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MOBILE INFOCOMMUNICATION SYSTEMS

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Background. An increase in the number of users and services with the support of the required quality of service, an increase in the coverage area of one operator’s radio access network, and most importantly, the emergence of packet-switched technologies and systems, has led to a significant complication of the core mobile communications network and its nodes, an increase in the functionality and intellectualization of the network core. Gradually, it was the core network and the technologies of its functioning that became more significant than the radio access network. Hence, for the construction of mobile communication systems, more integrated information and telecommunication technologies, especially from the field of network and information technologies, became popular.

Objective. The aim of the paper is to present the concept of the architecture of mobile infocommunication systems as systems whose services make a significant, even decisive, contribution to the functioning of the infrastructure of modern society, built on the constant exchange and assimilation of information.

Methods. The structural and functional methods of constructing the architectures of information and telecommunication systems are investigated.

Results. The signaling network of mobile infocommunications manages the maintenance of both individual wireless user terminals (telephones, smartphones, tablets), and many wireless inter-machine communication devices and the Internet of Things. In addition, the same alarm system supports various telecommunication networks of wireless subscriber access, automobile and other vehicles; creates an interface with wired / cable access networks.

Thus, the core network of mobile infocommunications can fully integrate interfaces with all types of telecommunications, which are designed to transmit many low-speed data streams, as well as to transmit high-speed data streams. There is a tendency to take over traditional old services, for example, the public telephone network and radio-relay communication lines, and turn them into private services of the mobile infocommunication network, which further enhances their importance. All this creates the prerequisites for the transformation of mobile infocommunication operator systems into the main (determining) players in the telecommunications market. Confirmation of this is the high characteristics that are to be achieved in the networks of the 5th and 6th generations of mobile infocommunications.

Conclusions. Mobile infocommunication systems have become a defining component of all telecommunication services provided to users and non-servicing nodes of sensor networks, and the infrastructure of core networks and access networks of mobile infocommunications has begun to determine the general technical infrastructure of telecommunications.

Keywords: systems of mobile info-communications; virtualization telecommunications; information technology; software-defined devices and networks.

I. Introduction

For many years, telecommunication and information technologies were considered as separate areas, but in recent decades there has been a continuous convergence and the creation of unified infocommunication (information and telecommunication) technologies. The term telecommunications itself appeared as the heir to the outdated term “electrical connection”, and therefore it does not fully reflect the fact that communications not only transmit, but also process information generated by means of information technology. The totality of information and telecommunication systems, which in the process of information processing act as a whole, is defined by the term information-telecommunication or infocommunication systems [1]-[6].

Currently, the formation of new and modernization of traditional methods of transmission of information and access to information resources continues. In particular, mobile technologies that allow its users (their mobile devices and applications) to simultaneously use mobile services and move freely are effective tools of modern infocommunication systems. Infocommunication systems according to the supported mobility (mobility) levels can be: with partial (portable terminals), incomplete (low terminal speed), and full (with terminal movement 300 km / h and higher) mobility [7] - [8].

An important component of infocommunications was cellular mobile (moving) communication systems that provide radio access to user terminals, during which the end equipment of at least one of the users can freely move within the infocommunication network, while maintaining a single unique identification number of the user's mobile terminal. Mobile communication systems have come a long way in development from ordinary cellular user access radio systems, the main purpose of which was to provide voice communications with the public switched telephone network (PSTN), to modern heterogeneous information and communication systems with mobility support, providing convergent communication services for voice and data transmission, services the inter-machine interaction of M2M (machine-to-machine) and the services of the Internet of Things (IoT) [9] - [10].

Early mobile communication systems (territorial telephony) were mainly determined by the implementation of their radio access system. A traditional telephone switching system (according to the principle of circuit-switched) such as a local automatic telephone exchange with several additional nodes (add-ons), which were supposed to coordinate the interfaces of the switching station with the channels of the wireless subscriber access network and provide support for subscriber mobility, served as the central node (core) terminals. Thus, when deploying early mobile communication systems, more attention was paid to the implementation of wireless technologies and the principles of the functioning of the user access network in the conditions of possible deep fading signals. Accordingly, the development of such mobile communication systems required, first of all, the availability of radio engineering training [11] - [12].

An increase in the number of users and services supporting the required quality of service, an increase in the service area of a single operator's network, and most importantly, the emergence of packet-switched technologies and systems, has led to a significant complication of the core mobile communications network and its nodes, and the growth of functionality and intellectualization of the network core. Gradually, it was the core network and the technologies of its functioning that became more significant than the radio access network. Despite this, the intensive development of the latter continues all the time and remains important, since it is the radio access network that remains the main interface for connecting most users.

Hence, for the construction of mobile communication systems, more integrated information and telecommunication technologies, especially from the field of network and information technologies, became popular.

Currently, mobile communications systems have emerged as information and telecommunication systems with mobility support, or - mobile infocommunication systems. The latter work equally effectively with both wireless and wired user access networks and the IoT [13] - [14].

The purpose of the work is to not go into details of modern telecommunication technologies (to improve the perception of the material), to present in the enlarged introduce the concept of the architecture of mobile infocommunication systems as systems whose services make a significant, even decisive, contribution to the functioning of the infrastructure of a modern society built on a constant exchange and assimilation of information (monitoring, management, broadcasting, processing, storage).

II. GENERALIZED STRUCTURE OF THE MOBILE INFOCOMMUNICATION SYSTEMS

Infocommunication wireless mobile system of user access - cellular system of mobile communication (CSMC) is a full-fledged information and telecommunication system, and its functions include the basic functions of the telecommunication system: transmission (transfer) of information; alarm (internal system control); switching of information flows (packets); general management.

A simplified network hierarchy of the cellular system / mobile network is shown in Fig. 1.

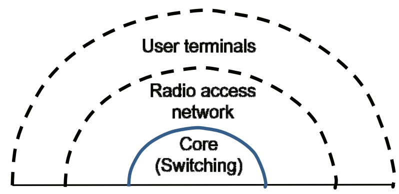


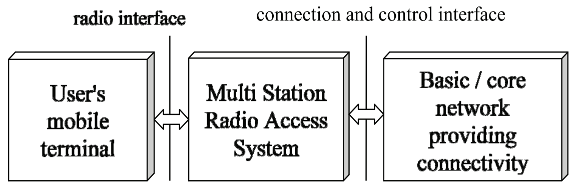
Fig. 1. Simplified network hierarchy of mobile cellular system from the user interface

The generalized structure of a single-cell mobile communication system for one user is presented in Fig. 2, and for a full-cell mobile communication system - in Fig. 3.

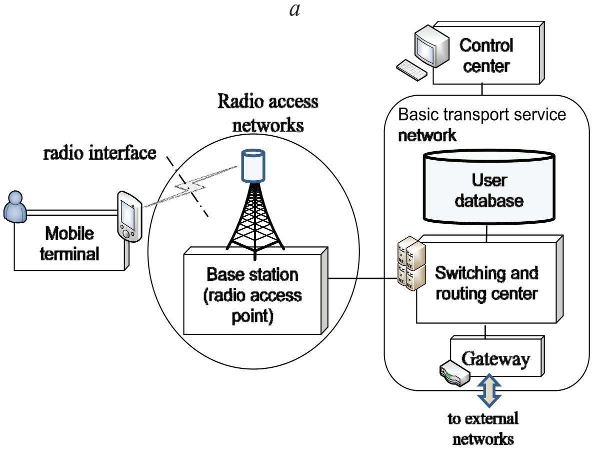
The simplest case is a single-cell mobile communication system to serve one user - one mobile terminal (MT) (Fig. 1). In this case, we have a system of interaction of three main objects: MT, wireless access network (radio access network) and the basic transport network of services. MT provides through a radio interface a connection with an access point (base station) of a radio access network. Through the access point, information is exchanged between the MT and the switching and routing center of the basic transport service network. The switching center is a key node of the core network and forms all MT connections, while performing its authentication and charging using a special operator user database. This means that this MT is already registered in this core network. Also, the switching center connects to other centers of the operator's network and external networks. General control over the operator's network is performed by the Control Center.

The following stages of MT operation in the operator's network can be noted:

- entry into communication;
- authentication;
- implementation of traffic channel connections in the network.



a



b

Fig. 2. The basic components (*a*) and the generalized structure (*b*) of a single-cell mobile communication system for one user

When approaching reality, as in a more complex case, there is a large and diverse branching of the network of the CSMC operator with a correspondingly more complex architecture (Fig. 3). For example, consider the case when there are a number of MTs working with access points in various radio access networks. The latter have corresponding connections to switching centers of dissimilar core networks. Moreover, due to its movement in the zone of deployment of radio access networks, MT constantly changes the access points that serve it. So for MT should always be available at least three of the following types of networks: home, where MT was registered and where data is stored about it; transit through which information intended for MT passes in transit, that is, without processing (it is only necessary if the network serves, does not have a direct connection to the MT home network), the service is the network that currently serves MT (it cannot be transit). All of these networks can be completely different in their structure and content.

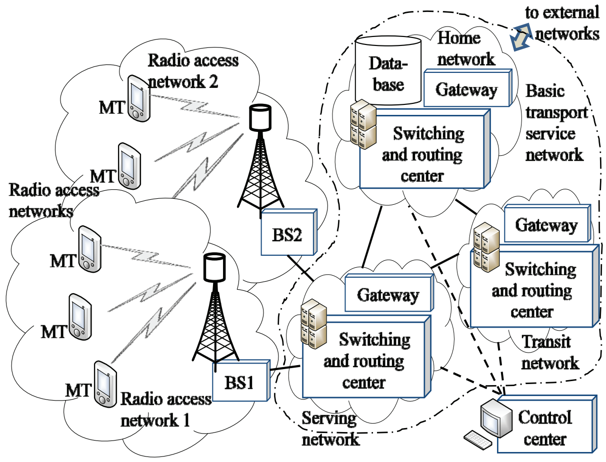


Fig. 3. Generalized network structure of a cellular mobile communication system of one operator

In order to network, which is shown in Fig. 3, it could be attributed to a modern full-fledged system of mobile infocommunications, it is necessary to take into account the possibility of connecting various types of radio access networks to the core network, as well as the presence of intelligent nodes (functions) of the signaling network that support mobility, autonomists and self-organization of the entire mobile infocommunication network. So, in Fig. 4 presents a simplified generalized structure of a mobile infocommunication system. User MT access to the core network can be either wireless or wired. Moreover, radio access can be implemented within cells with various wireless access technologies, for example, multiple access with a time division TDMA (time division multiple access), multiple access with a code section CDMA (Code Division Multiple Access) and multiple access with orthogonal frequency division multiplexing OFDMA (Orthogonal frequency-division multiple access). To provide the necessary interfaces with BS operating in various wireless standards, an interface controller is used, which can also provide an interaction interface between these BSs and wired access channels [10]. The core network signaling is based on the mobility management node, which provides support for continuous handover and location service of the user terminal and BS, user database (identifiers, service parameters, etc.) and a function of the rules and policies for call processing and billing, which provides an intelligent policy the functioning of the network and the servicing of each user in accordance with the established requirements for the quality of service of the requested services.

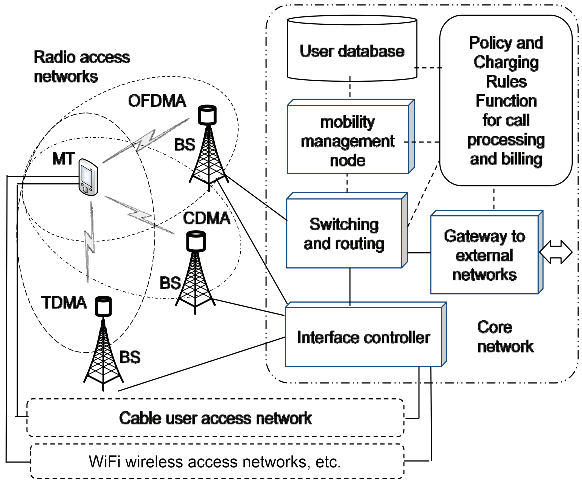


Fig. 4. Simplified generalized structure of the mobile infocommunications system

In this case, the user's MT can functionally be a conventional mobile phone / smartphone accessory to connect to wired networks, controlled by the operator, and terminal services machine to machine M2M and the IoT.

III. Virtualization of Equipment in Mobile Infocommunication Systems

The main feature of mobile info-communications is their flexibility (intellectualization and adaptability) of working with all wire and wireless access networks, as well as high-speed connection of the operator's core network to external information resources. The main way to get this flexibility is through virtualization of the system architecture by implementing SDR (Software-Defined Radio) and SDN (Software-Defined Networking) technologies. Here, the functional change does not occur by replacing the material part, but by changing its program part. That is, intellectualization of the complex structure of the network architecture was carried out by introducing the same programmable nodes, the function of which was determined not by the design, but by the position in the structure and data from other nodes [16] - [19].

However, certain requirements are imposed on the implementation of SDR and SDN technologies in the network of a major mobile infocommunications operator with respect to preserving all the functionality inherited from existing (traditional) cellular mobile telecommunication networks. Currently, the power of computing systems has reached levels sufficient to process the algorithms embedded in the mobile networks of GSM/UMTS/LTE standards. This, in principle, allowed operators to switch to SDR systems and get compact and efficient base stations. However, there was a problem associated with the used frequency range and the required output power for mobile networks of different standards. When switching to the SDR architecture, this problem was solved by connecting several radio modules to a common processor unit, each of which provides the generation of radiation power signals in a certain frequency range.

What communication standard will be supported in this case is determined by the processor unit and the operator's strategy for refarming (the procedure for replacing the used radio technology) of some standards with others (Fig. 5). The interface from the processor unit to the radio transmitter is also standardized, and all manufacturers offer their own options for implementing the CPRI (Common Public Radio Interface) protocol. The latest implementations of the CPRI protocol are also supported by manufacturers of transport network equipment, for example, radio relay lines, which allows connecting radio transmitters at considerable distances from the processor unit. This embodiment of the SDR-concept significantly reduces the number of processor units required and at the same time provides traffic aggregation from all standards of mobile communication networks into one transport network. However, this also changes the structure of the multi-level model of open systems (Fig. 6).

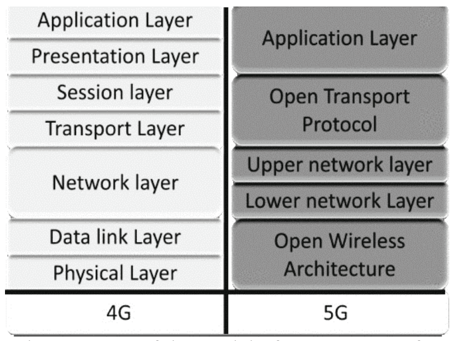


Fig. 5. The structure of the model of open systems for mobile information communications of the 4th and 5th generation with an open wireless architecture according to [16]

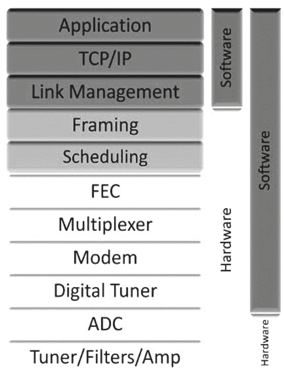


Fig. 6. The structure of a multi-level model of open systems for mobile infocommunications using SDR solutions according to [16]

Then, to receive traffic from a multi-standard GSM / UMTS / LTE radio network, a distributed operator network architecture was implemented according to the recommendations of 3GPP (3rd Generation Partnership Project) [20].

Moreover, each node represents a whole rack of equipment with specific interfaces, nodes, boards, etc. The suppliers of different nodes are different manufacturers, the equipment belongs to different generations or even epochs of network development. It is quite difficult to operate such a " multi-storey" structure; qualified engineers are required, moreover, with experience in operating various equipment, various manufacturers. The concept of virtualization of not only equipment, but also the SDN network itself, is called upon to solve this problem by optimizing such an architecture.

Currently, mobile infocommunication methods of software-configured transport networks have been combined with the algorithms of "virtualization" - Mobile Virtualization. The result of this association was a new architecture for the construction of mobile networks - Mobile SDN [19]. The basic approaches used in the design of mobile SDN networks are the same as for transport networks:

- separation of the signal level (traffic control protocols, signaling protocols of the transport layer, etc.) and user traffic;
- virtualization of necessary processes on powerful server platforms, providing the necessary processor power for signaling processing and interface capacity for transmitting user traffic.

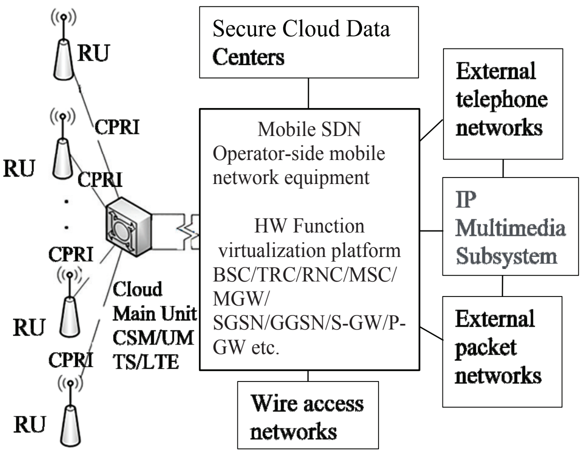


Fig. 7. Mobile infocommunications network using SDR and SDN approaches in terms of operator equipment (CPRI - Common Public Radio Interface; RU - radio unit)

The new architecture actually means replacing all types of various equipment of mobile networks (BSC / RNC / MSC / MSS / SGSN / GGSN / MME, etc.) with a common HW (Hard Ware) platform, on which all their functions are virtualized. If you build a network using the SDR and SDN approaches, then from the point of view of the operator equipment, you can get the structure shown in Fig. 7.

A mobile network built on the principles of Mobile SDN, supplemented by a radio network built on the principles of SDR, allows you to create modern networks of mobile info-communications on which you can easily switch from standard to standard (GSM-UMTS-LTE), providing modern services. To implement the new functionality introduced in the new standard, it is enough to update the software on an operator platform with virtual machines.

This concept of virtualization is now at different stages of industrial implementation. SDR can be called a fait accompli: all the latest models of base stations from leading manufacturers are implemented according to this scheme, allowing you to use a common processor unit and ensure the operation of radio transmitters of a given range simultaneously in several standards. The concept of SDN in mobile backbone networks is only gaining momentum. Leading equipment manufacturers continue experiments with virtualization of various functions on the basis of production servers from third companies or using their own developments.

IV. The Predominance of Mobile Info-Communications

The large contribution of the mobile info-communications services provided in Ukraine is clearly confirmed by the figures given according to the State Statistics Service of Ukraine (excluding VAT, excluding the temporarily occupied territory of the Autonomous Republic of Crimea, Sevastopol and part of the temporarily occupied territories in Donetsk and Lugansk regions) [21] , [22]. So, in 2018, revenues from the provision of communication services amounted to UAH 61,976 million, of which revenues from the provision of telecommunication services amounted to 91.1%, and revenues from the provision of postal services and courier services amounted to only 8.9%.

In the structure of revenues from the provision of telecommunication services in 2018, the largest share was made up of mobile (moving) communications - 61.9% and fixed access to the Internet - 14.4%, the total share of which in the total revenues from the provision of telecommunication services was 76 3% (Fig. 8).

In the structure of income from the provision of mobile (mobile) communication services, the largest shares are: income from the provision of voice telephony services - 41.9% and Internet access - 45.8%, the total share of which is 87.7% (Fig. 9).

According to the summer "Report on the work of the National Commission implementing state regulation in the field of communications and informatization for 2018" (Nkrzi.gov.ua) for the period from 2016 to 2018, there was a steady upward trend in the income from the provision of mobile (mobile) communication services, In 2018, they increased by 11.1% compared to 2017 (see Fig. 10) [22].

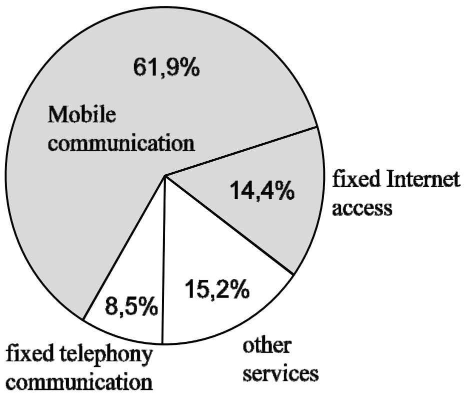


Fig. 8. The structure of revenues from the provision of telecommunication services for 2018:
fixed telephony (4786 mln. UAH) mobile (moving) communication (34 978 mln. UAH) fixed Internet access (8136 mln. UAH) other services (broadcasting of television and radio programs and their maintenance, satellite communications etc.) (8575 million UAH)

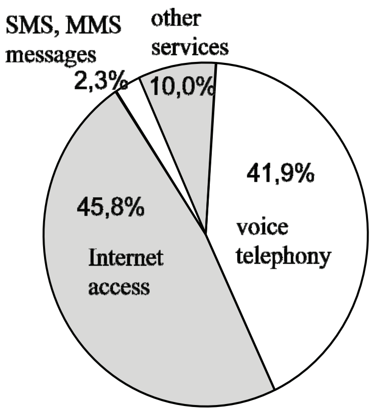


Fig. 9. The structure of income from the provision of mobile (moving) communication services and their share in 2018 according to the data of operators, mobile (mobile) communication providers:
voice telephony (14664 mln. UAH.) Internet access (16036 mln. UAH.) SMS, MMS messages, content services (807 mln. UAH.); other services (traffic termination and transit, other services related to voice traffic) (3471 mln. UAH)

In 2018, revenues from the provision of Internet access services outweighed revenues from voice telephony services. The share of income from the provision of Internet access services in the total revenue of mobile (moving) communications amounted to 45.8% in 2018, which is 13.0% more compared to 2017, while the share of income from the provision of voice services telephony decreased by 11% and amounted to 41.9%. The trend continues to fall in the transmission of SMS, MMS messages, the share of revenue from the provision of such services in 2018 amounted to 2.3%.

The number of active identification telecommunication cards of a mobile (moving) communication network at the end of 2018 amounted to 54 007 thousand units.

Configuration of devices and endpoints is possible from mobile clients. Once they are connected to the gateway, clients can access the device configuration file using a GET-request. The configuration API resource provides only those attributes that can be created or updated by users, such as location.

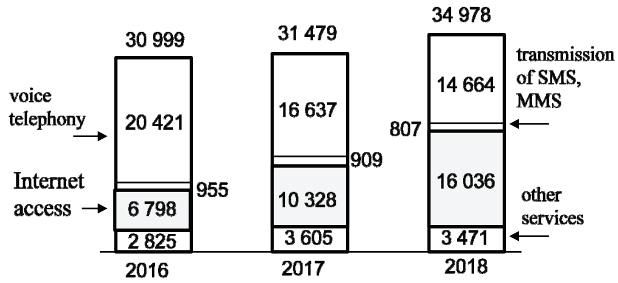


Fig. 10. Dynamics of revenues received from the provision of mobile (moving) services for 2016-2018, UAH million

According to Cisco Systems forecasts (Cisco VNI Global Mobile Data Traffic Forecast report (2016-2021)), by 2021 mobile data traffic will reach the following indicators [23]:

- the share of mobile data traffic will be 20% of all IP traffic (in 2016. This figure was only 8%);
- there will be 1.5 mobile devices per capita, about 12 billion. Devices connected to mobile networks, including inter-machine communication modules (2016 indicators - 8 billion devices and 1.1 devices. Per capita);
- the speed of mobile connections will triple and by 2021 it will reach 20.4 Mbps (2016 indicator - 6.8 Mbps);
- M2M connection represent 29% (3.3 billion.) Of all mobile connections (2016 indicator - 5% (780 million)). With the proliferation of the IoT applications in the consumer and business segments, M2M will become the fastest growing type of mobile connection;

- 4G in 2021 will account for 58% of all mobile connections (in 2016 - 26%) and 79% of all mobile data transfer traffic;

- the total number of smartphones will reach 6.2 billion. And will exceed half of all devices and connections (2016 figure - 3.6 billion).

Until 2021. Global mobile data traffic will reach 49 exabytes per month, or 587 exabytes per year. The equivalent of the projected annual growth (587 exabytes per year): this is 122 times more than all global mobile traffic generated just 10 years ago in 2011; it's 131 trillion. images (e.g. MMS).

V. Conclusion

Mobile infocommunication systems have become a defining component of all telecommunication services provided to users and non-serving nodes of sensor networks, and the infrastructure of core networks and access networks of mobile infocommunications has begun to determine the general technical infrastructure of telecommunications.

The architecture of mobile infocommunications is built on a distributed basis using the concept of virtualization based on flexible technologies of the software-defined radio subsystem SDR and software-configurable network construction SDN. The infrastructure structure of mobile infocommunications is virtualized by moving from creating a separate equipment node to a virtual (software) function that can perform the actions of this node. At the same time, cloud and fog computing technologies are widely used.

The signaling network of mobile infocommunications manages the maintenance of both individual wireless user terminals (telephones, smartphones, tablets), and many wireless inter-machine communication devices and the IoT. In addition, the same control system supports various telecommunication networks of wireless subscriber access, automobile and other vehicles; creates an interface with wired / cable access networks.

Thus, the core network of mobile infocommunications can fully integrate interfaces with all types of telecommunications, which are designed to transmit many low-speed data streams, as well as to transmit high-speed data streams. There is a clear tendency to absorb traditional old services, for example, the public switched telephone network and radio-relay communication lines, and turn them into private services of the mobile infocommunication network, which further enhances their importance. All this creates the prerequisites for the transformation of mobile infocommunication operator systems into the main (determining) players in the telecommunications market. Confirmation of this is the high characteristics that are to be achieved in the networks of the 5th and 6th generations of mobile infocommunications.

Acknowledgment

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Системи мобільних інфокомунікацій

Проблематика. Зростання кількості користувачів і сервісів з підтримкою необхідної якості обслуговування, збільшення зони обслуговування мережі радіодоступу одного оператора, а головне, поява технологій і систем з комутацією пакетів, привели до суттєвого ускладнення базової мережі мобільного зв'язку та її вузлів, зростання функціональності і інтелектуалізації ядра мережі. Поступово саме базова мережа і технології її функціонування стали більш вагомими ніж мережу радіодоступу. Звідси, для побудови систем мобільного зв'язку стали затребуваними більш інтегровані інформаційно-телекомунікаційні технології, особливо в галузі мережних та інформаційних технологій.

Мета. Мета роботи полягає в тому, щоб представити концепцію архітектури систем мобільних інфокомунікацій як систем, послуги яких вносять значний, навіть визначальний, внесок у функціонування інфраструктури сучасного суспільства, побудованого на постійному обміні і засвоєнні інформації.

Методи. Досліджуються структурно-функціональні методи побудови архітектур інформаційно-телекомунікаційних систем.

Результати. Сигналізація мережі мобільних інфокомунікацій справляється з обслуговуванням як окремих безпроводових користувацьких терміналів (телефони, смартфони, планшети), так і безлічі безпроводових пристроїв міжмашинної взаємодії та Інтернет-речей. Крім цього, сигналізація також підтримує різні телекомунікаційні мережі безпроводового абонентського доступу, автомобільного та іншого транспорту; створює інтерфейс з проводовими/кабельними мережами доступу.

Таким чином, базова мережа мобільних інфокомунікацій може повністю інтегрувати в собі інтерфейси з усіма видами телекомунікацій, які призначені як для передачі множини низькошвидкісних потоків даних, так і для передачі високошвидкісних потоків інформації. Має місце тенденція поглинання традиційних старих послуг, наприклад, телефонної мережі загального користування і радіорелейних ліній зв'язку, і перетворення їх в приватні послуги мережі мобільних інфокомунікацій, що ще більше піднімає їх важливість. Все це створює передумови перетворення операторських систем мобільних інфокомунікацій в головних (визначальних) гравців ринку телекомунікаційної сфери. Підтвердження цьому є ті високі характеристики, які належить досягти в мережах 5-го і 6-го поколінь мобільних інфокомунікацій.

Висновки. Системи мобільних інфокомунікацій стали визначальною складовою частиною всіх телекомунікаційних послуг, що надаються користувачам і вузлам, що не обслуговуються, для сенсорних мереж, а інфраструктура базових мереж і мереж доступу мобільних інфокомунікацій стала визначати загальну технічну інфраструктуру телекомунікацій.

Ключові слова: системи мобільних інфокомунікацій; віртуалізація; телекомунікації; інформаційні технології; програмно-визначувані пристрої та мережі.

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Системы мобильных инфокоммуникаций

Проблематика. Рост количества пользователей и сервисов с поддержкой необходимого качества обслуживания, увеличение зоны обслуживания сети радиодоступа одного оператора, а главное, появление технологий и систем с коммутацией пакетов, привели к существенному усложнению базовой сети мобильной связи и ее узлов, рост функциональности и интеллектуализации ядра сети. Постепенно именно базовая сеть и технологии ее функционирования стали более весомыми чем сеть радиодоступа. Отсюда, для построения систем мобильной связи стали востребованными более интегрированные информационно-телекоммуникационные технологии, особенно из области сетевых и информационных технологий.

Цель. Цель работы состоит в том, чтобы представить концепцию архитектуры систем мобильных инфокоммуникаций как систем, услуги которых вносят значительный, даже определяющий, вклад в функционирование инфраструктуры современного общества, построенного на постоянном обмене и усвоении информации.

Методы. Исследуются структурно-функциональные методы построения архитектур информационно-телекоммуникационных систем.

Результаты. Сигнализация сети мобильных инфокоммуникаций справляется с обслуживанием как отдельных беспроводных пользовательских терминалов (телефоны, смартфоны, планшеты), так и множества беспроводных устройств межмашинного взаимодействия и Интернет-вещей. Кроме этого, таже сигнализация поддерживает различные телекоммуникационные сети беспроводного абонентского доступа, автомобильного и другого транспорта; создает интерфейс с проводовыми/кабельными сетями доступа.

Таким образом, базовая сеть мобильных инфокоммуникаций может полностью интегрировать в себе интерфейсы со всеми видами телекоммуникаций, которые предназначены как для передачи множества низкоскоростных потоков данных, так и для передачи высокоскоростных потоков информации. Имеет место тенденция поглощения традиционных старых услуг, например, телефонной сети общего пользования и радиорелейных линий связи, и превращение их в частные услуги сети мобильных инфокоммуникаций, что еще больше подымает их важность. Все это создает предпосылки превращения операторских систем мобильных инфокоммуникаций в главных (определяющих) игроков рынка телекоммуникационной сферы. Подтверждение этому те высокие характеристики, которые предстоит достигнуть в сетях 5-го и 6-го поколений мобильных инфокоммуникаций.

Выводы. Системы мобильных инфокоммуникаций стали определяющей составной частью всех телекоммуникационных услуг, предоставляемых пользователям и не обслуживающим узлам сенсорных сетей, а инфраструктура базовых сетей и сетей доступа мобильных инфокоммуникаций стала определять общую техническую инфраструктуру телекоммуникаций.

Ключевые слова: системы мобильных инфокоммуникаций; виртуализация; телекоммуникации; информационные технологии; программно-определяемые устройства и сети.