

New Architecture for a Centralized Next Generation Profile Register in Future Mobile Telecommunication Networks

A.Diehl ^{1,2}, J.Soler ³, W.Fuhrmann ⁴, U.Bleimann ⁴, P.Reynolds ², B.Ghita ²

¹ Diehl-Develop.com, Stuttgart, Germany

² Network Research Group, University of Plymouth, Plymouth, United Kingdom

³ Technical University of Denmark, Copenhagen, Denmark

⁴ University of Applied Sciences Darmstadt, Darmstadt, Germany

email: andreas.diehl@diehl-develop.de

Abstract

The evolution of mobile telecommunication networks resulted in logically and physically distributed subscriber profiles, specialised interfaces and network-specific protocols. Access to complete subscriber information and integration of service-oriented technologies are challenges of a centralized Next Generation Profile Register (NGPR). This paper addresses the future integration needs of a NGPR and presents the actual status of the research work and the proposed framework of the NGPR.

Keywords

FlexiNET, GSM, HLR, HSS, NGPR, SOA, Subscriber Profile, UMTS

1. Introduction

The Universal Mobile Telecommunication System (UMTS) Release 5 (Banet et al, 2004) (Kaarainen et al, 2001) is a 3rd generation mobile network and consists of three domains; the Circuit Switched (CS) domain, the Packet Switched (PS) domain, and the IP Multimedia Subsystem (IMS) (ETSI TS 123 228, 2004). In general the domains can be divided into IP (PS/IMS) and non-IP networks (CS). Beside the well defined telecommunications real time systems, the Operations Subsystem (OSS) administers subscribers as customers and manages the network. The OSS and dedicated interfaces are not standardised and integrate main subscriber databases in a proprietary way. OSS of a mobile network includes for example the Customer Clearing and Billing System (CCBS), Customer Relationship Management (CRM) and the network management.

These co-existing diverse domains are based on different technologies and communication protocols of a single operator. The subscriber can use different technologies deployed in separated domains (e.g. data services / voice only services). As subscriber data can always be seen domain independent as data that is related to the subscriber an integration approach has been investigated. This paper facilitates a generic database architecture that is defined as Next Generation Profile Register (NGPR). The following section discusses the integration need of current heterogeneous database identities deployed in mobile telecommunication networks. Afterwards the generic database architecture is presented in the Information Society Technology (IST) FlexiNET project. The idea of a centralized NGPR refers not to a multi operator scenario. In the following the subscriber data convergence for the network of a single operator is described. The last section addresses the NGPR concept in detail.

2. Integration need of subscriber databases in telecommunication networks

The diverse co-existing mobile telecommunications networks deploy several network-dependent database instances. Therefore a database look-up of a single mobile subscriber and the dedicated subscribed services is a challenging task.

2.1 Distributed main subscriber profile and subscriber data

Main subscriber profiles are distributed over the different databases of the diverse mobile network. The main GSM subscriber profiles are stored in a distributed environment, where each Home Location Register (HLR) contains a predefined block of subscribers. Signalling requests investigate the HLRs by location tables. For example, subscribers from external networks use the Mobile Station ISDN (MSISDN) number to allocate and call a subscriber attached in the home network. Leading providers use two digits of the Subscriber Number (SN) of the MSISDN to mediate between the HLRs (Figure 1). HLR mediation can be eliminated by a logically centralized data network node. For UMTS, the Subscription Locator Function (SLF) manages distributed Home Subscriber Server (HSS) systems.

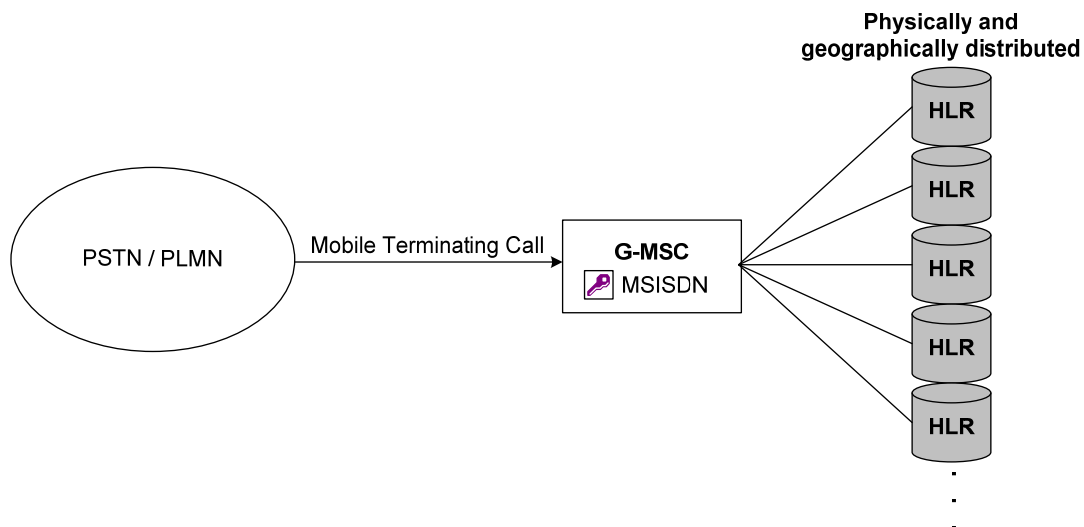


Figure 1 - HLR mediation

2.2 Different database storage entities for one subscriber

Beside the main subscriber profile stored in the HLR or HSS, other profiles are co-existing (e.g. in WLAN and OSS databases). Databases within the OSS or the service control point (SCP) normally use the same keys to extend the subscriber profile with data from intelligent networks, business applications, or billing functionality. Also different radio interfaces like WLAN, Bluetooth and others handle separated subscriber profiles. The integration of all separated profiles would support a unified data access interface.

2.3 Specific Interfaces

The 3rd generation partnership project (3GPP) standardises interfaces and protocols, but implementations are generally vendor-dependent because of vendor-specific standard extensions. This requires software modification to support specialised network nodes. Therefore, a flexible service concept should facilitate the inter-working between vendor-dependent network nodes.

The addressed issues such as the logically centralized data node, the unified data access interface and the vendor independent inter-working as well as the standardisation issues have to be taken into account when designing a NGPR. A NGPR should be based on open interfaces, interoperable services and a common subscriber profile.

3. IST FlexiNET beyond 3G project

The EU-Project Flexinet (FlexiNET, 2005) addresses a novel centralized data storage concept (Lopez Aladros et al, 2003) (Rupp et al, 2004.1 and 2004.2). FlexiNET cross-connects UMTS and WLAN mobile networks via network gateways (Figure 2). FlexiNET uses SOAP services to interoperate between the access networks, the application servers and the centralized data gateway node (DGWN).

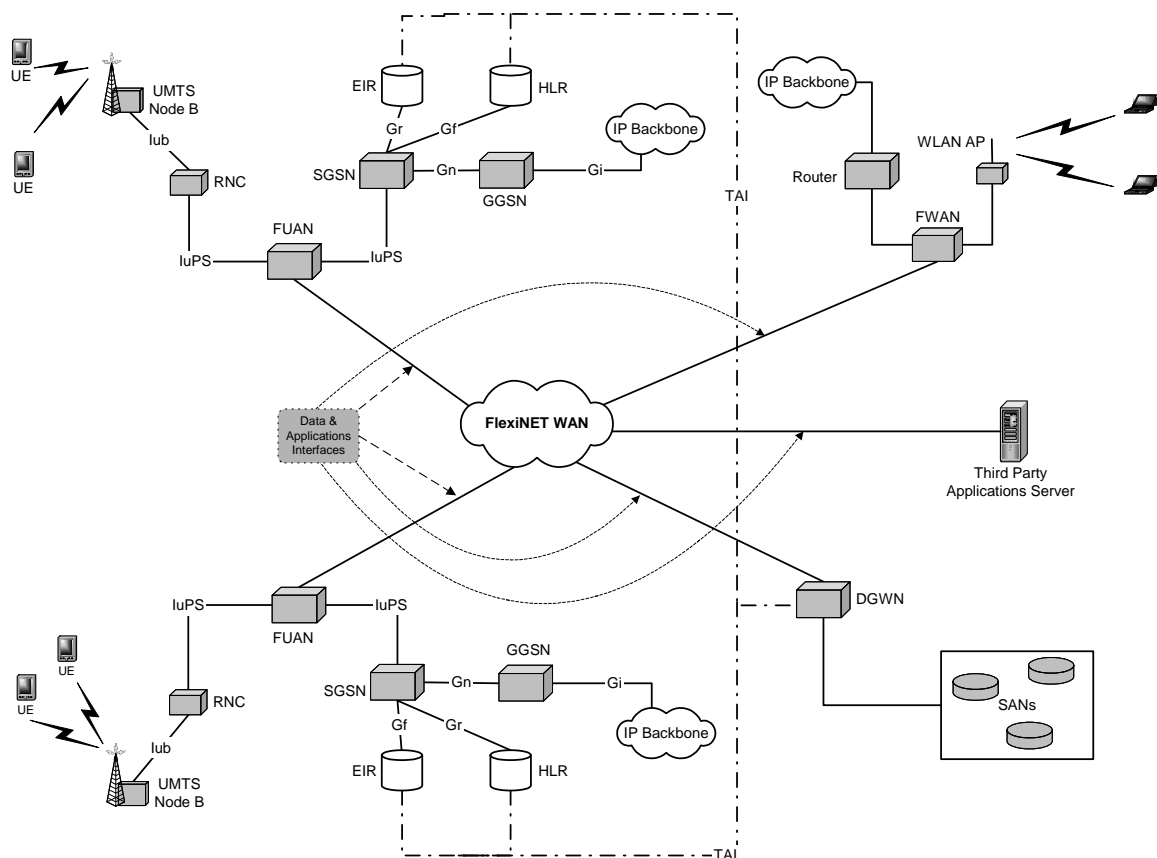


Figure 2 - FlexiNET Network Architecture Overview

This concept enables interoperability for closed networks and deploys a common application interface and data interface for the WLAN and UMTS network. These wireless networks are integrated by the FlexiNET UMTS Access Node (FUAN) and the FlexiNET WLAN Access Node (FWAN). The network access points provide gateway functionality and support cross-connect control as well as switching/routing control. FUAN complements existing UMTS access nodes and provides adequate interfaces to switch between the traditional network and FlexiNET. Also FWAN inter-works between the WLAN infrastructure and FlexiNET nodes to access common services and generic subscriber data. The DGWN provides subscriber and application data by data centric services for the access networks. The inter-working bus with legacy switch platforms is used to connect traditional network nodes with FlexiNET nodes. This mechanism uses standard signalling interfaces to switch between the networks and

accesses co-existing subscriber data of the UMTS/WLAN core network. The integration and consistency of legacy infrastructure within the novel framework is realized via the Telecommunications Application Interface (TAI).

4. The Proposed Framework of the NGPR

4.1 Introduction

The research work is mainly done in the context of FlexiNET and aims to design a centralized Next Generation Profile Register (NGPR) for all mobile telecommunication domains (Figure 3). The NGPR should be able to integrate existing XML telecommunication standards by adopting a service oriented architecture (SOA) for mobile telecommunication networks. First a suitable, service-oriented gateway technology has to be investigated in order to interoperate between the SS7-based (ITU-T Q.700, 1993) and IP-based networks (section 4.4).

Another challenging task is the integration of the different subscriber profiles in a generic subscriber data model of centralized NGPR. The data model should support existing data structures as well as generic data structures. In contrast to interface and protocol definitions the data model definition of a subscriber profile is not standardised. An approach for a data model supporting generic as well as concrete network-dependent data is presented in section 4.2.

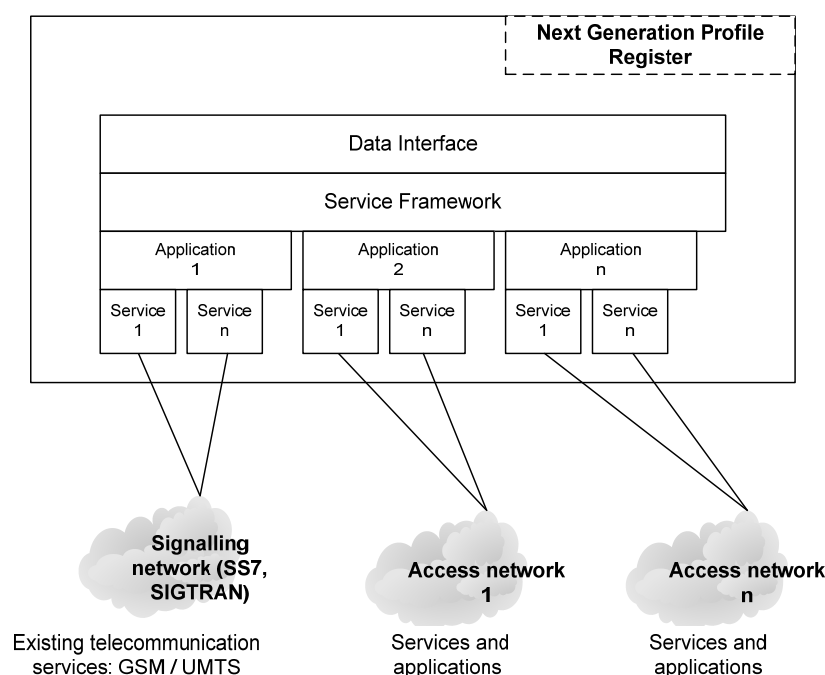


Figure 3 - Preliminary Design of a NGPR

The data model has to be integrated by a service framework that combines several data-centric services of a single application. The service framework will enable an efficient deployment of services allowing any type of defined data structures. This framework supports legacy or common/generic services deployed by a well-defined process and registered without the need of a system restart.

The data interface aims to provide various networks common access to the general, integrated profile data. The offered services may also be reused for composing new services, for example, a wireless local area network (WLAN) service may use parts of the offered HLR

services for its authentication and authorisation process. These service-oriented concepts are well known, for example, from web services.

4.2 Subscriber Data Model

The data model for a NGPR is proposed to be object-oriented. Object-Oriented Programming (OOP) defines objects that encapsulate data and operations on the data. Objects allow the re-usability of code and dedicated interface definitions are used for interoperability. Apart from supporting application logic, modern object-oriented concepts additionally support persistent storage capabilities. Object-oriented databases as well as object-relational mapping technologies are able to integrate persistent object data in applications. The need to translate persistent data-objects into relations or other data model structures is eliminated.

The data model should be independent of specific network or service architectures. The concept and an example of an object-oriented profile data model has been outlined (Diehl et al, 2005.1). The superset object of the data model identifies the complete set of subscriber-related data combined in the subscriber's profile. This profile consists of different data associated with the network dependent data storage entities of the various access networks.

For network-independent applications, a subscriber profile is identified by a generic key of its complete profile. Therefore, run time services dedicated to the applications can access and integrate the complete data sets related to the subscriber. For legacy applications, the existing keys of the corresponding data storage entities may be used. As an illustration, a HLR data model is considered as an example for the NGPR that describes persistent mobile subscriber data such as location, basic telecommunication services, supplementary services etc.

In GSM, two primary keys are defined for database access, the International Mobile Subscriber Identity (IMSI) and the Mobile Station ISDN Number (MSISDN). Conventional GSM services (3GPP TS 09.02, 1998) use the IMSI to access the HLR profile data and the MSISDN as a key for the HLR mobile data. Billing services, for example, may access the whole profile by using the complete profile key of a superset profile. The network dependent profile inherits common information about the subscriber that is stored in the superset object.

Profile data of a subscriber from different access networks is always identified by the network dependent subscriber profile key. Therefore, the superset object references one or more specific profiles of the data storage entities of an access network. The specific data storage entity contains the network-specific or database-specific profile data. However, a NGPR data model aims to define as much generic data in the generic superset profile as possible to provide a network-independent model.

A concrete implementation of the superset profile (class Userdata) and network dependent profiles (classes WLAN_Userdata and UMTS_Userdata) is presented in the FlexiNET data model (Figure 4). Re-usable data can be associated or inherited (e.g. class PWDbasedAuthentication, Location in Figure 4) by other network profiles, which may belong to different access networks. This means that data can be reused between the former separate profiles.

Another concrete approach for modelling persistent authentication data has been addressed (Alazeib and Diehl, 2005) using the Ontology Web Language (OWL) (McGuinness and Van Harmelen, 2004). OWL shares and distributes knowledge, represents a rich vocabulary for modelling and focuses on structural properties.

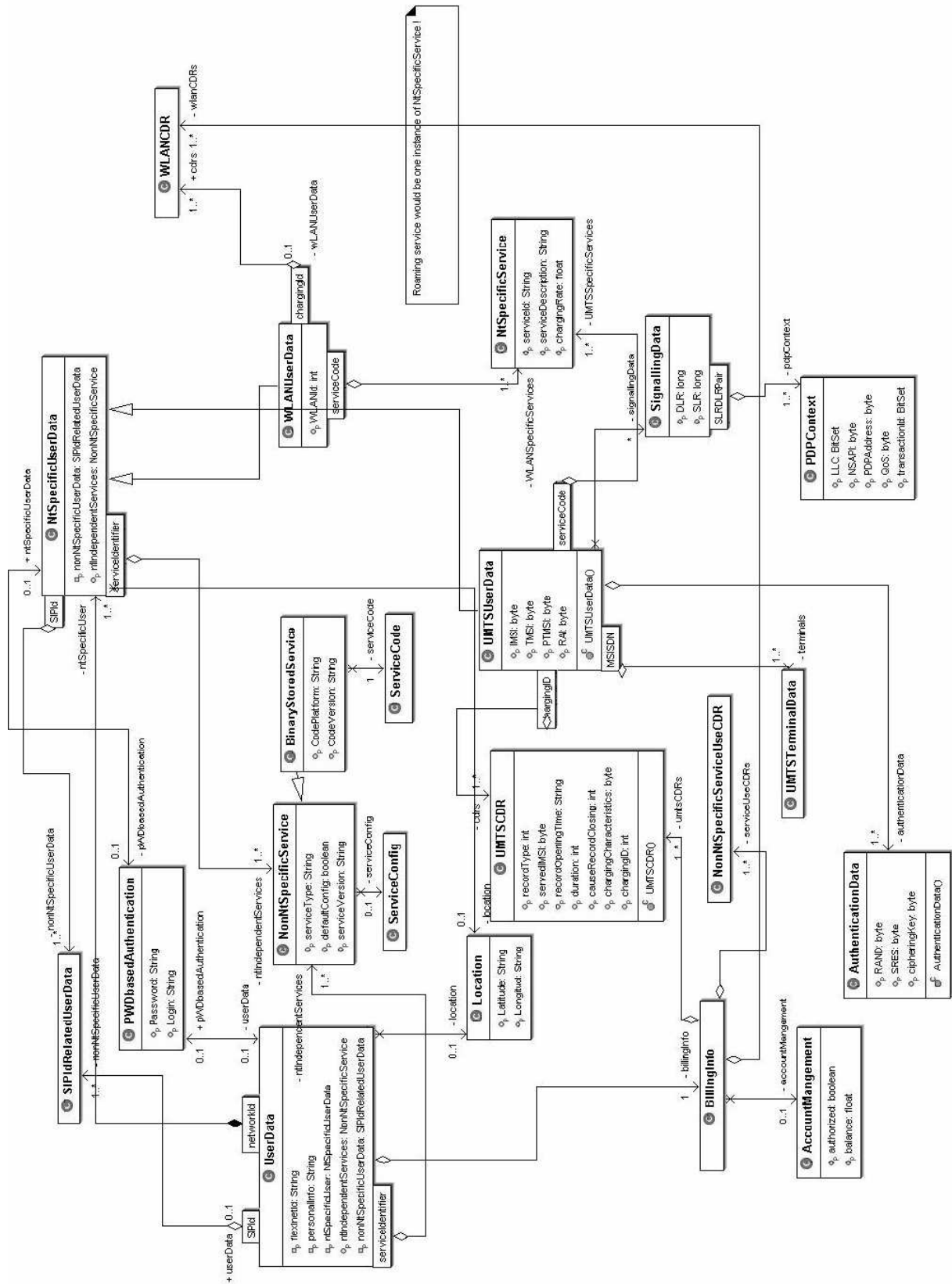


Figure 4 - Overview of the FlexiNET user and services data model

4.3 Services Framework

The service and application model should support a service-oriented architecture. Application and administration services are distinguished to separate telecommunication requirements from administrative tasks. For example, the deployment process can be seen as an administration service offering deploy and undeploy functionalities (Diehl et al, 2005.2). Other administrative services include load services used for inserting new service objects or for copying data from legacy network nodes, etc.

Application services may be further sub-divided into run-time and provisioning services; services in general offer create, update, modify, or delete operations related to user interfaces on the subscriber profile. The HLR services for GSM and UMTS are, for example, part of the HLR application. Other applications may include different access networks or new service platforms. Specific HLR application services include, for example, the legacy signalling operations of the MAP such as UpdateLocation, CancelLocation, SendAuthenticationInfo etc. Concrete HLR application services use a concrete factory design pattern to build the concrete data object (refer to Diehl et al, 2005.2). The concrete factory class always inherits from a super application factory class.

This architecture strictly separates the services and their building processes from the persistent data. The service logic is encapsulated in the specific service object and only the interface of the service object needs to be advertised to a broker or trader function. “get” and “set” methods of the concrete data object can be used by the concrete factory for data object interaction. The concrete factory, depending on the operation type, is responsible for building the object. A database handler is used to integrate the built objects in the Profile Model and objects that have been set as persistent can be stored in the database.

The service and application model is protocol independent. For a sample implementation the SOAP protocol (Mitra N. et al, 2003) and other web services standards are considered. SOAP-based web services are a common supported way of realising SOA.

4.4 Service-Oriented Interoperability

Service-oriented interoperability between SS7-based and IP-based networks can be guaranteed by gateway-functionality (Diehl et al 2004). The gateway performs the necessary conversions between MAP messages carried on top of SS7 and MAP messages carried on top of SOAP. In GSM MAP messages are always encapsulated by Transaction Capabilities Application Part (TCAP). In GSM TCAP is encoded by ASN.1/Basic Encoding Rule and in UMTS by the ASN.1/Packed Encoding Rule. In order to support a service-oriented architecture TCAP has to be separated from MAP and embedded into SOAP. ASN.1 /XML Encoding Rule (XER) and ASN.1 Extended XER are able to integrate telecommunications messages into modern service oriented architectures. A NGPR should integrate those encoding rules to enable service mediation from legacy systems.

5. Conclusion

This paper presented the concept of a centralized subscriber database that allows the integration of all subscriber related data in a single subscriber profile. The generic profile of all subscriber related data supports the efficient integration of multiple applications. The profile model is modular and data objects form the building blocks that can be reused in different services and applications. SOA is realized in a network-independent way for the telecommunication networks to support the transparent “access on demand” paradigm.

Legacy systems and their data models can be integrated using appropriate gateway adaptation functions. Research work will be carried out defining the final integrated architecture of the NGPR. Focus of the further work is interoperability, open interfaces, service mediation and the evaluation of the model.

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