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Mobile Cellular Network Based on Software Defind Radio

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Abstract— World Forum for Research in Wireless Communications it is expected that in 2015 the volume of traffic around the world will be 23 exabytes[1]. The existing division of the radio spectrum has serious limitations for this growth. Today there are many standards, mixed wireless networks and mobile devices. The rapid development of wireless communication systems leads to the problems of interaction and compatibility. The decision of all these problems can be find by using software-defined radio technology. In the proposed system, algorithms of mobile network development using software-defined radio technology are to be implemented.

Keywords— Mobile cellular communications, software-defined Radio, Man-Machine Language (MML), Radio Access Network (RAN).

I. INTRODUCTION

According to the World Forum for Research in Wireless Communications[2](Wireless World Research Forum, WWRF) it is expected that in 2015 the volume of traffic around the world will be 23 Exabyte's . The existing division of the radio spectrum has serious limitations for this growth. Today there are many standards, mixed wireless networks and mobile devices with many standards. The operators develop heterogeneous wireless networks to provide access to many services. The mobile devices with many standards use several active applications simultaneously to work with the different networks or the network recourses. Functioning of such mobile devices requires coordination and control of the capacity efficient using of the radio resource and the radio access networks.

The rapid development of means and wireless communication systems is ahead the processes of standardization and leads to the problems of interaction and compatibility. So, there are the problems:

1) Significant growth of mobile traffic in the conditions of limited range;
2) lack of coordination and control of the capacity efficient using of the radio resource and the radio access networks.
3) actual lack of common standards for radio systems with the possibility of reconfiguration. According these problems it is needed to find solutions in this area. The decision of all this problems can be find by using software-defined radio (SDR) technology which requires the development of special algorithms for software updating and adapting. In this paper the algorithms of mobile network development using software-defined radio technology are proposed.

II. RELATED WORK

Currently, SDR is widely used in cellular communications, where real-time support of the different changing radio protocols is required. In receive mode SDR can provide higher efficiency than "traditional" techniques. In digital signal processing their filtering is more closed to the ideal. In addition, by using software algorithms can be implemented functions, which are very difficult to get in analog processing.

A. Mobile cellular network based on SDR

Software-defined radio is a radio communication system which used software for modulation and demodulation operations of the radio signals. SDR change the priorities, and the processing unit becomes the core of radio system.

When using the SDR almost all operations for the signal processing are shifted on software that runs on hardware of the mobile or cellular base station. So, the operation control of some specific specialized microprocessor is designed for this signal processing. The aim of this approach is to develop the flexible and adaptive system. Such kind of the system can send and receive all radio signals using SDR.

The deal implementation of SDR-receiver is the antenna connection directly to an analog - digital converter (ADC) which is connected to a powerful processor unit. In this case, the software running on processor unit provides processing of the incoming data stream and converts them into the desired format.

The ideal SDR-transmitter would operate similarly. The software would form a data stream that would be transferred to a digital-analog converter (DAC) connected to the antenna.

These problems force operators to look for the new solutions to reduce the unit capital and operating costs, to develop the networks quickly and efficiently. In multi-channel and RF systems, the hardware defined radio implementations require a significant amount of analog signal processing for every channel, leading to larger board size, increased analog design complexity, limited flexibility, and RF interference susceptibility. With the Software Defined Radio (SDR) approach digital domain—providing various benefits[3]

- Low Analog Complexity
- Less susceptibility for RF interference
- Unlimited flexibility

- **Analog power does not increase with increased Rx channels**

The flexibility possible with software-defined radios (SDRs)[4] is the key to the future of the wireless communication systems. Wireless devices relied on highly customized, application-specific hardware with little emphasis on future-proofing or adaptation to new standards. This design approach generally yielded power- and performance-optimized solutions at the expense of flexibility and interoperability.

Technology Software Defined Radio (SDR), which are started to be used by advanced base stations equipment vendors for radio access network (RAN), becomes more relevant and an effective solution to these problems

New radio systems are known by various marketing names: Single RAN, Uni-BTS, Multi-RAN and Multi-standard Radio. But they all mean essentially the same thing - a relatively simple mechanism of modernization, which allows one base station to support simultaneously several different radio technologies.

But a phased transition is still possible, and the mobile operators already can choose available software-modifiable equipment for the evolution of their networks.

III. DEVELOPMENT OF AN OPTIMAL ARCHITECTURE FOR NETWORK UPGRADE

Possible way for the development of mobile networks may be in the next direction of radio access networks modernization with using the transition to LTE technology. LTE technology for the service providers (operators) reduces the network cost of owning and operating allowing them to have some of the core network (MME, SGW, PDN Gw), but RAN divide for sharing. This can be achieved by flexible program mechanism allowing each base station to be connected to multiple CN nodes of the different operators.

When the mobile terminal included in the operator's network, it connects to the corresponding node CN, based on the service provider identifier sent from the mobile terminal. RAN sharing as a concept was proposed by Orange and T-Mobile in the UK, and could become a model for many operators in their migration to 4G. The operators have already invested large amounts in obtaining licenses for 3G frequency spectrum and 4G, and to realize the return on these investments in the future they will have to follow the model of sharing the radio access network, providing operators the necessary requirements of the network. In this case the transition occurs from a fully separate networks (separate: sites, the network planning, base stations and spectrum) to the most optimal variant of the full radio access network sharing, spectrum, and overall planning. And in this case, for base stations the SDR technology is very easy to allow the gradual such functioning equipment upgrading by program way without significant additional investment in equipment.

LTE technology will allow for the higher frequency bands to create sufficient capacity for the transmission of multimedia traffic, and the lower - to ensure wide coverage, albeit with some damage to the bandwidth. LTE is able to work in a large number of frequency bands. When bandwidth is 1.4 MHz, LTE allows three times more efficient to utilize frequency resources than the cellular networks of second generation. Efficiency is determined by the number of bits that can be sent at 1 KHz allocated frequencies.

This concept is based on technologies such as Software Defined Radio (SDR) [8]and Cognitive Radio (CR), whose systems use radio and reconfigurable networks capabilities for self-adapt to the dynamically changing environment.

A. State phases of the BS software

If one considers the base station software as a single management object or as one application, then it is possible to define the main phases of its operation, a transition to which is executed at the certain events that occur during operation of the base station (increasing the number of software failures, necessary to perform action on a particular schedule, etc.), and in case of the commands, written in Man-Machine Language (MML).

Phase 0 “Off”

In this phase the base station is in the standby mode and the software isn’t loaded into processor RAM of the functional modules and O&M. The external power is connected to the base station, but the internal power supply off. Thus, all functional modules and functional elements of the BS are inactive except for independent software module of BS power management. This module should provide an opportunity to remote turn on and off the internal power sources for BS by sending MML command from OSS or from the control element(O&M terminal). Switching to the Phase 0 is executed from the Phase 7 by remote external MML command or emergency in the case of forced power interruption from any phase. Passing from Phase 0 to Phase 1 is executed at the event of its successful completion.

Phase 1 “Start”

In this phase the synchronized and consistent (in a strictly fixed order) turning on the internal power supply of the BS hardware modules and activation of the boot modules , the management interface of BS internal resources are carried out. In fact, the boot modules have to be located in processors ROM of the BS modules, and boot programs have be activated immediately after power-on to the processor modules. Also, switching to Phase 1 is executed from phase 6 in the case of unsuccessful testing of functional modules after software initialization or from the phase 7 by remote external MML command. Passing from Phase 1 to Phase 2 is executed at its successful completion event.

Phase 2 "Downloading software from flash"

In this phase the parallel software download from the flash memory modules into the RAM of the BS main O&M module and all regional processors that provide the work of functional modules and the BS[9] functional elements. Also, passing to Phase 2 is executed from phase 5in the case of unsuccessful software initialization or from the phase 7 by remote external MML command. Passing from Phase 2 to Phase 3 is executed by its successful completion event.

Phase 3 "Downloading configuration from flash"

In this phase the parallel download of the BS configuration files from the flash memory modules into the RAM of the main O&M BS module and all regional processors to provide of the functional modules and functional BS elements is executed. Passing to Phase 3 is executed also from phase 7 by remote external MML command. Passing from Phase 3 to Phase 4 is executed by its successful completion event.

Phase 4 "Running software"

In this phase it is executed the synchronous and consistent running (in a strictly fixed order)of the downloaded software modules in the main O&M processor and later in regional processor functional modules, under the management of O & M module. Passing to Phase 4 is executed also from phase 7 by remote external MML command Passing from Phase 4 to Phase 5 is executed at its successful completion event.

Phase 5 "Initialization"

In this phase it is executed synchronous and consistent initialization of all program modules and blocks with the initial set of these blocks variables, and configuration of software complex for programs support, defined by configuration files, and the actual bringing of all working modules to an active state, ready for testing BS applications. Passing to Phase 5 is also executed from Phase 7 and Phase 8 by remote external MML commands. Passing from Phase 5 to Phase 6 is executed by its successful completion event, in case of unsuccessful completion of Phase 5, passing to Phase 2 is executed for restarting software in some or all BS modules.

Phase 6 "Testing"

In this phase it's executed parallel independent testing of all the hardware and software modules correct functioning according to the performance algorithm. Then testing is executed of the all modules collaboration within the application, specified by configuration data. Passing to Phase 6 is executed also from phase 7 by remote external MML command. Passing from Phase 6 to Phase 7 is executed by the its successful completion event, in the case of unsuccessful completion of Phase 6, passing is executed to Phase 1 for the initial start, or if necessary - repair execution.

Phase 7 "Functioning"

This is the main phase, in which the functioning of the base station is executed. It provides execution of all applications, defined by the BS configuration data and its resources control, configuration and providing of its interaction with other elements of the mobile network: Radio Network Controller (RNC), Base Station Controller (BSC), Operational Support Systems (OSS), etc. Switching to Phase 7 is also executed from Phase 8 and Phase 9 after their completion. Passing from Phase 7 to Phase 8 is executed by external MML command when software upgrade is requested. Passing from Phase 7 to Phase 9 is executed by the external MML command when software backup is requested. Passing from Phase 7 to Phase 6 is executed by external MML command when regular or compulsory testing is requested. Passing from Phase 7 to Phase 5 is executed by external MML command for restarting the software modules. Passing from Phase 7 to Phase 4 is executed by external MML command or in the case of detecting software failure. Passing from Phase 7 to Phase 3 is executed by external MML command, or in the case of detection configuration data failure to reload configuration files from flash memory. Passing from Phase 7 to Phase 2 is executed by external MML command, or in the case of detection of non-revolving by means of restarting crashing software for reloading of the software module from flash memory. Passing from Phase 7 to Phase 0 is executed by external MML command to switch off internal power supply BS.

Phase 8 "Software modification"

In this Phase 3 main functions of software modification are executed: Correction of software block Software update of the functional module and the functional element Software upgrade of the base station Return from Phase 8 to Phase 7 is executed by external MML commands at the completion of software correction or update. Passing from Phase 8 to Phase 5 is executed by external MML commands when the software upgrade function is completed.

Phase 9 "Software backup"

In this phase it is executed backup of all software modules, memory modules, data blocks and links of the program modules and blocks from the main O&M module, the functional blocks and functional elements in structured DUMP, that includes 3 files: programs, data and references, which are stored in the flash memory of O&M main module. Return from Phase 9 to Phase 7 is executed after completion of backup Phase.

IV. CONCLUSION

Thus, it is considered a new concept of development a multi-standard mobile network. It includes the architecture of the base station development with the requirements for its functional units and the method of reconfiguration of the radio access network. The method of reconfiguration is based on the state graph of the base station functioning, the block diagram of an operations sequence of base station functioning, the block diagram of an operations sequence of the base station software upgrade, the principle of the software modifications control and structural pattern of the BS control objects with the reconfiguration[10] ability. This allows to development a radio network that is different from existing single standard mobile radio networks by the reconfiguration opportunity without changing the hardware of the radio access network. It also gives the ability to support many radio standards based on the one universal base station platform with flexible antenna systems and using SDR technology.

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