Integrated Management Solution Architecture

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Abstract

This paper discusses the integrated management architecture for building end-to-end management applications. While many efforts has been made by the industry to define the management architecture, the great challenge to the telecommunication software development industry is still the technology management strategy to cope with existing and emerging new network and management technologies. Although many these new technologies enable us to build more functional solutions to our business problems, if the process to manage their evolution and the strategy to integrate them are not defined properly, they can be very disruptive to our application solutions development.

This paper demonstrates the software engineering process using the integrated management as an example. We discuss some of the principles and experiences of integrated management. We examine the purposes and types of technology integration, the technology management and the application integration. Finally, we discuss a software solution using for the integrated architecture, which does not only support for management technology integration, but also for application integration.

Keywords

Service and network management, integration, CORBA, TMN, OSI

1 Introduction

The global trend of deregulation and competition in telecommunication industry has increased the urgency for the industry to re-examine the fundamental business model and technology framework. The requirements for new services to be offered at lower cost are forcing telcos to streamline the business processes and optimize technology strategy. The software development suppliers are facing increased challenges to provide a technology framework to deliver solutions to meet today's new business requirements and objectives.

One of the challenges facing today's software practitioners is the technology integration. The consequences of the multiple technology environment have created the challenge to build integrated solutions to business problems. Whereas many of us may have accepted the notion of the *right technology for right problem domains*, it is still too hard to practice it in the real world.

The notion of right technology for the right problem domain reflects the maturity of the industry towards new IT technologies. This notion asserts that it is the business

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problems and challenges caused by deregulation and competition that drive the progression of the management solution development process. Technologies are important but they are only the means to achieve the business objectives. This paradigm shift is crucial as it helps to achieve the following goals:

- Management solution development becomes more customer solution focused.
- Development efforts are more result oriented, rather than technology indulgence and experiments.
- Solution development processes are more concerned with end-to-end needs.
- Software practitioners are more concerned with integrating different technologies rather than constantly picking the best technology.

These have helped us to focus to develop integrated solutions and avoid technology wars. This paper deals with the technical challenges of building such integrated solutions in a multiple technology environment. The focus of the paper is not on the validity of the architecture, as we believe that different integrated architecture should exist. The focus is on the solution development and management processes and principles. By discussing a set of common integration issues normally facing the integrated solution developers, we demonstrate the software engineering process from realising business requirements, analysing different technologies, using right technology for right problem domains and finally selecting technology to implement the integrated architecture.

2 Integration Purposes

Integration is one way of deploying multiple technologies to solve complex business problems. Integration itself is not a goal, rather it is a vehicle to achieve business goals. For two given technologies, there may exist several different ways to integrate them. It is often hard to reach a simple conclusion that one approach is the best before we know why we are trying to integrate them.

In the area of telecommunication network and service management, technology integration is required to achieve interoperability between different management domains. A large network management environment may use different management technologies such as CMIP and SNMP in different subsystems. An integration is thus required in order to support the communication between these subsystems.

Integration also helps to strengthen the existing solutions by introducing new technologies which offer better features in certain functional areas. For example, distributed technology can be introduced to provide the management system with a distributed environment. This introduction requires the integration of the distributed technology with the existing management solutions.

It is also useful to provide a domain independent (or protocol independent) application development and deployment environment. In a large telecommunication network, it is common that different network equipment and network technologies (ATM, SDH/SONET, WDM (Wavelength Division Multiplexing), FrameReply, etc.) are used. They are normally managed by different systems using different management technologies (CMIP, TL1, SNMP, CORBA, Java). It is always desirable but hard to develop network management systems supporting transparent end-to-end applications from the individual underlying management technologies. The problem becomes more acute when the migration of these technologies take place. In many cases, the migration forces the change in the management applications—a painful process that should be avoided at any cost. To make the management applications independent from the underlying technologies, an integration layer is required which encapsulates all the underlying technologies and provides a domain independent environment for the applications.

The service management and network management have different business focuses but they are closely related. Telecommunication services are supported by networks and elements. Service management layer needs to communicate with network management layer in order to perform its management activities. The management functions supported by these layers and the technologies used in managing these layers need to be integrated to provide a better service and network management environment.

Finally, technology integration also helps migrating the legacy systems to more advance technology frameworks for application development and deployment. Integration is also a common mechanism to allow legacy systems to be used in a newly developed system to reduce the development cost.

In TMN network and service management, perhaps the most important purpose of the integration is to achieve three management scenarios as illustrated in Figure 1:

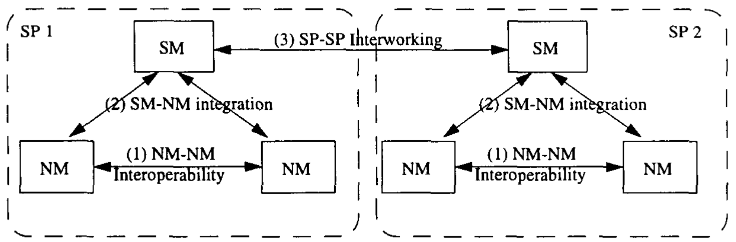

Figure 1: Intra-SP and inter-SP integrations

The first scenario (NM-NM interoperability) is domain (or protocol) independence managers and applications. This scenario focuses on the network interoperability. It deals with the business requirements to integrate different network equipment and subnetworks of different technology. OSI initiative provided a framework to support this integration in one technology domain.

Figure 2 depicts a scenario where a network technology independent component is required to support more generic network and service management functions. This component acts as a cross-domain manager which insulates the applications from the underlying network and element management systems. It also provides, through adapters as integration points, interworking with different legacy systems.

This scenario provides an integrated network management system supporting a truly end-to-end network view of TMN functions. An example is that the cross-domain manager is a network connection manager which provides end-to-end connections across all different subnetworks with different network technologies and management systems.

The second scenario (SM-NM integration) is service and network management integration. This integration deals with the business requirements to support smooth information and process flow from services to network. Lack of this integration is well

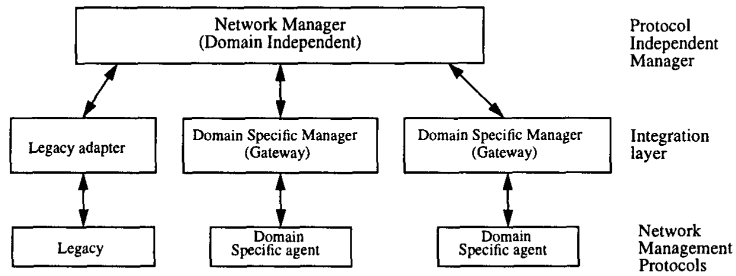

Figure 2: Cross domain manager

recognized as the key problem inhibiting many service providers. Some work in the TINA-C service architecture and TMF SmartTMN initiatives [12,13] provided technology solutions to support this integration. Figure 3 illustrates this scenario. In this scenario, the challenge is to have an integration environment to support functional abstraction. The management function at the higher level of functional hierarchy is modelled by a more abstract object model. For instance, the service level managed object is an abstraction view of the network level managed objects. The key issue of service management and network management integration becomes the issue of object model integration. An explicit domain independent layer in network management, as depicted in Figure 2, provides a much better support for SM/NM integration.

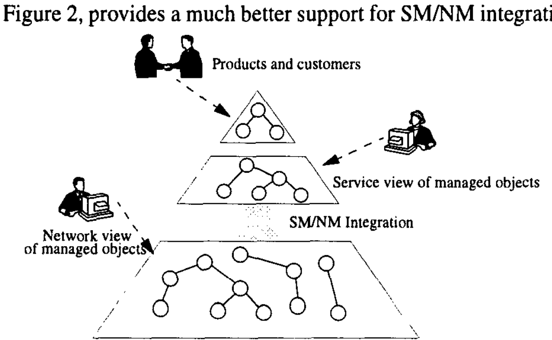

Figure 3: Object abstraction of TMN

The third scenario (SP-SP interworking) is interworking between different service providers. This integration deals with the business requirements to support integrated services and management application development within a service provider or between service providers. The recent technology direction set by TMF (Telecom Operation Map and Technology Integration Map) provided technology solutions to support this integration.

3 Integration Approaches

The integration between the network protocol technology, the common distributed application technology and the user access technology is becoming the focal point in the management technology integration. Given the prominence of the OSI technology in traditional TMN framework and the recent industry acceptance of CORBA, we use the different ways of their integration to illustrate how they can provide solutions to the integration requirements discussed before.

- Gateway integration approach
  A Gateway is a piece of software which sits in the intersection between two different environments with different object models. The gateway behaves like a mediation device to translate object definitions and functions from one environment to another. One way of interfacing CORBA and OSI based TMN system is to build a gateway between the CORBA environment and the OSI network management environment. The main functionality of the gateway is to perform the protocol translation between systems developed in these two different technologies.
- Abstract object definition approach
  The abstract object definition approach is based on the principle that each level of objects is an abstraction of the objects at the level below. Objects at different level may be implemented using different technologies. Therefore, the process of object abstraction is treated as an integration point between different management technologies. The abstract object definition approach has two specific design goals:
  - the ability to manage a large network at a higher abstraction level with more abstract concepts
  - the ability to retrieve details when required.

  In the case of CORBA/OSI integration, this approach is to introduce a set of CORBA objects at an appropriate level of the management hierarchy. These CORBA objects represent a view more abstract than the underlying OSI system required for integration. The underlying OSI system, represented by a set of GDMO objects is viewed as the specialization of the CORBA objects. The GDMO objects are therefore mapped into the CORBA objects not necessarily in a one-to-one manner. Section 4.3 provides further details of this approach.
- Application interworking approach
  The application interworking addresses the horizontal integration of different operation systems with different technologies and different object models. A typical example of this integration is the interworking between different service providers' operation support systems.
  It is neither necessary nor possible for every service providers to accept same technology and same object model and process model to implement their respective OSS systems. It is however crucial for different service providers to exchange application information between their OSS systems for the support of integrated, one-stop-shopping customer requests. In the new deregulated environment, this is important even just for the purpose and to the extend of fulfilling regulatory obligations (for example, the government mandated wholesale-retail interconnection requirements).

All three approaches can be used in an integrated architecture to satisfy three types of requirements discussed in section 2. The gateway approach is more suitable for the interoperability between network management systems as shown in Figure 1. It offers limited value in service management and network management integration. The abstract object definition approach is more suitable for the service and network management layers integration. It is also capable of supporting integrations between different network management technologies, such as CMIP and SNMP by using the same abstract object definitions at CORBA layer. However, its value as protocol interoperability technique to CMIP and SNMP is limited. The application interworking approach is more suitable to support the interworking between different service providers at service management layer. It is not suitable for network level interoperability or network to service integration.

A critical technology issue in an integrated telecommunication management architecture is the definition of an integrated information model. This information model defines the management activities and information flow-through from customer interactions with the management system, through to all different layers of the TMN architecture and across all different management functions. Only when this information model and process flow-through is properly defined, the true integrated architecture and management solutions can be achieved. This information model and process flow-through is at the heart of the management of the business process life cycle, as it provides us with a description of the business purposes and activities the integrated architecture and software components are meant to implement.

4 Integrated Management Architecture

This section presents an integrated management architecture for building distributed network and service management solutions. This architecture can be used as an evolving platform to define, deploy and manage customer and business solutions.

The focus of this architecture is on how to support telco business solutions and to deliver the services to the customers. It focuses on the integrated business processes and information flow-through. This architecture addresses the business requirements and objectives for the integrated management. It supports the definitions of management functions and business processes and the interactions between them. The architecture presented in this section is not focused on technology choices.

4.1 Integrated architecture

The integrated management architecture depicted in Figure 4 contains the following three environments:

- A customer access management environment—It offers the functionality for customers to access telecommunication services and customer care management.
- A service management environment—It offers a set of service management functions and a set of business processes. It is a middle layer between customer management environment and network management environment. On the one hand, it presents the network capabilities in terms of services which can be understood by customers. On the other hand, it relates customers' service requests to a set of operations which can be understood by network functions.
- A network management environment—It is an environment for managing networks and network elements required to support the services to end-customers.

The layers in the architecture reflect different views in the different levels of object abstraction. The managed environment (including elements, networks, services and

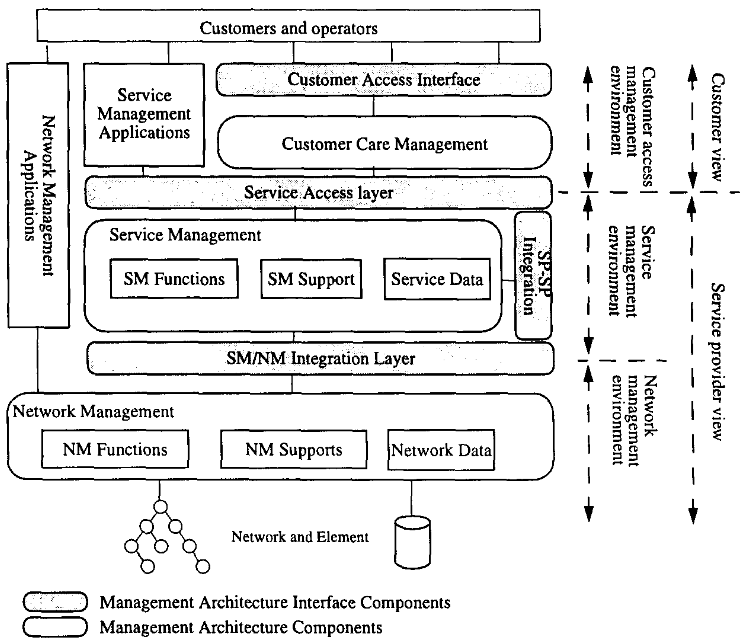

Figure 4: Integrated management architecture

customers) represents a continuous steps of abstraction upwards. In this abstraction process, the managed environment manifests different views. The service access layer and customer care layer reflect the customer view of the service provider environment. The rest of the architecture reflects the service provider's view. Within this, it can still be partitioned to that represents a product and service view and that represents a network resource view.

The key value of this architecture is to treat the technology integration as the crucial part of the technology management process. The shaded boxes in the Figure 4 illustrate that in our application modelling and technology management process, we need the following strategies before we get to the technology selection point:

- Customer access strategy
- Service process interaction strategy
- Network function interaction strategy
- Business interaction strategy

Definition and management of these strategies form the core of the business solution life cycle and technology evolution management process. As each of these strategies deal with some fundamental business solution management issues, such as:

- Business application support multiple modality—Can solution functionality be accessed through multiple interfaces (voice, web, smart devices, etc.)?
- Can it cope with constant service and business process changes? This is the fundamental requirement to avoid the big bang business process reengineering.

- Can applications cope with the network changes? Do we have an application semantics that is not dependent on the network configuration?

The implementation of these strategies will eventually map into some technology integration methods. But it is fundamental that these strategies are not after thoughts of the application modelling, rather they are the integral part of the modelling process, and the technology evolution management process.

This architecture is extensible. In terms of functionality supported, more functional blocks can be added to different environments to increase the management capability and scalability. In terms of application development, different telecommunication business processes can be implemented using the customer access environment, service management environment, and directly using network management environment. In terms of managed network, multi-technology transmission networks can be added with little impact to the business processes already implemented.

This architecture can also be scoped down by including a subset of the functionality in each management environment to meet the minimum telco management requirement.

Different technologies can be used to implement different components in these management environment. Distributed OO technologies, such as CORBA, can be used as the platform to support the integration between environments, and between different components.

4.2 Service management environment

At the core of the integrated architecture is the service management environment. This environment is composed of three key parts: the service management processes, the process interactions, and integrations.

The service management environment defines a number of service management processes and these processes support essential service management activities. Examples of service management processes are:

- Service order and management process
- Performance management process
- Problem management process
- Fault management process
- Billing process
- SLA management process

Some of these processes are supported by some internal OSS, such as service configuration, trouble ticketing. The interactions between these processes are essential to archive integrated service management within a single service provider's service management environment. More importantly, the service management environment also defines a number of interface components supporting integrations with system components outside the service management environment. These interface components include:

- A service access interface which can be used by customer management layer and service management applications for issuing service management requests. These requests will invoke the service management process workflow. Potentially, the same interface can also be used by other service providers.
- A service management and network management integration layer which bridges two object models and associates service management requests to a set of network management requests.

- An SP-to-SP interworking component which supports OSS interconnections with peer service providers for service components.

Figure 5 depicts the service management environment architecture and the components. In this paper we focus on the process interaction issues and the service management integration issues.

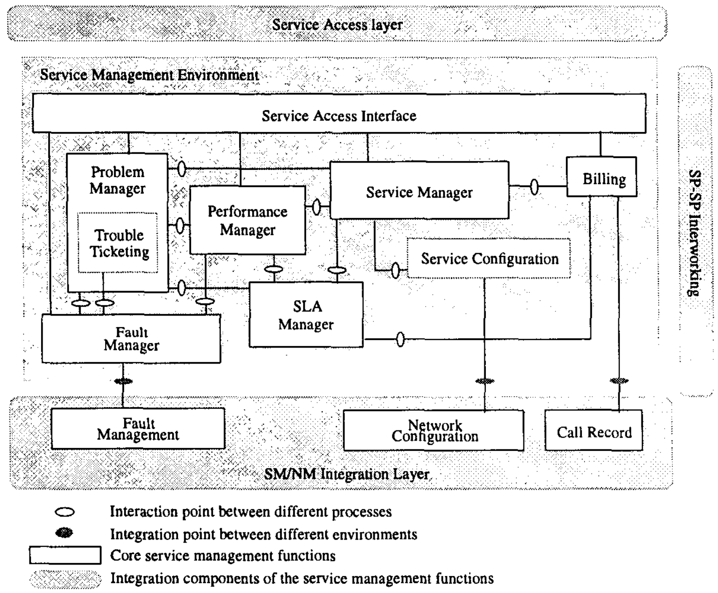

Figure 5: Service management components and process interactions

4.2.1 Service processes interaction

Figure 5 also illustrates the potential interaction points between different service management processes:

- The interaction between the service manager's ordering process and service configuration process. Service configuration maps service requests and service parameters to the network requests.
- The interaction between the service order process and the billing process. An example of this interaction is for the billing process to record the start and termination of a service.
- The interaction between the service order process and the SLA manager for SLA creation, deletion, update and negotiation.
- The interaction between the service order process and the performance manager. This interaction allows the automatic generation of performance monitoring criteria according to the SLA.
- The interaction between billing system and SLA manager. An example of this interaction is for billing system to retrieve the agreed SLA from the SLA manager. Some SLA may include a special rate negotiated during the service ordering phase, SLA compensation or repair charges.

- The interaction between performance and SLA managers. This interaction allows the performance manager to monitor SLA terms and to determine whether a performance degradation has caused the violation of the SLA.
- The interaction between the performance manager and the fault manager. This allows the establishment of whether the faults in network elements affect some services and their performance.
- The interaction between the performance manager and the problem manager. This allows problems to be reported and handled when poor performance is detected by the performance manager.
- The interaction between the fault manager and internal trouble ticketing system. This interaction allows the fault manager to issue a trouble ticket automatically when a fault has be identified.
- The interaction between the fault manager and the problem manager. This allows problem manager to check service fault records to determine the potential cause of the reported problem.
- The interaction between the problem manager and the service ordering process for the creation of an alternative service when repairing a problem for the existing service.
- The interaction between problem manager and SLA manager for obtaining the agreed SLA to determine the billing adjustment.

These interaction points are part of the application modelling. They form the service interaction model. The goal of the architecture is to provide the functionality to define, manage and evolve these interactions.

4.2.2 Interworking between service providers

The SP-to-SP interworking enables the peer service providers to cooperate in an end-to-end service provisioning and management scenario, where multiple service providers are involved in a single customer request for services. This function is also important to support one-stop-shopping, so that the customers' requests are managed by one single service providers of their choice.

There are two types of architecture approaches to support SP-to-SP interworking. The first approach is a tightly coupled approach such that the interworking SPs both adopt the same business process model and business object model. The second approach is for interworking SPs to rely on mediation devices, commonly referred to as the OSS interconnection gateways, to achieve process and information exchange.

Using the tightly coupled approach requires a tighter integration between the two service management environments. A generic service interaction model and its common processes need to be supported by both interworking service providers. The software integration can be made easier if both providers support the model using same technology and interface definitions.

Interactions of this approach normally happen between same pair of processes in different service providers' environment. In a tightly coupled integration environment, these functions can be provided as the extension to the existing functions supporting the customer-to-provider relationship. For example, the core of the customer care system which interacts with the service management processes can be extended to act as the gateway to interact with the peer SPs processes. Further, this interaction layer may well be a logical component in an actual software design. For example, if CORBA is used by both interworking service providers as the service management platforms, interactions between these two service providers become interactions between cooperative CORBA systems. SP-to-SP service requests are invoked to the same objects representing ordering, problem handling, performance processes, but living in different service management domains.

The second interworking approach is based on the principle of satisfying the minimum interworking requirements. In this approach, two interworking SPs are not required to have common business processes and information models for their service management functions and interfaces. Their service management environments may not interoperate at the process level, nor do they interoperate at the technology level, as the service management environments may be supported by two different and non-interoperable technologies.

This approach requires a minimum set of interconnection gateways to be defined and these gateways operate as mediation devices between two service management domains. The example of this approach includes the so-called OSS interconnection gateways adopted by the industry to mediate the wholesale–retail relationships.

The interconnection gateway approach defines a set of business processes common to every service providers. Each gateway defines and mediates a specific business process. The gateway supports different protocol definitions at two end points. The service providers are required to integrate these end points with their own service management environment.

4.2.3 Service and network integration layer

The service and network integration layer plays an important role in the entire integrated management architecture. This layer is responsible for bridging the differences between service management environment and network management environment and acts like a vertical mediation device between these two environments.

There are two aspects of the integration functions supported by this layer: the integration between the different object models, and the technology integration strategies.

The object models representing service management processes and network management processes are quite different. Service object model represents more dynamic complex services and the network object model represents relatively stable and less complex but finer grain network objects. The service interaction model is treated as a higher level abstraction of generic network model. The service and network integration layer needs to understand both these object models and is responsible for the integration between them.

As an example, a service configuration can act as a mediation between service ordering object model and network configuration model. It converts a customer order provisioning task into a set of network resource configuration tasks. In order to perform this conversion, the process supports the service interaction model by using the topology and connection management functions in the generic network model. It maintains the relationship between customer services and network topology and connections. This frees the service management system from having to know the precise and detailed information about the network infrastructure.

The second aspect of the service management and network management integration deals with the technology integration strategies. It is quite common that different management technologies and platform products are used to manage services and networks. Therefore, the service and network integration layer is also responsible for the integration between different management technologies. For example, when CORBA is used to support service management functions and OSI is used to support network management functions, then this integration layer will be responsible for implementing CORBA/OSI integration strategies.

4.3 Network management environment

Network management environment supports integrated network management functions. This environment contains two major components as illustrated in Figure 6:

- a generic network model which provides the service management layer with a generic network management interface. This model offers the higher level network management functions to support the integration with service management.
- A set of integration points to specific network management systems (NMS) or network element management systems (NEMS).

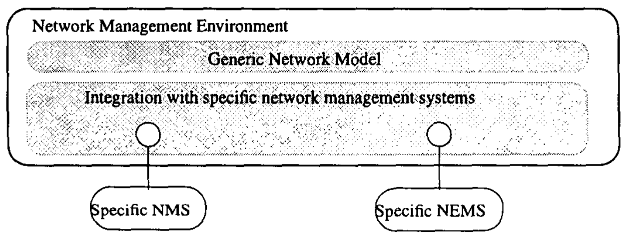

Figure 6: Network management environment

4.3.1 Generic network model

Generic network model presents a generic network view to the service layer. It contains a number of functional submodels such as topology model and connection model. The basic topology model represents the physical topology of the managed network, the network equipment (switches, routers, multiplexers) and their connectivity. The global logical network view can then be constructed based on these elements, for example, SDH/SONET rings, administrative domains or ATM virtual LANs, etc. The connection model represents the service-oriented views of logical connections created dynamically in this physical network.

The generic network model serves two purposes in the integrated management architecture. One is to support the service management layer by only exposing the service access points and encapsulating the complexity of the physical network structures. The other is to provide a layer of integration between different network technologies.

A network management system based on the generic network model supports network management applications which are developed for network operators. These applications perform the network administration, operation, management and maintenance tasks. The same network management system also supports service management systems to perform day-to-day service management activities.

4.3.2 Integration points

The integration points in the network management environment are interfaces between the generic network model and the underlying specific network management systems. Each integration point supports a set of generic interfaces defined in the generic network model and maps these interfaces into the underlying network technology it supports.

An integration point provides the following abstract views:

- the topological view of the managed network. This view describes the number of subnetworks contained in the managed network and the way they are connected. This view serves two purposes. It provides the application with a simplified network topology and services and it represents the managed network's internal structure. This internal structure is used by the internal algorithm to determine how a management request can be delegated to its subnetworks.
- the network service view. The network service view represents the services made available by the network to its users, such as the ways the network can be used to transfer data from one place to another. The network service view includes the external network access points and the types of connections that can be established between these access points. The network service view is made available by a network to its users, such as service management layer, and its super network.

Hence, each network integration point performs two major tasks. One is to maintain the rules of abstraction and specialization between specific network management system and the generic network management system represented by the generic network model. The other is to translate a generic network model management request into a set of specific management requests supported by the underlying specific network management systems.

4.4 Characteristics of the integration

Different integration approaches were employed in this integrated architecture. The abstract mapping approach is primarily used for semantic abstraction of management functions. Although the primary example of this approach is given in the CORBA/OSI integration context, it is by no means that the approach is limited only to the integration of these two technologies. For instance, in the service management environment where a single technology such as CORBA is used, it is still the essential function of the integrated architecture to generalize management functions to present more abstract view of services and service management functions. The generic network view needs to be generalized to support the services and service management processes and business objects. These processes and business objects need to be generalized to support customer care functions and customer management processes.

The architecture also support horizontal interactions and interworking between multiple management processes. It does that by supporting business process workflow and their integration with the business objects. The application interworking approach is also applied to the SP-to-SP interworking scenario to support more transparent customer services.

5 Conclusions

Building integrated management solutions to support the business process re-engineering is a long term evolving task which presents with many challenges and difficulties.

We have dealt with a number of new challenges to the integration of the multiple technologies and operation systems to create integrated solutions.

In this paper, we analysed different integration requirements and integration approach and presented a management architecture which supports different integrations.

Although CORBA is becoming the strong technology choice for the telco industry and OSI is almost an incumbent technology for network management, we hope that the principles and processes discussed in this paper will not assume that these are the only technology choices. It is more important to have an integrated environment which allows us to develop management applications for business purposes.

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