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COMMUNICATION NETWORKS AS BASE FOR MOBILITY – TREND DEVELOPMENT OF NETWORK ARCHITECTURES

New network architectures are required for a flexible service provisioning. These are characterized by the transition from channel-switching to packet-switched networks. The amount of the collected information needs to be provided in these network architectures at the right time at the right place for processing in the control systems and end-systems. The warranty of parameters such as duration and availability within the network architectures is a requirement for the function of the service to be provided. The requirements must be specified for an application to a suitability of the architecture in terms of safety with the required parameters for reliability and specifically to evaluate the high availability.

Keywords: *Mobility, network architectures, next generation networks, future internet, reliability, high availability, security.*

1. Introduction

Information and CommunicationTechnology based fixed and cellular networks offer the potential to control increasing traffic density efficiently when combined with intelligent traffic systems.

A customizable offer of services and profitable operation of the network infrastructure cause a transition from conventional channel transmission to packet transmitting networks. For existing services it has to evaluate whether requirements of the specific service to the network are still fulfilled. The cloud shown in Fig. 1 conceals the network structure that has to be considered [1].

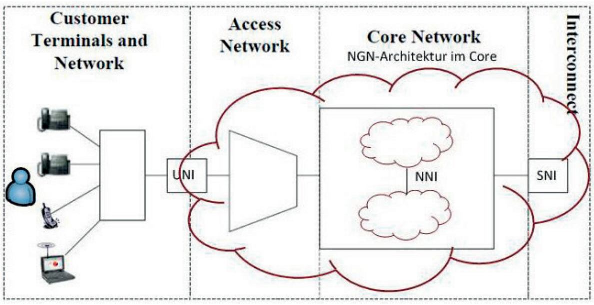

Fig. 1 Network Infrastructure According to [1]

Security sensitive services within critical infrastructures have specific requirements regarding availability of the network architecture. According to the federal ministries definition, also transport and traffic as well as information technology and telecommunications are such critical infrastructures [2].

2. Network Architectures

2.1 Conventional Networks

In conventional network architectures each service has been operated on a separate network suiting the individual requirements. This resulted in parallel networks, such as voice communication and data communication as well as distributive networks for cable television and networks for traffic-control systems and traffic-security systems. Those networks have been optimized in terms of the characteristic properties like availability, Quality of Service, signal propagation delay, transmission rates and network management. ISDN (Integrated Service Digital Network) has been the first architecture which combined voice- and data-communication [3].

Realizing new services causes extensive time and technical effort conditioned by the inflexible structures. For flexible introduction of new services and economical operation of

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networks modular structures are required, which consist of transport-, service control- and service-provision-layer. Figure 2 shows the link between conventional network architectures and modular network architectures.

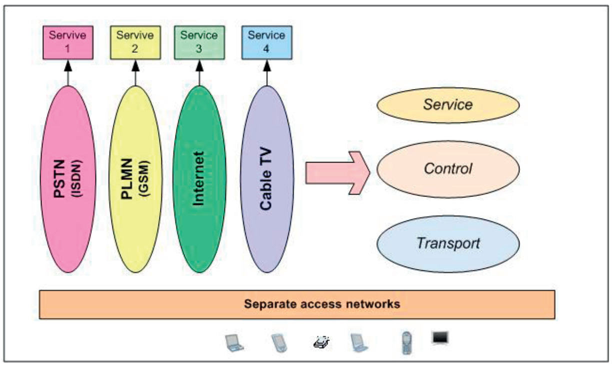

Fig. 2 Conventional Networks

2.2 Next Generation Networks

In new generations of network architectures all kind of services are operated through a common core network. The technologies accessing the core network will be standardized. This evolution follows the target of making services reserved by users available anywhere and anytime. Finally user-mobility, terminal-mobility and service-mobility are supported.

The ITU-T (International Telecommunication Union - Telecommunication Standardi-zation Sector) defines a Next Generation Network (NGN) in specification Y.2001 as follows [4] and [5]:

- Provision of telecommunication services through a packet transmitting network.
- Usage of different wideband quality of service capable transport technologies where service oriented features are independent from the actual used transport technology.
- It supports unlimited access of the users to different service providers.
- It supports general mobility for a steady service provisioning to the end users.

The NGN architecture has been elaborated in the specification Y.2012 of ITU-T and is shown in Figs. 3 [6] and [7].

In the NGN-Architecture a separation of transport layer from the service-controlling-layer has been realized. The transport-stratum performs connectivity for all components and separates functions. These are required for point-to-point and point-to-multipoint information transmission, mobility management as well as transmission of control- and management-information. The

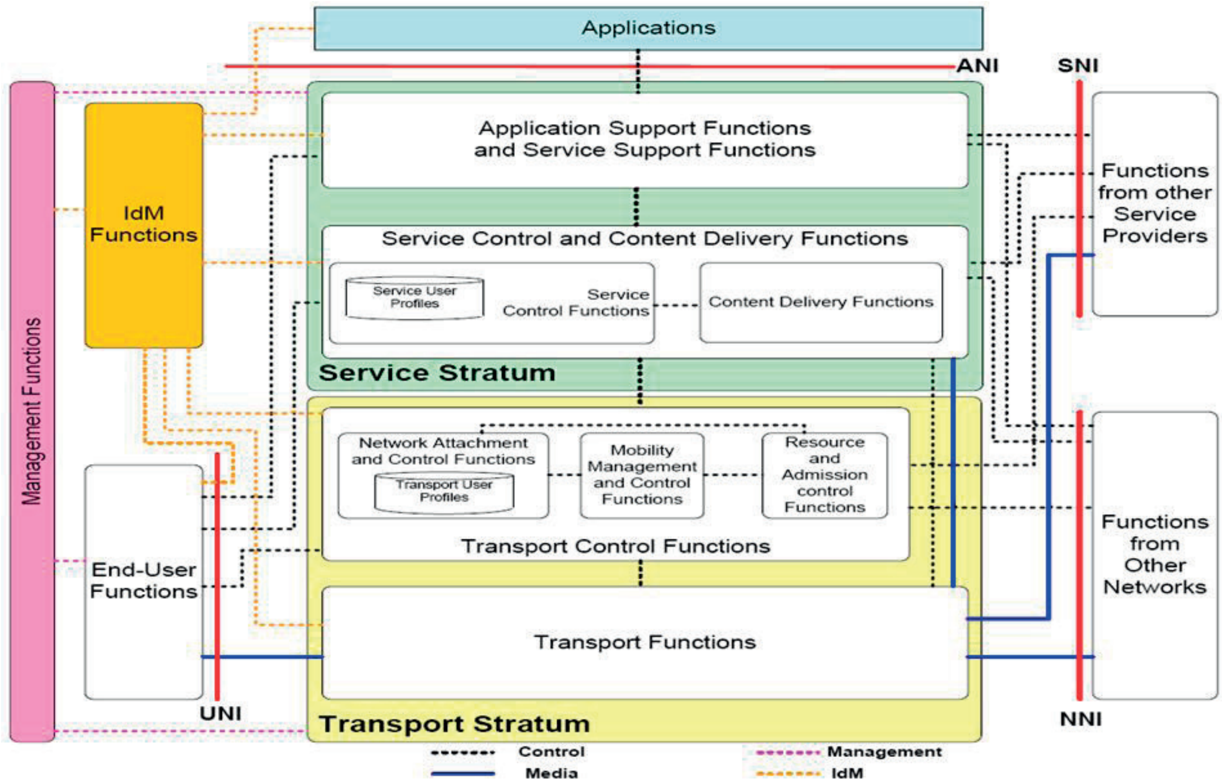

Fig. 3 NGN-Architecture According to ITU-T [6]

service stratum comprises functions for authorization between user and service, to signal services, to register, to authenticate and to authorize as well as gateway functionalities. The identity management (UserID, E-Mail, telephone number) is controlled by the Identity Management Functions (IdM) block.

2.3 Future Internet

The NGN is based on a packet-transmitting network which has only been applied to the internet so far. Distributed architectures in the internet, which increased constantly due to more and new services within the last decade, will cause limited service quality.

For the prospective internet an improvement approach exists and is specified under the designation Future Internet (FI). There is no valid standardization by national or international organizations yet. FI activities are promoted by e.g. 4WARD. It is an association of IT-companies, operators, system producers, developers and universities. FI pursues to suit the service demand and to consider mobile devices requirements. FI is also described as "Internet of Things" and "Industry 4.0" [8].

The architecture is based on four fundamental statements [9]:

- Development of heterogeneous networks,
- Self-management of networks,
- Network connection as an active element and
- Network as information-hub.

The skeletal structure of FI is shown in Fig. 4 [10].

A service stratum is composed of a quantity of K virtual nodes. A function block with a specific task is called Netlet. Communication between strata is realized through the Stratum Service Point (SSP) and the Service Gateway Point (SGP). Strata management is performed by the Management System (MS). The control stratum handles e.g. network rights. The information stratum documents the service strata's structure. Databases in shape of construction areas and design patterns supervise the compliance rules for new shortcuts and virtual nodes [9] and [11].

Realizing the discussed NGN- and FI-Architectures leads to centralization of network nodes. High performance and scalability of these centralized nodes on the one hand and the usable transmission rates on the other hand will lead to economical operator models in a centralized environment. Datacenters will contain telecommunication nodes and service servers besides large-capacity computers. In fact, this will lead to modified requirements towards the availability of network nodes and datacenter infrastructure.

3. Application the new network architectures at Authorities and Organizations handling security tasks (BOS)

The states Hamburg and Schleswig-Holstein (SH) authorized Dataport to construct the access network to the digital radio network of authorities and organizations handling security tasks. In this example several network aspects will be discussed with reference to Schleswig-Holstein.

The access network comprises ca. 160 base stations which are coupled with switching centers. The base stations are arranged in a ring topology and have a 2 Mbit/s connection to the switching centers. Furthermore, the control centers are connected with

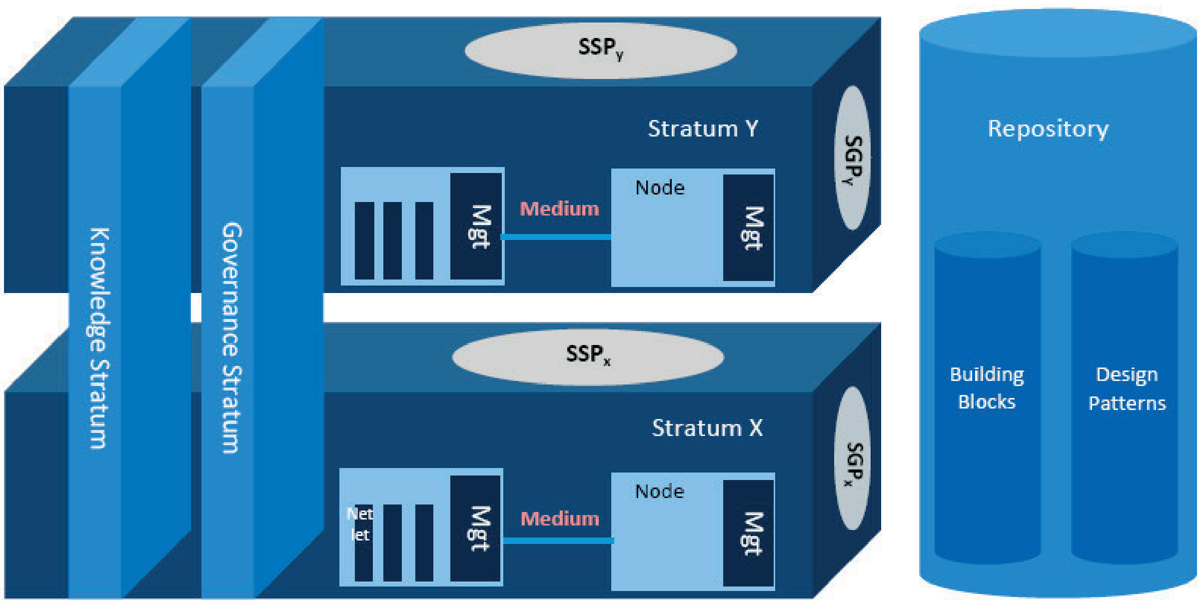

Fig. 4 Future Internet Architecture [10]

10 Mbit/s connections. The access network construction in Schleswig-Holstein has been combined with the buildup of a state network (LNV+) for regional authorities. The fundamental structure is shown in Fig. 5.

A specific requirement of the BOS-Access-Network is a signal propagation delay between the furthest stations in the ring and the switching centers of 10 ms while normal operation. A packet-transmitting infrastructure cannot be realized with the required signal propagation delay. The essential transmission paths have been realized as fixed network connections through a conventional SDH-Network (Synchronous Digital Hierarchy Network) based on the time multiplex method. Between neighboring stations in rural areas directional radio transmission is used. The required network availability is 98.5% and 99.95% for redundant routes. Realization of redundant connections is not possible if the base station is physically linked by a single path which terminates at a central switching point. When performing the radio field planning it has to be taken into account that superposition with a neighboring station is assured in case of total failure of base stations. This approach increases the number of stations that are required.

The dependency between service requirements, choice of network architecture and further parameters is shown in that example.

4. Approaches to a Solution

Assurance of parameters such as availability and signal propagation delay is a condition for functionality of services to be migrated in packet transmitting networks. Applicable methods have to be chosen for verification.

Analytic evaluation is achieved by abstraction which describes the network architecture of the overall system by a simplified system function S(t). For complex systems the approach to break away multiple single systems pursued. In Fig. 6 the system S is to be modeled such that requirements of the service towards the network are realized. This method is applicable regarding runtime behavior [12].

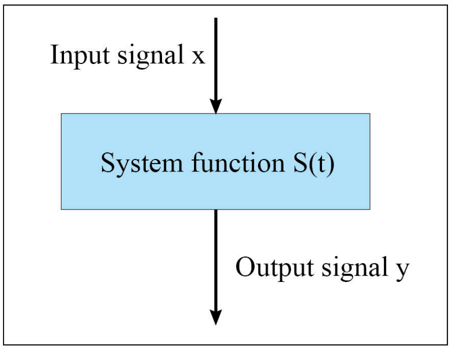

Fig. 6 Abstraction of Network Architecture as a System Function

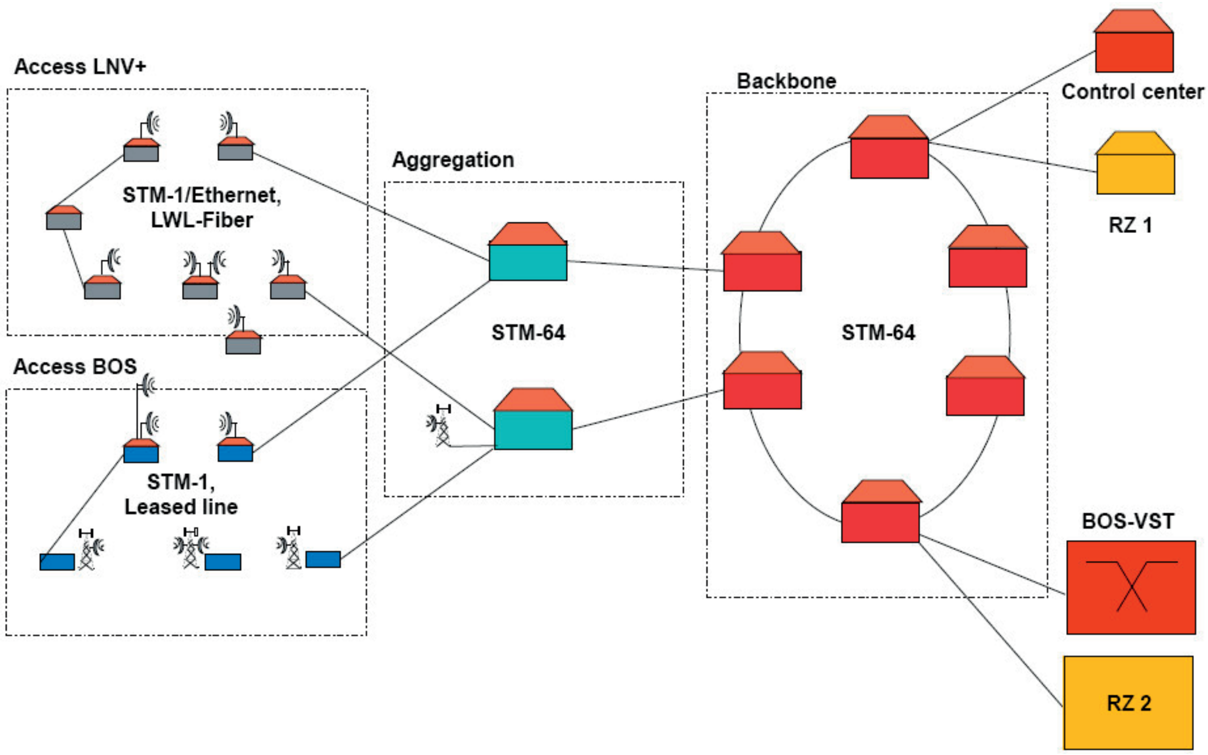

Fig. 5 Structure of BOS-SH and LNV+

Calculation of availability can be performed by application of reliability- and probability-theory. In Fig. 7 the overall system is separated into single system blocks. As the network architectures are defined by composition of subsystems, this method results in a combination of elements. Every element is associated with a corresponding availability. The block diagram is represented as a composition of series- and parallel-connections [9] and [13].

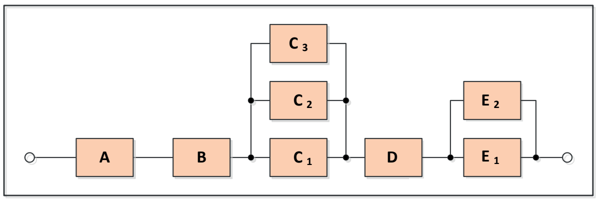

Fig. 7 Block Diagram of an Overall-System

The reliability can be described mathematically by a binary reliability-model. The element states $z_i\ i \in [1,n]$ and the structure function

$$z_{Sy} = \varphi(z_1, z_2, ..., z_n) \quad (1)$$

serve to determine the system state z_{Sy}. The element states z_i are time invariant boolean variables which describe the operability of element *i*. Based on that the system availability can be calculated if the individual elements availabilities are known and random indicator variables z_i are used.

The structure formula for the system shown in Fig. 8 is calculated as follows:

$$z_{Sy} = z_A \cdot z_B \cdot [1-(1-\bar{z}_{C_1}) \cdot (1-\bar{z}_{C_2}) \cdot (1-\bar{z}_{C_3})] \cdot z_D \cdot [1-(1-\bar{z}_{E_1}) \cdot (1-\bar{z}_{E2})] \quad (2)$$

A calculation of the availability of a Stratum (overall system) with the aid of practically relevant availability of the individual elements proved in [9] the following result (Details are shown in Fig. 4):

A: Knowledge Stratum $z_A = 0.99306$
B: Governance Stratum $z_B = 0.99306$
C_1: Node $z_{C1} = 0.99996$
C_2: Node $z_{C2} = 0.99996$

C3: Node (in Fig. 4 is not shown explicitly) $z_{C3} = 0.99996$
D: Interface SSP and SGP $z_S = 0.99999$
E1: Medium $z_{E1} = 0.995$
E2: Medium $z_{E2} = 0.995$

Die result obtained with formula (2): $z_{Sy} = 0.986134$

The Federal Agency for IT-Security (BSI) developed a procedure for maintenance of action ability in case of IT-System failure throughout a High-Availability-Compendium. Consideration of business processes is focused in this compendium. The goal of the BSI- compendium is provisioning of guidelines for responsibility perception at critical processes on management levels. Promotion of reliability and sustainability are prioritized in the development process of new high available architectures [14].

5. Conclusions

The technological development to Next Generation Network and to the Future Internet takes place with large speed. The network architectures represented in the section 2. 2 and 2. 3 are moved gradually. For flexible and economical provision of services modular network architectures based on packet transmitting structures are essential. The usage of those architectures for conventional services and especially security relevant services has to be evaluated with particular care. This might cause an adaption of the architecture. Well-defined requirements of the service towards the architecture are the condition to derive terms of reference for the network operator.

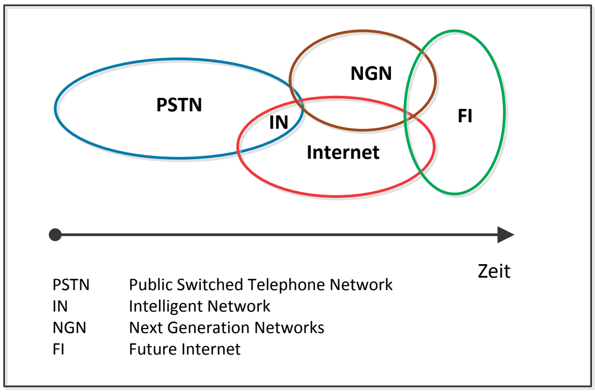

Fig. 8 Architecture Convergence

A convergence of the presented architectures on the direction of Future Internet is shown in Fig. 8.

The reliability theory provides methods to be applied to future network structures and packet-oriented transmission technologies. This gives clear results, whether these network structures and transmission technologies are suitable for users with security tasks. The network operator must determine for the individual network elements (see Fig. 7 suitable default to the functionality, the communication protocols and the availability in particular the redundancy of important components. The result of the arithmetical example in chapter 4 shows that the availability for the overall system after Fig. 7 must be still increased. This can be achieved for example by a redundancy of individual elements.

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