Architectures for the Information Systems, Network Resources, and Network Services

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Abstract

Task of automation of productive and administrative processes, operating activity, general system providing, and also facilities, that provide creation, treatment, maintenance, moving away and transporting of information is actual. The united system of business processes allows conducting the synthesis of information and communication systems for national operator of telecommunications and informatization industry. In this work, we developed architectures for the information systems, network resources and network services based on information and communication systems synthesis, which enables to automate production and management processes, operation activities, production tools and ensure system-wide support of telecommunications operator. The research deals with the structural synthesis of architectures of four basic telecommunication networks: transport, IP, mobile and fixed. To standardize each network architecture, eight sets of network resources (levels) were selected. Based on the results of the analysis, a conclusion about the development potential of each network, depending on the trends in modern telecommunication services, may be drawn. The architectures of the public telecommunication operator's communication services means of production, which include platforms of network resources and network services, are considered. The paper proposes a methodological framework for the synthesis of information and communication technologies systems of a telecom operator with a view to set up a unified information platform, which is represented as a universal architecture of information and communication systems.

Keywords

Modern telecommunication services, transport network, IP-network, mobile communications network, fixed communications network.

1. Introduction

The main objective of this study is to conduct synthesis of the information and communication systems (ICS) of a national operator in the field of telecommunications and informatization in order to automate production and management processes, operation activities, production means, system-wide support, as well as tools that enable the creation, processing, storage, control, monitoring, diagnostics, removal and transport of information (Fig. 1) using the architecture of the Uniform Information Platform [1–5]. It consists of four main vertical levels, which correspond to the physical arrangement of the system, and five horizontal levels, which represent five building principles thereof.

Vertical levels are, namely:

1. Structure of business processes.
2. Structure of subsystems.
3. Information structure.
4. Integration structure.

In the case of ICS development for a telecommunications operator, advanced Frameworx elements [6, 7] may be used: it is possible to use a modified business process map, Telecom Operations Map (eTOM), as a structure of business processes; modified map of subsystems, Telecom Application Map (TAM), as a structure of subsystems; modified data model, Shared Information/Data (SID) model, as an information structure; and a modified integration environment, Integration Program (TIP), as an

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integration structure.

The information platform is based on five basic principles, namely: the use of a unified information model; common shared telecommunications infrastructure; clearly defined and described in ontology interfaces; independence between business processes and applied subsystems; mechanisms for building the distributed system with soft links between its components.

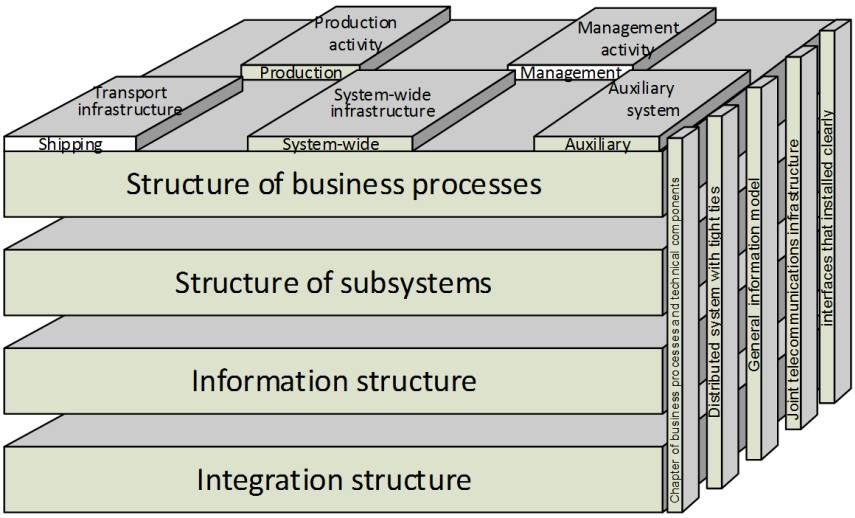

Figure 1: Single information platform

2. Universal ICS Architecture

Common shared telecommunications infrastructure allows to create a single information platform that will be represented in our paper as a universal ICS architecture (UAICS) (Fig. 2).

The UAICS is a single system which may be used by a telecommunications operator for:

- all types of networks (including network services), optical transport network, Internet network (data network), fixed telephone network, mobile phone network;
- all types of products, customers, services, resources, company management and business issues.

Standardization of the UAICS includes:

- determination of complete list of architecture components;
- determination of functional boundaries of components;
- determination of interfaces (protocols) for components interaction.

The primary purposes for standardization of architecture are as follows: acceleration of company services launch by reduction of time expenditures required for implementation and upgrading the information systems, improvement of implementation efficiency and cutting costs for development and use of information systems through:

- prevention of functions duplication; use of open interfaces;
- repeated use of similar elements.

During the study, the architecture has been tested for conformance to generally accepted standards and concepts applicable in telecommunications and IT fields (Frameworx, TM Forum, eTOM, TAM, SID, SDF, ETSI TISPAN, etc.) [7].

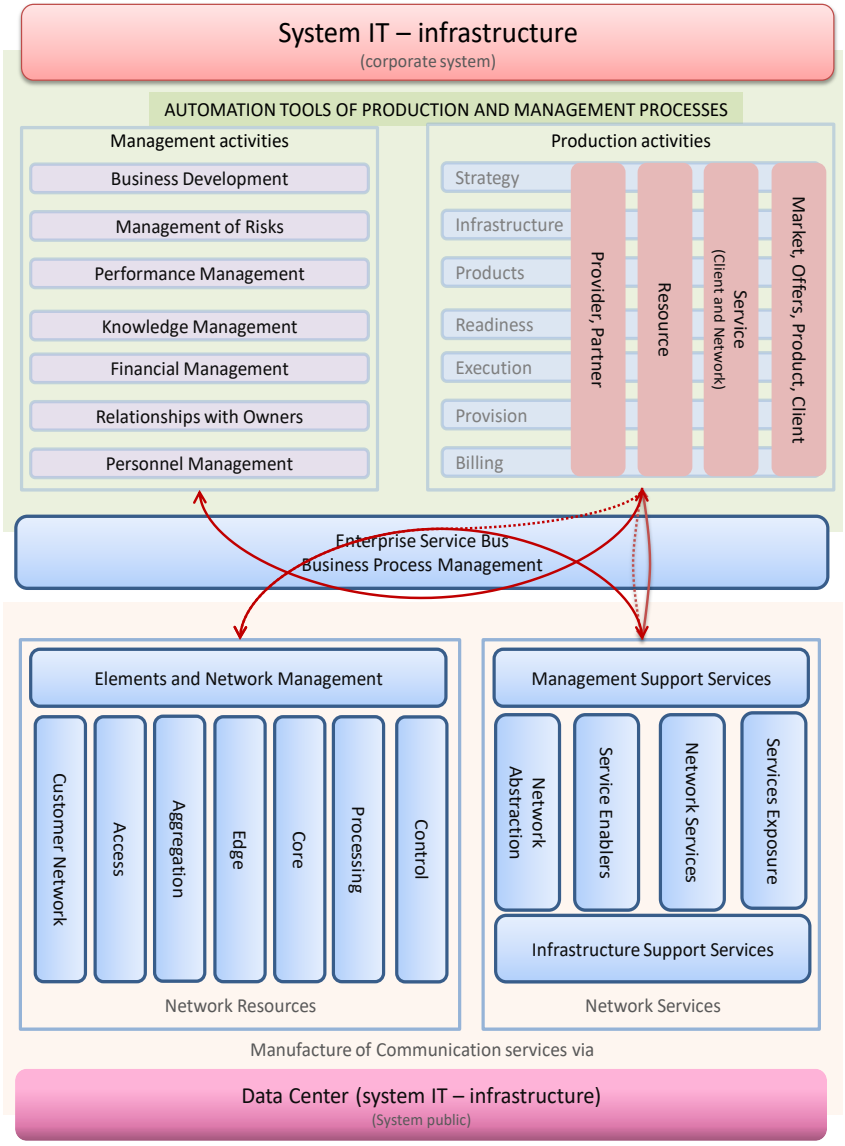

Figure 2: Highest level of information systems architecture

3. The Operator's Information and Communication Systems

The operator's information and communication systems are classified according to their fields of use. Information systems may belong to one of three classes:

- Automation Tools for production (Vv) and service management processes of operator (Vu), which provide for automated collection, storage, processing and release of information required for management functions. All processes related to the lifecycle of services, resources, customer (user) service technology support and maintenance of services' sales and revenue accounting. For systems in this class, the notion of "service" means a commodity with added value. The customer buys a service as a commercial product.
- Automation Tools for network services production (Vp). Information systems for management of technical processes which ensure control of equipment and technological modes in the automated cycle of network services production, provision of network services based on functional capability of equipment's construction units. Systems in this class use the notion of "network service", which is not a commodity and is not offered on the market.

- Tools of system-wide software (Cs) (they are infrastructural in relation to the mentioned above tools).

Within a single class, systems covering certain functional areas are grouped into platforms, which in turn consist of the complexes.

The class of automation tools for production and management processes includes the following platforms:

Vu - automation of production activities (OSS / BSS);

Vv - automation of management activities (ESS).

The class of public communication production services *(Vp)* includes the following platforms:

Vp_1 - network resources;

Vp_2 - network services.

Tools of system-wide software *(Cs)* include the following complexes:

Cs_1 - system of IT- infrastructure, alone:

Cs_{11} - corporate systems.

Cs_{12} - systems of general use.

Cs_2 - Enterprise Service Bus – Business Process Management (the Platform of Information Exchange (PIE) and Business Process Management (BPM)).

In this paper, we will have a closer look at the architectures of network resources and network services platforms.

4. Architecture of the Network Resources Platform

We distinguish four networks (transport, IP, mobile and fixed communication). To unify architectures for each network, eight complexes (levels) of network resources were defined:

$Vp_{1i}=f(m_1,m_2,m_3,m_4,m_5,m_6,m_7,m_8)$, where m_1 – customer's network; m_2 – access; m_3 – aggregation; m_4 – edge; m_5 – core; m_6 – data processing; m_7 – signaling processing; m_8 – management of the network resources.

The capabilities of modern network resources platform allow for creation of network services.

The network resources platform interacts with the network services platform solely through the level of signaling processing.

All systems of network resources platform use the notion of "Resource" only.

Functional use of eight complexes (levels) of network resources platform is shown schematically in Fig. 3.

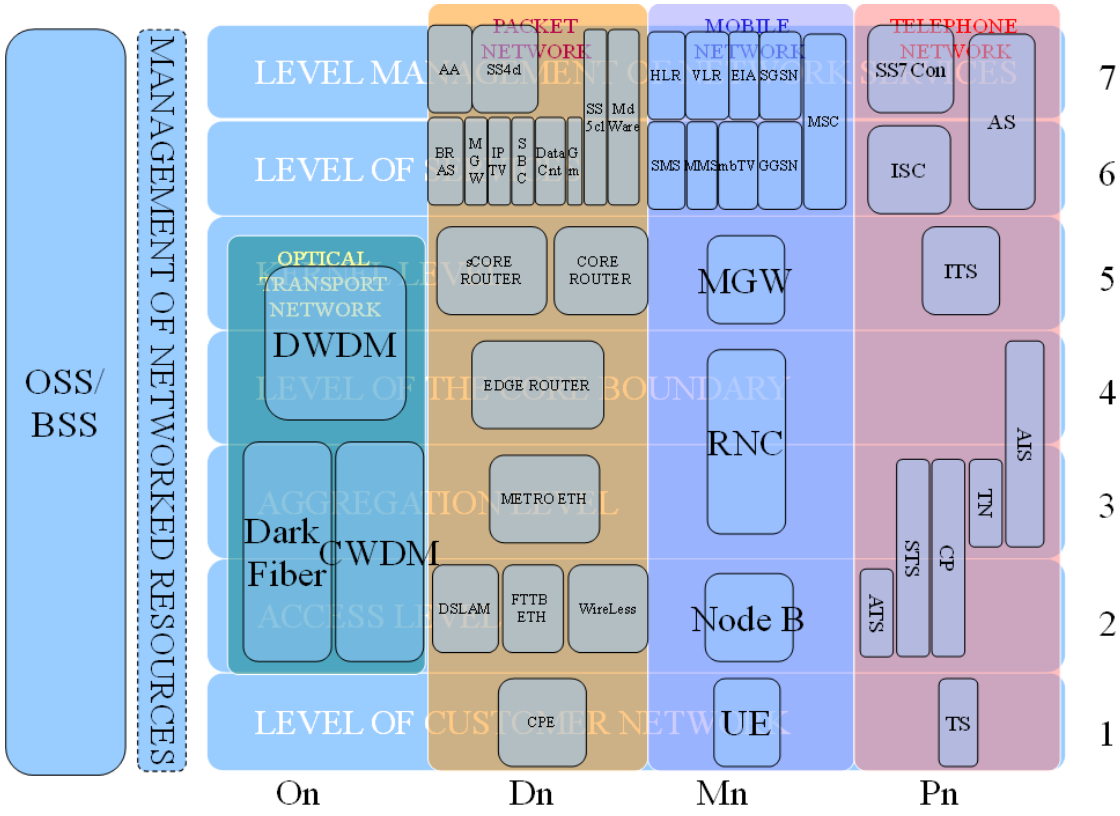

Figure 3: Architecture of network resources platform

At the level of customer network, the following tasks are performed:
m11 – information input - output;
m12 – data processing;
m13 – connecting customer terminals;
m14 – transporting traffic from customer terminals with access level.
At the access level, the following tasks are performed:
m21 – connecting customer networks (in degenerated case – customer terminal);
m22 – transporting traffic from customer's networks to the level of aggregation.
At the aggregation level, the following tasks are performed:
m31 – connecting access nodes (optical, xDSL, wireless);
m32 – transporting traffic from access nodes to the level of the edge.
At the edge level, the following tasks are performed:
m_{41} – connecting aggregation nodes;
m_{42} – skipping (using policies) data and network (RCEF, C-BGF) signaling;
m_{43} – recoding data on transition to other networks (T-MGF);
m_{44} – transporting traffic from aggregation nodes to the core level or to other networks.
At the core level, the following tasks are performed:
m_{51} – connecting edge routers (user access, data processing, signaling processing, connections with operators);
m_{52} – transporting traffic between edge routers.
At the data processing level, the following task is performed:
m_{61} – processing customer data (MRFP).
At the signaling processing level, the following tasks are performed:
m_{71} – management of customer requests for data exchange (AGCF, P-CSCF, A-RACF, SPDF);
m_{72} – management of requests for customer data processing (MRFC);
m_{73} – management of requests for exchange of data with other networks (BGCF, MGCF, SGF);
m_{74} – processing software including routing all requests (I/S-CSCF).

At the level of network resources management, the interaction with the OSS systems is performed.

The capabilities of network resources platform allow for creation of network services [8-12].

The network resources platform does not include application servers, account management and etc. These functions are performed by the network services platform. The network resources platform interacts with the network services platform solely through the level of signaling processing. The network resources platform interacts with the platform of production activity automation through the levels of network resources management and signaling processing.

5. Architecture of Network Services Platform

Network services platform is an essential element of the architecture, especially in terms of provision of telecommunication services. The primary purposes of this platform are as follows: to accelerate the launch of company services by reduction of time expenditures and costs required for products implementation and upgrading, improve products launch efficiency and cut costs for their development and operation through prevention of functions duplication, use of open interfaces, and repeated use of similar elements.

Network services platform Vp_{2i} consists of six complexes (levels) (Fig. 4): $Vp_{2i} = f(p_1,p_2,p_3,p_4,p_5,p_6,p_7,p_8)$, where:

p_1- abstraction of network resources.

p_2- internal interfaces of network services.

p_3- logic of network services.

p_4- external interfaces of network services.

p_5- general functions of network services.

p_6- management of network services.

Level of network resources abstraction includes network adapters (network activators of low level to ensure the access to appropriate elements of the network and network capabilities). Level of network resources abstraction is a network abstraction layer. It uses the “process operation” notion.

Level of internal interfaces of network services performs abstraction of network service capabilities for the above level. It uses the “component of network services” notion. A set of OSA/Parlay API is an example of this interface.

Level of network services logic abstracts means for implementation of services in application servers for the above level. In fact, at this level, a finished network service is generated, which has a customer value as such or may be integrated into other services. Network service may be part of the company’s products or may be presented as an external product (outsourcing) and incorporated into the products of third parties. It uses the “network service” notion.

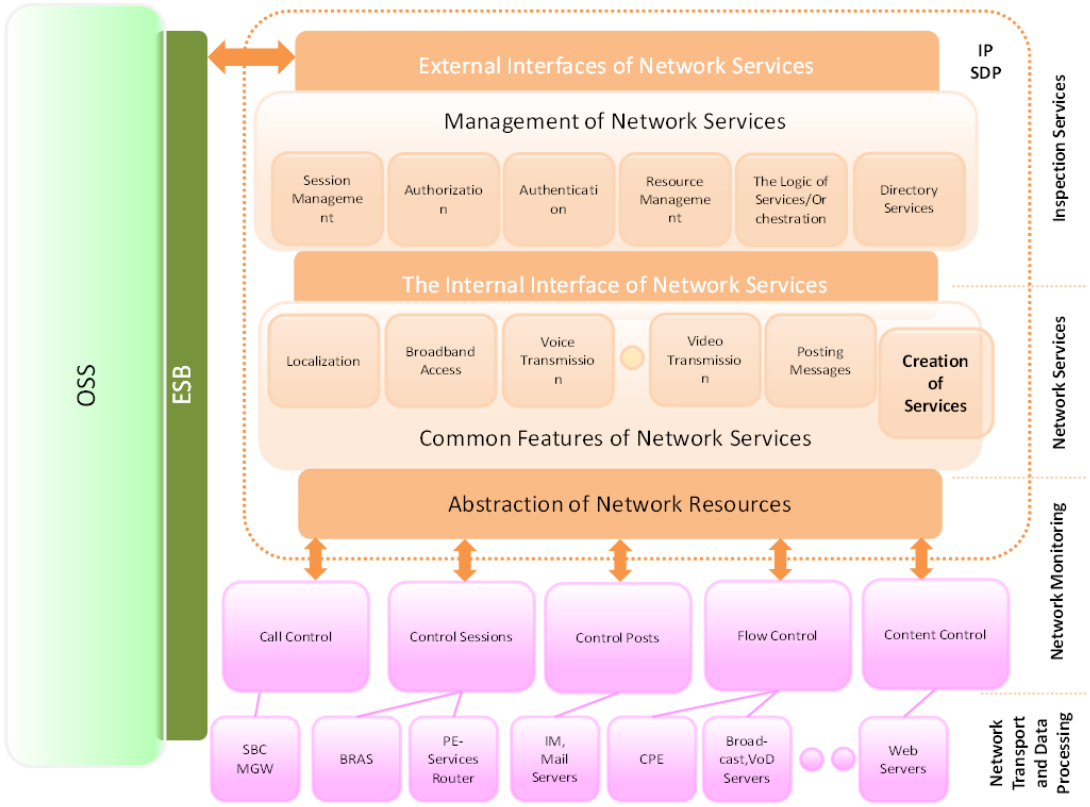

Figure 4: Architecture of network services platform

Level of external interfaces of network services provides access to third parties' services. Parlay-X API set is an example of this interface.

Level of general functions of network services includes components necessary for the provision of services, their components and interfaces.

This level describes the prerequisites for the proper functioning of the service. Level of general functions of network services includes the features of the SDF Infrastructure Support Service (TM Forum). At this level, the following functions are provided:

p_{51} – management of sessions.
p_{52} – identity management.
p_{53} – account management.
p_{54} – resources management.
p_{55} – service catalog.
p_{56} – runtime environment.

Level of network services management provides the life cycle support of the network service. Level of network services management includes features of the SDF Management Support Service (TM Forum).

The network services platform interacts with the network resources platform only through the level of the network resources abstraction.

As part of communication services provision process, the services platform interacts with operational processes support platform through the levels of network services management and network services logic. The services platform provides data on services consumption, and also receives requests for activation / deactivation of services on the network using these interfaces (while operational processes support platform performs the following functions: processing product orders, decomposition of services, management of services activation sequence on the network).

The platform of networking services generally uses the notion of "network service."

Capabilities of the network services platform determine the services, which can be sold to consumers. This approach provides the opportunity for the formation of a new architecture of telecommunication systems and services based on "cloud technologies."

6. Conclusions

This paper describes a methodological framework for the synthesis of information and communication systems of telecommunications operator using the architecture of the Uniform Information Platform.

It consists of four main vertical levels, which correspond to the physical arrangement of the system, and five horizontal levels, which represent five building principles thereof.

Vertical levels are, namely: 1) structure of business processes; 2) structure of subsystems; 3) information structure; 4) integration structure.

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7. References

[1] Redko V., Sergienko I., Stukalo A. (1992). Application systems. Architecture, construction, development. Kyiv, Naukova dumka, 1992, 320.

[2] Repin V., Elyferov V. (2004). Process approach to management: Business Process Modeling. Moscow, RIA "Standards and quality," 408.

[3] Rinks, D. (1986). A heuristic approach to aggregate production scheduling using linguistic variables: Methodology and Application" in Yager R.R.(ed.) "Fuzzy Set and Possibility Theory", Recent advances. Moscow, Radio and Communications, 408.

[4] Barabash O., Open'ko P., Kopiika O., Shevchenko H., & Dakhno N. (2019) Target Programming with Multicriterial Restrictions Application to the Defense Budget Optimization, *Advances in Military Technology*, 14, no. 2, 213-229. DOI: 10.3849/aimt.01291.

[5] Barabash, O., Kopiika, O., Zamrii, I., Sobchuk, V., Musienko, A. (2019). Fraktal and differential properties of the inversor of digits of Q_S-representation of real number. In: Modern Math- ematics and Mechanics. Fundamentals, Problems and Challenges, 79–95. DOI: 10.1007/978-3-319-96755-4_5

[6] Kopeika O., Tarasenko I., Kisselevskiy A., Karichenskiy A., Valiulin T. (2007). Softline applies TMF standards as a guide when building Resource Inventory solution for nation-wide carrier Ukraine Telecom. TM Forum Case Study Handbook, 3, 27.

[7] CCITT Recommendation X.700 (09/92). (1992). Data Communication Networks: Management framework for Open Systems Interconnection (OSI) for CCITT applications / International Telecommunications Union. Geneva.

[8] Shmalko A. (2001). The digital telecommunications network: Fundamentals of Scheduling and building. Moskow, Eko-Trendz, 282.

[9] Choi M.-J., Hong J.W.-K. (2007). Towards Management of Next Generation Networks // IEICE Transaction Communications E Series B. 90, No. 11, 3004-3014.

[10] Rubinstein, M., Duarte O.C., Pujolle G. (2000). Evaluating the Network Performance Management Based on Mobile Agents. Proc. of 2nd International Workshop of Mobile Agents for Telecommunication Applications (MATA), Paris, France, September.

[11] Kopiyka, O. (2014). The architecture of network in the modern data-centers. Scientific notes Ukrainian Research Institute of Communications. #2 (30), 34–41.

[12] Dovgyi, S.O., Yurikov, O.I., Zozyuk, M.O. (2020). On one statistical On one statistical model of error rate in the stream of packet data transmission through communication channels . Cybernetics and Systems Analysis, 56, 739–744. https://doi.org/10.1007/s10559-020-00294-x