The Solution of Insufficiency of Radio Frequency Spectrum in Republic of Kazakhstan

Olzhas Abishev, Dong-Kwan Jo and Joong Soo Chung

Department of Information and Communication Engineering, Andong National University,
tel: +82-54-820-5644.
oabishev@yahoo.com, espoirblue@naver.com, jschung@andong.ac.kr

ABSTRACT

The objective of this paper is to propose a system by means of which the utilization of radio frequency spectrum may be improved from the state of extreme inefficiency at the present time in Kazakhstan to a state of efficiency and equilibrium in the future.

The main solutions to efficiently use radio frequency spectrum in Kazakhstan will be described in this paper. There are "Spectrum Utilization, Spectrum Sharing and Reuse the Spectrum" in which the radio frequency can be propagated in wide range using small amount of spectrum, or broadcast several channels via one spectrum sharing. In order to embed these systems in practice it will be better to make modifications consider Government policy and geographical and social requirements.

1. Introduction

Radio frequency spectrum in Kazakhstan, as in other countries, was first used about 100 years ago for navigational safety and military operations. Since that time, the utilization of spectrum has expanded steadily and greatly. Today, in many countries, mobile telephony shows a penetration exceeding one-half of the population and spectrum is used widely for many purposes.

Such remarkable development of the utilization of radio frequency was achieved, needless to say, by a succession of technological advances. Typically, a new technology was introduced by making use of a new "band" of radio frequencies which had so far been unused; that is to say, the development process was an expansion of the frontier of spectrum utilization. The issue to be dealt with in this paper arises from fact that such frontier is nearly exhausted today.

It should be noted, however, that, while the frontier may have been exhausted, it does not mean that there is no way to find additional spectrum for new services. There still remains a great many opportunities of increasing the supply of spectrum by means of *Spectrum Utilization, Spectrum Sharing and Reuse the Spectrum.* A large portion of the spectrum bands which have been allocated and assigned to users remains unused or used very insufficiently. As a consequence, the state of utilization of radio frequency spectrum at the present time is in extreme disequilibrium; some spectrum is used efficiently with a large amount of expenditure on new equipment, but other spectrum is used inefficiently with old and obsolete equipment.

The objective of this paper is to propose a system for improving the efficiency of spectrum utilization, spectrum sharing and reuse the spectrum. In view of the above observations, we will adopt the following strategy for the presentation in this paper. First, we concentrate on spectrum utilization and spectrum sharing. This mean, that there is need for improving technical regulations; on the contrary, we think there is a strong need for it.

2. The Telecommunication Infrastructure in Republic of Kazakhstan

Kazakhstan is a former Soviet Union Republic, which gained its independence in 1991. Until 1995, the telecommunication sector was wholly state-owned. It was controlled and operated by the Kazakh Ministry of Transport and Communications (MTC).

A number of private companies were allowed to enter the market since 1995 Law on licenses has been adopted. This law was representing a set of general rules applied to state licensing but did not take into account a number of sector specific elements (like radio spectrum distribution).

The government plans to prepare a new conception for the distribution and the use of radio frequencies taking into consideration the need to ensure an adequate distribution of the radio spectrum's resources among the public and private sectors. It also foresees to review tariffs for the radio spectrum use as well as the creation of an efficient control mechanism.

According to the Communications Law, governmental and private networks can be used for the provision of telecommunications services to the general public when the owner of this network receives a telecommunications licence. Commercial broadcasters can create and use their own networks or lease it from the state owned operators.

Taking into consideration its huge surface (2,717,000 sq km), small density of population (5.5 people per sq km) and difficult landscape (mountains and plains) the development of satellite telecommunications has a particular interest in Kazakhstan. It also has to be reminded that Kazakhstan has inherited (from the Soviet Union) an important satellite ground infrastructure.

2.1. Main problems Existing in ICT of Kazakhstan

Internal field:

Lag of normative base, which regulating social relationship and balanced technical policy in Telecommunication area from field pace development.

a) No systematic approach because of weak science well-founded methodological base.
b) Practically all special science-technical and project bases related with ICT located in Russian Federation.
c) The extreme situation in existing problems to create and providing government support to organizations specializing in projecting, marketing and science research fields, elaboration of science methodological base.
d) Most laws made by the government, out of presence of many norms, are necessary not standardized to the relations in modern level of developing field which assure to their perspective in future.
e) Requirements to elaborate and improve the normative acts, which regulate relationship between communication operators, service providers, market regulator and consumer.
f) The monopoly on Public Telecommunication Network.
g) Insufficiency of radio-frequency spectrum.
h) The absence of eminently qualified specialists in ICT field.
i) The absent sectored systems for standardization and certification.

External field:

- Development of the country in the area of communication
- Development of the country's economy

3. Insufficiency of Radio Frequency Spectrum in Kazakhstan.

The growth of telecommunications and information services has led to an ever-increasing demand for spectrum among competing businesses, government agencies, and other groups. Because two or more telecommunications signals occurring simultaneously and in the same location can interfere with each other, the spectrum must be managed to prevent interference. The process of spectrum management includes establishing a regulatory structure, usually within the government, which develops general policies, allocates spectrum, establishes service rules, assigns spectrum to specific users, and enforces the rules that users must follow.

Since RF signaling is regulated by national governments, all of the RF technology suppliers must share their assigned RF frequency spectrum that's in common with other authorized RF-based devices and systems. The devices that share the 868MHz (EU), 915MHz (US), and ISM 2.4GHz bands that unlicensed, mesh network-based control networks operate on include 802.11 (Wi-Fi) routers and network interfaces, cordless phones, Bluetooth devices, audio and video extenders, closed circuit television transmitters, and other control networking devices.

· The interference between different wireless devices reduces reliable communication between any two devices. Various RF technologies use different techniques to mitigate interference caused by other devices in their space.

For example, Wi-Fi use direct sequence spread spectrum (DSSS) to distribute the information over a wider bandwidth, while Bluetooth uses frequency hopping spread spectrum (FHSS) to randomly move from channel to channel. Cordless phones based on both DSSS and FHSS are available on the market. Interference among multiple DSSS devices operating in adjacent bands poses a problem due to overlapping caused by spectral re-growth of the frequency bands. The net result, compounded by shared use of a limited frequency range, is reduced system performance and reliability. The growing number of RF devices operating within the shared frequency bands is creating virtual RF traffic jams, and a corresponding degradation in reliability.

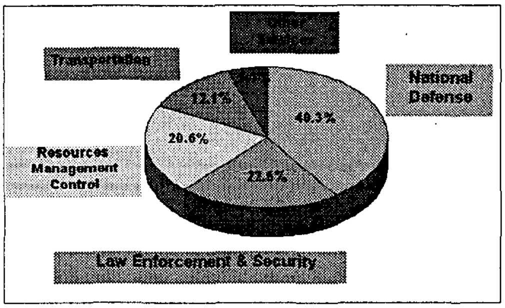

Table1. Republic of Kazakhstan's Government Spectrum Use

4. Methods to efficient use of Radio Frequency Spectrum

There are two types of efficiency which regulators have to take into account when considering spectrum management. *First*, technical efficiency, which principally refers to the requirement that different users and different uses of radio frequencies should not interfere with each other. It also refers to the need to tackle a host of related problems, such as the use of faulty or non-standard equipment, the unauthorized or illegal use of frequencies, spillover signals effects from neighboring jurisdictions administrations, the use of inappropriate levels of power, finding the optimum location for antennae, and so on, all of which can effect affect the attenuation, successful transmission and reception of signals, the problems of cross-talk and the general problem of channel radio interference. These problems are what economists call 'negative externalities' which means that the use of one channel can have an adverse impact on those that are external to it. Achieving technical efficiency is really the work of the engineers inside the regulatory body.

The second type of efficiency is economic efficiency. This is a much wider regulatory issue because it involves a judgment regarding the allocation of relatively scarce spectrum among alternative uses to provide different, in some cases competing, types of services.

4.1. Challenges in Spectrum Management.

Spectrum management has been traditionally practiced on a centralized, "command and control" basis by governments.

While this government controlled, centralized system was adequate when demand for the resource was more limited and the pace of technological and marketplace change was slower, its adequacy is now being challenged by a host of developments including:

- *Rapid growth in the demand for spectrum* in terms of the sheer number of new users (as in wireless Local Area Networks), new uses (such as new RFID tags), and more bandwidth requirements per user (like sending images to or from cellular subscribers).
- *Rapid technological change* in the underlying wireless network infrastructure and the devices that are used to communicate with that infrastructure; these changes include, in particular, converged networks and devices that are capable of handling voice, data, image, video and multimedia traffic and networks and devices that have increased processing power and associated flexibility (such as software defined radios) that allow more efficient use of the scarce resource.
- *Increased globalization* which means that decisions taken in one country or region have greater implications for other countries or regions (in terms of harmonization and standardization) while, at the same time, developments such as software defined radios allow greater flexibility in terms of technology deployed.

4.2. Spectrum Utilization.

Another trend in spectrum management that deserves close attention refers to the development and utilization of software-programmable radios (software defined radio - SDR).

The SDR concept provides an efficient solution to the problem of building multimode, multi-band and multi-functional wireless devices. These devices can be enhanced using software programmability, which allows easy changes of the radio's fundamental characteristics such as operating frequency, modulation type, bandwidth, and access schemes. With software programmability, high-speed digital signal processing performs many of the functions previously carried out in hardware, and the radio is able to transmit and receive over a wide range of frequencies.

Thus, SDR will allow precisely matching dynamic user requirements to dynamic network and spectrum utilization conditions. Traditionally, manufacturers have been responsible for the approval of their wireless equipment for a specific set of technical parameters. With SDR, this responsibility may need to be shared with the service providers. In fact, SDR will provide flexibility to manufacturers; they will be able to mass produce common hardware platforms. In addition, service providers must be aware of the potential technical and sharing constraints over the complete range of operating frequencies.

In summary, SDR technology could provide a leverage to harmonize emission standards across frequency bands on a global or regional basis, may improve access to new services and make more efficient use of the radio-frequency spectrum. Looking at the issue from a regulatory point of view two aspects should be considered.

4.3. Spectrum Sharing

There are also novel and rapidly evolving applications and technologies for which experimentation is important. Such applications are poorly served in a system where access to spectrum involves long administrative delays. Consequently, there is a need for shared spectrum that allows real-time access. Real-time sharing is made difficult by three problems. The *first* is that, as devices do not have exclusive access, they may interfere with each other's transmissions. To deal with this mutual interference, a set of rules are required which dictate when, where, and how devices may transmit. The *second* problem is that, since shared spectrum with real-time access would be valuable for a wide variety of applications and devices, there is motivation to create bands supporting diverse applications rather than create many different bands of shared spectrum. These applications may vary greatly in terms of average data rate, transmission duration, or even the technology used. Such variations make it difficult to enforce efficient utilization for all applications. The ***third*** problem is that, since spectrum is shared, there is no inherent incentive to use the spectrum efficiently, which may result in a tragedy of the commons. This problem made the Citizen Band radio service highly inefficient and undependable in crowded regions, where users wasted spectrum with high-power transmitters.

This problem can occur if too many devices are deployed in shared spectrum, or if individual devices waste spectrum. In the former case, the problem is relatively easy to avoid by requiring a fee to be paid for each device deployed, and for a number of reasons, this is a good policy. However, in the latter case, the problem is more difficult.

It is equally important to evaluate whether these provisions are necessary, since an overly restrictive etiquette can both reduce the spectral efficiency and increase the cost of unlicensed devices.

4.4. Reuse the Spectrum

Unlicensed reuse of already licensed spectrum to increase the spectrum efficiency is relevant topic in today's regulation. The regulator has significant interest in this field, since its task it to make sure the existing allocated radio systems are not interfered by new allocations. On the other hand, the regulator is interested in the increase of social welfare, and therefore also the increase of spectrum efficiency. Ultrawideband (UWB) technology provides an interesting case to view of this topic. From regulatory point of view, UWB needs some alternative regulatory actions to consider, since the implementation of the system differs greatly from the traditional radio systems.

The definition for UWB, according to the CCI, is any radio technology with a spectrum that occupies more than 20 percent of the center frequency or a minimum of 500 MHz. Today, UWB operates on an unlicensed radio spectrum from 3.1 GHz to 10.6 GHz, which is allocated by the CCI in 2004.

However, UWB does not use the entire 7.5 GHz band, or even a large portion of it, but the minimum bandwidth of 500 MHz defined by the CCI. This CCI regulation expands the design options for UWB communication systems. System designers are free to use a combination of sub-bands within the spectrum to optimize system performance, power consumption and design complexity. UWB systems can maintain the same low transmit power as if they were using the entire bandwidth by interleaving the symbols across these subbands. Figure 3 illustrates the operation principle of UWB compared with GSM and UTMS.

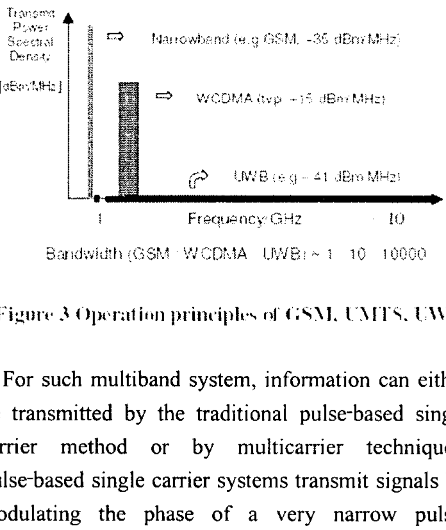

Figure 3 Operation principles of GSM, UMTS, UWB

For such multiband system, information can either be transmitted by the traditional pulse-based single carrier method or by multicarrier techniques. Pulse-based single carrier systems transmit signals by modulating the phase of a very narrow pulse. Advantage of this method is a very simple transmitter design, but there still exist several disadvantages, e.g. to collect enough signal energy in a typical usage environment (with many reflecting surfaces); switching time requirements can be very strict; the receiver signal processing is very sensitive to group delay variations; and, spectral resources are potentially wasted in order to avoid narrowband interference. Multiband OFDM transmits

data simultaneously over multiple carriers spaced apart at precise frequencies. With this method the transmitter complexity is only slightly increased. Advantages of multiband OFDM include high spectral flexibility, resiliency to RF interference and multipath effects, and better efficiency. OFDM modulation techniques have been successfully applied to several other high performance popular commercial communications systems including WLAN 802.11a/g and WiMAX 802.16a.

5. Conclusion

The allocation of such a large range of spectrum for unlicensed use, as in the case with UWB, indicates a significant shift away from a regulatory viewpoint that has up till now been dominated; the licensed spectrum usage philosophy. This action has been significant enough to raise many concerns from several directions, particularly regarding UWB's ability to coexist with existing radio services such as IEEE 802.11a wireless local area networks (WLANs), radar systems, etc.

However, a wider perspective based on total spectrum utilization viewpoint reveals the potential for achieving more efficient spectrum utilization (i.e. acceptance of impacts on existing systems with the greater common net good obtained by introducing such new overlay-friendly technologies such as UWB). Studies of licensed bands have shown that a significant percentage of spectrum remains unused, averaged over time, contributing to this spectral inefficiency. The commercial success of WLAN technologies, particularly 802.11, has led to need for increasing globally harmonized allocations of unlicensed spectrum.

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