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FLEXINET—A Network Service Architecture

GPRS, WLAN integration, mobile number portability and UMTS are some of the new technologies which are foreseen to carry many new service applications. In the near future, it is expected that mobile networks will go beyond connecting people and will connect an increasing number of machines, appliances, consumer devices, sensors and actuators. Also, users will connect through personal area networks and the importance of user profiles and service profiles will grow. Given the current strictness of network design, these services will further increase the complexity of today's networks. The reasons are established design principles, which require new, dedicated network elements for new service applications. In addition, the applications contain their own customer 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. In current designs, 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 article presents a concept to simplify current and future telecommunication networks. The concept contains a number of measures which complement each other but can be implemented independently one from another. This concept is under investigation in the context of FLEXINET (IST-507646), a project within the EU IST framework programme 6.

Introduction

Telecommunication networks and the Internet have been using different approaches to network intelligence. The traditional telco approach is to use intelligent network elements together with stupid terminals. This is where telephone networks come from (to think of POTS). Even later technologies such as ISDN, GSM and UMTS networks have been designed this way: each client has a number of intelligent servers in the network. Each service has a dedicated network or dedicated network elements. Servers are in the domain of the network operator. The traditional Internet way prefers to keep networks and network elements simple and stupid. They work with intelligent clients and servers. Being an overlay network, the meaning of a domain is also different. Certainly, clients and servers for content and applications are outside of the network operator's domain. Services of Internet service providers (ISPs) largely provide access to the Internet and little else. Figure 1 shows a summary of the situation.

With data traffic and the Internet dramatically increasing over the last years, IP has gained acceptance as the universal glue for connectivity. The meaning of 'convergence' basically is IP over any kind of network, as well as any kind of service over IP. This principle has also been

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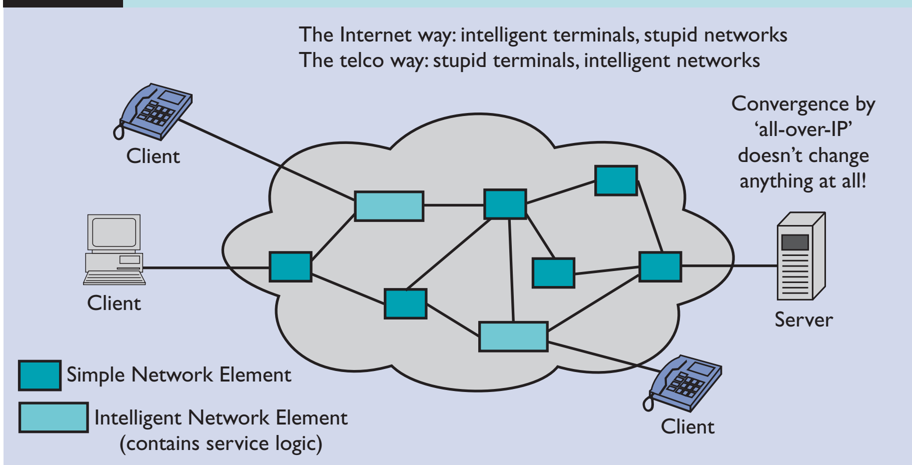
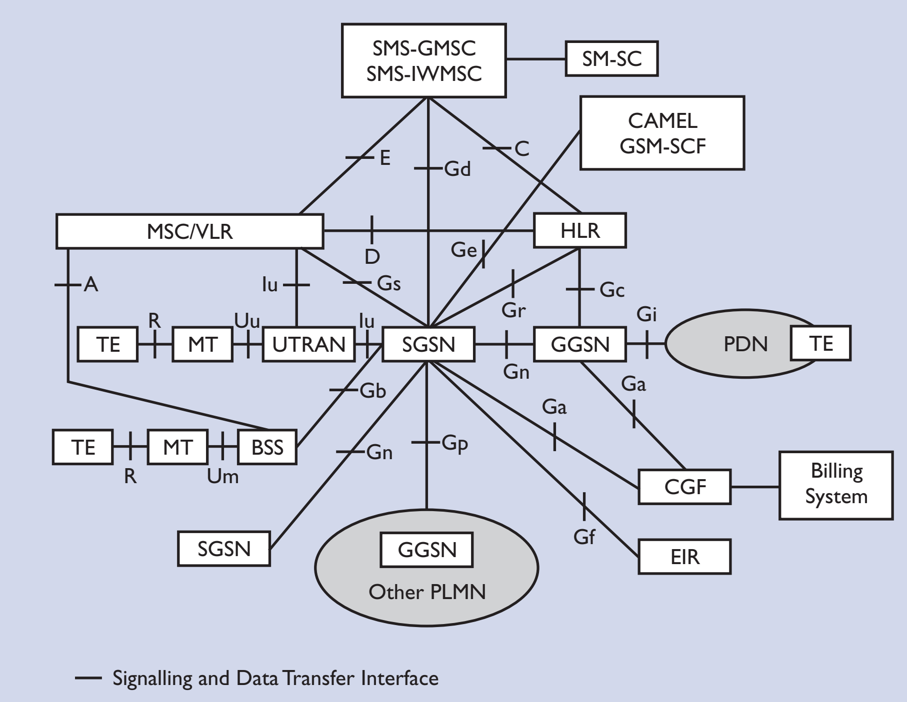
Figure 1 Summary of approaches to network intelligence



adopted by the telco community, so current designs by ETSI and 3GPP are IP-enabled. Still, the so-called *next-generation networks* keep the traditional design principles and basically use IP as a transport layer. Basically, this conflicts with the nature of IP networks (for example, servers not belonging in the operator's domain). More significantly, it does not meet demands on a flexible and easily scalable network architecture for a multitude of new service applications.

Figure 2 The current architecture of core networks



Positioning of Current 2G and 3G Network Architectures

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; for example, short messaging service, location-based services, multimedia messaging services, Java downloads, instant messenging, and data services of all kinds. 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.

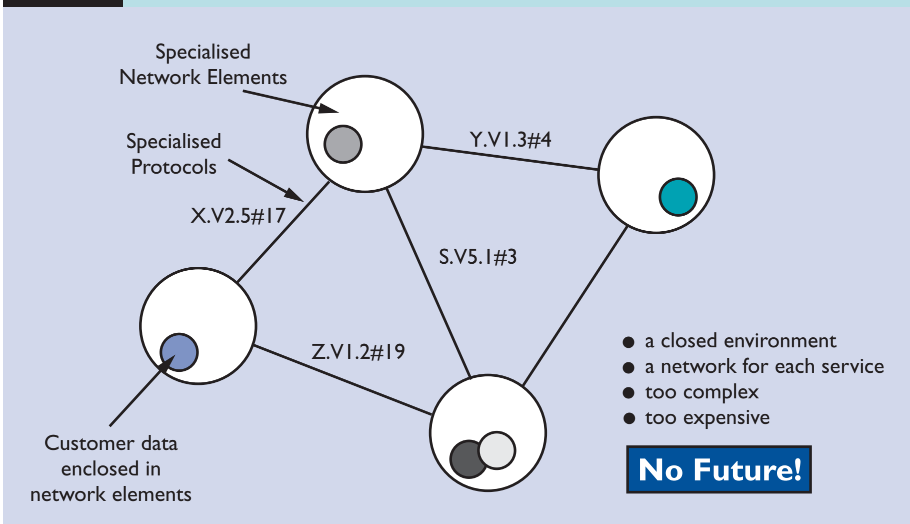
The high costs associated with the acquisition of UMTS licences and the deployment of those networks have compromised the financial health of many mobile network operators, in particular in Europe. They are forced to increase cash-flow; that is, reduce cost and increase revenue. Because western countries have quite saturated markets, there will not be a dramatic increase in revenue because of new customers. Therefore, the only way to increase these revenues comes from increasing the average revenue per user (ARPU) and that can only be 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 most likely be divided into many niches, and applications will have to be developed to cover each of those market niches. Taking into account that, for each successful service, four will fail to attract attention, network operators will be forced to integrate in their networks about 250 new services in order to get 50 money makers. In terms of the integration cost for a network operator; mobile networks were not designed to easily attach new services and capabilities. Figure 2 shows the current architecture of a 3G mobile core network, which provides mobile telephony, as well as access and transport of data.

The initial, clear network architecture of GSM 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 already find about five network domains in a UMTS network: the access domains for GSM and UMTS, 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 3 shows, in an abstract way, the situation for the envisaged problem in current telecommunication networks.

The network elements are optimised for different functions and communicate with each other. In the most unfavourable case the communication protocols are different on different interfaces. In addition, each network element hosts a specific set of customer data in memory and on local disks and can be regarded as 'owner' of the customer dataset. In most cases, the specific datasets of different network elements have some redundancy. For example the phone number and the customer identity will be present in most of them.

Extensions for more functionality in the network require new network elements and new or extended protocols; they also require the storage of a customer dataset in the new

Figure 3 Issues of today's network architectures



network elements. If the current design principles are maintained, telco networks will become more and more complex. Mobile networks are good examples for telco networks which enter the complexity trap. The expenses for network planning and network maintenance are rising significantly.

Next-Generation Networks

In the early stages of digital telecommunication networks there was a trend to concentrate all types 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 'Freephone' (service function).

Under monopolistic conditions, networks have remained rather static concerning changes and evolution. The focus is on providing infrastructure and a basic service to everyone. In this case, the approach of concentrating functions into single network elements has been a good approach. However, after the telecommunications deregulation starting in the United States and the UK, 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 new services implied new software upgrades for 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 specialised service nodes (few of them) could communicate with the switches. This was called an *intelligent network* at the time; it has been very successful since its introduction in the late 1980s. Almost all implementations worldwide of mobile pre-paid cards are based on intelligent networks.

Networks were getting increasingly 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. This is also the objective of the NGN. NGN splits the control and the transport functions apart, and defines an interface between them. 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. Currently it is accepted that a network can be split into four different planes. The connectivity plane offers the resources for the transportation of the payload and the signalling 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 customer 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).

While this looks nice on a blueprint, the authors believe that the introduction of the NGN concepts still results in networks which are too complex and a different approach to splitting a complex problem 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 applies if the company does not know its customers. In today's 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 optimised, highly available, highly automated and secure solution for data storage. The use of SAN in telecommunication computing would reduce OPEX significantly.

The second problem concerning data is their unavailability to other applications. That will be illustrated with some 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 database containing mobile user information). To reach this information, an interface called *customised 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 were open to other applications, via a standard database 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 centre (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 several thousand users that have a best-effort quality of service (QoS) in their contracts, the priority may be lower than if the problem affects 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 realised by themselves that there is a problem. Again, network data and customer data have to be crosschecked to achieve that.

Example 3

Granting network access through different technologies requires a multitude of network entities and protocols. While GSM has very nicely managed network access throughout the world (with any network operator who maintains roaming agreements with others), it does not provide access through other technologies outside the GSM network, such as GPRS or WLAN. Those require special entities for authentication and authorisation (such as SGSN or radius server). To think further along this line, why should a mobile customer not use his/her mobile set to connect via a Bluetooth access point to his/her usual service? Why should he/she not connect his/her mobile set to the next telephone socket or LAN socket and make a call?

The examples should help to explain that customer data and service profiles play an important role in business today. As a logical consequence, the authors propose networks to be equipped with a 'storage plane', which 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).

FLEXINET—A New Approach to Service-Oriented Architectures

Further developing these 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 customer data,
- logical consolidation of customer data, and
- harmonisation of interfaces.

They are explained below.

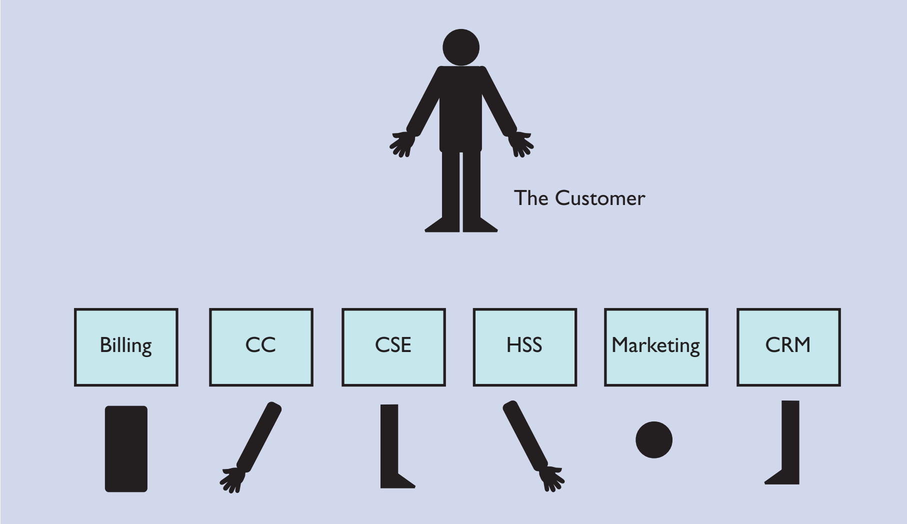
Physical consolidation of customer data

Network elements are now exempted from the storage of customer data. Data is hosted in dedicated servers specially optimised for data management (database servers). The access to the data is realised 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 elements (that is, application servers) and uses standard state-of-the-art IT technologies. Management and provisioning systems 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 do not need to care about storage, backup and recovery of customer data and can focus on their principal tasks in a mobile network. 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.

Logical consolidation of customer data

In current mobile networks the network elements are 'owners' of their customer data. This is due to the fact that the standardisation bodies have a functionally centred view on the networks. A function like HLR takes centre stage; customer data are associated to the function to enable the function to fulfil its tasks. This leads to the fact that multiple customer datasets exist in a mobile network for the same customer. They are treated independent from each other even if data are replicated. Figure 4 shows this situation in simple terms.

Figure 4 Today customer data sets are associated to functions



Apparently, it makes sense to have at least a common view on the collectivity of all data of a customer. This goal is pursued by the 3GPP standardisation with its generic user profile (GUP). The 3rd Generation Partnership Project (3GPP) takes responsibility for the standardisation of mobile networks like UMTS. The introduction of a logical data model goes further than the GUP. This data model should include all data that describe a customer and should put the customer into the centre instead of the function as shown in Figure 5. The functional entities like call control, SCP, marketing, etc. get appropriate rights to access the customer data.

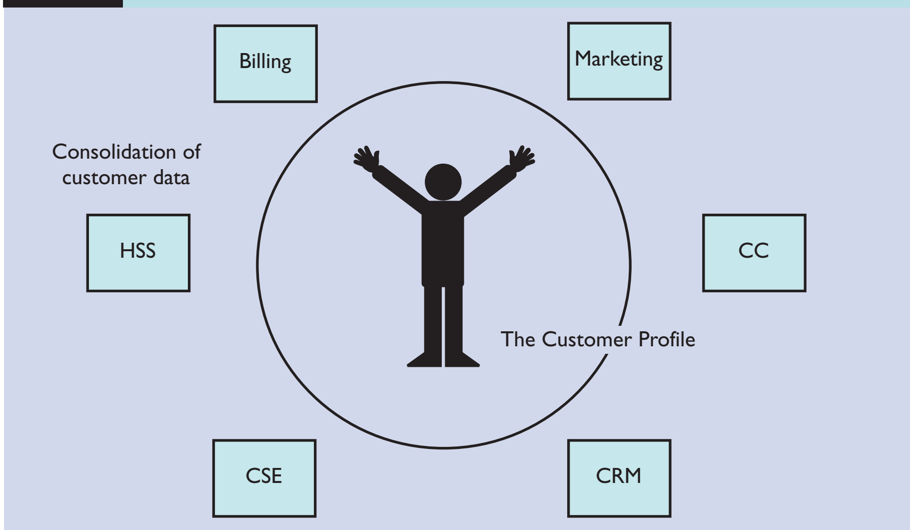
The data objects are to be defined for such a uniform logical data model. Further methods for manipulation of the data are needed like Create, Modify, Delete, Display, Increment and Decrement. A uniform logical data model offers a unique view on the customer data for all users of the data. This helps to simplify today's complex processes in a network operator's company for customer data administration or network extensions. Besides this, the customer 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 and access method 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 authentication, authorisation and accounting (AAA) server and the HLR. This integration is attractive to network operators because it leverages on the infrastructure and know-how network operators have in customer care and billing.

Harmonisation of interfaces

The variety of interfaces and protocols increases with rising functionality of a telco

Figure 5 The target is to associate customer data to the customer



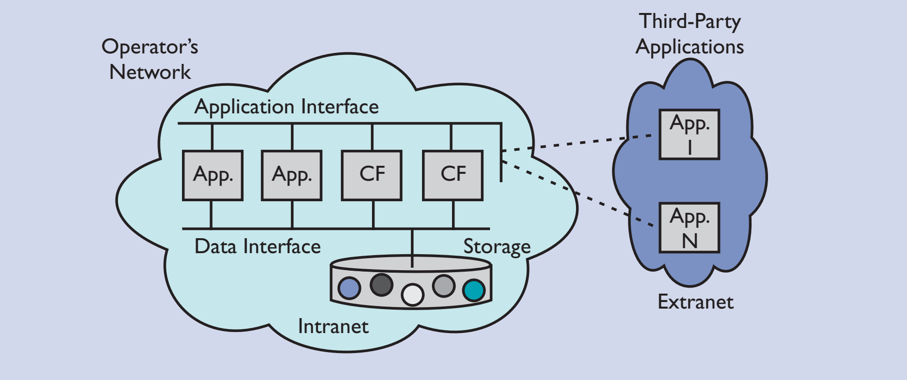
network. For new functions, new network elements and new protocols are defined. Some simplification would be desirable in this area. Figure 6 shows a network with only two kinds of interfaces, a data interface and an application interface.

The concept corresponds with a bus architecture, which allows components to be plugged in on demand, similar to upgrading a PC by plugging in additional boards into the next free slot. Concerning the service architecture for networks, an upgrade with a new function should mean the new function is plugged onto the common data interface and the common application interface. A system with an architecture as shown in Figure 6 should allow an easy upgrade with new features and applications.

Also, current network elements may be decomposed into their elementary functions. These common functions (CFs) are then at the disposal to all applications. Authentication makes a good example for such a common function, along with authorisation and accounting. 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). As a design principle, the data interfaces should be kept in isolation from third-party applications. A proxy function should bridge third-party applications and the operator's data if needed. Several technologies have been analysed for a practical implementation of those interfaces. A very promising one is web services.

Web services are already used in the business plane and are perceived as a technology for enterprise application integration (EAI). 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 services straight on. Web services and their underlying principles have the potential to realise the application interface and perhaps also the data interface. However, it needs to be verified that the hard requirements in a telco network, like very short response time, can be fulfilled with this solution. For the data interface, the object management group provides feasible concepts such as ODL which would allow remote access to customer datasets from applications within the network operator's domain. The date interface thus represents the access layer on top of a database management system and storage area networks.

Figure 6 A service architecture—only the data interface and the application interface are remaining

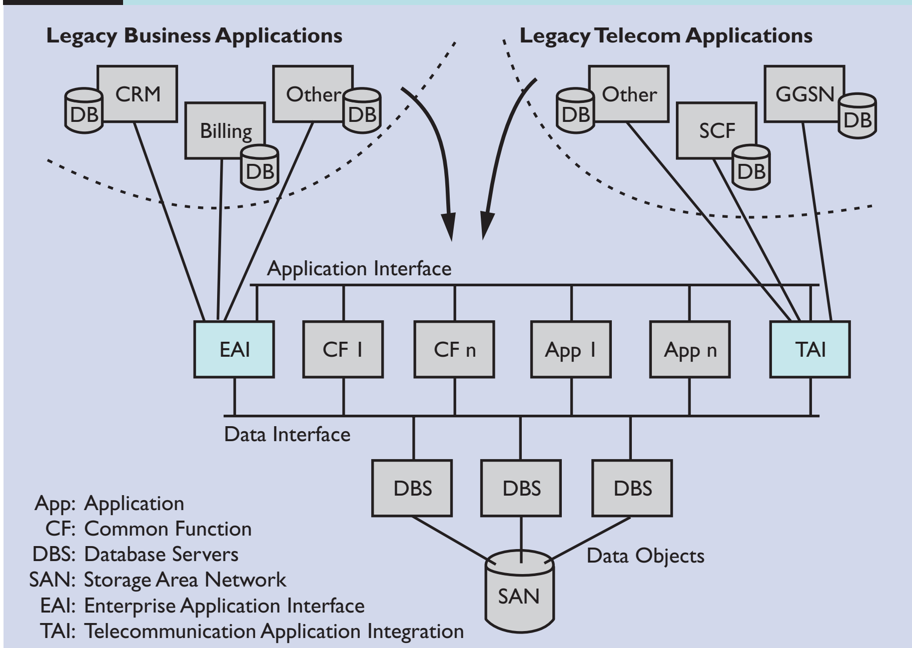


While this new architecture may well apply for a greenfield scenario, the question remains how well it suits existing network infrastructure. Certainly we cannot assume that anyone will replace existing infrastructure with something else just because of its technical appeal. Most likely, new services will be implemented according to the new service architecture. For some of the existing infrastructure, it makes sense to build adaptors in order to make them compatible with the new architecture. One such example is to make the HLR usable for authentication and authorisation for other services such as WLAN access. Another example is the logical consolidation of customer datasets. Figure 7 shows the general concept. There are two areas of integration. One is about the general business process, such as customer relation management, accounting and billing. This area corresponds to the classical enterprise application integration. Such components will be integrated by using the gateway called *EAI* in Figure 7. For network elements such as service control points, HLRs, radius servers, SGSN and MSCs, a different kind of gateway is used. These gateways will need to speak the many languages (that is, signalling protocols) used in telco networks. In analogy to EAI, those gateways are called TAI for telecommunication application integration.

FLEXINET-Enabled Networks

GSM, UMTS and WLAN are just the beginning of an increasingly wireless infrastructure. Other technologies such as Bluetooth and ultra wideband will increasingly supplement today's technologies. Indications are that radio connections will go far beyond terminals for mobile people, but increasingly connect machines, appliances, consumer devices, sensors and actors. The majority of the applications will be data services. Among the applications are

Figure 7 Integration of legacy systems using gateways



navigation services, remote diagnosis, information systems, teleservices including logistics and administration for remote equipment as well as personal area networks. Irrespective of the access technology, most of the applications will communicate over larger distances; that is, they will need connection to core networks. The core network operator will need AAA functionality to offer transport services, but it may also decide to make AAA a business and provide it for other service providers and their applications. Figure 8 shows the scenario. FLEXINET may represent a decisive step in this direction and may provide some further insights for future communication services.

In the beginning of this article, it was stated that telco networks and the Internet take a different approach to network intelligence. The Internet way prefers to keep networks simple and stupid. So where does this approach lead to? What are the minimum requirements for core networks? For a mobile operator with an established customer base, one key asset are the customer datasets, which lead to the AAA infrastructure already mentioned above. Any other services can be placed outside the operator's network domain. With the latest generation of mobile phones, this is even possible today. Just like using communication services such as ICQ or other instant messenger services from PC to PC, such communication software may be downloaded to a mobile device. The software contains everything needed for communications, including address books, exchange of messages and conversation via voice or video. All the network operator needs to provide (and can account for) is transport services.

Most probably, people are willing to pay extra for a better quality of transport. So one other component in the network domain will be an intelligent transport service, which is aware of quality of service. Other properties may be multicast and multisession capabilities, which could be implemented by programmable networks. Also, the core network will need to be able to negotiate service levels with other network domains (that is, the intelligent transport layer contains an SLA broker). A third essential component of core networks may be proxies. Proxies are required in order to optimise load and traffic and to keep information close to the consumer. In a future scenario, which will be dominated by mobile users and mobile devices, proxies may also be required to represent devices which are temporarily switched off or unavailable. Most importantly, proxies in combination with AAA are well suited for a secure network environment. They belong to the network operator domain and thus can be trusted representatives of customers. They also help to maintain the privacy of customers by translating customer identities to third-party services (such as pseudonyms for location-based services).

Figure 8 AAA is becoming a key concept for core networks

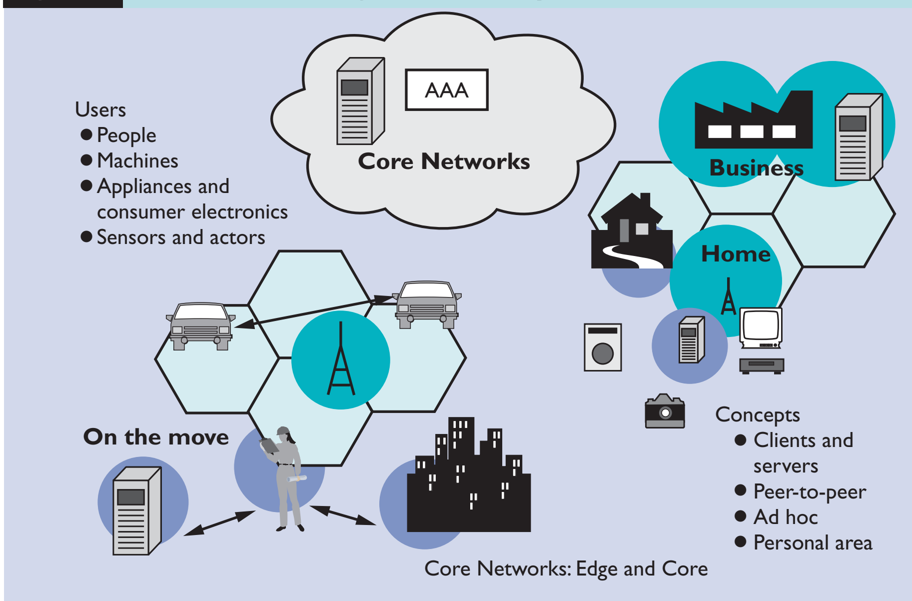
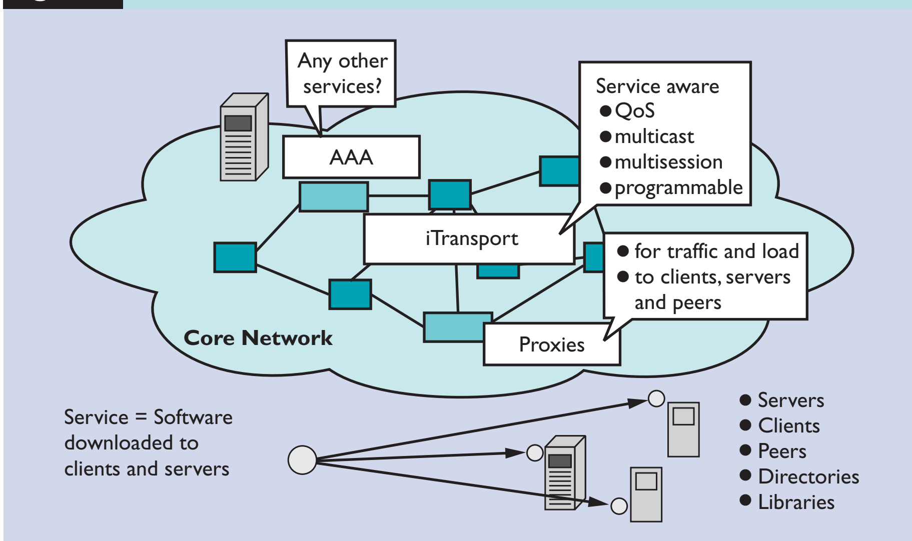


Figure 9 Core network essentials



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