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Overview of Fifth Generation Mobile Communications

Kavita Sogale, Dr.D.J.Pete

PG.Student - Dept.of Electronics, Data Meghe College of engineering.
Mumbai University.
ksogale@gmail.com.
Professor and Head - Dept. of Electronics, Data Meghe College of engineering.
Mumbai University.
pethedj@rediffmail.com

Abstract-- This paper explores future mobile systems with emphasis on re -configurability based on cognitive and software defined radios, 5G (fifth generation) Network architecture consisting of reconfigurable terminal able to autonomously operate in different heterogeneous access network is proposed. The proposed network is enforced by nanotechnology, cloud computing and based on all IP Platform. The paper highlights 5G main development challenges and illustrates why there is a need for 5G. New standard releases beyond 4G are in progress by standardisation bodies , but at this time are not considered as new mobile generations since implementation and rollout of systems complaint with 4G is still on the way; the goals of a 5G based telecommunications network would ideally answer the challenges that a 4G model would present once it has entered widespread use.

Index terms--Cognitive radio, Flat IP network, 5G Network architecture, Nanotechnology, Cloud computing.

I. INTRODUCTION

Cellular generations differ, in general, in four main aspects: radio access, data rates, bandwidth and switching schemes. The 1G (first generation) cellular systems, mainly analogue system had a bandwidth ranging from 10 to 30 KHz depending on system type and service. Offered data rates were around 10Kbps after analogue to digital conversion. Radio access scheme was FDMA and switching was all circuit. Suitable for voiceservices. The first phase of 2G (second generation) GSM systems offered a data rate up to 9.6Kbps and increased in the second phase to reach a peak rate of more than 300Kbps with bandwidth of 200KHz [1]. Switching started to be packet in addition to circuit beginning from the second phase and radio access was TDMA/FDMA. For the 3G (third generation) systems, the peak data rate began of 2Mbps in the first phase and approached 50Mbps in consecutive phases at constant wide bandwidth of 5MHz [2]. The approved access scheme for the 3G was CDMA and switching continued to be circuit in addition to packet. However, at the start of 3.5G, with HSDPA system and thereafter it was focussed on packet switching only. In 4G (fourth generation) cellular systems, peak data rates started at 100Mbps and supposed to reach the order of more than 1Gbps at the downlink benefiting from a variable bandwidth up to 20, 40, or even 70MHz. Switching was approved to be packet only –all IP, and radio access changed from CDMA to OFDMA and SC-FDMA in addition to cellular systems, current wireless technologies include wireless local area networks (WLAN) 802.11 and wireless metropolitan area network (WMAN) 802.16. Moreover, ad-hoc wireless personal area network (WPAN) and wireless networks for digital TV are gaining more interest. Future generation will include new systems such as broadband wireless access systems, intelligent transport systems, high altitude platform station systems and millimetre –wave local area networks. Key to the future generations of mobile communications are multimedia communications, wireless access to broadband fixed networks, and seamless roaming among different

systems. In 4Gmobile systems different access technologies, such as WLAN, WMAN and cellular, are combined on a common platform and interoperate to offer different service in different radio environments. On the other hand, the 5G (fifth generation mobile and wireless networks) can be a complete wireless communication without limitation, which bring us a perfect real world wireless web (WWWW).at present, 5G is not a term officially used for any particular specification or in any official document yet made public by telecommunication companies or standardisation bodies such as 3GPP, Wi-MAX forum, or ITU-R. The rest of the paper is organised as follows: Section 2 reviews the need for 5G. Section3 highlights main development challenges. Section 4 presents a proposed 5G network architecture. Section 5 concludes the paper.

II. NEED FOR 5G

The major difference, from a user point of view, between current generations and expected 5G techniques must be something else than increased maximum throughput; other requirements include:

- Lower battery consumption.
- Lower outage probability; better coverage and high data rates available at cell edge.
- Multiple concurrent data transfer paths.
- Around 1Gbps data rate in mobility.
- More secure; better cognitive radio /SDR security.
- Higher system level spectral efficiency.
- Worldwide wireless web (WWWW), wireless based web applications that include full multimedia capability beyond 4G speeds. More applications combined with artificial intelligence (AI) as human life will be surrounded by artificial sensors which could be communicating with mobile phones.
- Not harmful to human health.
- Cheaper traffic fees due to low infrastructure deployment costs.

The 5G core is to be a re-configurable, multi technology core. The core could be the convergence of new technologies such as nanotechnology, cloud computing and cognitive radio and based on all IP Platform. These new technologies and the above mentioned requirements pose the following challenges toward 5G development:

III. 5G MAIN DEVELOPMENT CHALLENGES

A. *Cognitive radio (CR)-new ways of using spectrum:*

New mobile generations are typically assigned new frequency bands and wider spectral bandwidth per frequency channel, but there is little room for new frequency bands or larger channel bandwidths. This is because spectrum has been and will continue to be a scarce resource for the mobile – communication industry. The other possibilities for increasing the spectrum availability are of interest. This could include the use of unlicensed spectrum, or secondary spectrum primarily used for other communication services, as a complement to operation in the licensed spectrum. White space is related to the cognitive radio technology which allows different radio technologies to share the same spectrum efficiently by adaptively finding unused spectrum and adapting the transmission scheme to the requirements of the technologies currently sharing the spectrum which ultimately depends on software defined radio.

B. *Software defined radio (SDR) – reconfigurability enabler*

Software defined radio (SDR)[3] benefits from today's high processing power to develop multiband , multistandard base stations and terminals .for example ,to increase network capacity at a specific time (e.g. During festivals or events),an operator will reconfigure its network adding several modems at a given base transceiver station(BTS). In the context of the expected 5G systems, SDR will become an enabler for terminal and network reconfigurability through software download.

C. *Reconfigurable –interoperability between several types of wireless access network:*

Seamless interoperability among heterogeneous networks represents the corner stone for the success of 5G systems with different evolving technologies. A novel solution that ensures interoperability between several types of wireless access network is given by developing IEEE 802.21standard.the heart of the 802.21 framework is the Media Independent Handover Function (MIHF), responsible for communication with different terminals , networks and remote hardware or software. The reconfigurable interoperability offers network providers with a possibility to choose, with minimal investments, between alternative wireless access networks. The selection could be made based on several criteria such as:

- Comparison between the availability of access resources and specific service requirements (e.g. channel state, probability, vertical handover, users QoS requirements).
- Load balancing and sharing between different spatially coexisting wireless networks.
- Efficient spectrum sharing.
- Congestion control.

In general, the main requirements for interoperability that need to be taken into consideration are as follows :

- Initial network selection (INS): INS is one of the basic functions of interoperability process between heterogeneous networks. A clever selection of a suitable network by users would result in lower blocking probability, higher capacity and enhanced QoS. The achievement of these enhancements depends on the integration architecture of the two technologies and on developing efficient INS mechanisms and criteria.
- Mobility support (vertical or internetwork handover); once a network has been selected, the user is subject to change the initially selected network according to various conditions; hence the importance of an

efficient Inter-network Handover (INH) criteria arises. Decision for INH could be based on an evaluation of a cost function that covers all possible inter-network handovers key factors as discussed in[33].

- Partnership or roaming agreements between different interoperating networks operators.
- Handling subscriber billing and accounting between roaming systems.
- Identification of subscriber should be done as if it is in a pure one system environment.

D. *Network energy efficiency:*

Low energy consumption for mobile terminals has been an important requirement since the emergence of hand held terminals roughly 25 years ago. With sufficiently low energy consumption, reasonably sized solar panels could be used as power source. Nevertheless, the future evolution of cellular systems should further strive for minimising transmission of signals strictly not needed.

E. *Nanotechnology:*

Nanotechnology[4],[5] is the application of nanoscience to control process on nanometre scale; between 0.1 and 100nm .the field is also known as molecular technology (MNT) where MNT deals with control of the structure of matter based on atom by atom and molecule by molecule engineering. Nanotechnology will have considerable impacts on both mobile device as well as core network as follows:

- The mobile device has become more than a communication device in modern world ;with nanotechnology mobile phones can act as intelligent sensors that have applications in many industries among them transportation ,communications, medicine and safety.
- The core network requires high speed and a reliable capacity to manipulate and interoperate increasing number of heterogeneous access technologies. At present, nanotechnologies are used in digital signal processing(DSP) fabrication, introducing new perceptions in DSP designing that increases the overall system speed &capacity.

F. *All IP network:*

The internet is open not only to developers but also to all manner of criminals and viruses ,developers and operators face new security challenges which should be solved properly. The All-IP Network (AIPN) is an evolution of the 3GPP system to fulfil the increasing demands of the cellular communications market.

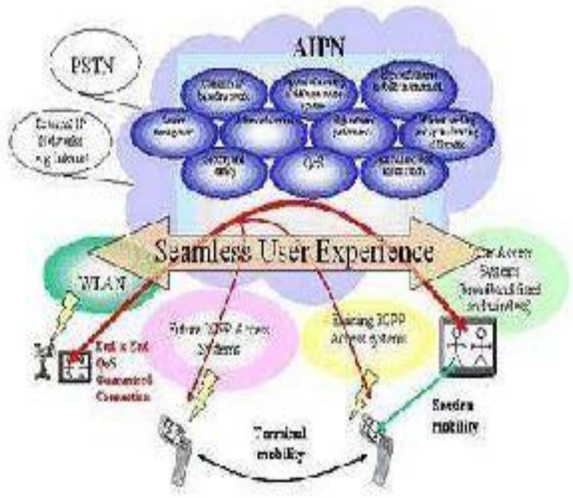

Fig. 1 All IP network

The key benefits of AIPN architecture includes a variety of different access systems provision, lower costs, universal seamless access and reduced system latency.

G. C*loud computing:*

"Cloud computing is a model for enabling ubiquitos, convenient ,on demand network access to a shared pool of configurable computing resources (e.g. networks ,servers, storage, applications ,and services)that can be rapidly provisioned and released with minimal management effort or service provider interaction ."… a definition from [36]. Hence, cloud computing is a technology that uses the internet and central remote server to maintain data and applications. In 5G networks this central remote server could be a content provider. Cloud computing allows consumers and business to use applications without installation and access their personal files at any computer with internet access. The same concept is going to be used in multi-core technology where the user tries to access his private account from a global content provider through cloud computing.

H. *Adaptive Coupling –Reconfigurable Integration*:

Depending on the level of integration that is required between available radio access technologies, a variety of approaches can be taken for effective interoperability. On one hand, if the integration between different technologies is tight, the provisioning of the service is more efficient and network selection as well as the vertical handover process is faster. Moreover, tight coupling suffers from potential of load congestion when one network full load is immersed on the other. On the other hand, if the integration between different technologies is loose, the delay of handover process is significant. On the positive side, loose coupling allows for the flexibility and independence of implementing individually different mechanisms within each network. Adaptive coupling is a new proposed mechanism that adaptively changes coupling level from open, loose to tight and even very tight according to load status and delay constraints .

IV. A PROPOSED 5G NETWORK ARCHITECTURE

Terminals and network components are dynamically reconfigured (adapted) to new situation .network operators use the reconfigurability to introduce the value added services more easily. Recofigurability is based on cognitive radio. Cognitive radio technologies includes the ability of the devices to determine their location, sense spectrum used by neighbouring devices ,change frequency ,adjust output power and even alter transmission parameters and characteristics. A cognitive radio is a transceiver that is able to understand and react to its operating environment. Hence, the radio is aware and cognitive changes in its environment and responds to these changes by adapting operating characteristics in some way to improve its performance.

A. *Reconfigurable- multimode –terminal*

The 5G potential will require the design of a single wireless user terminal able to autonomously operate in different heterogeneous access networks. However the richness of the services will necessitate higher bit rates, which will be main driving factor towards broadband multimedia development. Fig. 2 shows a reconfigurable transceiver in both terminal and base stations it can be reconfigured via a control bus supplying the processing units with the parameters downloaded from remote reconfiguration database via a predefined broadcasting download channel. Such a configuration guarantees that the transmission can be changed if necessary. A reconfigurable transceiver is built in open –architecture and based on radio system software [6]

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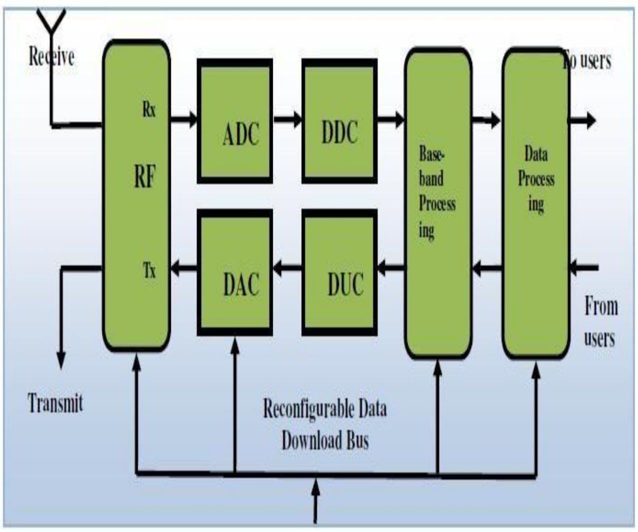

Fig. 2 High level structure of Reconfigurable Transciever

The RF front –end functions as the transmitter and receiver for the RF signal received via the antenna. The IF section is responsible for analogue –to-digital (ADC) and digital-to-analogue conversion (DAC) on the receive path and the transmit path respectively. The digital down converter (DDC) and the digital up-converter (DUC) that proceeds and precedes the ADC and DAC respectively, jointly assume the functions of the modem. The link layer protocols, modulation and demodulation operations are implemented in software. An ideal reconfigurable transceiver is one that is programmable up till the RF section, i.e. capable of performing high speed and power efficient analogue-to-digital conversion and vice versa right at the antenna. However, supporting the required digital bandwidth, dynamic range and sampling rate for efficient implementation of programmable RF section is still a challenge for more development.

B. *Reconfigurable multi- technology core*:

The main challenge for a reconfigurable multi – technology core is to deal with increasing number of different radio access technologies based on solid interoperability criteria and mechanisms.

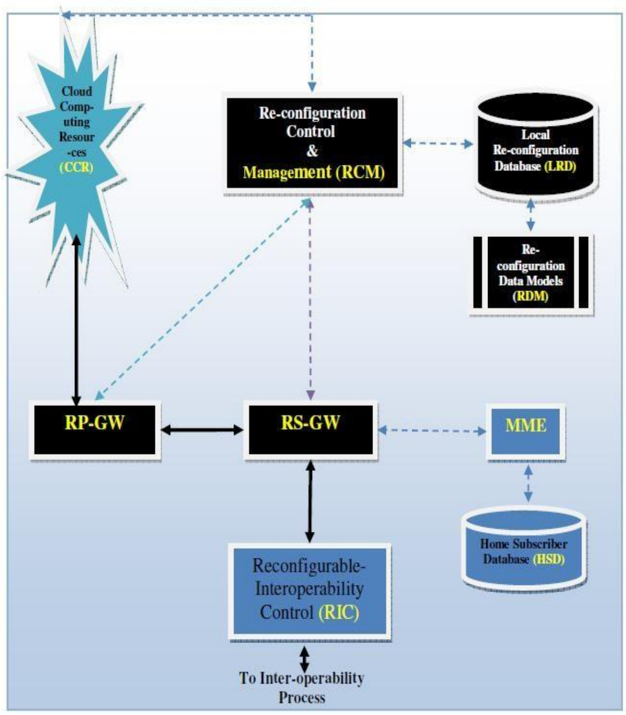

Fig. 3. High level of Reconfigurable multi- technology core

The core is a convergence of the aforementioned nanotechnology, cloud computing, and cognitive radio[7],[8] and based on All IP Platform core reconfigurability could be a self –adaption to a dynamically –changing environment or mission oriented adaption to meet a given set of mission requirements with the aim of improving service delivery and spectrum utilisation reconfiguration could be in both software and hardware. Hardware reconfiguration is mainly performed by the operators; adding additional equipments to increase network capacity at a specific time. However ,in software reconfiguration and with the power of SDR ,network is dynamically reconfigurable ,which means that the programs as well as the communication links between the processing elements are configured at run-time .Fig. 3 shows a high level structure of reconfigurable core network as an evolution of the evolved packet core (EPC)of 4G network. Local reconfiguration database (LRD) attached to reconfiguration data models (RDM) are connected to gateway entities via reconfiguration control and management (RCM) units .RCM is also connected to cloud computing resources (CCR)to link core network with remote reconfiguration database (RRD). Basic entities of the EPC are enhanced with reconfigurable capability such as reconfigurable Serving gateway (RS-GW) and reconfigurable packet data network gateway (RP-GW).RS-GW is linked to different access technologies via reconfigurable interoperability control (RIC)unit .RIC controls interoperability process and enables RS-GW to forward and receive packets to and from the selected base station /eNB serving the UE. To serve the user with All IP based mobile applications and services ,RP-GW interfaces ,via CCR, with the internet and other packet data networks (PDNs).the mobility management entity (MME),as a signalling only entity ,links RS-GW to home Subscriber Database (HSD)node.

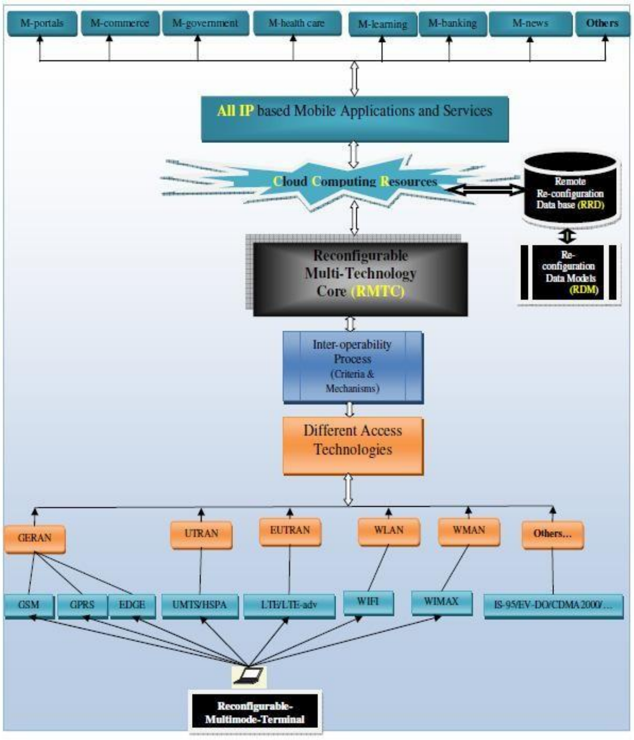

Fig. 4 . A proposed 5G network architecture

Fig. 4 shows a proposed 5G network architecture. All IP based mobile applications and services such as mobile portals, mobile commerce, mobile health care, mobile government, mobile banking and others, are offered via cloud computing resources (CCR). CCR links the reconfigurable multi technology core (RMTC) with remote reconfiguration data from (RRD) attached t reconfiguration data models (RDM). RMTC is connected to different radio access technologies; ranging from 2G/GERAN to 3G/UTRAN and 4G/EUTRAN in addition to 802.11x WLAN and 802.16x WMAN.

V. CONCLUSION

The paper was focussed on building the reconfigurable mobile system benefiting from latest technologies such as cognitive radio, SDR, nanotechnology, cloud computing and based on All IP Platform. The goal was for both terminal and core network to dynamically reconfigured to new situation and changes their communication functions depending on network and/or user demands. The paper discussed 5G main development challenges and clarified the necessity for 5G. This paper helps to promote stronger links between people working in different fields creating future concepts of mobile communication ,internet services ,cloud computing ,All IP network ,and nanotechnologies .the 5G technology includes all type of advanced features which makes 5G mobile technology most powerful and in huge demand in near future .

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