

# RESTRUCTURING THE TELECOMMUNICATION NETWORKS

## Simplification of the Network Infrastructure by implementing Storage Networks and Web Services techniques

**Franz-Josef Banet**

Alcatel SEL AG

FJ.Banet@alcatel.de

**Rodolfo López Aladros**

Alcatel SEL AG

R.Lopez-Aladros@alcatel.de

**Dr. Stephan Rupp**

Alcatel SEL AG

S.Rupp@alcatel.de

**Dr. Ehrhard Winter**

E-Plus Mobilfunk GmbH

Ehrhard.Winter@eplus.de

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### Abstract

GPRS, Location Based Services (LBS), WLAN integration, Mobile Number Portability and UMTS are some of the new technologies and services that are responsible for the increasing complexity of today's networks. Those new services require new network elements and applications to run. And those applications need their own subscriber data, usually stored locally in the application's database (distributed across the network), managed from their own management systems and with their own interfaces to Subscriber Care and Accounting Systems. More, databases like HLR, AAA-Servers, MMS, Number Portability and others keep a significant amount of identical data that have to be kept consistent across all applications. For Network Operators, the effort to plan, to administrate and to introduce new services in those networks increases dramatically. This paper presents a three-orthogonal-way concept to simplify current and future telecommunication networks. They complement each other but can be implemented independently one from another. In addition, a telco project is presented (PoLoS, Platform for Location-Based Services) where some of the ideas presented in the paper have been implemented.

**Physical Consolidation of Subscriber Data:** That means, physically separating data from the applications. Application servers are freed from pure administrative data management processes like storage of data, data protection, data availability, data performance, back-ups and disaster recovery. Those tasks can be performed much more efficiently by applying storage networking solutions like SAN (Storage Area Networks). In a storage network, data are physically consolidated in order to achieve economy of scale. This way provides cost reduction in operational tasks.

**Logical Consolidation of Subscriber Data:** From a Network Operator perspective, subscribers are people using a network in a certain way that is described by a profile they may be able to change. Nowadays, subscriber data is dispersed across the network and in some cases, even redundant. Data are autarkic to each application (almost). To get a global view on subscriber profile (for Customer Care and Accounting activities), subscriber habits (data mining, marketing strategies) or managing the associated data (provisioning tasks) is not an easy job. A common data model describing subscriber data would allow the development of applications that would use these data and not own them. The Generic User Profile (GUP) standardization in UMTS is a step in that direction.

**Harmonization of Interfaces:** The high number of different interfaces as present in current telecommunication networks has to decrease dramatically so that the networks become simpler and clearer again. That step decreases the complexity of the network management and the integration of new services and features. One very interesting and promising technology to bring together the current mesh is

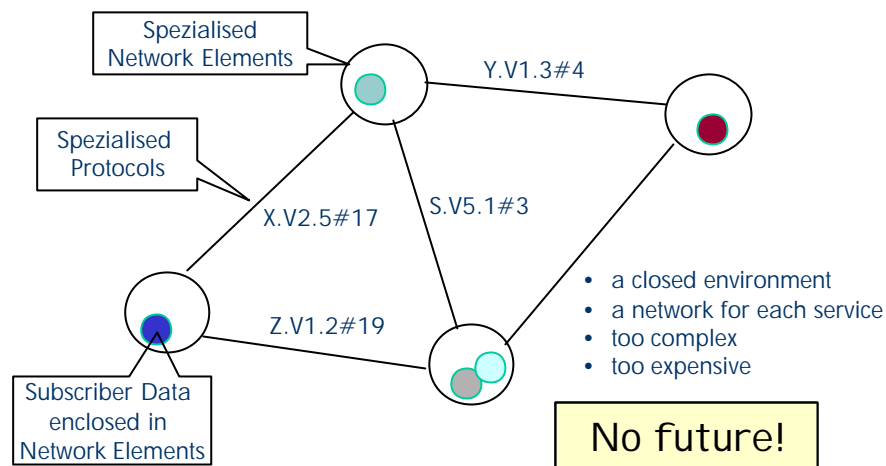
Web Services. Existing functions and applications could be encapsulated as Web Services in a way to offer a standard interface to new applications and network functions developed with this new technology.

## **1. Introduction**

Mobile networks were primarily designed for mobile telephony. The selected network architecture was simple, elegant and adequate to fulfil that function. However, today networks are supporting several other services and capabilities they were not designed for, as for Short Messaging Service, Location Based Services, Multimedia Messaging Services, Data services and so on. Actually, more and more services are being deployed and will be deployed in the near future. Networks are getting more and more complex and difficult to manage, which increases the Operating Expenses (OPEX) of Network Operators.

The high costs associated to the acquisition of UMTS licenses and the deployment of those networks, have compromised the financial health on the main Mobile Network Operators, specially in Europe. They are therefore, forced to increase cash-flow, that is, reduce costs and increase revenue. Because western countries have quite saturated market, there will not be a dramatically increase in revenue because of new subscribers. Therefore, the only way to increase those revenues come from increasing the Average Revenue Per User (ARPU) and that can be only achieved if users are given new services they are willing to pay for. The problem is that the killer application has not yet been found. Instead, the market will be divided into many niches and applications will have to be developed to cover each of those market niches. If we take into account that for each successful service, four will fail to attract users attention, network operators will be forced to integrate in their networks about 250 new services in order to get 50 money makers. Think in terms of the integration cost for an Network Operator; mobile networks were not designed to easily attach new services and capabilities. Some of those successful services may even cover the integration costs in a period of two-three years.

The initial, clear network architecture has been extended with add-ons to include those new services and features. That is, they are implemented in new network elements which, in addition need new communication protocols or extensions of existing protocols to work properly. Together with GSM-access we find about five network domains in a UMTS network: the access domains, a circuit switching domain, a packet switching domain and an IP-multimedia domain. In each of those domains several network elements can be found. The example with four network elements in Figure 1 shows, in an abstract way, the situation for the envisaged problem in current Telecommunication networks.



**Figure 1** *Subscriber data storage and the variety of interfaces in today's Telco-networks*

The network elements are optimized for different functions and communicate with each other. In the most unfavorable case the communication protocols are different on different interfaces. In addition each network element hosts a specific subscriber dataset in memory and on local disks and can be regarded as “owner” of the subscriber dataset. In most cases the specific datasets of different network elements have some redundancy. For example the phone number and/or the subscriber identity will be present in most of them.

Extensions for more functionality in the network require besides new network elements and new or extended protocols also the storage of a subscriber dataset in the new network elements. If we continue to go ahead this way the Telco-networks will become more and more complex. Mobile networks are good examples for Telco-networks where this can be looked at today. The expenses for network planning and network maintenance are rising significantly.

## 2. Network restructuring and the example of New Generation Networks (NGN)

On the early stages of digital telecommunication networks there was a trend to concentrate all type of functions needed to run telephony services in the switches (network elements primarily in charge of setting up the voice channels). So, there were switches able to “switch” (transport function), able to handle calls (control function) and even able to provide advanced services like “Free-phone” (service function).

Under monopolistic conditions, networks remain rather static concerning changes and evolution. In this case, the approach of concentrating functions into single network elements was a good approach. However, following the telecommunication deregulation starting in the United States, operators were forced to compete, prices dropped and other sources of revenue were needed to compensate the balance. As new services were deployed on the network (Premium-rate calls for instance, very successful in hot-lines, sex-lines and information-providers), it became clear that hosting those services into the switches was too expensive to manage –the introduction of a new services implied the upgrade with the new software of all switches in the network. As a solution, it was decided to separate the service function from the switch and define a protocol through which specialized service nodes (few of them) could communicate with the switches. That was called “Intelligent Networks” at the time and, it has been very successful since its introduction back in the late 80's. Almost all implementation, world-wide, of mobile Pre-Paid cards are based on Intelligent Networks.

The point is that networks are getting even more complex. A way of solving a complex problem is to break it down into several but smaller problems. That is what was done when introducing “Intelligent

Networks” and it is also the objective of the NGN. NGN splits the control and the transport functions, defining an interface between them. In Figure 2 it is shown how a Mobile Switching Center is configured today.

### Example: Circuit Switching

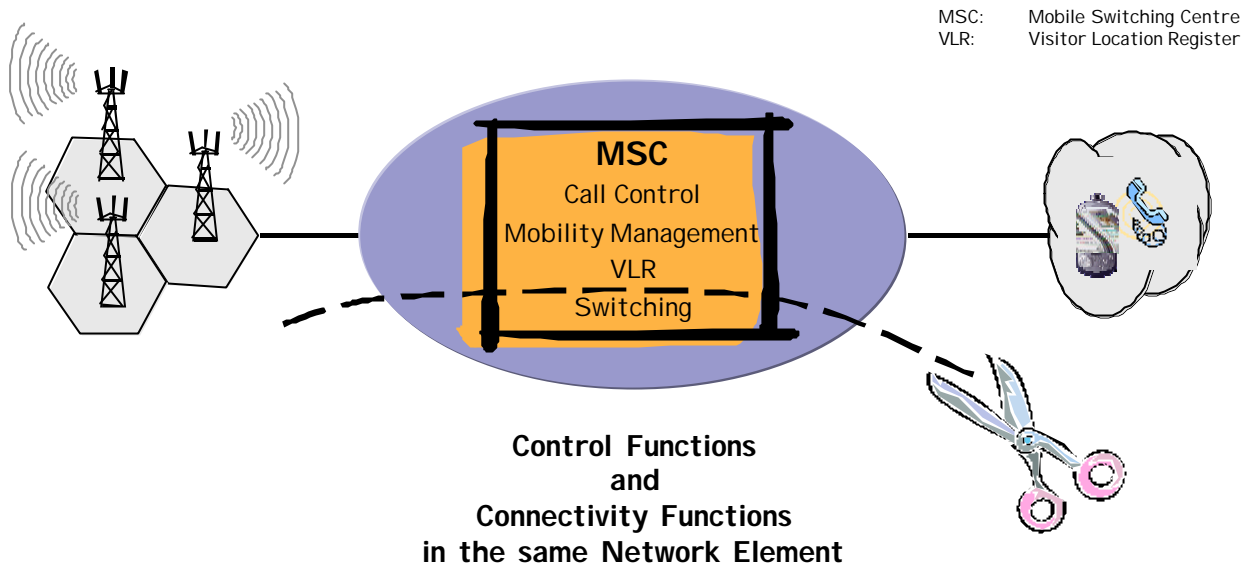


Figure 2 Today’s MSC: Control and connectivity functions are combined

After applying NGN concepts, the switching function is separated from the call control function. In a more abstract way, the standards talk about separating functions into planes. That is shown in Figure 3 for the control and transport planes.

### Example: Circuit Switching

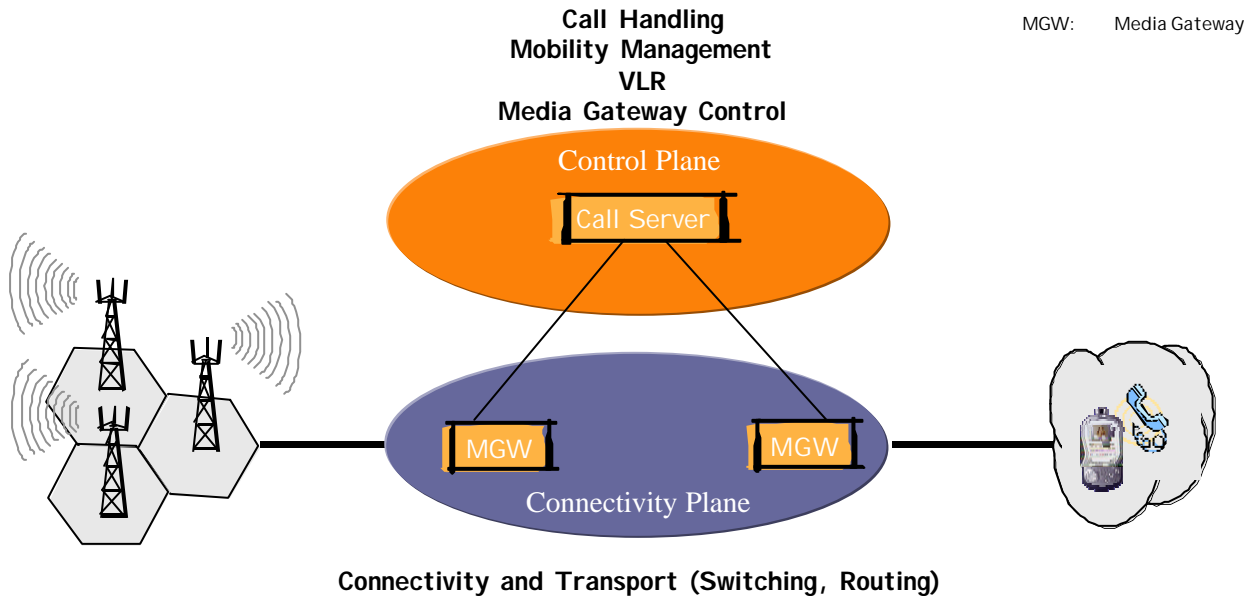
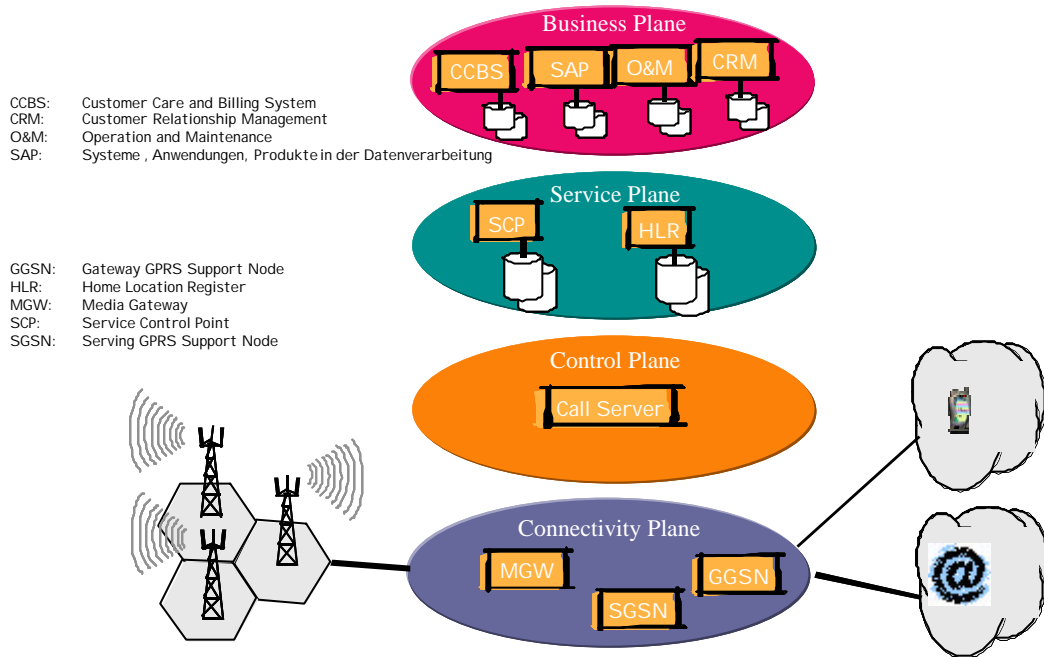


Figure 3 Control and Connectivity (transport) planes

Currently it is accepted that a network can be split into four different planes as shown in Figure 4. The Connectivity Plane offers the resources for the transportation of the payload and the signaling messages. Above that the service control and the resource control for voice, data and multimedia services is managed in the Control Plane. Network elements, that host the master subscriber datasets of a mobile network, can be found in the Service Plane. Principal network elements in there are the Home Location Registers (HLRs) and the Service Control Points (SCPs).



**Figure 4** *The planes of a mobile network with Direct Attached Storage in Service Plane and Business Plane*

The authors believe that even with the introduction of the NGN concepts, networks are still too complex and some additional splitting should take place. The proposal is to separate data from applications. Why data? Readers may agree that information is the most important asset an operator has. Information is about who the customers are, who the users are, what use they make of the services, when they used them and how long, etc. A company unable to charge for the use of services (billing information) can not survive. The same if the company does not know its customers.

In nowadays networks, data (information) are attached (belong) to a certain application and, are spread across many computers, more or less isolated from other computers (applications). Data are stored on local (to the computer holding the application) disks. This kind of storage is called Direct Attached Storage (DAS). Such a configuration has two main problems.

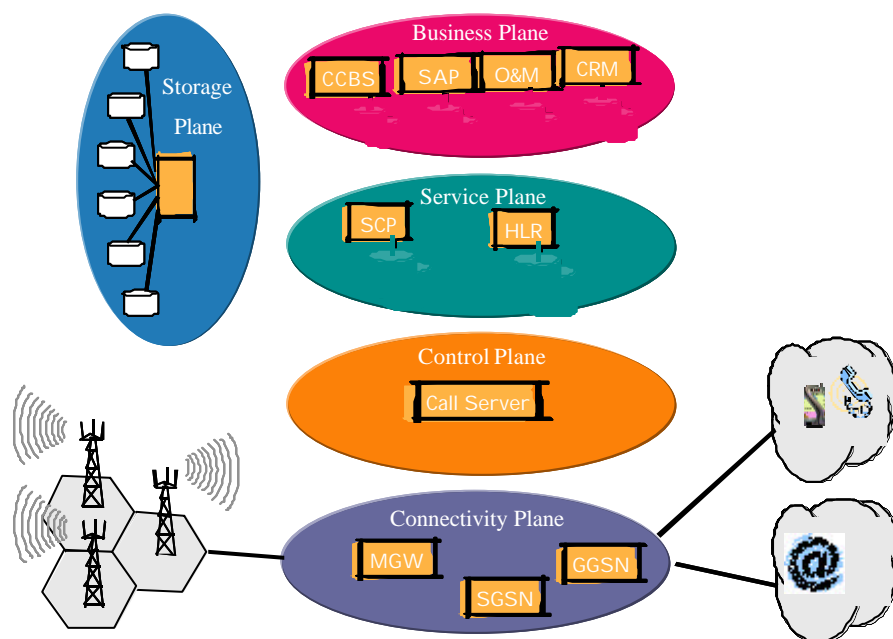
The first one is operational cost. For security reasons backups must be prepared frequently, in some nodes (computers) even several times a day, depending on how often data change. Those back-up streamers or DVDs have to be brought to a physically separate room (better separate building) to prevent losing data in the event of a catastrophe (fire, etc.). That implies a heavy use of human effort, which is expensive. Current storage technologies like Storage Area Networks (SAN) provide a very optimized, highly available, highly automated and secure solution for data storage. The use of SAN in telecommunication computing would reduce OPEX significantly.

The second problem nowadays concerning data is their unavailability to other applications. That will be illustrated with two examples.

Example 1. In order to offer mobile Pre-Paid services, the Service Control Point (SCP, a node of the above mentioned Intelligent Networks) needs information which is stored in the Home Location Register (HLR, a data base containing mobile user information). To reach this information, an interface called Customized Applications for Mobile network Enhanced Logic (CAMEL) has been defined. This interface has to be supported by both, the HLR and the SCP. Depending on the version of the CAMEL protocol, more or less HLR data is accessible to the SCP. If the HLR data would be open to other applications –via an standard data-base interface, the SCP would not need to first, support the CAMEL interface and second, it could reach HLR data without having to wait for the next CAMEL version to include the specific data it may need to offer a sexy new service.

Example 2. The Network Operation Center (NOC) of a certain operator detects some problems in the network. Usually each problem is given a certain priority that is assigned pending on the effect on the running business. If the problem affects some thousand users that have a best effort Quality of Service (QoS) in their contracts, the priority may be lower than if the problem affects to only one user who has a very demanding QoS agreement with the operator. The problem is that this type of weighting is only possible if the NOC applications have access to commercial data (customers, contracts, etc.), which is not the case today. In the same way, the Customer Care department would like to inform important customers about network problems before the customers realized by themselves that there is a problem. Again, network data and customer data have to be cross-checked to achieve that.

That explained, it becomes more clear what an important role data play in business today. Therefore the readers should not be surprise to see extension of the NGN plane model shown in Figure 5.



**Figure 5** *Storage consolidation in a Storage Plane*

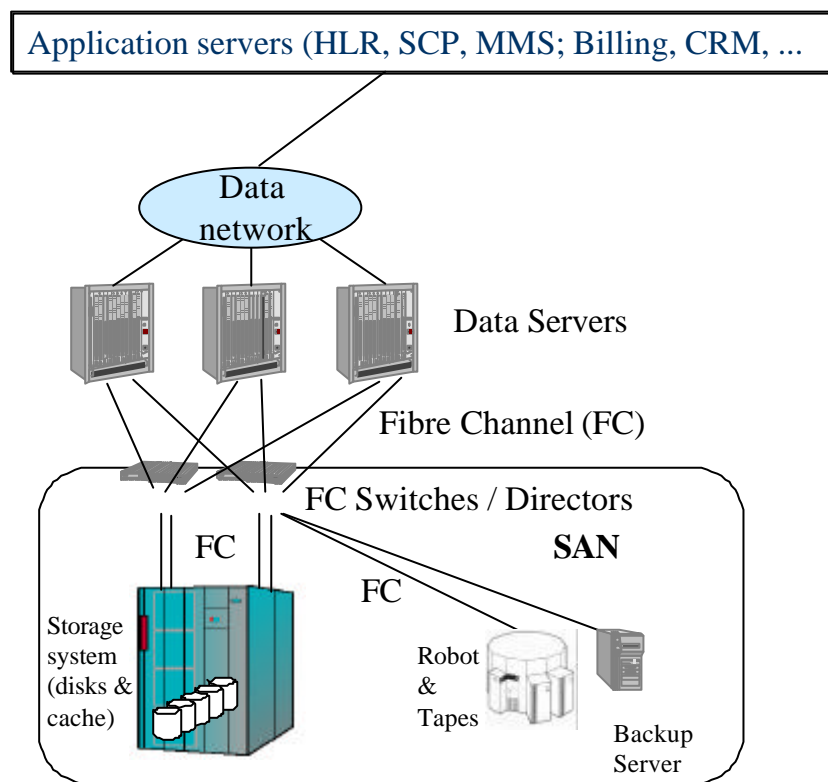
The “Storage Plane” offers the opportunity to simplify the management of data and at the same time, opens the door to data reusability and simplification of interfaces (among applications).

### 3. Three orthogonal directions to simplify Network Operators' live

Further developing those ideas, the authors have identified three ways to simplify today's networks. These three ways are independent from each other and at the same time complementary. They are "Physical consolidation of Subscriber data", "Logical consolidation of Subscriber data" and "Harmonization of interfaces". They are explained here after.

#### 3.1. Physical Consolidation of Subscriber Data

Network elements are now exempted from the storage of subscriber data. Data is host in dedicated servers specially optimized for data management (database servers) as shown in Figure 6. The access to the data is realized via a common data interface. This architecture facilitates the integration of new application servers, speeds up the introduction of new services, facilitates the network management, simplifies network element (i.e. application servers) and uses standard state-of-the-art IT technologies. Management and provisioning system have direct access to data and need no detour via the network elements. Last but not least the functional range of the network elements will be downsized to their principal tasks. For instance, HLR and SCP need not care about storage, backup and recovery of subscriber data and can focus on their principal tasks in a mobile network.

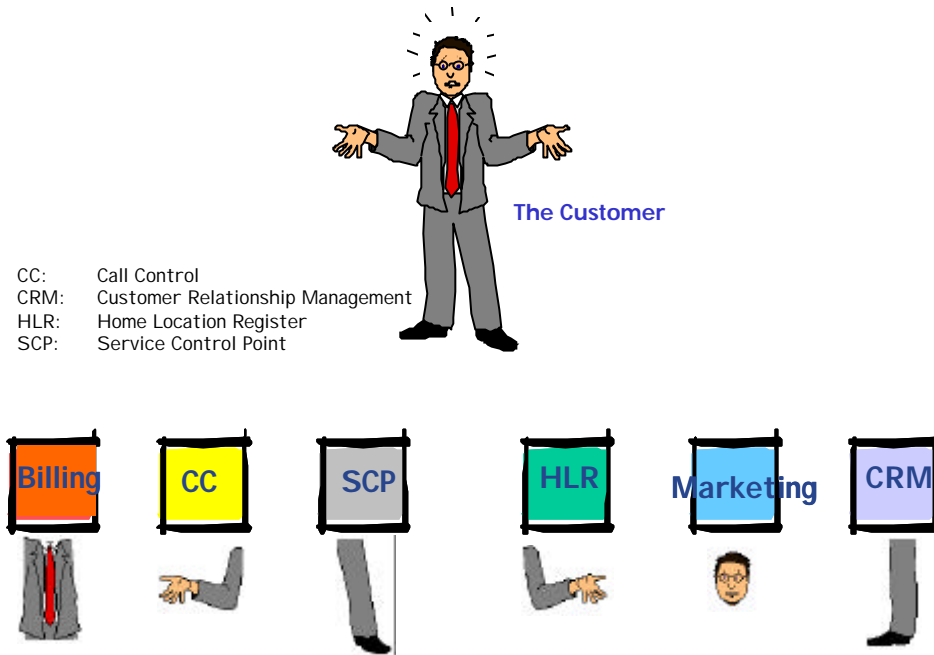


**Figure 6** Getting data out of network elements

Another advantage is that storage networks technology is in most cases already established in the IT-environment of mobile operators (applications running on the Business plane). Technology, skills and know-how are already available inside the company.

### 3.2. Logical Consolidation of Subscriber Data

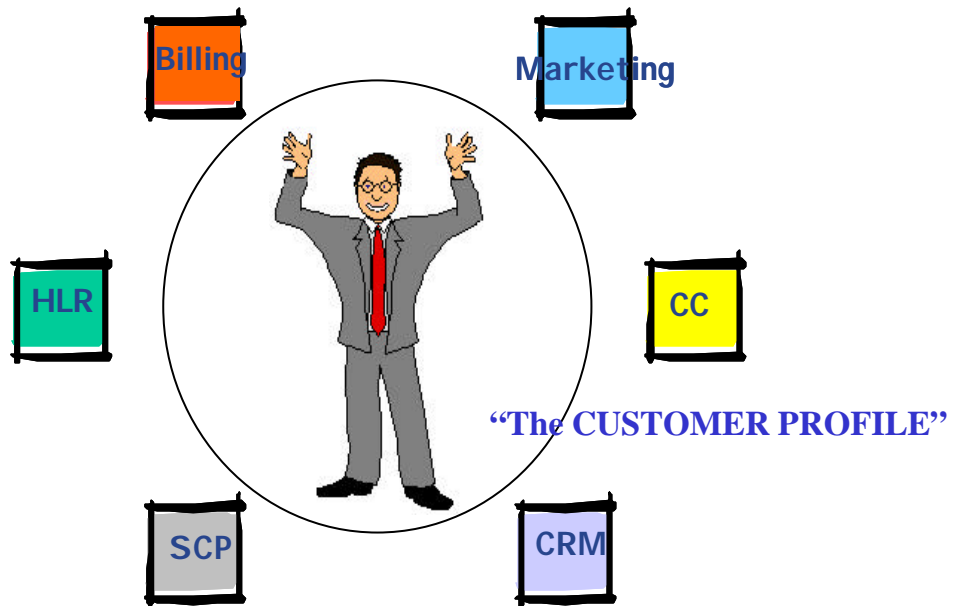
In current mobile networks the network elements are “owner” of their subscriber data. This is due to the fact that the standardization bodies have a function-centered view on the networks. A function like HLR takes center stage, subscriber data are associated to the function to enable the function to fulfill its tasks. This lead to the fact that multiple subscriber datasets exist in a mobile network for the same subscriber. They are treated independent from each other even if data are replicated. The situation is clarified in Figure 7.



**Figure 7** Today subscriber data are associated to functions

It makes sense to have at least a common view on the collectivity of all data of a subscriber. This goal is pursued by the 3GPP-standardization with their Generic User Profile (GUP). The 3<sup>rd</sup> Generation Partnership Project (3GPP) takes responsibility for the standardization of mobile networks like UMTS.

The introduction of a logical data model goes further than the GUP. This data model shall include all data that describe a subscriber and puts the subscriber into the center instead of the function as shown in Figure 8. The functional entities like Call Control, SCP, Marketing etc. get appropriate rights to access the subscriber data.



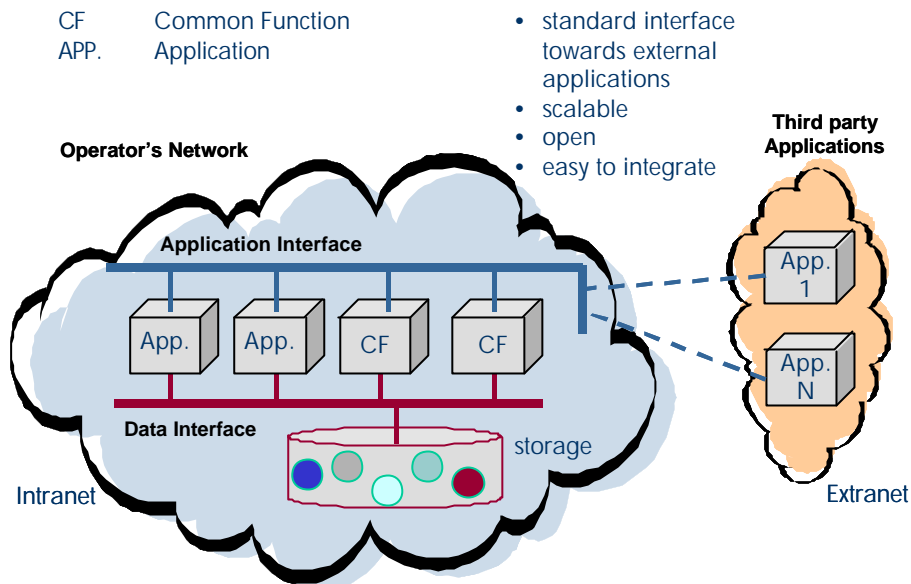
**Figure 8** *Aim is to associate subscriber data to the subscriber*

The data objects are to be defined for such uniform logical data model. Further methods for manipulation of the data are needed like Create, Modify, Delete, Display, Increment and Decrement. A uniform logical data model offers a unique view on the subscriber data for all users of the data. This helps to simplify today's complex processes in a network operator's company for subscriber data administration or network extensions. Besides this the subscriber data can be seen as a fund, which is not to be underestimated. This fund lies about to a large extend unused in the network elements. A uniform logical data model in conjunction with a common data interface simplifies the usage of the fund.

A good example of the benefits of such a model is the integration of WLAN and Mobile access. A common profile access would be much easier to handle than implementing a gateway bridging the AAA-server and the HLR. This integration is very attractive to Network Operators because it leverages on the infrastructure and know-how Network Operators have in Customer Care and Billing.

### **3.3. Harmonization of Interfaces**

The variety of interfaces and protocols increases with rising functionality of a Telco-network. For new functions new network elements and new protocols are defined. Some simplification would be desirable in this area. Figure 9 shows a network with only two kinds of interfaces, a data interface and an application interface.



**Figure 9** Only the Data Interface and the Application Interface are remaining

An analogy of the IT industry will help readers to better understand this concept. Upgrading a PC is easy by plugging an additional board into the next free slot on the motherboard. The slot comprises access to the common data bus and to the common processor bus. Taking this image for comparison, the upgrade of a network with a new function could mean to “plug” this new function onto the common data interface and the common application interface. A system with an architecture as shown in Figure 9 allows an easy upgrade with new features and applications.

It is recommended to separate current network elements into elementary functions. These Common Functions (CFs) are then at the disposal to all applications. Also third party applications could use them. Besides applications for authentication, rating etc. this could as well be policy handlers for Service Level Agreements (SLAs). It is strongly recommended to keep the data interface isolated from third party applications. A proxy function should bridge third party applications and the operator’s data if needed.

The authors have analyzed several technologies for those interfaces. A very promising one is Web Services.

Web services are already used in the Business Plane (see Figure 4) specially in Enterprise Application Interface (EAI) solutions. Server and client in a Web Services environment use the Simple Object Access Protocol (SOAP) for their communication. We can imagine that a communication protocol of a mobile network like MAP (Mobile Application Part) can be encapsulated with SOAP. In a first step this would help to make existing network elements and their incorporated functions look like a Web Service. All “encapsulated” network elements would have a common application interface then. New functions and applications can be designed as Web Service straight forward.

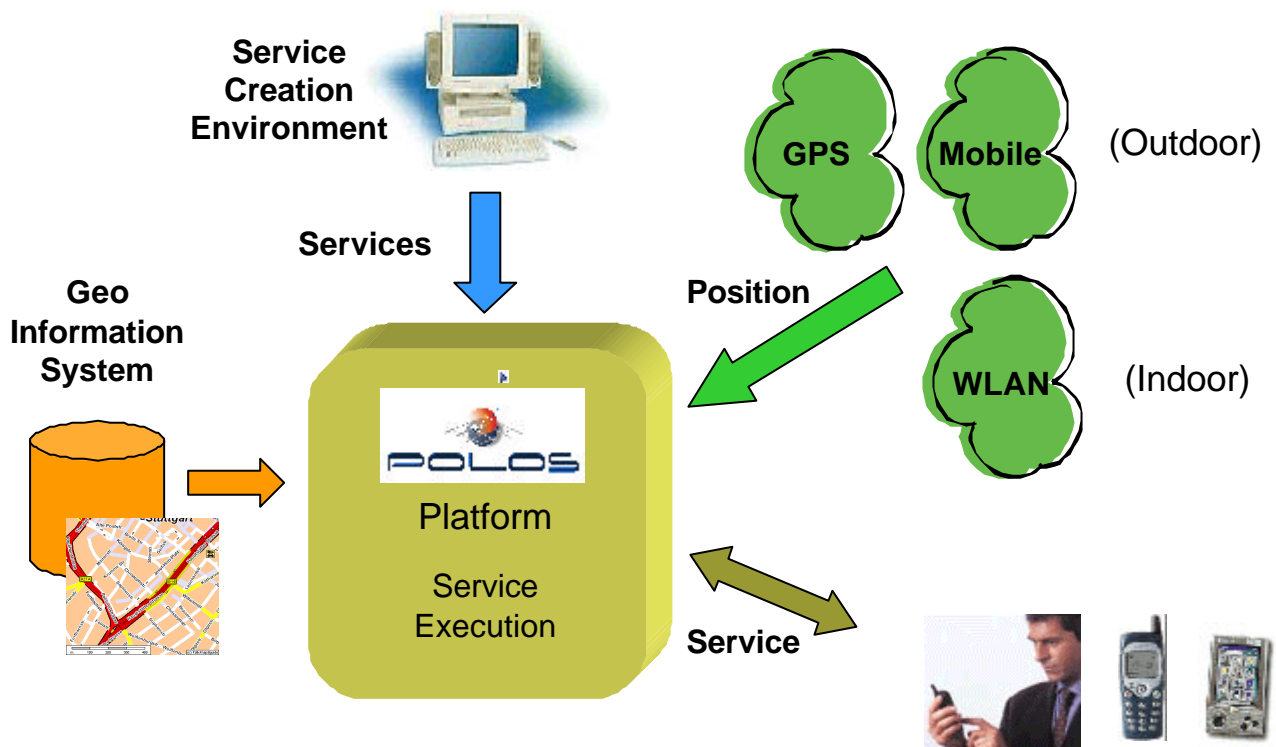
Web Service and their underlying principles have the potential to realize the application interface and perhaps also the data interface. It must be verified that the hard requirements in a Telco-network, like very short response time, can be fulfilled with this solution.

#### 4. PoLoS, an implementation example

The feasibility of the above-described ideas is under verification in various projects. One of these projects is PoLoS (Platform for Location-Based Services), promoted by the European Union in the frame of the Information Society Technologies Program (IST).

The PoLoS project investigates existing schemes for Location-Based Services (LBS) and latest technological achievements in the sector of Geographical Information Systems, positioning techniques and network interfaces in order to design and implement a platform capable of providing the full functionality needed to design, create and deploy location based services. To achieve this functionality, the platform features a component-based architecture, with each component having a specific and clearly defined functionality. The platform is independent of the underlying network infrastructure and the LBS creation is supported from a Service Creation Environment (SCE). The architecture is applicable to several types of networks, including GSM/GPRS/UMTS networks as well as WLANs. It also supports GPS-enhanced devices that make use of mobile networks exclusively as transport medium.

The system includes a series of interface specific components like Geographical Information System (GIS) components, interface and terminal components and positioning components. Such components are generic in nature and applicable to all business scenarios/domains. A general-purpose execution kernel that processes service specifications and invokes the peripheral components as needed complements the architecture. This kernel, along with the peripheral components, provides cross-domain functionality hence remains totally unmodified irrespective of the Location-Based service that is developed and run by the service provider or operator. Peripheral components also include interfaces to charging and billing infrastructure to cater for evolved models for charging of Location-Based services.

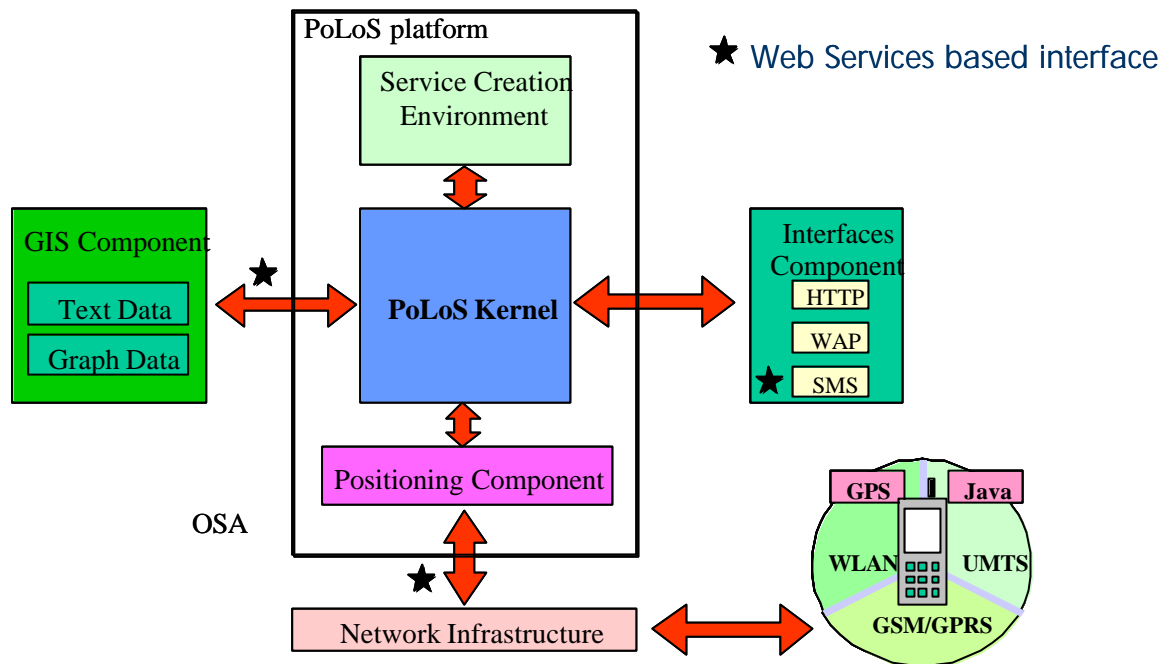


**Figure 10** General overview of the PoLoS project

Currently, there are a number of platforms for Location based services available in the market by major telecom manufacturers. However, such platforms are manufacturer specified and, in the majority of cases, simply hide the specific positioning technologies that are used by the network and feed user coordinates (e.g. longitude, latitude) to application servers where the actual LBS is executed. The PoLoS project focuses on the development and deployment of services and tries to consolidate several technologies and operation schemes of the LBS world under a single, generic platform. It will be possible to adapt the

PoLoS platform to any upcoming communication system and standard and retrofit in existing systems, while remaining compatible with future systems.

One of the aims of the PoLoS implementation was the simplification of the interfaces in order for the platform (PoLoS server) to quickly and effortlessly adapt to different operator and provider environments. That was achieved by using Web Services techniques in the interfaces towards networks and service providers systems (see Figure 11).



**Figure 11** Web Services based interfaces LBS-Server in the EU-Project PoLoS

To show the advantages of using web services techniques more in detailed, the interface between the PoLoS server and the networks providing the location information will be explained further (see Figure 12). The positioning gateways deliver positioning data of mobile subscribers to the PoLoS-Server. The PoLoS-Server itself provides applications with appropriate location information extracted from the GIS. Several kinds of positioning gateways are possible depending on the kind of access network. The PoLoS project has covered UMTS and WLAN networks. The positioning gateway for the GSM/UMTS network is called Gateway Mobile Location Center (GMLC) and the gateway for the WLAN network is called Gateway WLAN Location Center (GWLC).

The protocol stacks in Figure 12 belong to the PoLoS-Gateway at the border of a UMTS network and to the part of the PoLoS-Server which interfaces the PoLoS-Gateway. The PoLoS-Gateway GMLC functionality and communicates with the UMTS network elements using the Mobile Application Part (MAP) protocol. A Web Services interface provides the PoLoS-Gateway with an open interface to LBS-Servers like the PoLoS-Server.

For instance, the functional interface offered by the GMLC is fully compliant with the Open Service Access (OSA) specification 3GPP TS 29.198-6 V5 (Parlay 4) [2]. By exposing its Web Services Description Language (WSDL) description file to LBS servers, those LBS servers (i.e. the PoLoS-Server) should be able to adapt, on-line, to this interface and use the parts of it they may need (supposed they

support some OSA version). In this way, integration issues like naming convention, parameters positioning, etc. are nicely avoided.

The main advantage of this interface is that the PoLoS-Server is able to interact with different networks. Functional tests can be realized with positioning gateways and PoLoS-Server being at different locations, interconnected via an IP network like the Internet.

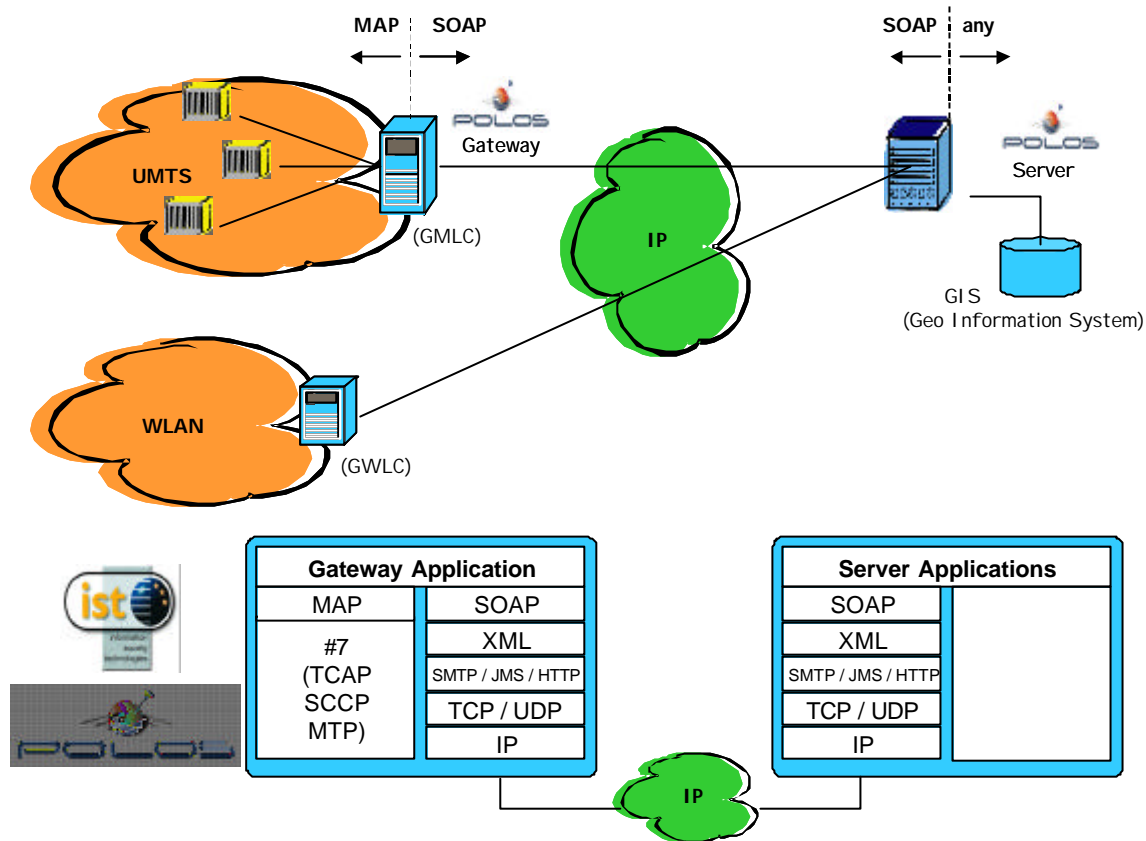


Figure 12 Web Services as Application Interface for LBS-Server in the EU-Project POLOS

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