Management Service Design: From TMN Interface Specifications to ODP Computational Objects

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This paper addresses the relationships between Telecommunications Management Network (TMN) and Open Distributed Processing (ODP) standards in respect to the methodologies for the development of Management Services (MSs). In the light of emerging object-orientation in the telecommunications environment the development of object-oriented MSs becomes a major issue. ODP standards represent the foundation of object-oriented service design, for both telecommunication and management services. TMN represents the world-wide accepted framework for the management in telecommunications. Although TMN concepts promote the object-oriented modeling of management information, the modeling of MSs is still function-oriented and in infancy. Within this paper we will illustrate, that TMN concepts for MS design can be combined adequately with ODP computational modeling methodologies. The basic idea of this "integrated" MS design methodology is to map TMN Management Functions onto ODP Activities for computational modeling. An example for the presented approach will be given for the modeling of a User Registration MS in the context of an advanced Personal Communication Support System, currently under development at the Technical University of Berlin for the Deutsche Telekom Berkom.

Keywords: Activities, Computational Objects, Management Functions, Management Services, ODP, TMN

1. INTRODUCTION

The telecommunications world is changing its face. Progressing liberalization and increasing competition on the one hand, and the development of international standards for the uniform provision and management of telecommunication services, such as *Intelligent Networks (IN)* [Q.1200] and *Telecommunication Management Network (TMN)* [M.3010] on the other hand, pave the way towards an open telecommunications environment. In such an open environment telecommunication services and their corresponding management services should be introduced efficiently and rapidly, where the reuse of existing services and service components represents an important prerequisite. This is the reason for the world-wide acceptance and global deployment of IN and TMN standards, since both allow for the uniform and rapid design of telecommunication and management services. However, the basic service design methodologies of both concepts are primarily function-oriented, which limits the power of these concepts. This was the starting point for investigating the application of object-oriented methodologies derived from the computing world for telecommunication and management service design.

The application of object-oriented principles into the telecommunications environment, as promoted by emerging *Open Distributed Processing (ODP)* [X.90x] standards, is therefore currently in the focus of international research. In particular the harmonization of IN and TMN concepts in the light of the ODP Reference Model (RM-ODP) represents a challenging aspect of this research, where in particular the work of the international Telecommunication Information Networking Architecture Consortium (TINA-C) [TINA-C] could be seen as the major representative. In addition, several RACE and EURESCOM projects are currently investigating the evolution of TMN concepts, taking into account upcoming ODP standards. The problem is evident: management service development originating in the world of telecommunications with a functional modeling approach can not immediately be specified as an ODP conformant distributed application and thus cannot benefit from the research on ODP.

In this context this paper focuses on the integration of TMN and ODP concepts in the field of *Management Service (MS)* design, trying to bridge the gap between the function-oriented TMN MS design methodology, as defined in the TMN recommendation M.3020 [M.3020] and the object-oriented modeling approach of ODP. Based on the assumption, that the TMN Interface Specification Methodology corresponds to the ODP enterprise viewpoint, we propose a mapping of the identified *TMN Management Functions*, representing the smallest parts of a MS visible to the user, to *ODP Activities*, which consist of one or more Computational Objects within the ODP Computational Viewpoint.

The proposed approach is described in more detail in the following chapter, whereas chapter 3 provides a detailed example, which illustrates the design of an advanced "User Registration" MS in the context of a TMN-based *Personal Communication Support System (PCSS)* [Maged-95]. The PCSS represents a generic support platform which provides for personal mobility and service personalization to an open set of communication services based on the current advances in mobile computing and (universal) personal telecommunications. A short summary in chapter 4 concludes this paper.

2. A GENERAL METHODOLOGY FOR THE DEVELOPMENT OF MANAGEMENT SERVICES

Management Service (MS) design always starts with an analysis of the requirements the service has to satisfy. These requirements arise at the business level of an organization and are investigated within the ODP Enterprise Viewpoint. The methodology to be followed in the development of an MS, is to relate these requirements to the systems processing capabilities. To do so, a set of terms and concepts is needed, appropriate to express the captured requirements from the user perspective on the one hand and from the system's viewpoint on the other. The RACE project PRISM, which is investigating Service Management based on TMN standards, has established a generic Management Service Model [PRISM-93]. This model is based upon the TMN Interface Specification Methodology [M.3020], and is briefly introduced below because we apply this model to our MS design methodology.

The PRISM MS model is visible at the ODP Enterprise Viewpoint through the type of functions the MS offers. A distinct boundary exists between the user who selects the functions to use and the system which implements them. The set of functions available may be considered to occur at an interface to the service. The user interface is made up of three types of components. These, in descending level of decomposition, are:

- *Management Service (MS)*, which is an offering by a MS provider to satisfy a specific communication management need of a management user.

- *Management Service Components (MSCs)*, which represent reusable components that can be assembled to form MSs.
- *Management Functions (MFs)*, which are the smallest parts of an MSC with the ability to cause effects in the management system.

All the three types of components are visible to the user, i.e. there is a representation of them at the user's interface. The relationships between these interface components, the user and the Management System are shown in Figure 1. It has to be stressed that the implementation of the MS is independent of the functionality visible at the user interface.

FIGURE 1. Enterprise View of a Management Service

After introducing the PRISM service model we are now ready to describe our MS design methodology which starts at the Enterprise Viewpoint. At the business level of an organization requirements for managing telecommunication applications and systems arise and are discussed by the different actors of the enterprise. A subsequent requirements analysis identifies the management requirements in more structured manner. The concept used here to group the management requirements, are the Telecommunications Management Functional Areas (TMFAs) [H400]. An analysis within every single TMFA ensures a comprehensive requirements capture. The identified requirements have to be mapped on the functions and processing of appropriate MSs. A prose description of MSs satisfying the management requirements is the initial step towards an MS Enterprise Specification. A more detailed image of the MSs is gained by applying the PRISM MS model as a specification tool. The MS Specification advances to a composition of reusable components. MSs are composed of MSCs which themselves are built of lower level MSCs or MFs.

On the other side Computational Objects (COs) interacting in ODP Activities have to be identified within the ODP Computational Viewpoint, using the ODP Computational Viewpoint Language. COs are ODP objects contained in computational specifications and are defined in Part 3 of the RM-ODP [X.903]. ODP Activities are single-headed graphs of actions defined in Part 2 of the RM-ODP [X.902].

The control flow between the computational objects can be illustrated by *event trace diagrams* providing a high level view on the management activities. Another specification tool in the computational viewpoint is an *activityflow diagram* specifying the sequence of operation invocations of one management activity. Finally, a detailed computational specification is defined, using *object class* and *interface templates* for specifying computational objects, interfaces, and operations. An information model specifying the information objects used in the management system extends the MS specification. The information model may conform to the OSI Management standards [X.720] or may be specified with the terms and concepts of the ODP Information Viewpoint Language contained in RM-ODP Part 3 [X.903].

FIGURE 2. Development Path of the proposed MS Design Methodology

Before starting with the modeling of the Engineering Viewpoint, ODP transparencies have to be defined. The computational objects are now mapped to *Basic Engineering Objects* and are distributed in the system. A Distributed Support Environment (DSE) which realizes the specified transparencies has to be used. Finally, technical issues are elaborated on in the Technology Viewpoint. However, the two latter viewpoints are not treated in this paper. Figure 2 shows the proposed design methodology, pointing out the path which starts from an management requirement analysis and leads to specifications at different ODP viewpoints.

2.1 Problem: The Gap in the MS development path

The MS design methodology starts with the Enterprise Viewpoint modeling using the TMN concepts for MS decomposition. This step ends with an identification of MFs representing the lowest level components of the user interface of an MS. This function-oriented approach of the TMN Interface Specification Methodology complicates a subsequent ODP conformant modeling since ODP is based on an object-oriented approach. The MF's capabilities cannot be directly modelled in the ODP Computational Viewpoint Language because there does not exist any concept associated to a TMN MF. This problem represents a conceptual gap in the design path of a MS illustrated by the question mark in the white arrow in Figure 2. This situation calls for a solution that integrates the functional approach and the object oriented approach and thus harmonizing the two worlds of TMN and ODP.

2.2 Solution: Mapping between TMN Management Functions and ODP Activities

The gap between the functional approach and the object-oriented approach, as identified above, is now closed by the thesis that every identified TMN MF can be modelled as an ODP Activity. There is a natural correspondence between a MF that changes something in the system and an ODP Activity which is composed of actions, i.e. something that happens in the system. Figure 3 focuses on this overlap of the TMN functional approach and the ODP object-oriented way.

FIGURE 3. Correspondence between TMN Management Functions and ODP Activities

A TMN MF which is the lowest user perceivable structure in the user interface of an MS is associated with an ODP Activity. The triggering of an MF corresponds with an operation invocation of an activity's head action. This occurs at an operational interface of an appropriate ODP computational object. The Activity may be composed of several chained actions which may involve the interaction of several computational objects. The tail action of that Activity, however, has to occur at the same object where the Activity has been started. We define an activity originating from an MF as a *Management Activity* in contrast to other internal activities in an ODP system. The MF, which could be specified in terms of pre- and post conditions, benefits from the modeling power of ODP which enables the integrated specification of functional aspects (e.g. operations), dynamic aspects (actions and activities) and structural aspects (relationships between computational object).

Unfortunately there is no general algorithm that takes us automatically from a TMN MS specification to an ODP Computational specification. In particular, the MS designer will need a lot of experience to transform a TMN MF into an ODP Management Activity and has to consider every individual case separately. Nevertheless, the following steps present a general design guideline for the transformation of a TMN MS functional decomposition to an ODP conformant specification:

1. Starting point is the functional decomposition of the MS under consideration, i.e. appropriate MSCs and MFs have been identified.
2. Identify possible entities involved in the realization of a MSC/MF, referred to as "Management Process" and identify possible information flows by means of an Event Trace Diagram.

3. Identify candidate COs engaged in each MF/management activity being part of the identified Management Process (from step 2) and draw an Activity Flow Diagram.
4. Give a detailed Computational Specification using an appropriate specification template.

3. MODELING OF A USER PROFILE MANAGEMENT SERVICE FOR A PERSONAL COMMUNICATION SUPPORT SYSTEM

This chapter provides an illustration of the proposed approach. The field of application of the presented MS design methodology is a TMN-based *Personal Communication Support System (PCSS)*, currently under development at the BERKOM II project "IN/TMN Integration" performed by the Department for Open Communications Systems at the Technical University of Berlin for Deutsche Telekom Berkomp (•De•Te•Berkomp•). The PCSS provides IN-like personal mobility and service personalization capabilities by means of TMN concepts in a generic way for a broad range of telecommunication services. In the following we will provide a brief overview of the PCSS and address in particular the development of User Registration MF being part of a User Profile Management Service, based on the presented MS design methodology.

3.1 PCSS Overview

The PCSS has been specially designed for providing *personal mobility, personalization of services* and advanced service interoperability. It enables users to configure their communications environment according to their specific needs, with respect to parameters such as *time, location, quality, medium, cost, accessibility and privacy* [Eckardt-94]. The PCSS incorporates the most recent developments in the area of mobile computing and (universal) personal telecommunications. However, the basic idea of the PCSS is to use advanced TMN concepts for the realization of IN service feature related to universal personal communications [Maged-95].

One of the most prominent principles of the PCSS is the largely person-oriented and location-oriented operation of the PCSS in order to support real personal communications. This attribute distinguishes the PCSS approach from other advanced telecommunication services and IN services which are primarily based on (network) numbers when specifying features such as "call forwarding on busy (CFBY)".

In a less strict usage of the term, the PCSS denotes the *PCSS infrastructure* comprising the Core PCSS and elementary management services or enabling technologies provided as specialized services. In this category of services, we find the different registration services gathering the elementary location information of the various users to be written into the respective "user profiles". An important registration service in this context is the *Automatic Registration Service* which currently uses the Active Badge System of Olivetti. The *User Profile Management Service* represents another important example of elementary management services comprising the PCSS infrastructure. This management service provides a user interface to the Service User Profile and is used to display any information contained in the user profile as well as to modify certain data entries within the profile. In particular, different types of registration will be supported by this services as will be described in the next section.

The individual components of the Core PCSS and the main applications interacting with those components are displayed in Figure 4. The central data structure within the PCSS profiles is the *Generic Service User Profile* containing all the information required to support personal mobility, personalization of communication services, and advanced user information services.

An application programming interface (PCSS API) specifically defined for the context of the PCSS provides various types of teleservices and location-aware information services, such as an *User Location Information Service*, with personal communications-related information. More details on the PCSS can be found in [Maged-95].

FIGURE 4. Applications of the Core PCSS

3.2 Modeling of the PCSS User Profile Management Service

The requirements identified for the PCSS *User Profile Management Service* can be captured according to the PRISM Service Model, leading to the decomposition into MSCs and MFs as illustrated in Table 1. This corresponds to step one of the design guidelines given in section 2.2.

MS: User Profile Management	
MSC No. 1: User Registration	
MF No. 10:	Manual Registration
MF No. 11:	Automatic Registration (Enable/Disable)
MF No. 12:	Scheduled Registration (Enable/Disable)
MSC No. 2: Authentication	
MF No. 20	User Authentication
MF No. 21	Provider Authentication

TABLE 1. Functional Composition of the User Profile Management Service

The User Profile MS is composed of several MSCs, where some MSCs have been defined within other MSs and will be reused here (e.g. MSC Authentication). Within the scope of this paper we want to concentrate on the MSCs *User Registration* and *Authentication*. The *User*

Registration MSC constitutes three MFs: the first, “Manual Registration”, enables the user to explicitly specify a communication end point for all incoming calls, the two latter, “Automatic Registration” and “Scheduled Registration” provide the ability to select the registration mode, respectively. The MF “Automatic Registration” corresponds to the use of electronic location techniques. The MF “Scheduled Registration” allows the user to specify a time dependent routing of incoming calls to different communication end points e.g. to the office in the morning and to the conference room in the afternoon. The *Authentication* MSC provides for user authentication and provider authentication which is prescribed for accessing the User Profile according to the PCSS’s security policy.

Before turning to the Computational Viewpoint Specification we want to provide an overview of the User Registration Process (which could be regarded as the computational modeling of the corresponding MSC) with the event trace diagram shown in Figure 5, thus following step two of the design guidelines.

FIGURE 5. Event Trace Diagram for the PCSS User Registration Process

There are four parties involved in the User Registration Process: The “User” who wants to register himself to the PCSS, a “Registration Manager” which is in charge of managing the User Registration Process, an “Authentication Manager” responsible for the user’s authentication and the “User Profile” which holds registration and authentication relevant data. (Note that these “parties” are not Computational Objects. They are only used to obtain a general overview of the User Registration Process. However, the identified parties could serve as a basis for the later identification of COs.

The User Registration process starts with the User initiating the registration via the

Registration Manager. He selects one registration type (i.e. manual, automatic, and scheduled) and in case of manual registration provides a target communication end point (i.e. a room number or a terminal address). The Registration Manager starts the authentication process at the Authentication Manager's interface. The Authentication Manager selects a PIN-based (Personal Identity Number) authentication mechanism according to the PCSS security policy. In case of success he certifies the user's authenticity to the Registration Manager who subsequently executes the registration at the User Profile Manager. After that the Registration Manager reads the actual values of the three registration attributes (i.e. manual, automatic, and scheduled) and reports the new registration state to the user.

Being now familiar with the User Registration Process as a whole, we can turn to the Computational Specification according to step three of the design guidelines. This process is composed of four Management Activities, corresponding to the MFs *Manual Registration*, *Automatic Registration*, *Scheduled Registration* and *User Authentication* respectively. In the following we focus only on the Management Activities for *Manual Registration* and *User Authentication* MFs. Figure 6 depicts a combined activity flow diagram for both Management Activities.

FIGURE 6. Activity Flow diagram for the Manual Registration and User Authentication Management Activities

The Manual Registration Activity comprises the following Computational Objects (COs): *User Agent*, *Registration Manager*, and *User Profile Manager*. The User Authentication Activity, marked with the shaded area, additionally includes the *Authentication Manager* CO. The diagram illustrates the CO's interactions. Operation invocations at CO interfaces together with a sequence number constitute the Management Activities. The operation names are further specified by arguments but not in an exhaustive manner. The operations are now described in the order of their sequence number:

(1) Manual Registration: This operation invoked at the Registration Manager's interface is the head action of the Registration Management Activity. The User CO is the client object providing a target communication endpoint as input parameter. The operation is an

interrogation, meaning that the User CO expects a reply message from the Registration Manager CO. The reply message is stored in the output parameter “register state” and informs the user about success of the Activity and the actual registration state.

(2) Request User Authentication: This is the head action of the User Authentication Activity initiated by the Registration Manager CO at the Authentication Manager CO’s interface. Within this interaction the Registration Manager takes the client role and the Authentication Manager plays the server role. Again this operation is an interrogation. The Registration Manager CO provides the “personalID” of the user to be authenticated and expects an authentication certificate as a result parameter.

(3), (4b) PIN Request: This is the second action within the Authentication Activity. The Authentication Manager, acting as the client object, invokes this interrogation at the User CO’s operational interface. The User CO starts an interactive dialog with the real user via some GUI to request the user’s PIN. This interaction is modelled as internal action. The User CO, acting as the server object, finally delivers the requested PIN as an output parameter of this operation.

(4) PIN Check: This operation also belongs to the User Authentication Management Activity. The Authentication Manager CO invokes this interrogation at the User Profile Manager CO’s interface, provides the user’s PIN and expects a boolean output parameter stating whether the PIN is correct or not.

(4a) Log Authentication Attempt: Depending on the result of the PIN Check operation the Authentication Manager selects this operation or terminates the User Authentication Management Activity with an authentication certificate delivery to the Registration Manager CO. In the case of a negative result of the PIN Check, i.e. the user PIN was incorrect, the Authentication Manager invokes this operation at the User Profile Manager’s interface, providing a time stamp and an integer value to increase the counter for the failed attempts. If the attempt counter reaches a threshold value, the Authentication Manager CO terminates the activity with a negative authentication statement.

(4b) PIN Request: This operation is the same as in sequence number (3) and is invoked after a negative result of the PIN Check. The user has the possibility to provide a new PIN, however the maximum number of failed attempts is limited.

(5) Write Attribute: This operation is an announcement, i.e. the Registration Manager CO invokes this operation at the User Profile Manager’s interface without expecting a terminating operation, which delivers any results. This operation is only selected in case of a positive authentication result, otherwise the Activity is terminated. The parameters contain the attribute to be set (“registeredManuallyTo”), and the new value of that attribute (e.g. a “roomID”).

(6) Read Attribute: The Registration Manager invokes this interrogation at the User Profile Manager’s interface in order to retrieve the actual values of the provided Attributes (registeredManuallyTo, registeredAutomaticallyTo, registeredbyScheduleTo). The values of these attributes form the actual state of the Registration and are delivered to the User Agent CO. This action terminates the Registration Management Activity successfully.

The Activity Flow Diagram already provides a level of granularity identifying COs and interactions between them in a detailed manner. However, to overcome the descriptive fashion and to gain a formal and comprehensive computational specification of the identified COs, interfaces and operations, appropriate CO specification templates have to be used, such as

those defined in the TINA-C Computational Modeling Concepts [TINA-93]. An example for the Registration Manager CO specification is given below. This represents step four of the proposed design guidelines:

```

object template Registration Manager;
operations
    void ManualRegistration (in roomID target, out string registration state);
        /* This operation invoked by an User Agent starts the Registration Management
        Activity and delivers as a result the actual registration state */
    void AutomaticRegistration (in boolean enabled, out string registration state);
    void ScheduleRegistration (in boolean enabled, out string registration state);
initialization
    void init (out interfaceref RegMInterface);
required interface templates
    UProfileInterface, AuthentMInterface;
behaviour
    "An instance of this object template executes the Registration Management Activity. It provides
    operations for three different registration modes. Within the course of the registration process it initiates
    an instance of the Authentication Management Activity and invokes depending on the authentication
    process's result, Write Attribute and Read Attribute operations at the User Profile Manager's interface.
    If the Registration Management Activity selects a success termination, the Registration Manager
    delivers the actual registration state to the invoking User Agent."
supported interface templates
    interface template RegMInterface;
        operations
            ManualRegistration, AutomaticRegistration, ScheduleRegistration;
        behaviour
            "This is the template of an interface provided by an object that provides operations to User
            Agents for PCSS Registration in three different modes."

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This specification represents the input for the Engineering Viewpoint modeling and directly prepares a subsequent MS implementation.

4. CONCLUSION

This paper has focused on the aspect of management service design taking into account the function-oriented interface specification methodology of current TMN standards and the object-oriented modeling concepts of emerging ODP standards. Since ODP represents the fundamental framework for the long term evolution of the telecommunications environment towards object-orientation, TMN concepts have to be aligned with ODP standards, in particular in the still evolving area of MS design and specification. Within this paper we have illustrated that both TMN and ODP concepts could be combined for the sake of object-oriented MS design, where TMN interface specification concepts will be used within ODP enterprise modeling, and ODP computational modeling concepts will be used for the object-oriented MS specification. In particular, the proposed mapping of TMN Management Functions onto ODP Activities bridges the gap between TMN and ODP modeling concepts. We thus demonstrated the common use of the TMN functional approach and the ODP object-oriented approach combined in one design methodology. An example modeling of a "User Profile Management Service" has been provided in order to illustrate our approach.

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