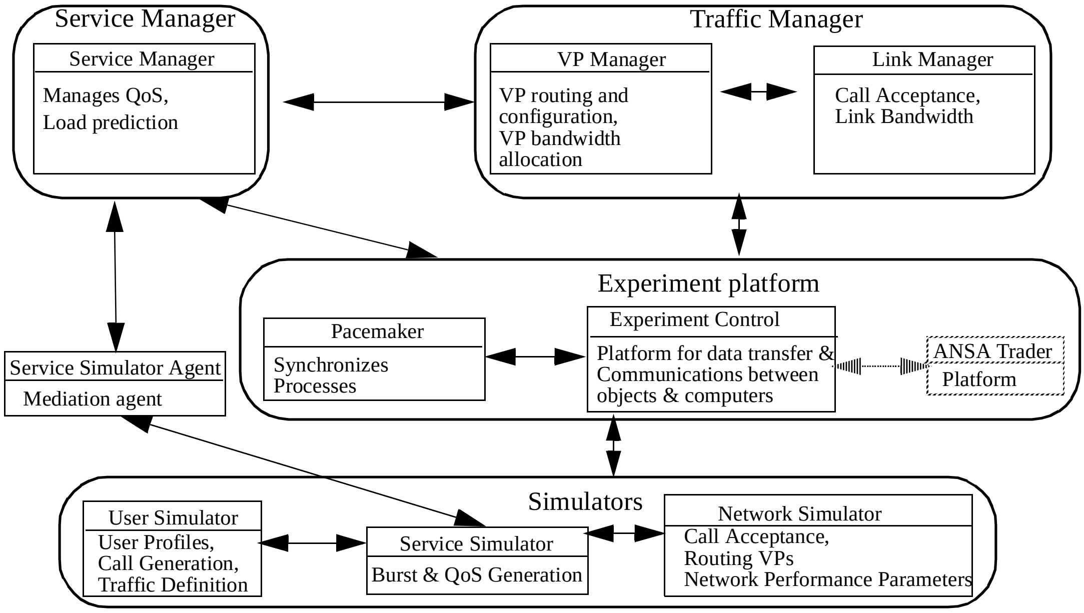

FIGURE 4. Experiment Components Functional Blocks

4.4 Engineering Viewpoint

This is the physical implementation of the computation viewpoint onto an information processing system. The experiment is engineered by mapping experiment functional blocks to the operating system processes. The techniques used in the experiment for the implementation are part of this viewpoint.

The mapping of the functional blocks to the processes is achieved by a configuration file, in most cases there is a one to one mapping between the functional block and a process.

Figure 5 shows the engineering techniques where used in the experiment.

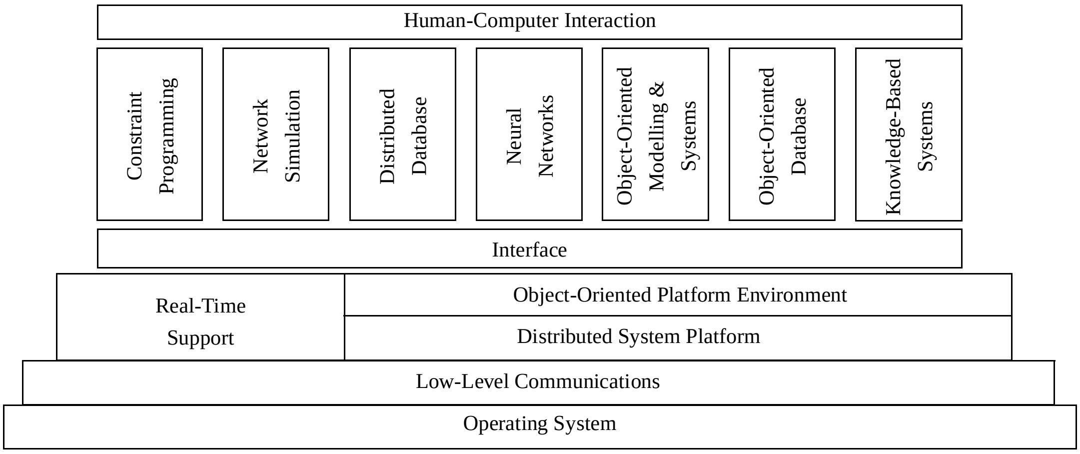

FIGURE 5. Experimental Advanced Information Processing techniques

4.5 Technology Viewpoint

The hardware and the software tools used in experimental are highlighted in this section. The tools used to implement the engineering techniques used shown in figure 6

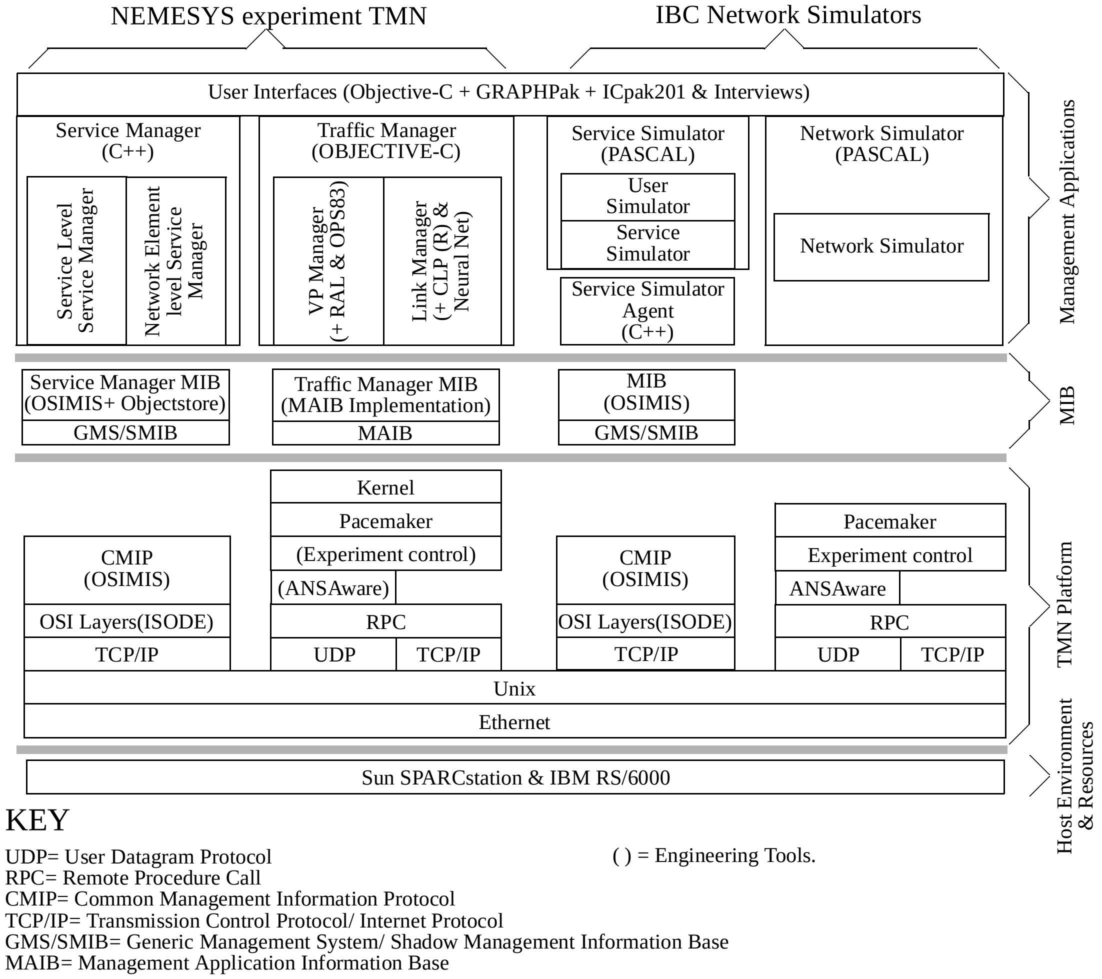

FIGURE 6. Experiment Technologies and their relationship to the TMN Layers

5.0 MODELLING THE SERVICE MANAGEMENT FUNCTIONS USING OSI/NM PERSPECTIVES

The ODP viewpoints provide a powerful tool for modelling distributed systems of any nature. TMN is a distributed application of specific nature and it is based on an object-oriented framework: the management of physical or logical real resources is enabled through abstractions of them known as Managed Objects (MO), accessed via a management protocol [12]. Management applications in agent roles support these objects while applications in manager roles access them in order to implement management policies.

The OSI Network Management Forum (OSI/NMF) [4] has defined five different perspectives, each modelling a separate aspect of the management system and collectively addressing the problem of distributed interoperable network management. The service management functions of the experiment TMN system were modelled using these perspectives and also implemented using real interoperable management services and protocols.

5.1 The Enterprise Perspective

The enterprise perspective of network management is concerned with user requirements, policies and the broadest level of interoperability modelling. Interoperability is achieved using the interoperable interface across a management network, in this case the TMN.

In the NEMESYS experiment there is one TMN owned by one organisation but control and management of the IBC network and services may be distributed within that organisation. Teleservices for example are offered by providers having no control over the management of the underlying IBC network. Instead, they should interact with the ATM network providers to introduce and withdraw services, point-out problems and provide statistics that may serve for a better planning at the network level.

These interactions should occur over interoperable interfaces and aspects such as interoperability, shared conceptual management information schema and interworking policies become important. Interoperability is achieved by using the OSI management protocol CMIS/P over a full OSI protocol stack. This is adequate for the management applications of the teleservice provider as there exists a common understanding of the management needs and information model. An interworking policy must be agreed which leads in a shared conceptual management schema.

In this case, the teleservice suppliers provide complaints on network connections offering poor quality of service according to previously agreed thresholds and they also process utilisation data to provide load predictions for the future. This is the agreed interworking policy and these interactions are naturally realised as event reports emitted from the related managed objects: QoS complaints are emitted from network connection objects receiving a poor service and load predictions from a “network” managed object as understood by the teleservice provider. The structure of the management information exchanged and its semantics must be commonly understood and that is what is achieved through the shared conceptual schema.

5.2 The Single Managed Object Perspective

Management systems exchange information modelled in terms of managed objects. The properties of a managed object are defined in an abstract form [13] and this specification together with the management access protocol CMIS/P [14], [15] identify uniquely the interoperable interface.

The managed objects are modelled according to the management application needs. As a first step after the requirements specification, the managed objects should be identified. This is a difficult task as all management capabilities should be expressed as managed object properties. Extensibility provisions to management needs should also be made and careful modelling may minimise the interactions between management applications.

From this perspective, the necessary managed object classes need to be identified. This includes their attributes, supported actions and emitted notifications. Operations on attributes and actions may trigger interactions to the associated real resource: it is through this modelling that management capabilities will be achieved, enabling monitoring through event reporting and reading of attribute values and control (intrusive management) through setting attribute values and actions.

In the case of service management, the managed object classes that may be identified relate to service associations (calls), network connections, service providers, service users, networks, services, performance profiles etc.

5.3 The Managed Object Relationships Perspective

Managed objects do not exist in isolation. In fact, relationships such as inheritance and containment are fundamental to the existence of managed objects: managed object classes come into existence through registration to a global inheritance tree while managed object instances are named through containment relationships in the Management Information Tree (MIT) [12].

Information and behaviour may be inherited through generic objects and also alternative behaviour may ne supported through polymorphism. For example, the classes teleservice and bearer-service are refinements of the generic class service.

With containment, managed object instances acquire unique names through the relative names of their containing objects. Containment relationships are specified through name bindings which tell which class can be the superior and which attribute names the particular class in that instance.

There are also other relationships such as IS-CONNECTED-TO, BACKS-UP, USES which may be expressed by special attributes or even special relationship managed objects.

The inheritance and containment trees for Quality of Service Management are shown in Figures 7 and 8.

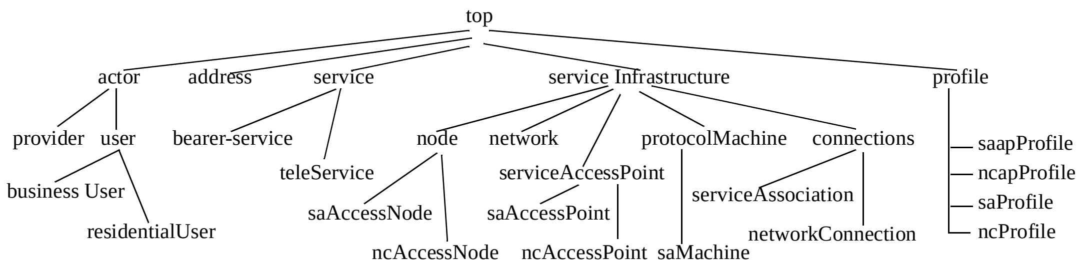

FIGURE 7. Managed object relationships perspective- Inheritance Hierarchy

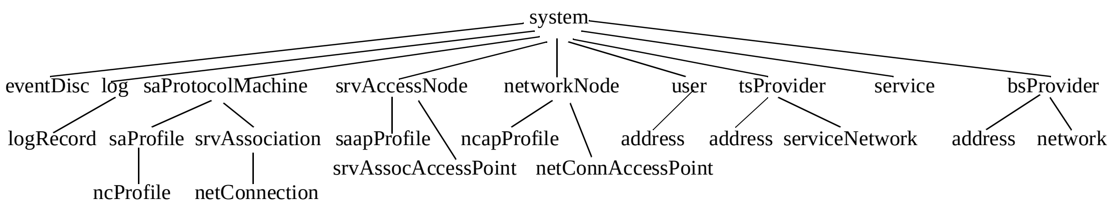

FIGURE 8. Managed object relationships perspective- Containment Hierarchy

5.4 The Logical Distribution Perspective

The relationships between managed objects do not consider at all their distribution. The global QoS containment tree shown in figure 8 is physically distributed across many interoperating management applications across the network. This physical distribution is decided upon the management needs and the authority relationships.

In this case, the relationships are hierarchical as the management model complies closely to the TMN Logical Layered Architecture [2]. There are three layers in this architecture regarding QoS management. The Network Element layer which in this case comprises the actual teleservices, these being the “elements” of service management. Monitoring and controlling these may be done in an non standard way, but an object-oriented view can be presented to higher layers through a mediation function (SSA - Service Simulation Agent as services and the IBC network are simulated). Objects at this level comprise service associations, the underlying network connections and associated profiles.

The Network Element Management layer manipulates managed objects at the network element layer and creates higher level abstractions. These are service and network access points and associated profiles. It is also responsible for producing the quality of service complaints when the monitored QoS decreases and for aggregating utilisation information at each access point. The latter is used by the layer above in order to evaluate patterns of usage in the service network.

Finally, the Service Layer has a global view of the service network in terms of service providers, services and users. A part of this information is made available to peer level functions of the network providers. Load predictions derived from the patterns of usage are sent to assist to their management functions. The management schema is exported and the management knowledge is shared. This logical distribution is presented in Figure 9, the containment relationships and the managed object classes at each layer being shown.

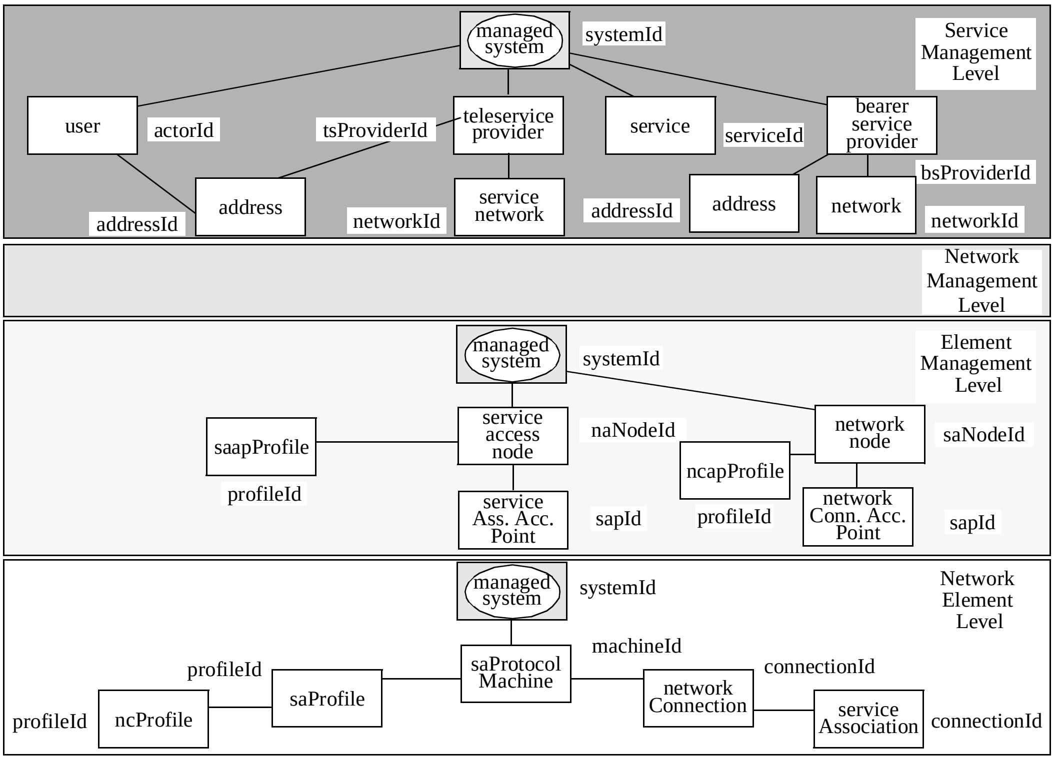

FIGURE 9. Logical distribution perspective

5.5 The Physical Distribution Perspective

The physical distribution covers the mechanisms, structures and rules when the cooperating applications are realised by a physically distributed set of information processing systems. The logically layered management information model may be realised as a set of distributed applications (figure 10). At the lowest layer, services will exist at the customers premises and there may be many mediation function boxes. The actual services and users are simulated by one application, the service and user simulator. There is also one only mediation function block, the SSA.

The same applies to the other two layers where there is one only Operations System in each layer: the Network Element Level Service Manager (NELSM) and the Service Level Service Manager (SLSM). In a real system, there would probably exist more operations systems in each layer and relationships would also be peer-to-peer as opposed to strictly hierarchical.

Interoperable interfaces and protocols used are also important. The Q_3 and X interfaces are realised as managed object interactions through CMIS/P and a full OSI stack. The Qx interface to the actual services could non standard: in the experiment case, it is a TCP-based message passing mechanism between the Service Simulator and the SSA.

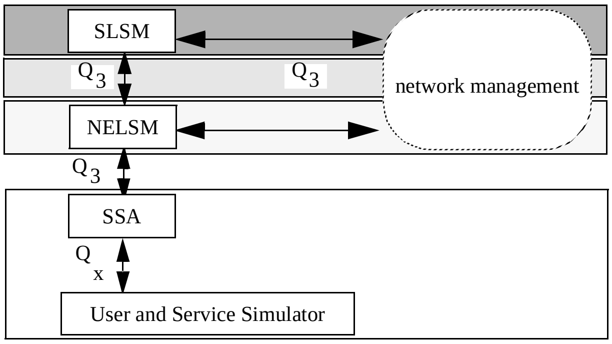

FIGURE 10. Physical distribution perspective

6.0 CONCLUSION

Broadband Networks and Open Distributed Systems are technologies which significantly change the way information is processed and disseminated.

Broadband Network Management Systems will naturally linked to form large distributed systems, which will be inherently heterogeneous. Management Systems will have to be open in order to facilitate interaction and cooperation between themselves.

Open Distributed Processing sets up the framework within which this cooperation will be feasible.

This paper presents the applications of the ODP and OSI/NM frameworks to the design of Traffic and Quality of Service Management Systems for Integrated Broadband Communications Networks.

It argues that the ODP and OSI/NM viewpoints represent a significant modelling tool in the analysis of the problem domain as well in the design of a solution.

The useability of the ODP modelling in TMN requires automation tools which will assist in the development and the formalization of the models and their consistency.

Viewing the system from five different viewpoints produces five different abstractions which must be consistent with each other. Maintaining the consistency when developing five different models of the same system is one of the main issues to be clarified in the future.

7.0 ACKNOWLEDGEMENTS

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