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PROCESSES OF THE TELECOM OPERATOR'S INFORMATION ARCHITECTURE TRANSFORMATION

The **subject** of the article is the architecture of information systems of telecom operators (BSS/OSS), requirements for it and the processes of its transformation. The **goal** is to transform the existing information environment of the operator into an open digital ecosystem, in accordance with business and technological requirements for the functionality and architecture of information systems of communication operators, which will introduce new business models, services and products, communication channels, and increase competitiveness. The following **tasks** were solved at the study: analysis of the current state of telecommunications and information systems used by telecom operators; analysis of requirements for business support and operational information systems, collection and analysis of requirements for the architecture of modern information systems in the field of telecommunications, analysis of the transformation process from the existing BSS/OSS architecture of the communication operator into the target architecture of the digital communications provider, elaboration of a recommendations for an intermediate architecture. To solve these problems, **methods** of system and business analysis were used, in particular, methods of analysis of software requirements, technologies for developing software application architecture. The following **results** were obtained. The current state of the telecommunications services industry, the features of the existing information systems of telecommunications operators (BSS/OSS) and the requirements for the architecture of such systems was analyzed. Strategies of transition to modern architecture was considered and analyzed. The target architecture of the digital service provider's information ecosystem and the process of transforming the existing BSS/OSS architecture into the target architecture were considered. Intermediate migration architecture was proposed. **Conclusions**: the transformation to modern information architecture will ensure compliance of BSS/OSS systems with market requirements and new technologies, adapt to their changes, allow operators to increase competitiveness, reduce operating and capital costs, create technological conditions for open digital ecosystem and transform the operator into a digital services provider. It was recommended to use an intermediate architecture based on the open standardized TMF API for such transformation.

Keywords: BSS; OSS; information architecture; telecommunications; telecom operator; requirements analysis; digital service provider; open information ecosystem; omnichannel; architecture transformation processes.

Introduction

Currently, the telecommunications sector worldwide is at the stage of changing technologies and business models, which has been called digital transformation. The driver is both a change in technology - the transition to the digital architecture of the IMS network and 4G/5G technologies, the development of technologies and services IoT/IoE, and the emergence of new models of doing business (including OTT, B2B2x/B2G2x) and changing customer expectations.

Under these conditions, the role of software is growing, which not only ensures the automation of operating and business processes, but also, in fact, the implementation of network functions and communication services.

One of the main components of the information infrastructure of the communication service provider (CSP) is OSS/BSS (Operation Support System/Business Support System). These systems manage interaction with subscribers and partners on the one hand, and network infrastructure and resources - on the other, and also to automate corresponding business processes.

Despite standardization efforts, the information infrastructure of most CSPs, especially those with a long history of operation, is a set of legacy information systems and applications, and has a number of shortcomings, which will be discussed below.

Therefore, the task of analyzing the current state and requirements for the architecture of modern information systems in the field of telecommunications, and the study of ways to transform it into the architecture of the information ecosystem of the digital service provider (DSP) is relevant.

Analysis of recent research and publications

Current state and trends in the field of telecommunications.

In the field of technology, the main trend is the transition to digital IMS architecture, and the introduction of LTE/5G, IoT/IoE services [1].

The IMS network provides all telecommunication services (voice, data, messaging, and multimedia) based on packet-switched IP networks - in contrast to "classic" networks, where voice switching was used for voice transmission. IMS architecture is a set of network functions, divided into three levels - transport, control and application – and connected by standardized interfaces. The network function is not tied to the specific technical implementation of the operator's core network.

The components of the IMS architecture are implemented as VNF – virtual network functions. This allows, in particular, to implement the concept of Network as a Service (NaaS), when the network infrastructure provides its resources as abstract network services through a technology-neutral API (e.g. TMF Open API - TMF909 NaaS API Component Suite). At the same time, the specifics of the service implementation are hidden from higher-level systems - BSS/OSS, which allows you to change the network infrastructure and technologies without affecting the BSS/OSS level system.

Thus, the IMS architecture allows you to build a software-defined network (SDN), which blurs the line between network and information infrastructures - there is a convergence of network and IT components into a single whole. As a result, the role of OSS/BSS (OSS in the first place) as a system that provides not only automation of operational and business processes, but also management

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and orchestration of network services, and becomes one of the main assets and resources of the operator.

We can also note the rapid development of M2M/IoT/IoE services and technologies and multimedia technologies that require appropriate communication and IT infrastructure for their implementation.

Development of related information technologies, such as big data, artificial intelligence (AI), and cloud computing, etc. potentially should give new qualities to OSS/BSS.

Standardization.

Given the complexity of business processes and organizational structure of the industry, and as a result - the diversity of information systems that automate these processes, and the difficulty of their integration, an important task is to standardize processes and related systems.

The first efforts to standardize information systems in the field of telecommunications and requirements for them were made in 1982 by the international organizations ISO (International Organization for Standardization) and ITU (International Telecommunication Union), which issued relevant standards (M.3000 series) and proposed a pyramid model OSS/BSS - Telecommunications Management Network (TMN) model.

The next step was to develop a number of standards for the non-governmental international organization TeleManagement Forum (TM Forum), established in 1995. A multilevel business process model - Business Process Framework (eTOM) [2], (fig. 1), a multilevel application model - Application Framework (TAM) [3] and a generalized information model - Information Framework (SID) [4]. These models later became part of the NGOSS (Next Generation Operations Systems and Software) Open Architecture Model, and later the ODA.

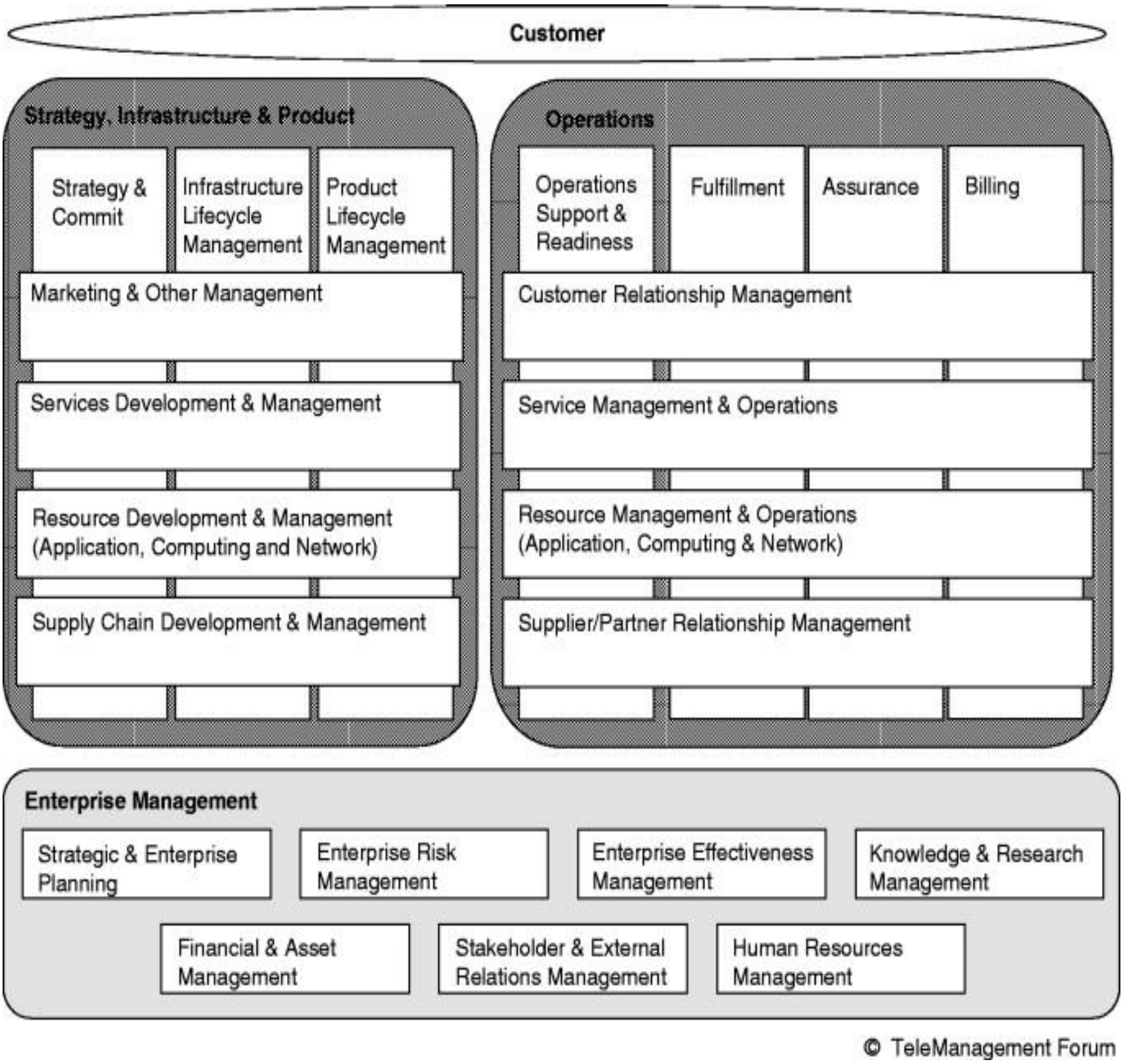

Fig. 1. Multilevel model of eTOM business processes

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Recent initiatives of the TM Forum are related to the development of standards for Open Digital Architecture (ODA) [5] and open API (Open API), as part of it.

The telecommunications market is characterized by high competition, the need for large investments in infrastructure, relatively low profitability, reduced ARPU. This requires telecom operators and providers to change the business model.

An important task for telecom operators is the transition from the role of communications service provider (CSP), which provides only transport for more profitable businesses (content providers, information and communication services, digital advertising, IoT services, etc.) to the role of digital services provider (DSP) [6], which provides a full range of digital services based on existing network infrastructure and partner information ecosystem.

In these conditions, one of the key competitive advantages is the reduction of time to launch new services and products (time-to-market), which is determined by the readiness of network infrastructure to new technologies and OSS / BSS readiness to support new products and business processes. Fierce competition on the one hand, and new technologies on the other contribute to the spread of new business models (OTT, B2B2x / B2G2x), when several partner operators are involved in providing services to the end user.

Customer expectations, at the present stage of development of technologies and telecommunications market, in addition to traditional requirements for the quality of services, their availability, security, broadband access, also affect aspects of user/operator interaction: the ability to interact and manage services exclusively through digital channels (digital experience), client-oriented and integration of interaction channels (customer-centric and omni-channel experiences). Subscribers are waiting for the possibility of using high-performance real-time services, which can be customized by performance, set of products and service quality (SLA), on-demand services, etc.

Current state of BSS/OSS in the field of telecommunications. Studies [7, 8, 9] demonstrate that the existing information infrastructure of telecom operators and its components, in particular BSS/OSS, do not meet the development of technology, modern market requirements and customer expectations.

Operators with a "history" a significant part of the infrastructure consists of legacy systems, architecture, and often the functionality of which does not meet modern requirements. The information infrastructure of a large operator can number hundreds and thousands of systems, whose functions are partially duplicated, which cannot be fully integrated and have no single management. As a result, complex business processes are implemented as separate fragments that require manual coordination and orchestration.

Much of the information systems used in telecommunications are based on proprietary and/or closed standards and interfaces. First of all, it concerns information systems – BSS/OSS. Network components (both hardware solutions and software) are usually built on the basis of open standards (RFC, ITU-T, ETSI), which allows the use of equipment from different manufacturers in the network, simplifies integration and reduces operator dependence on suppliers.

In contrast, BSS/OSS solutions are often closed, providing proprietary interfaces. Historically, many large vendors have been focused on providing a complete stack of BSS/OSS solutions, so their solutions support integration with systems of the same manufacturer, but have poor compatibility (by interfaces, architecture and data models) with systems of other vendors.

Leading providers (vendors) of OSS/BSS are trying to follow the standards and modern requirements for architecture; currently the compliance of the architecture and functionality of OSS/BSS with reference models, (fig.2), at least its declaration, is a prerequisite for success in the information systems market for telecommunications. In practice, such compliance is not always complete, and vendors are forced to maintain inherited systems and solutions, the development of which has a long history and the architecture of which does not meet modern requirements.

Telecom operators usually follow one of two strategies when implementing BSS/OSS. The "best-of-breed" approach provides a choice of solutions of different vendors, each of which best takes into account the requirement of the operator and the specifics of his business processes. The bottleneck here is the need to integrate heterogeneous systems, and integration costs are often comparable to the cost of BSS/OSS itself.

The "best-of-suite" approach involves the purchase of basic information systems from one manufacturer. This approach simplifies the integration of information infrastructure components, but requires significant efforts to customize them, and increases the dependence of the operator from vendor.

In the current environment, when applying any of these approaches, both when replacing existing solutions and implementing new systems, a lot of effort is required to customize them, adapt to the requirements of a particular CSP, integration with existing infrastructure and more. It also takes a lot of effort and time to implement new products and business models. The monolithic or tight coupled architecture of such systems means that their modernization (which is usually performed by the supplier according to the CR - change request procedure) requires significant resources and time. There is a high risk that BSS / OSS implementation projects based on outdated architectural principles will end in excess of cost and delay.

If the BSS/OSS component architecture does not support virtual deployment, it requires the operator to provide additional support costs for technical infrastructure (physical servers, data warehouses, etc.), complicates their administration, and scaling.

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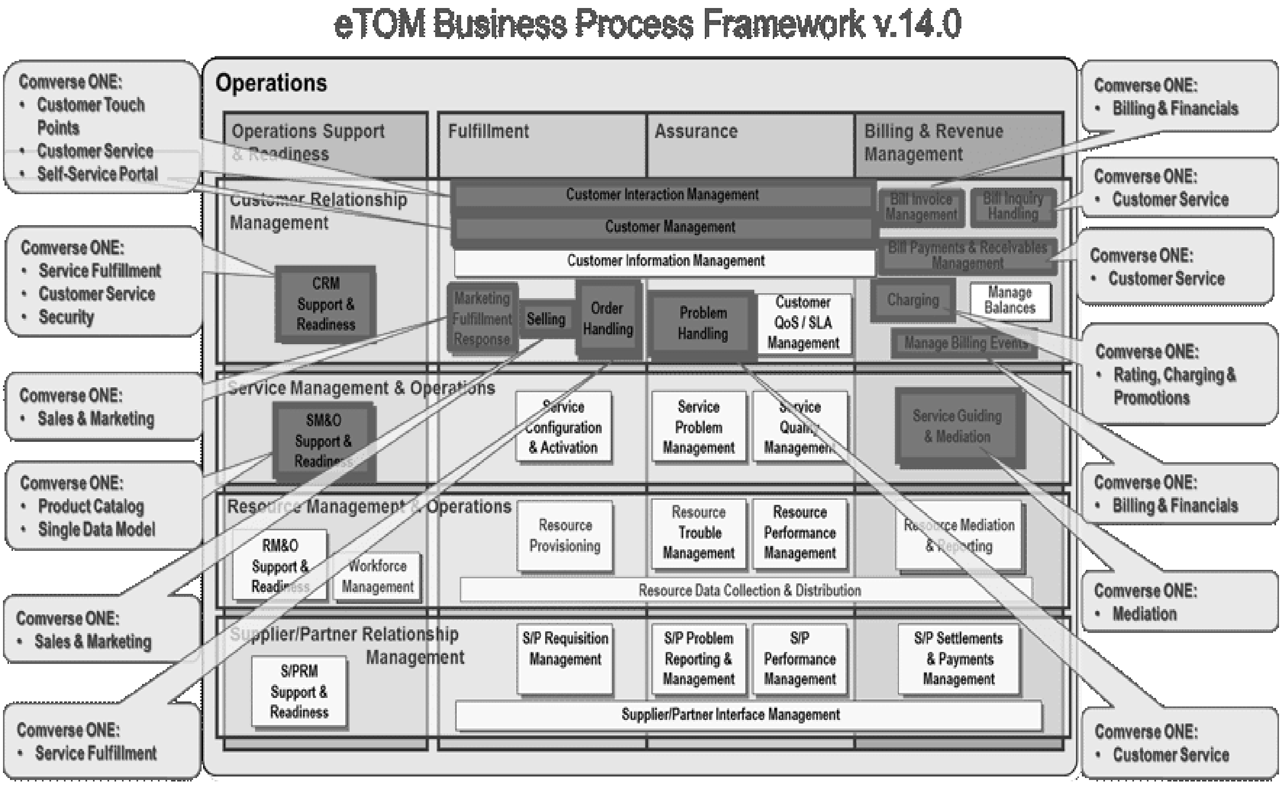

Fig. 2. Projection of Comvers BSS on the model of business processes of eTOM

Task of the study. Thus, it can be concluded that the existing BSS/OSS in the field of telecommunications, in particular their architecture, do not meet modern technological and business challenges, and need to be modernized. Actual is the task of analyzing the requirements for the architecture of such systems, and recommendations for the process of transforming the information infrastructure of the communication operator into an open ecosystem that would allow the introduction of new business models and products, increase the competitiveness and loyalty of subscribers and partners.

The **purpose of this article** is to analyze high-level business and system requirements for information systems in the field of telecommunications, to formulate requirements for the architecture of such systems, and to provide recommendations for the process of transformation of the existing information architecture of telecommunications operators into an open digital architecture.

Materials and methods used in the study - system and business analysis [10, 11], methods of analysis of software requirements, etc.

Study results

BSS/OSS requirements analysis. Briefly, the requirements for BSS/OSS can be formulated as follows: they must meet the modern level of technology development and business requirements.

Analysis of trends in the development of technologies and market requirements in the field of telecommunications, which were discussed above, allows to formulate the following functional and non-functional requirements for BSS/OSS information systems in the field of telecommunications:

- End-to-end automation of all business processes, which eliminates or minimizes staff interference not only in routine operations, but also in complex processes such as introducing a new product or connecting a new partner, and minimizes the need for manual orchestration of processes.
- Reduction of operating (OPEX) and capital (CAPEX) costs for information systems deployment, upgrade and maintenance of information infrastructure.
- Reduce the time to launch new services and launch new products and marketing offers (time-to-market).
- Rapid adaptation to changes in technology and business models, as well as the load on the network and / or a separate information system.
- Support for modern communication technologies, including LTE / 5G, in accordance with 3GPP, ITU-T and other standards and requirements.
- Future proof - possibility to implement future communication technologies, services and business models without the need to replace or deeply upgrade key BSS / OSS components and systems.
- On-demand scalability, adaptation to changes in traffic volumes and loads, which should ensure the availability of the systems and services for subscribers in a wide range of loads on the network and information systems of the operator.
- Independence from BSS / OSS vendors, the ability to deploy new components from different vendors and

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integrate them into the existing information infrastructure, and / or replace individual infrastructure components.

- Support for the software-as-a-service (SaaS) model, which is necessary in particular for the formation of the operator's partner ecosystem. Possibility of seamless integration with information systems of partners.

- Omnichannel - integration of different channels and seamless switching of communication with the subscriber to the optimal channel with preservation of context, and providing digital experience of subscribers.

Requirements for BSS/OSS architecture.

In order for BSS/OSS to meet the above requirements, their architecture must meet the following principles [8, 9, 12, 13]:

Compliance with open standards is primarily the standards of 3GPP, IETF, ETSI, etc. in part of network functions and interfaces, and TMF ODA in part of software architectures and interfaces. It is open standards that are supported by influential international organizations and constantly evolving, unlike proprietary ones, that ensure that the system will meet the current and future requirements of technologies and the market.

The use of open and standardized interfaces should ensure the integration and interchangeability of information infrastructure elements, its flexibility, and the ability to build an information ecosystem of a communication operator and integration with partners. In the field of telecommunications, this is primarily a set of specifications of the TM Forum Open API.

Component based loose coupled architecture, in contrast to the monolithic architecture of legacy systems, should provide BSS/OSS flexibility, and the ability to adapt them quickly to market changes and technology. There are no single requirements for using any single approach: it can be a microservice architecture [12], containerization, SOA, etc. Built on such principles, the system is a network of services that interact with each other and with external systems through the API; management and orchestration of services is performed in accordance with business policies and process models.

Cloud native architecture [9] - the readiness of the solution to complete virtualization and to deploy in an NFV environment, in a private or public (Amazon Web Services, Google Cloud, Microsoft Azure) cloud. This opens the way to scalability and, accordingly, availability of solutions for loads varying in a wide range, as well as the ability to provide software as a service - SaaS.

Model driven and configuration driven architecture. This means that changing processes in the system does not require modification at the level of program code (customization), but is performed by configuring the existing components of the system and integrating new ones. This approach requires a global product and service, a registry of network resources, and the use of modeling tools and standards such as TOSCA to describe services, YANG to describe resources, and BPMN 2.0 to model processes [14].

Support for CI/CD (Continuous Integration and Deployment) processes should ensure the ability to quickly and safely update components and (sub) systems that are already in operation.

It should be noted that the specified requirements are closely related to each other. For example, standard compliance includes standardized APIs and use of simulation standards, component architecture related to APIs and virtualization, etc.

Thus, the goal is to transform the outdated monolithic information architecture of communication operators into an open information ecosystem built on modern architectural principles and standards, (fig. 3). This should ensure that telecom operators turn into DSP, that provides service on the basis of communication network and information infrastructure. The target architecture should be built on the basis of loose coupled components that are deployed in the public or private cloud and are connected to each other and to external systems using an open standardized API [15].

A significant factor affecting the process of architecture transformation is the inability to simultaneously replace all legacy systems and components of existing information infrastructure. This is due to the large amount of necessary capital investments and high risks of untimely completion of such large-scale projects.

In the process of transforming the BSS/OSS architecture, several tasks must be solved:

- Decomposition of existing information systems into set of loose coupled components according to the model of processes and systems (eTOM and TAM, Open Digital Architecture), and transfer of components to the cloud environment. Legacy systems that cannot be transformed in this way must be replaced with new ones.

- Integration of product catalogs. This requires the analysis and revision of existing products in order to unify and simplify them, and the development of a single data model that allows you to describe all existing products, provide the possibility of their configuration and will meet current standards (including SID). Data from all available legacy directories must be combined into a single shared product catalog and accessible to all information components (usually via the API). At the transition stage, federalization or data consolidation can be used.

- Implementing a single environment for modeling, performing and orchestrating of business processes. This requires analysis and revision of existing processes for the purpose of their unification and digitalization, development of a common model using modern tools of modeling business processes (for example, BPML/BPME).

- Integration of channels of interaction with subscribers and partners, and transition to omnichannelity. This requires the separation of functions that provide interaction with subscribers and partners, from systems that implement basic processes and services, to a separate integration level that will ensure their orchestration.

- The transition of network infrastructure to IMS/SDN architecture, which meets modern standards, is able to support modern telecommunications technologies such as LTE/ 5G, Edge, Io T/Io E and provides real-time management of network resources by OSS/BSS

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information systems, including allocation of resources according to the current needs of the subscriber.

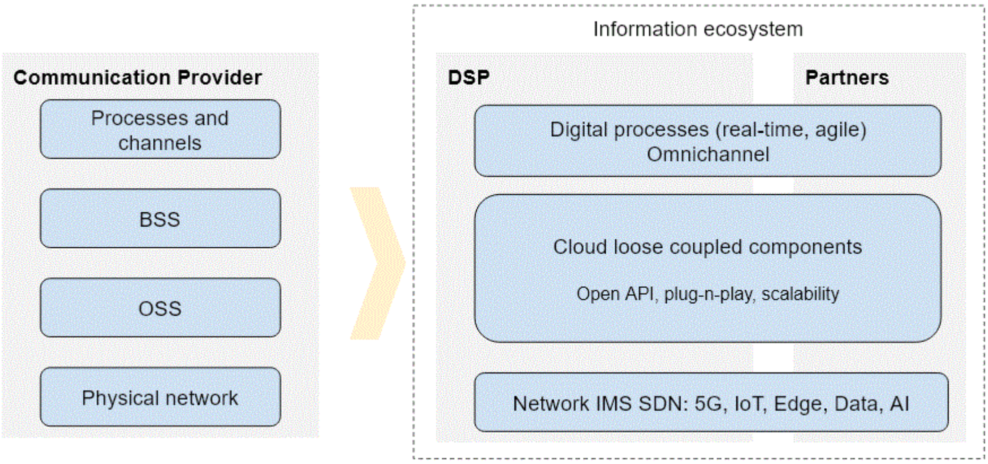

Fig. 3. BSS/OSS architecture transformation

In the process of transformation of the information architecture of telecom operators it is possible to apply several strategies [16]:

- greenfield – parallel deployment of a new information infrastructure, built on the declared principles, and gradual transfer of individual products and/or services and/or business segments. For example, first, prepaid mobile services and subscribers are transferred to the new infrastructure, then a contract mobile, then a fixed one. Thus, at the transition stage, there are two infrastructures - old and new - between which processes and services are distributed.

- brownfield – gradual replacement of individual legacy systems with new ones that meet the above requirements for architecture. The outdated system is simultaneously decommissioned; its functions are transferred to new components. For example, first, CRM is replaced, then systems of interaction with partners, billing system and so on. It should be understood that the improvement and modernization of existing legacy systems in such a way that they meet the above requirements for architecture are possible only from their developers and vendors. Systems that are no longer developed and unsupported must be unopposed.

- carve-out – gradual deployment of new infrastructure and transfer to it certain functions of existing systems. The inherited system, all functions of which have moved to the new infrastructure, is decommissioned.

Each of the above approaches has its own characteristics, advantages and disadvantages. The strategy should be chosen taking into account the existing architecture, business processes, the available project budget, etc. For large telecom operators, the parallel deployment of the new infrastructure in full requires significant resource costs – budget and time – until the first results are received. Therefore, a combined (brownfield and/or curve-out) strategy is usually used for gradually transition to a new architecture.

It is proposed to use intermediate (migration) architecture in the process of transformation and integration of all existing components and systems using a unified API, (fig. 4). It is proposed to use TMF Open API as a unified interface, which is the actual standard and already used by many telecommunication operators and vendors [17]. The presence of an open standardized interface will allow you to begin the transition to omnichannel interaction with subscribers, unify integration with partners and begin the development of an affiliate ecosystem.

The target architecture must be built using a multi-level component approach [18]. This will transform the monolithic architecture into a poorly connected one, and will create the possibility of gradual modernization as well as reuse of the component. New components must meet the above architectural requirements, in particular, be placed in a virtual (cloud) environment and integrated with Open API.

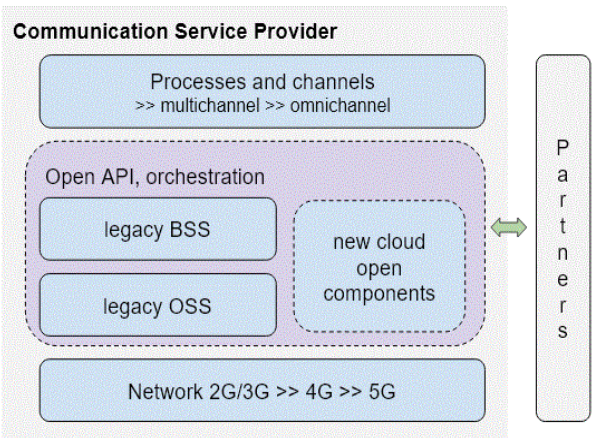

Fig. 4. BSS/OSS intermediate architecture

In parallel, the final transition of the communication network to the IMS/SDN architecture should take place, which will allow implementing the latest services and ensuring the convergence of network and IT-component into a single system.

Conclusions

The transition to the proposed principles of OSS/BSS architecture should ensure compliance of such systems with market requirements and new technologies,

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adapt to their changes, allow operators to increase competitiveness, reduce operating and capital costs, etc. The aim should be to create technological conditions for the development of an open digital ecosystem and the transformation of the telecom operator into a digital service provider.

The process of transformation of the architecture of the information infrastructure of telecom operators on the basis of an intermediate architecture built on the basis of the open standardized Open API TMF is proposed. This process should ensure a gradual transition to the target architecture.

The direction of further research is to improve the process of architecture transformation, detailing and analysis of intermediate architecture options.

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ПРОЦЕСИ ТРАНСФОРМАЦІЇ ІНФОРМАЦІЙНОЇ АРХІТЕКТУРИ ОПЕРАТОРА ЗВ'ЯЗКУ

Предметом дослідження статті є архітектура інформаційних систем операторів зв'язку (BSS/OSS), вимоги до неї та процеси її трансформації. **Метою** є трансформація наявного інформаційного середовища оператора зв'язку у відкриту цифрову екосистему, відповідно до бізнесових та технологічних вимог до функціоналу та архітектури інформаційних систем операторів зв'язку, що дозволить впровадити нові бізнес-моделі, послуги та продукти, канали комунікації із абонентами тощо, та підвищити конкурентоздатність. В роботі вирішуються наступні **задачі**: аналіз сучасного стану сфери телекомунікації та інформаційних систем, що використовуються операторами зв'язку; аналіз вимог, що висуваються до інформаційних систем підтримки бізнесу та операційної діяльності, збір та аналіз вимог до архітектури сучасних інформаційних систем в сфері телекомунікацій, аналіз процесу трансформації наявної архітектури BSS/OSS оператора зв'язку у цільову архітектуру інформаційної екосистеми цифрового оператора комунікацій, розробка рекомендації щодо проміжної архітектури. Для вирішення зазначених завдань були використані **методи** системного та бізнес аналізу, зокрема методи аналізу вимог до ПЗ, технології розробки архітектури програмних додатків. Отримані наступні **результати**. Проаналізовано сучасний стан галузі телекомунікаційних послуг, особливості наявних інформаційних систем операторів зв'язку (BSS/OSS) та вимоги які висуваються до архітектури таких систем. Розглянуто та проаналізовано стратегії переходу до сучасної інформаційної архітектури. Розглянуто цільову архітектуру інформаційної екосистеми провайдера цифрових послуг та процес трансформації наявної архітектури BSS/OSS у цільову архітектуру. Запропоновано проміжну міграційну архітектуру. **Висновки**: перехід до сучасної інформаційної архітектури забезпечить відповідність систем BSS/OSS вимогам ринку та нових технологіі, адаптацію до їх змін, дозволить операторам підвищити конкурентоздатність, зменшити операційні та капітальні витрати, створить технологічні умови для розбудови відкритої цифрової екосистеми та перетворення оператора зв'язку у провайдера цифрових послуг. Для трансформації рекомендується використовувати проміжну архітектуру на основі відкритого стандартизованого API TMF.

Ключові слова: BSS; OSS; інформаційна архітектура; телекомунікації; оператор зв'язку; аналіз вимог; провайдер цифрових послуг; відкрита інформаційна екосистема; омніканальність; процеси трансформації архітектури.

ПРОЦЕССЫ ТРАНСФОРМАЦИИ ИНФОРМАЦИОННОЙ АРХІТЕКТУРЫ ОПЕРАТОРА СВЯЗИ

Предметом исследования статьи является архитектура информационных систем операторов связи (BSS/OSS), требования к ней и процессы ее трансформации. **Целью** является трансформация существующей информационной среды оператора связи в открытую цифровую экосистему, в соответствии с бизнес-технологическими требованиями к функционалу и архитектуре информационных систем операторов связи, что позволит внедрить новые бизнес-модели, услуги и продукты, каналы коммуникации с абонентами и повысить конкурентоспособность. В работе решаются следующие **задачи**: анализ современного состояния сферы телекоммуникации и информационных систем, используемых операторами связи; анализ требований, предъявляемых к информационным системам поддержки бизнеса и операционной деятельности, сбор и анализ требований к архитектуре современных информационных систем в сфере телекоммуникаций, анализ процесса трансформации существующей архитектуры BSS/OSS оператора связи к целевой архитектуре информационной экосистемы цифрового оператора коммуникаций, разработка рекомендации по промежуточной архитектуре. Для решения указанных задач были использованы **методы** системного и анализа, в частности методы анализа требований к ПО, технологии разработки архитектуры программных приложений. Получены следующие **результаты**. Проанализировано современное состояние отрасли телекоммуникационных услуг, особенности имеющихся информационных систем операторов связи (BSS/OSS) и требования, предъявляемые к архитектуре таких систем. Рассмотрены и проанализированы стратегии перехода к современной информационной архитектуре. Рассмотрена целевая архитектура информационной экосистемы провайдера цифровых услуг и процесс трансформации существующей архитектуры BSS/OSS в целевую архитектуру. Предложена промежуточная миграционная архитектура. **Выводы**: переход к современной информационной архитектуре обеспечит соответствие систем BSS/OSS требованиям рынка и новых технологий, адаптацию к их изменениям, позволит операторам повысить конкурентоспособность, уменьшить операционные и капитальные затраты, создаст технологические условия для построения открытой цифровой экосистемы и преобразования оператора связи в цифрового провайдера. услуг. Для трансформации рекомендуется использовать промежуточную архитектуру на базе открытого стандартизированного API TMF.

Ключевые слова: BSS; OSS; информационная архитектура; телекоммуникации; оператор связи; анализ требований; провайдер цифровых услуг; открытая информационная экосистема; омниканальность; процессы трансформация архитектуры.

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