Journal of Network and Systems Management, Vol. 7, No. 4, 1999

Integrated TMN Service Management

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The deregulation of the global telecommunication industry has seen a change in the business and operational environment in which services are deployed and managed. The requirements have intensified to provide a management framework for telecommunication networks and services across multiple technology domains and using multiple management technologies. This paper describes an integrated TMN service management architecture that provides an environment for different service management functions anddifferent management domains tobeintegrated. To further substantiate thisarchitecture, asystem was built todemonstrate theintegration concepts. The research and development work reported in this paper focuses on the following two aspects of integration: first the integration between TMN network and service management functions; and next the integration between different service management functions. Aproof of concept system was developed todemonstrate such integration. It consists of the following components: Generic service ordering and provisioning; connection management based on *ageneric network model* concept; and service management based upon *service level agreement* management and *customer service management* concepts. This paper reports this work and the experiences gained from this research.

KEY WORDS: Integrated service management; customer service management; service ordering; service provisioning; connection management; CORBA; TMN.

1. INTRODUCTION

The worldwide deregulation of the telecommunication industry has forced the telecommunication corporations (telcos) to reorganize business processes and adopt new technologies to manage networks and services. As opposed to the network management, which addresses the cost reduction side of the equation, the service offering andservice managementactivities deal with the revenue generation. The technology framework in which the telco services are offered and

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managed becomes the major enabler for telcos to compete in the new business environment.

The telco industry has seen the following business trends and technology progression in recent years:

- Following deregulation and increased competition, customer care systems integrated with process reengineer ing have provided a competitive edge to the telco industry.
- The distinction between the traditional distributed computing environment and telecommunication environment has blurred following the use of computer technology. For example, some telecommunication services have only small differences from a traditional financial service.
- An integrated environment for both service offering and service management is essential to a telco's success. There is currently a chasm between TMN (Telecommunication Management Network) service management and network management [1]. The challenge facing the industry is to bridge this chasm by providing a reliable, scalable and extensible computing environment upon which telco services can be offered, managed and integrated with the network.

Significant contributions have been made and reported in literature in providing management functionality in different service management and network management areas, such as managing broadband virtual private network [2, 3] and managing ATM services and Quality-of- Service (QoS) [4, 5]. However, the telecommunication industry needs integrated business solutions and evidence that distributed computing environment can be integrated seamlessly with the existing TMN, OSS (Operation Support System) and the user environments. Without this integration, distributed object technology will have very limited role within the telecommunications industry.

This paper reports our effort to define and build such an integrated management framework for telecommunication networks and services. The following types of integration have been identified:

- Between different service management functions, such as FCAPS (Fault management, Configuration management, Account management, Performance management, and Security management)
- Between different management domains, such as SML, NML and EML (Service Management Layer, Network Management Layer and Element Management Layer). In particular, network management and service management,
- Management solutions across multiple technology domains such as ATM, SDH/SONET, Frame Relay and IP,

- Management solutions using multiple management technologies such as OSI, CORBA, Java, etc.

We have developed the following two important concepts to help achieve these integrations:

- A *Generic Network Model* concept [6] is developed to achieve the integration between different management domains and across multiple technologies. A generic network model is a technology neutral information model for network functions. It supports network and service management functions in a technology and protocol neutral manner.
- A *service level agreement* management and *customer service management* concept toachieve the integration between service management functions. That is,the functionalitytosupport customerservice lifecycle and quality-ofservice is used as the integration point for FCAPS functions.

To investigate these integrations, a proof of concept system was developed. It consists of the following components:

- A generic service ordering and provisioning component comformant to a snapshot of the Network Management Forum (NMF) Service Ordering Specification [7–9] currently under development.
- A CORBA-based connection management component based on the generic network model concept
- A service management component based on the service level agreement and a customer service management concepts

This paper reports this work in detail and the experiences gained. Section 2 briefly discusses the business requirements which provide a justification for this research. Section 3 proposes high level business solutions that could serve as an integration framework. Section 4 focuses on the business processes of the two integration scenarios (e.g., between service management functions and between service management and network management). Section 5 describes our integration architecture and the technology framework used for integration. Section 6 describes the proof of concept system in more detail. Finally, Section 7 summarizes our experiences and lists potential future work in this area.

2. BUSINESS REQUIREMENTS

A major problem faced by the telecommunication industry is how different management technologies can be used to provide solutions for the industry. The following issues are of major concern:

- availability and reliability—the ability to support telco business in a 7 × 24 way. This is the overriding requirement that the industry will not use any technology that cannot provide a reliable service.
- integration with different systems and legacy systems—the strategy to protect the huge investment the industry has already made inexisting systems. These systems include all existing network management, element management applications,comm unication stacks, OSS applications which support the telcos core business. A clear cut with the past, no matter how desirable, is not an option to the telco industry.
- customer service management platform—thestrategy toprovide afl exible and lightweight customer service management platform. This platform must be well integrated with the distributed object paradigm and must not place a huge overhead burden on the traditional client platform. With the popularity of the internet and Java technology, telcos need a cheap and flexible way to deploy services to customers quickly.

The Network ManagementForum (NMF) hasinvested significant effort into defining business solutions. One of its key programs, SMART (Service Management Automation and Reengineer ing Team), delivers business agreements that help Service Providers (SP) and network operators to automate information exchange. These agreements will not only improve customer care and service operations, they also eliminate the need for costly bilateral agreements among operators moving into global markets.

The SMART business process specifications deal with TMN based service management activities including service ordering, service provisioning, performance management, fault management, trouble ticket management and billing. One important concept, the management of service level agreement, is emerging as the integration point for these activities.

The proof of concept system discussed in this paper follows the direction of the NMF SMART program. It focuses on anintegrate dapproach todelivering SMART business processes.

The SMART Business Process specifications provide a Service Management framework which enables service providers to ask and receive the answers to a number of network planning and trend analysis questions. These questions include the following:

- what Service Level Agreements (SLAs) will be violated by a particular maintenance activity?
- what potential capacity problems are developing in the network?
- what SLAs are potentially going to be broken if network usage trends continue? or if certain network behavior scenarios occur?
- how an SLA isaffected when suborders from other service providers are not performing well?

The NMF SMART working groups have not defined how SLAs are managed. SLAs are of significant importanceand are central to the behavior of most business processes. As the SLA belongs to a group of specifications and not just toany particular specification, anSLA ManagementServer should bedeveloped. This will provide controlled access to the SLA information and will carry out the tasks required tom anage the SLA data (i.e., database management, life cycle management).

3. BUSINESS SOLUTIONS

The aim of the research and development work reported in this paper is to present a consistent architecture for building distributed network and service management solutions. This architecturecan be used as an evolving platform on which we can test, verify and demonstrate new technologies, and more importantly, this can be used as a platform to define and offer customer solutions.

The second purpose of this demonstration platform is to help customers in using appropriate technologies to support business processes. It is therefore focused on customer solutions, not technologies.

Webuilt an integrated management platform which has the following major components:

- *Customer Services Environment:* This environment provides a well integrated customer interface to the service provisioning and management environment. It is a cross platform, lightweight user environment which offers a service access environment for operators and endusers.
- *Service Provider Environment:* This environment supports the implementation of business semantics for applications, management functions, workflow for business processes, and basic distributed infrastructure support.
- *Network Environment:* This environment provides a downward integration between the service management environment and the network environment.

The strategy taken to execute the projects in this program has the following aims:

- To use the business process model provided by NMF as the basic underlying model.
- To implement a set of common business scenarios pertinent to the telco industry. The technologies used in the architecture are perceived as the enabling technologies which provide the functional capability, flexibility and reliability required bythe platform. Itis expected the architecturewill survive the impact of technology evolution and migration.

- To demonstrate the value added by the integration of components within aservice provider and the integration between different service providers.

4. SERVICE MANAGEMENT BUSINESS INTEGRATION SCENARIO

Figure 1 depicts the typical interactions in aservice provider's management environment.

This scenario shows the following basic components in each of the service provider environments:

- Customer contact interface
- Ordering system, which includes the backend workflow processes required to support the automation of the ordering process
- Problem reporting system, which contains trouble ticketing management (this may make use of workflow processes as well)
- Billing
- Local network and service configuration, which has access to managed network elements
- Fault management
- Managed network which provides the basic support for the service provided

There are two types of interaction points depicted in Fig. 1:

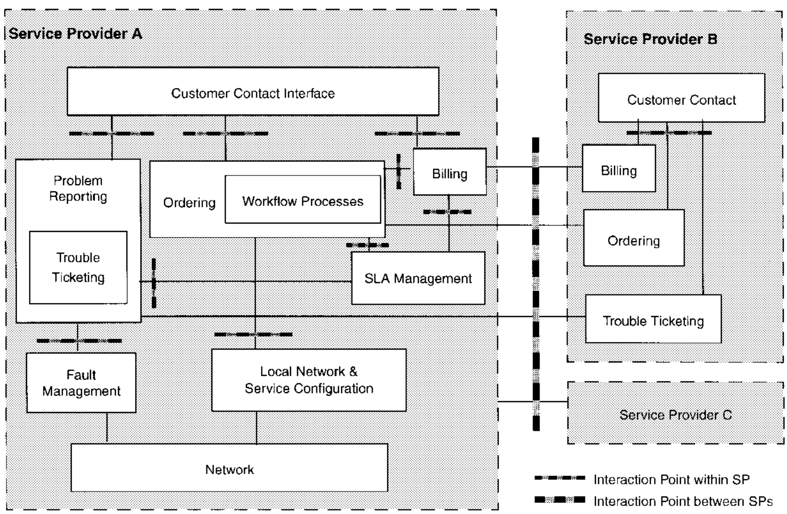

Fig. 1. Business processes integration scenario.

- *The interaction between different service management processes within a single service provider's domain.* There is a strong requirement that different service management functions be integrated to offer a complete service management function visible to customers and operators. This interaction will provide a common interface to both service providers and customers to access integrated service management functions. The integrated service management functions make use of the quality-of-service defined in the service level agreement established between customers and service providers. Each service provider can choose its own communication protocols between different service management functions.
- *The interaction of service management functions between different service providers.* There is a strong requirement for interoperability at the business level between different service providers in order to support customer service management functionality. In a global deregulated environment, this interaction is important for achieving *one-stop-shopping* for end customers. Standardized interfaces between different service providers are required in order to support this interoperability. Currently, standards communities, such as NMF, are making effort to define such interfaces. The Service Ordering interface, discussed (see [9]; and Chen and Kong [10]) and used in Section 6 of this paper, is one example.

5. INTEGRATED TMN MANAGEMENT FRAMEWORK

This section provides a focused discussion on the integration framework. The integration of TMN management occurs at many different levels and areas. Examples of such integration include integrations at user interface level, application level, technology level, integrations horizontally across FCAPS functions, and integrations vertically across different TMN management layers. In this paper, we focus on the following three aspects of the integration:

- The technology framework
  An integration architecture is proposed as a framework to develop TMN applications, where appropriate management technology is used for the different management domains.
- Integration between network management and service management
  This deals with the integration between network and service management functions. A generic network model is proposed as the source of integration.
- Integrated service management functions

This examines the issues of integrating different TMN service management functions. SLA management is used as a framework to integrate these functions.

5.1. Technology Framework for Integration

Multiple management frameworks and technologies exist to provide different management functions. Particularly, the TMN management framework and OSI-based management technology are prevalent within the Telco environment. Until now, GDMO object modeling and the OSI-based element and network management technology has been used to define the global telecommunication equipment and networks as well as to provide the management functions. This managed environment is large in size and growing rapidly. The management systems deployed to date to manage this environment are mostly centralized and facing problems of extensibility and scalability.

As the managed environment grows and the demand for the management system increases, the nondistributed architecture of OSI shows its limitations. The only alternative is to move to a more complex distributed architecture to support the required level to scalability. This requires a strategy for the integration of existing OSI technology with distributed computing technology.

At present Java and the Web are becoming more ubiquitous as GUI technology. It is becoming obvious that customer service management delivered through web technology is not only possible but also desirable. This customer service management needs to be well integrated with the underlying management technology. In light of this, we propose the following integrated management architecture (Fig. 2) for the integration of customer service management through to the element management.

Java and Web based technologies are ideally suited to the client interface

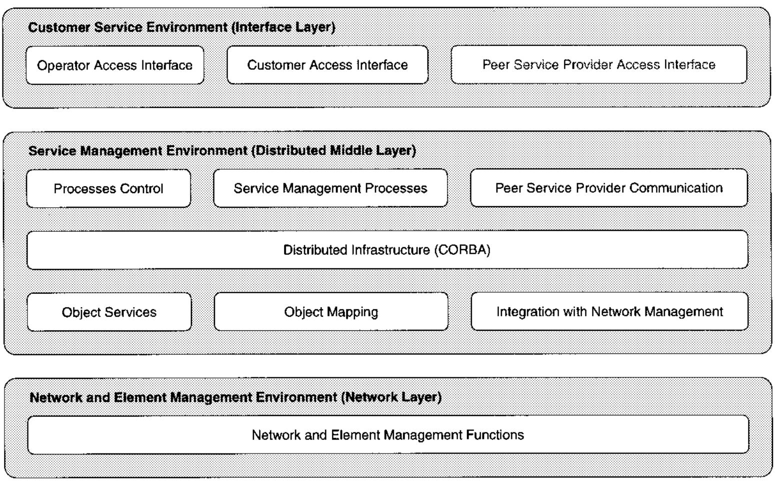

Fig. 2. Integrated management architecture.

and providing a technology framework for customer service management. Java and Web technologies are additionally suited to building lightweight GUIs and are easily integrated with object based technologies such as CORBA.

CORBA can play a very important role in the service management and network management layers of the TMN model. It allows the definition of coarse grain objects and supports abstract modeling ofnetworks and services tobe managed [6, 11]. The distributed infrastructure supported by the ORB and CORBA services provide the functionality that is required to build large scale distributed management software. It also provide improved scalability and location transparency which were features lacking from alternatives technologies.

The EML and some portions of the NML are considered by most of the industry as a problem that has been solved. While CMIP and GDMO were viewed by the industry as less than optimal solutions to the problem, the work that has been done by organizations such as ITU-T (particularly on the definition of Managed Information) is viewed as an adequate solution for this level. Though some have expressed a desire to implement all new software solutions (i.e., mediation devices) using CORBA, we do not view this as the area where CORBA can offer most value.

CMIP has largely been viewed bythe industry asthe correct solution for the management ofnetwork elements. Alot ofwork hasalready been invested inthis level ofthe TMN model. Effort defining the appropriateabstractions and models for theother layers (i.e., SML and NML) isviewed asa better investmentof time and development effort. The definitions of these abstractions and information models are the key to the integration of the TMN management domains.

5.2. Generic Network Model

One ofthe key issues, when using different management technologies, isthe integration of potentially different object models and definitions of the managed environment. CORBA/TMN integration is a good example. Many efforts have been made to translate the existing TMN network object model into CORBA world in order to use CORBA to manage telecommunication networks and elements. It is soon realized that different object mapping approaches can be used to maximize the advantages of using distributed technologies such as CORBA and to support different types of integrations such as integration between service management and network management [12]. In the area of CORBA/OSI integration for network management and service management, it emerges that the definition of a technology neutral object model for the managed environment is a key component in achieving an appropriate level of integration.

A Generic Object Model is also important for application integration. For disparate applications to be effectively integrated, there must be a shared data model. This model guarantees that each application will represent any common concepts in the same way, allowing this information to be viewed and manipulated by each application as required in a well-defined way.

For a network management application, the common data is the network model, which contains at least a model of the physical topology of the network—the hardware (switches, repeaters, multiplexers) and the cables or wireless connections that interconnect them. Logical constructs may be layered on top of this basic model: for example, SDH/SONET rings, administrative domains, or ATM virtual LANs.

Network management applications, in order to be integrated, must share this common network model. If this is not done, each application must maintain its own view of the network, which introduces the problems of ensuring each view is consistent with the other views. This makes it difficult to accurately represent the actual network being managed. Today's applications typically do not share a common model. Instead, information must be exported from one application to another, in a process which is often error-prone and time-consuming to implement and maintain.

If using CORBA as the distributed management platform, the common network model can be represented by distributed objects and the relationships between those objects. The various elements of the model are represented by CORBA objects supporting standardized interfaces and implemented in servers from a variety of vendors. A relationship service is used to store the relationships between those objects.

The implementation of these CORBA objects may interface directly to the hardware, or may act as gateways to other technologies, such as OSI. This allows legacy element management systems to be integrated into the CORBA-based solution.

In the demonstrator, we defined a simple generic network model. It uses a series of distributed objects to represent concepts such as network elements, ports, cross-connections and cables. The relationships between these objects is stored in a relationship service.

Connection management was implemented as a separate application that extended the basic network model; the routes for end-to-end paths were established by traversing the modeled network. CORBA objects were used to represent each path; the associations between these path objects and the elements in the basic network model that made up the path (mainly cross-connections) were added to the relationship service.

5.3. Integrated Service Management Functions

The service ordering process defines an SLA between the customer and the service provider. The ordering framework allows customers to negotiate the quality-of-service parameters in order to establish an agreed SLA with the service provider. The service provider may suborder part or all of the service from different service providers, thus resulting in SLAs between different service providers.

A performance management system is developed to manage all the performance parameters detailed in the SLAs. A network analyzer is incorporated in the performance management system. The network analyzer would take the performance data, trouble ticket and SLA information provided by the SMART Business Processes and combine it with the knowledge of the network topology to form a network model that can be analyzed.

The following SMART Business Processes are required to provide the data necessary for the analysis of the network:

- Performance Reporting
- Problem Handling
- Service Ordering
- Service Configuration

These processes enable the setup of network connectivity based on negotiated service orders and the reception of trouble tickets and performance data which enables the detection and analysis of network problems.

An automated service reconfiguration system based on the analysis results can also be developed.

The management of SLAs is an issue yet to be satisfactorily addressed by NMF. Currently, no agreement has been made on how SLAs should be managed. So the SLA Manager is potentially a major deviation from the model that may finally be developed by NMF.

6. INTEGRATED SERVICE PROVISIONING AND MANAGEMENT DEMONSTRATOR

Although the telecommunication management industry has undergone a change in mentality from *seeking the best management technology* to the *co-existence of multiple management technologies*, the key issue now is how to obtain benefit from an integration of different technologies in creating management solutions. The ability to reconcile different management models is the key to achieving successful integration. In the integration of CORBA-based service management and OSI-based network and element management environments, the key issue is to reconcile the differences between GDMO object model and the CORBA object model.

6.1. Demonstration Architecture

In order to evaluate the issues related to building integrated software solutions for managing a TMN environment, we have embarked on an exercise to build a demonstrator of the integrated architecture. The purpose of the demonstrator is to examine the issues related to the integration of multiple technologies, particularly OSI, CORBA and Java. The demonstrator also enables us to verify our understanding of the technical problems and solutions to TMN service management, which is a much less understood area compared to TMN network and element management. In addition, this made it possible to demonstrate the feasibility of integrating customer, service and network management environments, which are elements of the TMN framework as well as the service management business process model as defined by NMF.

The focus of this demonstration platform is to help customers use appropriate technology to support business processes. It is focused on customer solutions, not technologies.

We built a service provisioning system with ordering and end-to-end connection to management capability, and integrated this with service quality management. The system provides a customer service management environment, that is, it is available for both service providers and end customers to access the performance management functionality. A Video-on-Demand (VOD) was selected as the service used to demonstrate the functionality of the overall system.

Figure 3 depicts the functional architecture of the demonstration. A service level agreement is used as the integration point between the service provisioning system and the service management system.

The proposed OMG (Object Management Group) topology service and its implementation offers a useful environment for different CORBA-based applications and services to be integrated by supporting the functionality to establish object relations and query facilities to find out related objects.

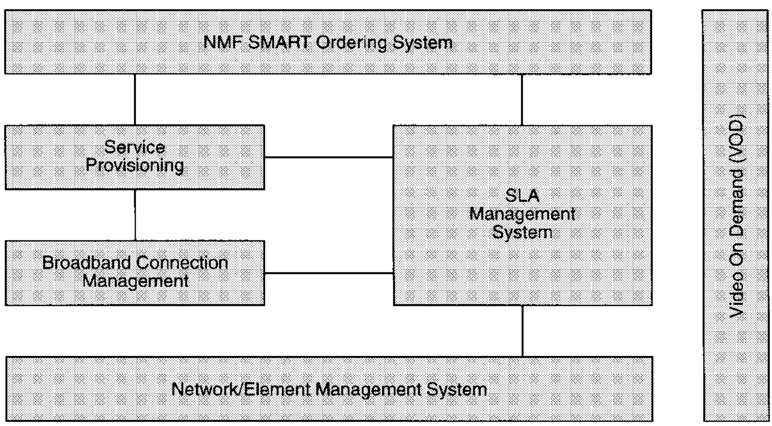

Fig. 3. Overall architecture.

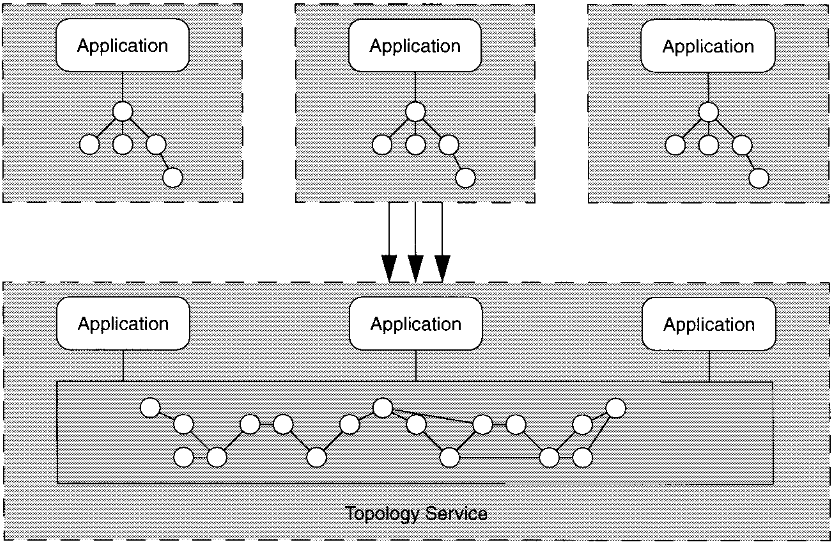

Fig. 4. Application integration based on topology service.

The Topology service is designed to serve as an integration point between separately-developed applications. Figure 4 depicts how the topology service can be used to integrate three separatelyd eveloped applications.

In the demonstration, we focus on:

- demonstrating the generic service ordering and provisioning concepts
- demonstrating how the topology service can be used as an application level integration framework
- demonstrating the use of the topology service as a method of integrating cross domain connection management systems

The integration scenarios prototyped include:

- the integration of service ordering and service provisioning frameworks.
- the integration ofconnection managem ent,and thegeneric broadband network model.
- the integration of connection management and performance management functions by aggregating their object models.

6.2. Service Ordering

The service ordering system was a proof of concept implementation of the NMF SMART ordering interface specification which is currently under development at NMF. CiTRs R&D team has made major contributions to the object model and its interface specification.

The service ordering system developed is a distributed system with the client components providing functionality for customer access and the server component providing functionality for managing the SPs environment. The ordering process contains features for service parameter negotiation, provisioning, *service level agreement* (SLA) management,and service delivery. Itincludes service provider workflow supporting process flowthrough, and a SPtoSP interface based on the NMFs service ordering object model created by CiTR and being progressed through the NMF.

Three software components are implemented in the ordering system: a customer management system acting as a client system; a service provider environment acting as a server and a trader subsystem.

The trader provides the service registration function which provides afederated view of all services offered by different service providers. In the demonstration, the trader is a simple implementation modeled on the OMG trading service.

6.2.1. Order Scenario

In the service ordering scenario, the customer orders a service from the *Main Service Provider* (MSP) which provides the sole contact point and the integrated management functions for the customer services. The MSP may in turn order services fromother *Subcontracted Service Providers* (SSP) to deliver a packaged service and facilitate all interactions with them on behalf of its customer.

The ordering process begins with a preorder from the customer which results in a proposal being generated by the MSP and presented to the customer. The customer can then negotiate the service quality parameters which will be used as the major parameters in the SLA. Finally, a firm order based on negotiated SLA can be placed and the service ordered can then be delivered.

Figure 5 depicts this service ordering scenario. The Service Ordering interface discussed [9, 10] is used as the communication mechanism in Customer-toSP and SPtoSP interactions.

The MSP may use the same information flow and process flow to order components ofthe endservice fromother service providers tofulfi llacustomer 's order. NMF hasdefi nedthe standard information and process flows for the ordering process. The process flow function is provided by a workflow system.

6.2.2. Customer Management

The main functionality of the customer management component consists of:

- *Network topology view:* This provides a customer network view of asim -

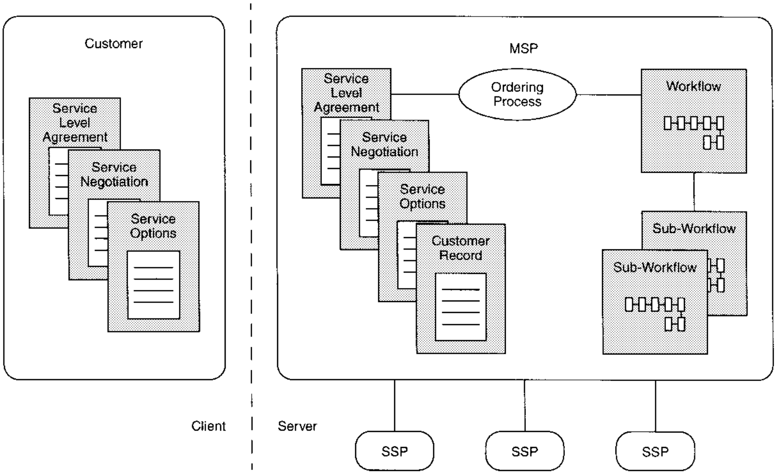

Fig. 5. Service ordering scenario.

ulated network environment which supports the customer's services. It includes the basic performance indicators for this subnet of the network and any connections required to support the services.

- *Service Ordering:* This enables customers to request offers, view SLAs, negotiate service offers and finally make orders.

The main customer GUI is shown in Fig. 6.

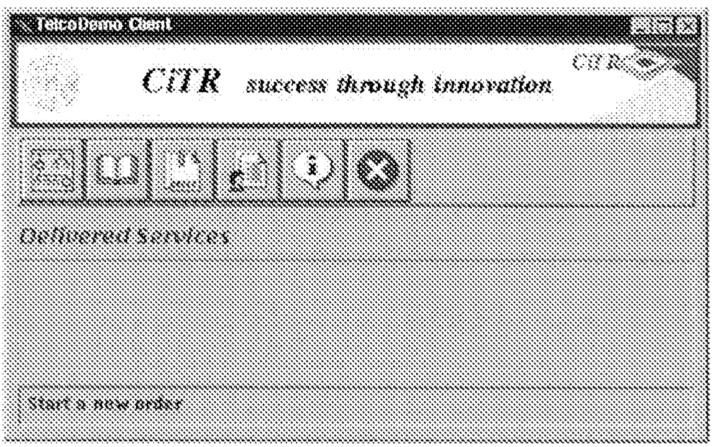

Fig. 6. Client GUI.

6.2.3. Service Provider Management Component

The main functionality of the Service Provider management component includes:

- *Network topology view:* This provides the SP operator with a complete view of the simulated network environment. This view includes all customer service and network performance information.
- *Network simulation and planning tool:* This provides a link between network management functions (network topology view) and service management functions (SLA view). The tool can also be used to simulate the impact of network status (e.g., congestion) upon services.
- *Service Level Agreement (SLA):* This function enables displaying ofactive SLAs. Expired SLAs may no longer be binding and therefore are not displayed.
- *Customer Workflow:* Allows tracking of progress made in the definition or delivery of a service. The display shows the workflow activities wich have been completed.

The service provider management component also consists of some look up functions which enable the operators to view:

- Service Orders
- Service Offers
- Customer Information
- Service Information

Operators can perform any of the above functionality by select an icon from the toolbar of the main Service Provider GUI. Figure 7 is the main Service Provider GUI.

6.2.4. Service Provider Workflow

The service provider workflow subsystem s is responsible for controlling the flow of the service ordering process. It follows the NMFs business process specifications for service ordering and monitors the status of ordering tasks.

Each task in this workflow can have its own sub-workfl ow if the task has workflow activities with sub-tasks. An example of this is the negotiation of service parameters which includes sub-workfl ow activities reflecting the different stages of SLA negotiation.

The workflow engine is very important as it enables coordination and control of the service ordering and provisioning tasks. It provides visual representation of the ordering and provisioning process.

6.2.5. SubOrdering

The NMF service ordering object model and interfaces are defined for the purpose of exchanging ordering information between two service providers. In

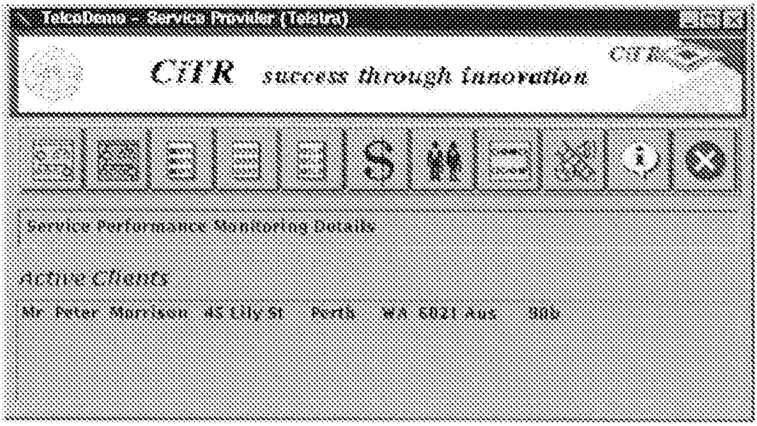

Fig. 7. Service provider GUI.

a typical ordering situation, when a customer orders a service from an MSP, the MSP may suborder part of the service from other service providers. This chain of subordering can theoretically continue to any length. The demonstration systemuses exactly the same software components (SP components, trader, workflow, etc.) to carry on this recursion to other service providers.

6.2.6. Trader

As indicated before, an OMGstyle trading service component was developed to provide the trading function. This was used as the mechanism for service providers to register and deregister their services which could be ordered. Since the OMG trader is a federated CORBA service, the demonstration' trader offers a federated view of services provided by any of the participating service providers.

6.3. Service Provisioning

This component is responsible for provisioning the service that is specified in the SLA. This includes the creation of abroadband virtual circuit between the customer premises and the service provider: this is accomplished by the Broadband Connection Management component, which is described in Section 6.4. Once the virtual circuit is in place, it is used to deliver the service (in the case of the demonstrator, this is video data).

In the demonstrator, the CORBA object representing the virtual circuit is associated at this point with the object representingthe SLA in the OMG topology service.

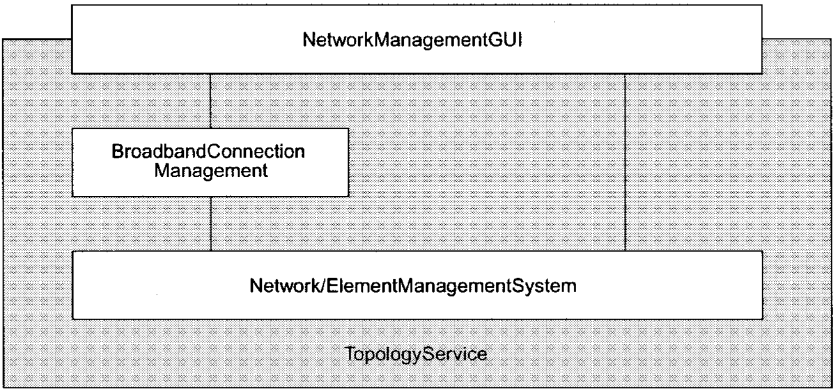

Fig. 8. Network management components.

6.4. Network Management

The network management system of the demonstrator contains three functional components:

- Network/Element Management System
- Broadband Connection Management
- Network Management GUI

The relationship between these components is shown in Fig. 8. Next, these components are described.

6.4.1. Network/Element Management System
This component is a realization of the proposed generic network model. It uses CORBA objects to represent the various elements of the network being managed. These objects are registered in the OMG Topology Service, as are the relationships indicating the physical connections between the objects. This subsystem provides all the functionality necessary to manage the network elements. This includes accessing of states and properties, adding and removing the representation of the elements from the OMG Topology Service.

6.4.2. Broadband Connection Management
This component uses the OMG Topology Service as an application-level integration framework, to extend the generic network model supported by the Network/Element Management System.

It allows endtoend paths (virtual circuits) to be established across the network represented by the generic network model. This process includes determining the best route through the network, and then setting up the necessary crossconnections on the network elements over which the path will run. The relationship between theCORBA object that iscreated torepresent thepath, andits associated networkle velcom ponents, isplaced inthe OMG Topology Service.

6.4.3. Network Management GUI

The demonstrator includes a Java-based GUI for monitoring the network topology and virtual circuits. The GUI provides a view of the network model as stored in the OMG Topology Service, the Network/Element Management System and the Broadband Connection Management components. The functionality of the Network Manager Java GUI includes:

- Topological view of the network
- Viewing of established paths across the network
- Dynamic update of the view for deleted/created paths
- Establishing new paths
- Removing existing paths
- Network element fault notification
- Path fault notification
- Network view layout options

The Network Manager Java GUI supports the update of multiple network view windows by sharing the common network model, thus ensuring data consistency. The Java implementation results in a light-weight , scalable, platform independent application that is suitable for use in both TMN and CNM (Customer Network Management) environments.

The architecture of the GUI consists of the following components:

- Network windowing system
- Network topology view component
- Network element view component
- CORBA client object cache and encapsulation component
- Path and network element notification system
- Path view/creation/deletion component

Figure 9 presents a specific network view. The nodes in Fig. 9 represent network elements, either switches or hosts. The edges are the physical connectivities between the network elements.

Figure 10 presents the network element view. The physical connectivity (e.g., cables, network elements) for a particular network element is displayed. User-network interface ports are placed tothetop ofthe network elementand network-network interface ports are placed to the bottom of the network element. Cross-connections are shown within the element itself. Each cross connection is associated with a single path.

Figure 11 shows the dialogue that allows the user to establish an end-to-end path across the network.

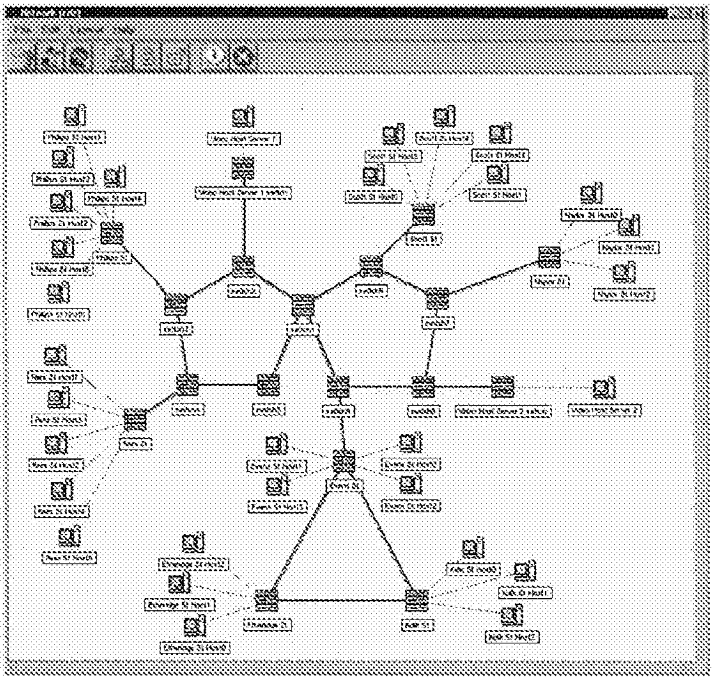

Fig. 9. The connection management and network view.

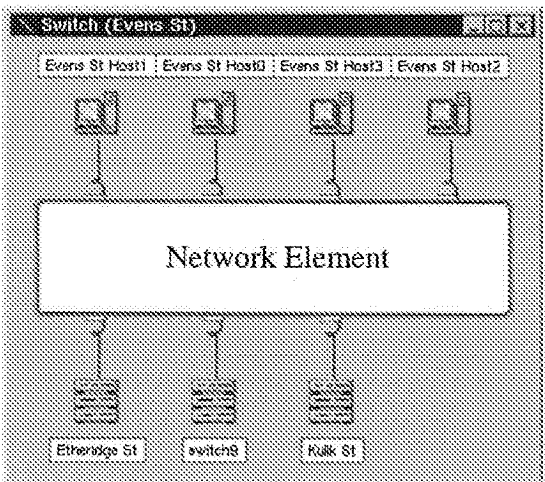

Fig. 10. The network element view.

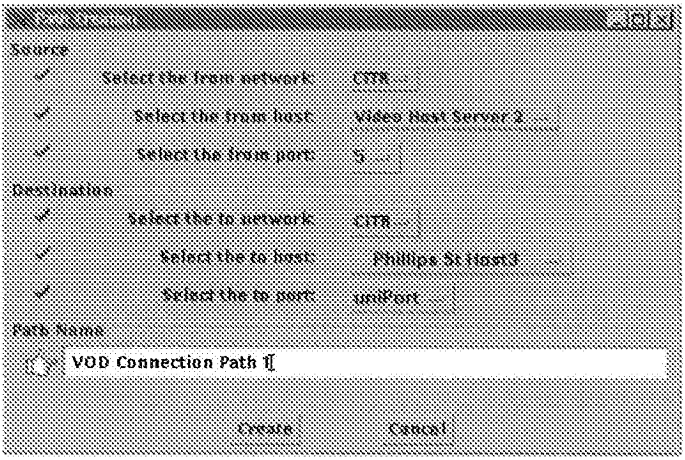

Fig. 11. Manual path creation.

6.5. Service Performance Management Subsystem

The demonstration system includes integration of service ordering, provisioning and other management activities. This integration includes the following components:

- service performance management
- network topology
- connection management
- performance management

Each of these components is SLA aware. Together they are integral in the monitoring and preservation of network conditions condusive to ensuring conformance to SLA conditions.

An SLA isused as the integration point between different phases of the service lifecycle. Figure 12 depicts this complete service lifecycle and the different subsystems involved.

Twoperforma nce management functions are supported inthis demonstrator. The first one provides monitoring functions for all SLAs. This enables operators

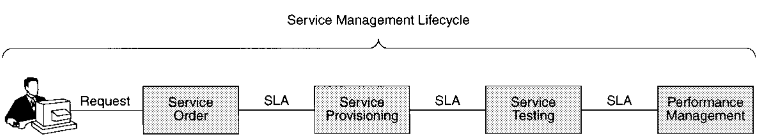

Fig. 12. Service management lifecycle example.

to monitor the qualityof- service parameters negotiated and to alert any breach and potential breach of these agreed service parameters.

To achieve these functions, the performance management system accesses, through the topology service, the connection information and associates with it the qualityofse rvice information in the SLA to establish the cause or potential cause of SLA violation.

For instance, whenever there is network congestion or failure, the connection management system will capture this at the network management level and update its topology information and display. At the same time, the performance management system will correlate this topology change and update the SLAs to reflect the degradation or breakdown of services affected by this network fault.

The same function is also available at the customer side where customer can see the correlation between the network performance and SLA conformance.

The second function supported by the performance management is network and service simulation and scenario management. The service provider operators can use this feature to simulate changes in network traffic and administrative/operational status of any connections and/or network equipment to determine the impact of this change to services carried by the network. For instance, the operator may *disable* a switch in a simulated network topology display to get a report of any services relying on this switch. This allows the operations and maintenance personnel to conduct a scenario analysis for a *what if I take this equipment out of service* scenario. This feature can also be used as a network capacity planning tool.

The performance management function can be invoked on both client and server side interfaces. The server interfaces enables service provider to monitor and plan network capacity and customer services. The client interface enables customers to manage their ordered services.

6.5.1. SLA Management

When a network object is double clicked, a list of SLAs currently depending upon this network object is displayed together with their color code to indicate the status of the SLA (normal, service degradation, violation, etc.) This is depicted in the following Fig. 13.

Figure 13 shows one violation of SLAs by listing it (6th in the list). When anoperator selects any SLA fromthe list, itsconnection information isdisplayed in the topology map display (by a solid black line), and the double click on any SLA results in the displaying of the details of the SLA.

The simulation andscenario management functions can beinvoked fromthe topology map. They enable the operator toincrease /decrease network trafficand to disable/enable the network objects. Any change will result ina corresponding change of connection information in the topology service.

The scenario manager will correlate the change in status of the network

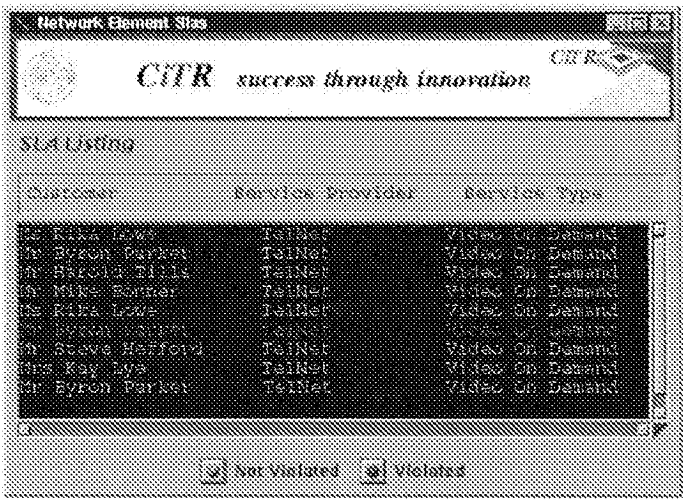

Fig. 13. The SLA list associated with a selected network object.

topology to the current SLAs and update the status of the SLAs if any changes are appropriate. This may result in a color change in the SLA list. Each SLA can be expanded to retrieve more detailed status information.

7. CONCLUSIONS

This demonstration system is implemented using CORBA, Java and OSI (simulated network environment). Our experience, gained through the development of the architecture and the proof of concept implementation, shows that the integration architecture discussed in this paper is viable. The use of the different management technologies (CORBA, Java, OSI) can add significant value if used wisely. Also an integration between these technologies can be achieved in a manner which suits the characteristics and satisfies the requirements of the systems in the telco domain.

We are currently extending the system in the following areas:

- Further developing the generic network model and associated network topology service tobe full CORBA service. This service manages the network topology independently and offers most ofthe functionalityrequired by a cross domain connection management.
- Adding more service management functionalitysuch asfault management and trouble ticket administration as CORBAba sed applications interacting with the performance and provisioning systems. These applications

will also interact with the network topology service in order to access network management functions.

ACKNOWLEDGMENTS

The authors would like to thank the other members of CiTRs Advanced Technology Development group for their contribution and review comments which led to the completion of this manuscript, in particular, Chris Phillips and Darrell Naylor. The authors also thank the *JNSM*s reviewers for their constructive comments and suggestions.

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