

# A Quality Assurance Process Model on Fault Management

Hyo-Soo Kim\*, and Cheong Ho Baek\*\*

**Abstract:** So far, little research has been conducted into developing a QAPM (Quality Assurance Process Model) for telecommunications applications on the basis of TMN. This is the first trial of the design of TMN-based QAPM on fault management with UML. A key attribute of the QAPM is that it can easily identify current deficiencies in a legacy system on the basis of TMN architecture. Using an empirical comparison with the legacy systems of a common carrier validates the QAPM as the framework for a future mode of the operation process. The results indicate that this paper can be used to build ERP (Enterprise Resource Planning) for a telecommunications fault management solution that is one of the network management application building blocks. The future work of this paper will involve applying the QAPM to build ERP for RTE (Real Time Enterprise) fault management solution and more research on ERP design will be necessary to accomplish software reuse.

**Keywords:** *TMN, fault management, ERP, UML, RUP*

## 1. Introduction

From the perspective of today's RTE (Real Time Enterprise) moving from monopolies to competition, telecommunications networks account for a large part of the operation of telecommunications services. A telecommunication OSS (Operation Support System) is a type of computing system which supports the telecommunications networks operator's business activities from customer service and market and sales activities through to the management of the access network and the switching systems. It is not easy to improve customer satisfaction, a key strategic factor, at a reasonable cost, or to use the telecommunications resources efficiently by reducing the operation costs and to provide time to market for new services. For these reasons, it is no longer cost effective to manage telecommunications network services. From an end-user's viewpoint [1], global connectivity means that:

- ① the network components must be transparent to business decisions;
- ② bandwidth should be automatically allocated depending on instantaneous needs;
- ③ network availability should be worldwide;
- ④ high quality and secure access should be possible from any location;
- ⑤ costs should be commensurate with business needs.

To accommodate these requirements, telecommunications network operators may enable enterprises to perform some TMN (Telecommunications Management Network) functions themselves [1].

So far, little research has been conducted into the development of a quality assurance process model (called QAPM) for telecommunications RTE on the basis of the TMN function. The objective of this paper is to introduce a TMN-based architecture which can provide an industry-standard foundation for world-class telecommunications system development and acquisition, and linkage between telecommunications business strategy and operational execution. And it also shows that the use of a TMN-based architecture and Unified Modeling Language (UML) will lead to the QAPM on fault management.

## 2. Problems of Non-TMN Systems

Service providers and network operators face, on the one hand, the challenge of dropping their operational costs to lower their price, and on the other, that of delivering quality in terms of high performance, security, and customization in order to adapt to the particular needs of each end-user [2].

According to N. Furley [3], British Telecommunications has invested hundreds of millions of pounds per annum in the development, procurement, and maintenance of its OSS. The problem is that almost every facet of this complexity impacts on the telecommunications operator's OSS. Over the years, this lack of a complete, coherent design framework has resulted in poor solution designs, which has in turn created a legacy in BT of:

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Manuscript received September 26, 2005; accepted November 1, 2006.

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- ① over 1,000 separate systems running 1,300 distinct applications;
- ② islands of automation with little integration or flow-through of processes;
- ③ stove-pipe solutions for particular services or networks with high levels of duplication;
- ④ poor data quality due to duplication and limited access to the data;
- ⑤ multiple computing platforms increasing integration problems.

The OSS legacy involves another problem when providing network management solutions. A high degree of investment has been made in these legacy solutions: consequently, it is difficult to discard solutions that have been working and in which heavy investments were made. This necessitates the co-existence of the legacy systems with the new standard network management solutions [4]. The support of multiple existing and as yet unknown services on a single platform naturally leads to the need for an integrated approach to network and service management [5].

According to M.3010 [7], a TMN is conceptually a separate network that interfaces a telecommunications network at several different points. The relationship between a TMN and the telecommunications network that is managed is shown in Fig. 1. M.3010 defines the general TMN management concepts and introduces several management architectures [6]: Five different types of function blocks are defined by the TMN's functional architecture.

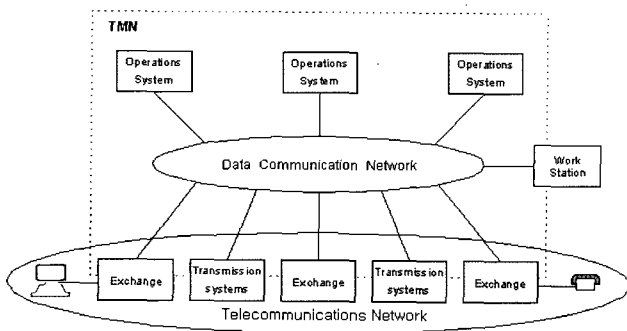


Fig. 1. TMN overview

Fig. 2 shows all five types of function blocks [51].

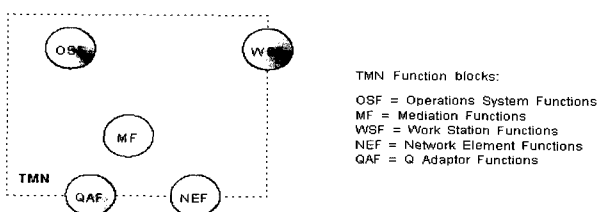


Fig. 2. TMN function blocks

In terms of the manager-agent model, the OSF may be seen as the manager specific functions. An OSF communicates with the NEF over a  $q_3$  reference point in Fig. 3.

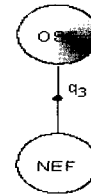


Fig. 3.  $q_3$  reference point

If necessary, these OSFs can communicate with each other over  $q_3$  reference points. The Q Adaptor Function (QAF) block is used to connect to the TMN entities, which do not support the standard TMN reference points [6]. In fact, TMN is an excellent and comprehensive tool for examining the different layers of management that are required by a service provider [8].

### 3. Layer Model of TMN Fault Management

Standards are essential in creating and maintaining open and competitive markets. Standards also are important in guaranteeing the national and international interoperability of data and telecommunications technology and processes [12]. The Bellcore TMN document references the ITU-T Recommendations M.3010, which serves as an international standard on TMN [9]. Bellcore is also a prime contributor to de jure standards process around the world, including North America. Bellcore adheres to its leading roles in establishing de facto standards for telecommunications services and in seeking to define the functionality of world-class telecommunications systems. As noted in [10], TMN must be implemented in a direct response to clear business goals such as the automation of business processes, in order to reduce operating costs while improving customer services, rather than just because it is a "standard." TMN management layers are shown in Fig. 4. The TMN model consists of five layers, usually arranged in a pyramid, with business management at the apex, service management as the second layer, network management as the third layer, element management as the fourth layer, and network elements at the bottom.

functionality (e.g. that service management is supported by network management).

Bellcore has developed a framework to define a comprehensive set of functions that TMN should provide [13]. Bellcore fault management consists of the following areas: fault localization, fault correction, trouble administration, alarm surveillance, testing,

and RAS (Reliability, Availability, and Survivability) quality assurance.

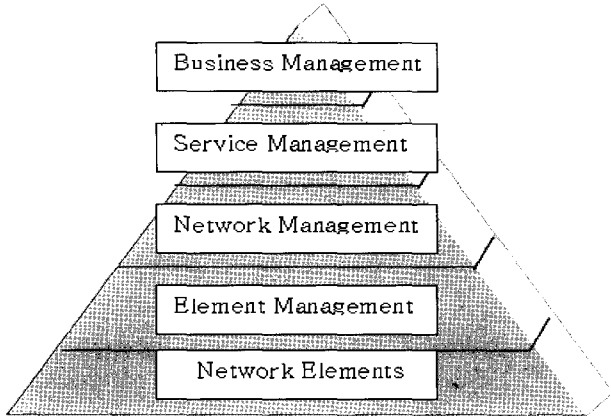


Fig. 4. TMN management layers

#### 4. Design of QAPM on Fault Management

Implementing a requirements management process ensures that the system that is delivered to the end-users meets their expectations [14].

According to Peter Eeles et al. [15], they found use cases to be a very effective technique for achieving requirements management. The use case describes the observable behavior of the system at the interface between the user and the system [17]-[19]. A requirements model is created in which we specify all the functionality of the system. This is mainly done by use cases in QAPM which is a part of the requirement model. They represent everything that needs to exchange information with the system [20]-[22]. In order to determine the scope of the QAPM on fault management, this paper uses the guidelines of the EBP (Elementary Business Process) use case [24]. The UML has emerged as the de facto and de jure standard diagramming notation for object-oriented modeling [23]. In particular, the Rational Unified Process (RUP), a detailed refinement of the Unified Process, has been widely adopted [37] [38]. A QAPM design by RUP Customizations is as follows. The timing and level of effort of requirements discipline across the iterations are presented in Table 1 [25]. This paper uses the identification of the actors and use cases in the inception and elaboration phases as a series of discrete and sequential steps [15]. In the fault management application system, this paper puts the actors in the “actors” package of the use case view, as shown in Fig. 5.

In the fault management application system, this paper put the use cases in the “use case” package of the use case view, as shown in Fig. 6.

Table 1. The level of requirements discipline effort

Artifact	Inception I1	Elaboration E1..En	Construction C1..Cn	Transition T1..T2
Use Case Model	<i>Start</i> - Define use case - Describe summarize type	<i>Refine</i> E1: document 40% written in detail E2: document 60% written in detail E3: document 80% written in detail E4: document 100% written in detail		

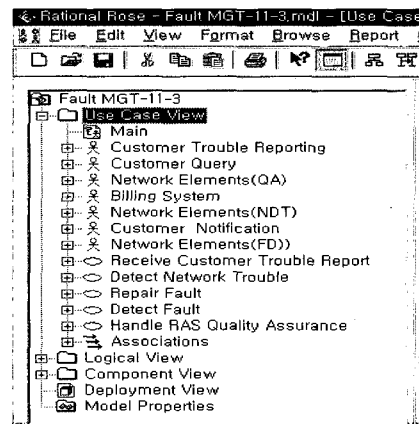


Fig. 5. “Actors” package in the use case view

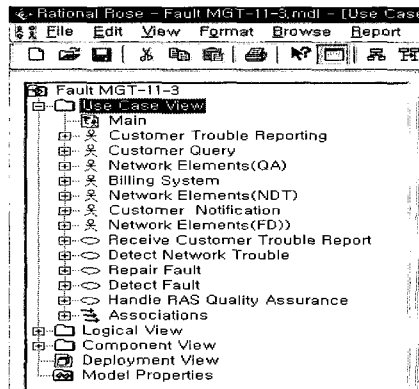


Fig. 6. “Use case” package in the use case view

This paper uses a PC (Pentium III 500MHz, 256 Memory) with Rational Rose 2000 [35] [36] and describes the TMN-based QAPM between the blocks within the system and the actors.

#### 5. Building of QAPM on Fault Management

TMN-based fault management is presented in Fig. 7. The QAPM captures the customer's expectations of the system functionality. Each actor is represented by a symbol outside the fault management, while the use cases are represented as ellipses

inside the fault management.

The OMT structural diagram in object-oriented analysis is one of the popular methods in object technology. The diagram also shows the internal relationship among the objects within the system [15].

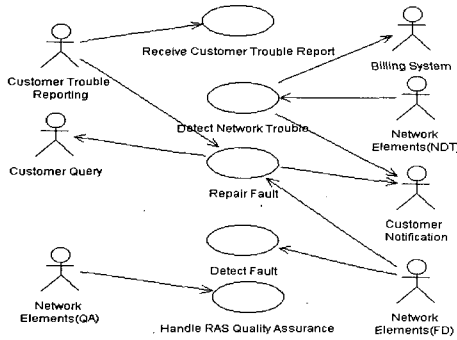


Fig. 7. TMN-based fault management

The TMN-based QAPM structural diagram for “handling RAS quality assurance” is presented in Fig. 8. The process model starts with fault detection at the NEL. The EML NE(s) fault reporting passes information to the NML network fault reporting for the purpose of quality assurance. The network fault reporting passes information to the network quality assurance goal setting. The SML service fault reporting captures fault information from the NML and passes to service availability goal setting.

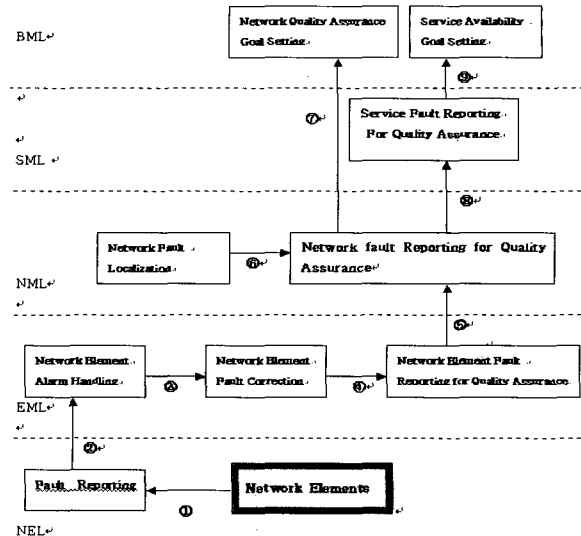


Fig. 8. QAPM structural diagram for “handle RAS quality assurance”

- ① Failure event detection in *Network Elements* is sent to *Fault Reporting*.
- ② A fault report in *Fault Reporting* is sent to *Alarm Handling* for alarm correlation and filtering of a new alarm event.
- ③ *Alarm Handling* sends the fault information to *NE(s) Fault Localization*.
- ④ After the fault has been cleared, *NE(s) Fault Localization* reports the fault to *NE(s) Fault Reporting for Quality Assurance*.
- ⑤ *Network Fault Reporting for Quality Assurance* reads reports of *NE(s) Fault Reporting for Quality Assurance*.
- ⑥ After a network level fault has been cleared, *Network Fault Localization* reports the fault to *Fault Reporting for Quality Assurance*.
- ⑦ *Network Quality Assurance Goal Setting* reads reports of network faults from *Fault Reporting for Quality Assurance*.
- ⑧ *Service Fault Reporting for Quality Assurance* reads reports of network faults from *Network Fault Reporting for Quality Assurance*.
- ⑨ *Service Availability Goal Setting* reads reports of service faults from *Service Fault Reporting for Quality Assurance*.

A Sequence diagram is useful for capturing interactions. To describe a sequence of stimuli (that is the event of one object communicating with another) [15], we use Rational Rose 2000 and describe a sequence diagram as a sequence of stimuli sent between the blocks within the system and the actors [29] [30]. The QAPM sequence diagram for the “handling RAS quality assurance” process is presented in Fig. 9. The QAPM has formulated the scenario as follows:

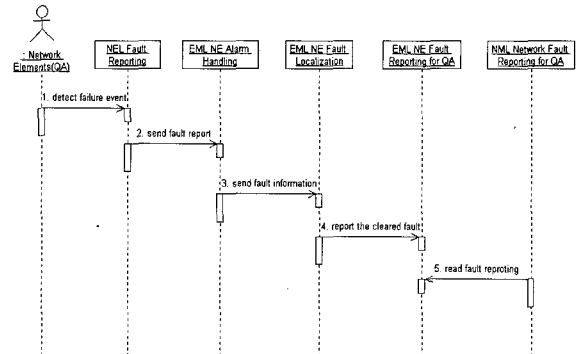


Fig. 9. QAPM sequence diagram

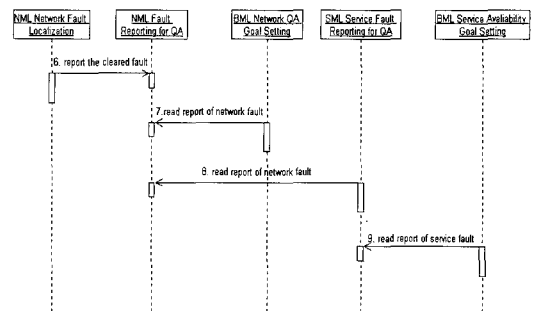


Fig. 9. QAPM sequence diagram (continued)

### 6. Evaluation

Using an empirical comparison with the legacy systems of a common carrier validates the QAPM as the framework of a future mode of operation process. As a fast information communication network provider and operator, the company had completed a 6,441 km-long fiber-optic backbone network consisting of ninety-four 2.5 Gbps circular networks that interconnected major metropolitan cities. Three legacy systems are picked up and their functions are analyzed and assessed. Legacy systems related to fault management are as follows:

- Operations and maintenance system (OMS)
- Network management system (NMS),
- Circuit test system (CTS)

The network management center, together with the IT expert, conducted an empirical assessment of current deficiencies in their fault management process on the basis of TMN architecture by performing a gap analysis between the QAPM and the legacy systems. Fig. 10 shows the symbols used in performing the gap analysis.

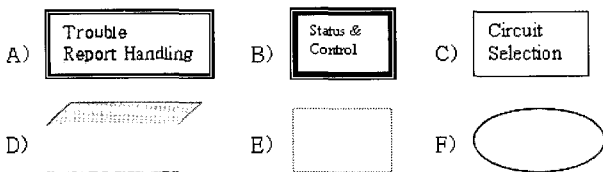


Fig. 10. Gap analysis symbols

The following is the meaning of each symbol.

- A) Operations and maintenance system (OMS)
- B) Network management system (NMS)
- C) Circuit test system (CTS)
- D) Manual operation, requires an automated expert system
- E) Partially manual operation
- F) Recommend a Web-based notification

Therefore, the QAPM in this paper is suitable for eliciting and analyzing the functional requirements of the fault management process.

As the rows (use cases) and columns (objects) are defined, this paper indicates a traceability relationship with symbol  $\circ$  in the cell that represents a use case that has one or more objects. Note that a single object may be implemented by multiple use cases. A single use case implements more than one object.

The gap is identified and presented as follows:

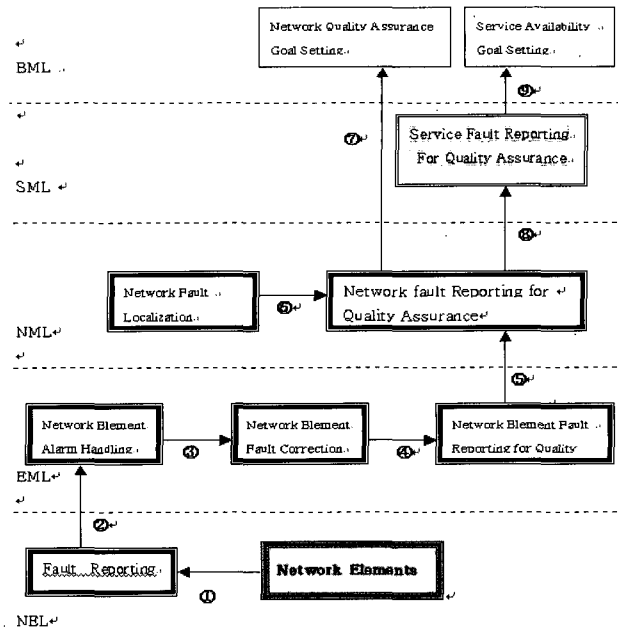


Fig. 11. Gap analysis diagram for QAPM

The result of the gap analysis is presented in Table 2. First, the QAPM is used in designing reusable components in fault management systems. The concept of the component has been a hot topic for the past year as the software industry has become increasingly developed [25]-[34]. Second, the QAPM provides a common framework for the integration of legacy systems as the future mode of operation on the fault management process. And we can identify and extract a missing object to be developed. Thus the QAPM provides a practical validation assessment tool adaptable to the requirements of the TMN-based fault management system.

### 7. Conclusion

So far, little research has been conducted into developing a use case model of telecommunications applications on the basis of the TMN function. A key concern of any application development is not only to get the system right but also to build the right system, where “right” means to meet the requirements of the end-users. The objective of this paper is to introduce a TMN-based architecture, which provides an industry-standard foundation for world-class telecommunications system development and acquisition, and linkage between telecommunications business strategy and operational execution. It also shows that the use of a TMN-based architecture and UML will lead to the QAPM of fault management.

**Table 2.** The results of gap analysis

Use case	EM									
	AHP	FCP	FLP	NOAGS	SAGS	TRHP	TFP	TP		
RCTR						●				
DNT	●							●		
DF			●							●
RF		●								
HRAS				●	●					

Use case	SM														
	ABC	CPV	CTR	FI	PSR	SDI	SERQA	ST	TCC	THD	TIO	TR	TRSC	TRH	TS
RCTR				●	⊗	●			●	●	○				●
DNT		●									○	○			○
DF			●												
RF	●		●					⊗			●			●	
HRAS							●						●		

Use case	NM												
	CDQ	CS	TC	FI	SPW	DFW	FC	NFC	NFF	NFL	NFERQA	TSN	TTA
RCTR	●	●	●	●	⊗	⊗			●	●	●		●
DNT					⊗	⊗			●	●	●		○
DF		●	●	⊗									
RF		⊗			⊗	⊗					●	●	●
HRAS					⊗	⊗					●	●	●

Use case	EM						NEL					
	NEAH	NFFC	NEFI	NFERQA	SC	TA	TS	AR	FR	NED	TA	
RCTR												
DNT	●											
DF	●		●			●		●	●	●	●	
RF	●	●			●			●	●	●	●	
HRAS	●	●		●				●	●	●	●	

Legend	●	Supported
	○	Partially in manual operation
⊗	Manual operation, requires an automated expert system	
○	Recommend a Web-based notification	

The main features of this paper are as follows:

- ① The first trial of QAPM of the fault management process with UML is introduced. The QAPM developed in this paper specifies all the functional requirements of the fault management process.
- ② The QAPM has the following effects. Based on UML and committed to TMN architecture, the QAPM first quickly provides a common frame of reference to identify and extract the relevant objects for the fault management requirements definition. Therefore, the QAPM in this paper is suitable for eliciting and analyzing the fault management requirements.
- ③ A key attribute of the QAPM is that it can easily identify current deficiencies in the legacy system on the basis of the TMN architecture. Using an empirical comparison with the legacy systems of a common carrier validates the QAPM as the framework for a future mode of the operation process. The result of the gap analysis is presented in Table 2.
- ④ The QAPM has the following advantages:  
**First**, the advantages of QAPM include the accelerated requirements engineering process: the QAPM can reduce costs for requirements elicitation, analysis, specification, validation, and maintenance [39]. Therefore, the QAPM in this paper increases clarity and assists requirement reuse. The QAPM is used in designing the reusable components in fault management systems. The concept of the component has been a hot topic for the past year as the software industry has become increasingly developed [26]-[34].

**Second**, the QAPM provides a common framework for the integration of legacy systems as the future mode of operation for the fault management process. We can also identify and extract a missing object to be developed. Thus the QAPM provides a practical validation assessment tool adaptable to the requirement of TMN-based fault management system.

This paper can be used to build ERP (Enterprise Resource Planning) for an RTE (Real Time Enterprise) fault management solution that is one of the network management application building blocks. The future work of this paper will be to apply the QAPM to build ERP for an RTE fault management solution; as such, more research on ERP design is needed to accomplish software reuse.

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