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SOFTWARE DEFINED RADIO CONCEPT IN WIRELESS SOLUTIONS

SZOFTVERRÁDIÓ KONCEPCIÓ A VEZETÉK NÉLKÜLI MEGOLDÁSOKBAN

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Abstract

Nowadays, in connection with the use of Software Defined Radio concept, we can find several researches and studies. The most important advantages provided by the SDR technology are the effective use of the frequency spectrum and an easy way of development of the wireless assets.
In one of my former articles I have dealt with the use of the SDR concept in the different systems. In this article, I analyze the use of SDR concept in the shorter effective range wireless communication solutions.

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Keywords: *Software-Defined Radio, SDR, WLAN*

Absztrakt

Napjainkban a szoftverrádió technológia alkalmazásával kapcsolatban számos kutatást és tanulmányt találhatunk. Az SDR technológia által biztosított két legfontosabb előny a frekvenciaspektrum hatékony használata, valamint a fejlesztés egy könnyebb lehetősége.
Egy korábbi cikkemben már foglalkoztam a SDR különböző rendszerekben történő alkalmazásával. Jelen cikkemben az SDR koncepció rövidebb hatótávolságú vezeték nélküli kommunikációs megoldásokban történő alkalmazását elemzem.

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Kulcsszavak: *szoftverrádió, SDR, vezeték nélküli hálózatok*

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INTRODUCTION

In connection with the testing, usage and further possibilities of development of the Software Defined Radio concept, we can find different thesis and researches. The SDR concept was evolved and reinvented by Joe Mitola around 1991, and now it is widely-used and researched. The definition for the Software Defined Radio, based on the former SDR Forum community, is the following: *"Radio in which some or all of the physical layer functions are software defined."* [1] During the tests and researches other SDR based solutions were invented as well, for example, Adaptive Radio and Cognitive Radio (CR). Based on the Wireless Innovation Forum, the CR is *„a radio in which communication systems are aware of their internal state and environment, such as location and utilization on RF frequency spectrum at that location. They can make decisions about their radio operating behavior by mapping that information against predefined objectives"*. [2]

These concepts are widely-used in the different military and civilian technical assets and systems to make our everyday life easier. In the following chapters, I will introduce the current use and possibilities of these concepts.

USE OF SOFTWARE DEFINED RADIO CONCEPT

Among the advantages of the SDR concept we have to highlight two issues, which can be found in every document. The first and most important thing is the possible development with lower cost because of the application of software changes. Earlier, we had to change the physical part of the system or the whole asset/system, but now, using the SDR concept, a software upgrade can be enough, installing new software or change of the former software on the current assets. This possibility can provide a faster and easier development with lower cost for developers, providers and end-users alike. [1] [3]

The other important issue is the effective use of available frequencies. The SDR and – its next steps – the adaptive and the cognitive radio based assets are used as solution for this frequency issue. There are more and more civilian (individuals, economic operators, etc.) and military assets, which are using different frequency bands. The role of the effective frequency management is very important, because of the growing number of different assets (mobiles, computers, smart assets, etc.), using different frequencies close to each other, and because of the expectation of the users, who want to use their assets without any limitations. Of course, there are limitations at the usable frequencies as well, but these limitations are mostly in-built, that is why the users generally do not recognize them. The usable frequencies in the specified types of equipment are given by the international and national frequency agencies. In connection with the Hungarian frequency management, we have to mention the International Telecommunication Union (ITU) and the Hungarian National Media and Infocommunications Authority[1].

In my former article, I have introduced the application of this SDR idea in the main and well-known systems, including civilian and military systems. Among them we can find communication systems, radar systems, Global Navigation Satellite Systems (GNSS)[2] and GSM mobile systems (Groupe Spécial Mobile). These systems are the biggest and most

[1] Nemzeti Média és Hírközlési Hatóság, NMHH

[2] The endusers use GPS for the Global Navigation Satellite Systems (GNSS) assets, but it is not the right naming method. The GPS (Global positioning system) name comes from the name of the US improved positioning system, US NAVSTAR GPS system. The four most important systems are the US NAVSTAR GPS, the Russian GLONASS, the European Union's GALILEO and the Chinese BeiDou (COMPASS).

common ones, in which the above mentioned possibilities – provided by these software defined radio concepts – are important and help the effective services at a high level and without interference. [3]

Unfortunately, there are not only advantages, but disadvantages as well. One of the most important one is the possible new way of attack. Earlier, we could have problems because of interference (unintentional jamming) or – in case of military equipment – because of the electronic jamming. In connection with interference and intentional jamming, I would mention a special case. In 2014, based on report, the Austrian, the German, the Czech and Slovak civilian air traffic control became blind for hours, because of a possible interference or jamming. Since at that time there was a so-called NEWFIP (NATO Electronic Warfare Force Integration Programme) electronic warfare exercise in Hungary, these companies thought, that the exercise is the cause of their technical problems. The Hungarian Ministry of Defense denied the charges, telling that the military assets did not work on the civilian frequencies, and the place of the exercise was far from the mentioned areas. After this incident several investigations were carried out, and they found, that a testing – carried out on a radarsite – caused the problem. [4] [5] The conclusion of this case is that we have to be prepared to solve different problems, sometimes without knowing the cause of the problem.

The one of the most important security problem of the SDR concept is that because of the IT parts, – which provide the advantages –the assets can be the target of computer hacking as well. [6]

WIRELESS COMMUNICATION SOLUTIONS

Nowadays, there are different wireless communication solutions, depending on the manufacturers, who take into account the expectations and the needs of individuals and the economic operators. It is very important, that these wireless assets are around us, but ordinary people do not know them very much, however, they use their services. The reason for the researches of the latest technologies is the fact that a new result, a new technology or idea has effects on other solutions, researches, and can influence further developments.

On Figure 1. we can see the improvement of wireless technology, including radio technology, assets or hardware, network technologies and applications. It is really hard to see through the effects of a single development. We can try to imagine our life without our mobile, but we can be sure, that we will not be able to list all fields of life, where GSM is used.

Obviously, within one article we cannot analyze every single way of wireless communication, that’s why I would only mention the groups of types. I would like to highlight the fact, that the larger systems – including GSM, GNSS, radar, communication systems – and their SDR application were introduced in my former article [1].

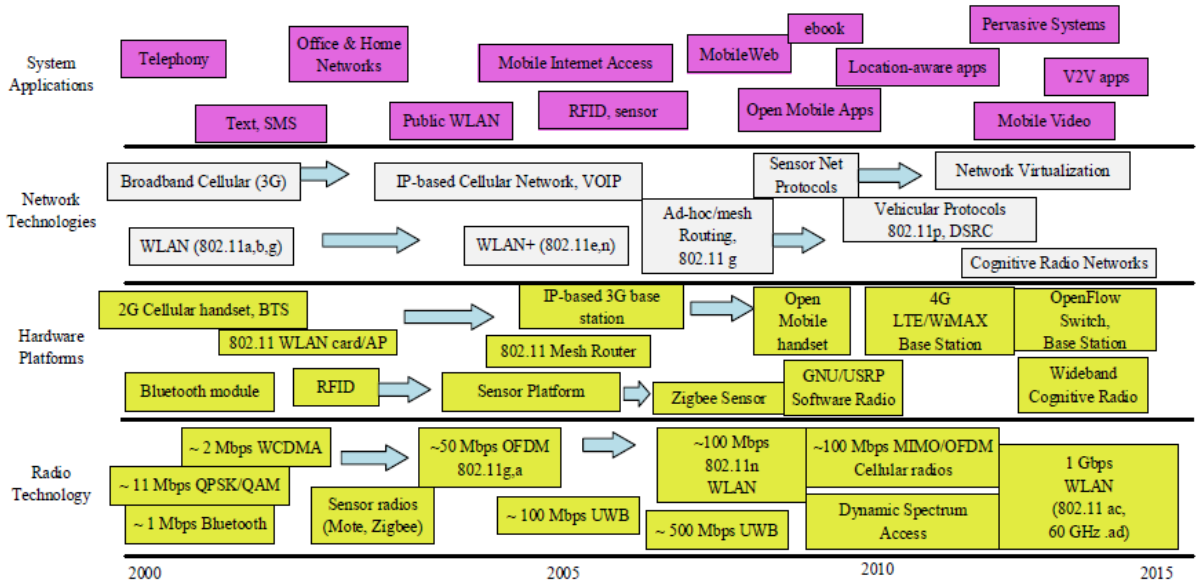

Figure 1. Improvement of wireless assets, systems and applications [7]

If we are talking about radio technologies, we can make differences between the different types based on their effective range. We can start the listing with the well-known Wi-Fi or Bluetooth connections, and via different less known (e.g. HiperLan[3]) or well-known solutions (e.g. WiMAX[4], Zigbee[5], etc) with higher and higher effective range, reaching the GSM solutions or satellite systems.

Figure 2. Types of Wireless Communciation [8]

In connection with the shortest effective range, I would highlight the Wi-Fi and the Bluetooth. The Wi-Fi has different standards with different features, shown on Table 1. The Wi-Fi is the most commonly used opportunity to build up a Wireless Local Area Network

[3] High Performance Radio LAN, HiperLan is a European standard, based on the author's opinion, it is less known among ordinary people.
[4] Worldwide Interoperability for Microwave Access
[5] Zigbee is an IEEE 802.15.4-based specification.

(WLAN). We can find Wi-Fi almost in every apartment, in many shops and airports. Some of them are open and free for everyone, but some of them are password protected.

Protocol	Frequency	Signal	Maximum data rate
Legacy 802.11	2.4 GHz	FHSS[6] or DSSS[7]	2 Mbps
802.11a	5 GHz	OFDM[8]	54 Mbps
802.11b	2.4 GHz	HR-DSSS[9]	11 Mbps
802.11g	2.4 GHz	OFDM	54 Mbps
802.11n	2.4 or 5 GHz	OFDM	600 Mbps (theoretical)
802.11ac	5 GHz	256-QAM[10]	1.3 Gbps

Table 1. IEEE 802.11 Wi-Fi protocol summary [9]

For building WLAN networks, we can use the Bluetooth capability as well, but generally this connection is used between 2 assets directly. It is because of the short effective range of this solution, which is typically some 10 meters. For example, this type of connection is used to pair a car computer with our smartphone.

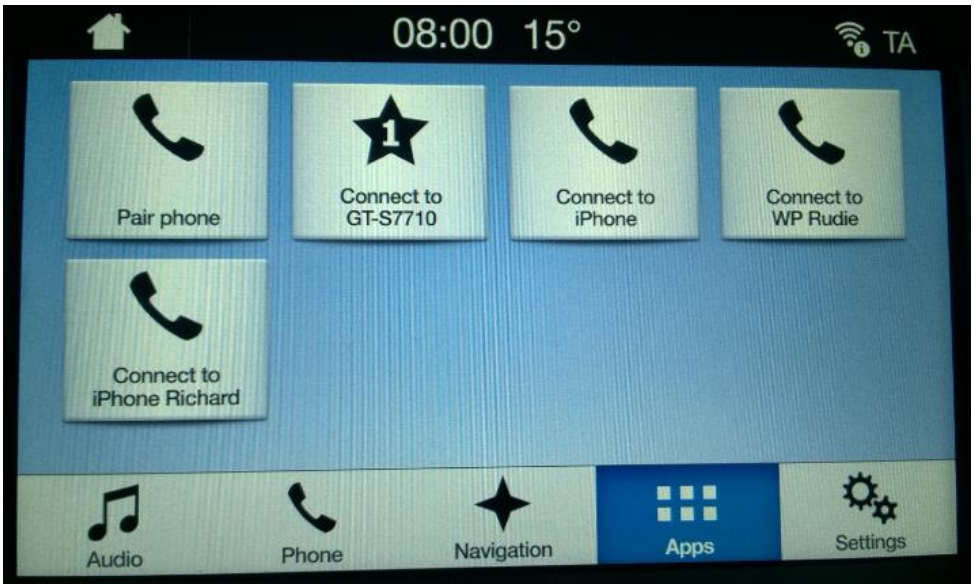

Figure 3. Pairing of phone and car computer using Bluetooth connection[11]

„WiMAX technology is a broadband wireless data communications technology based around the IEE 802.16 standard providing high speed data over a wide area." The WiMAX

[6] Frequency Hopping Spread Spectrum
[7] Direct-Sequence Spread Spectrum
[8] Orthogonal Frequency Division Multiplexing
[9] High-Rate Direct Sequence Spread Spectrum
[10] Quadrature Amplitude Modulation
[11] Own photo

stands for Worldwide Interoperability for Microwave Access (AXess) and used for a point to multipoint wireless networking. WiMAX technology uses OFDM and MIMO[12] solutions. [10]

Using these radio technologies, we can create networks to connect different assets in different distances. Based on the effective ranges, we can have Wireless Personal Area Network (WPAN), Wireless Local Area Network (WLAN), Wireless Metropolitan Area Network (WMAN), Wireless Wide Area Network (WWAN) or Global Area Network (GAN). [11]

If we are talking about wireless communication solutions, we have take into considerations not only the technologies based on radiofrequency, but other solutions as well. One of the newest wireless communication technology is the Light-Fidelity (LiFi) technology. LiFi is a method that uses the infrared and visible light spectrum for high speed data communication. The advantage of the use of the LiFi is, that *"the radio frequency (RF) spectrum is only a fraction of the entire electromagnetic spectrum. The visible light spectrum and the infrared (IR) spectrum are unregulated, and offer 780 THz of bandwidth."*[12] The most important advantages of the LiFi are the higher data transfer rate for internet application, better data security because of the line of sight (LoS) communication, lower power consumption, and the mentioned optical spectrum use instead of the crowded RF spectrum. Of course, there are disadvantages as well. The range is limited because of the line of sight (LoS) communication, it can be used only in indoor environment because of interference caused by sunlight and other optical sources. [13]

In connection with the radio technologies the possible interference and electronic jamming is an important question. As I have mentioned, the interference is an unintentional problem among the different systems, while electronic jamming – as part of the electronic warfare – means a deliberate activity. This method can be an answer in a situation, where electronic jamming can be used against us. In connection with the use of this system the problem is that if we would like to use this method instead of the former radiofrequency based system, we will need a new infrastructure. We can use it in smaller indoor places, in apartments and in offices. If we would like to use it at an airport or in an industrial environment, we have to carry out a very precise and careful design.

POSSIBLE USE OF SDR IN THE SMALLER EFFECTIVE RANGE WIRELESS NETWORKS

When I mention smaller effective range wireless networks, I mean the solutions between WPANs and WMANs. In connection with these wireless networks, we can find different applications. In this part, I would like to introduce some examples and analyze the new possibilities.

In connection with the car systems, I have mentioned the use of Bluetooth, but of course, there are other methods as well. One of them is the Continental improved "One World Radio" concept. One of the visible effects of this concept for the car users is that this in-built radio *"can receive multiple channels simultaneously and enables listening to different stations in the front and rear of the vehicle – without additional tuner"*. [14]

There are other researches as well in connection with the automotive industry. The long cable used in the cars can be replaced by wireless technology and to enable this technology, to

[12] Multiple Input Multiple Output

reduce the cost and provide a very stable and secure data exchange. The software defined radio technology can be used in this case as well. [15]

An other new field, where the SDR based assets can be used, is the Ambient Assisted Living (AAL) program, which is supported by the EU. This program is to help the aging population with using state-of-the art technologies. In this program, for example, the SDR can be used as a main unit for controlling different sensors and wireless devices in a smart house system. These assets made by different manufacturers can use different wireless protocols on different frequencies. [16]

In connection with WiMAX, we can find Hungarian proposals as well. Zoltán Rajnai has made a proposal for the use of WiMAX to provide communication system for a chemical biology group. [17] In my article regarding the SDR based electronic warfare assets, I have suggested the use of WiMAX, as a possible way to provide the needed data for the effective operation of the SDR based electronic warfare equipment. [18]

In the previous subchapter, I did not mention a relatively new network, the wireless body area network (WBAN), which is used in the healthcare systems. The WBAN helps to monitor the condition of the patients. The SDR can be used for providing a stable connectivity between the sensor – worn by the patient – and the healthcare center. [19]

In connection with the different sensors we have to discuss the definition Wireless Sensor Network (WSN) and the Software Defined Network (SDN). A Wireless Sensor Network (WSN) is a net of wireless sensors, to collect and transport data about the environment, in which the sensors are deployed. The sensors can collect data about health issues, disaster relief and environmental issues (for example, observation of earth movements, changes of weather, etc.), industrial environment, etc. The collected information is forwarded via wireless solutions to a central unit. To improve the capability of these kinds of networks we can use the Software Defined Network (SDN) concept. *"The idea of SDN is to provide more flexibility in the network by getting the advantage of re-programmability of the network devices during run-time."* This problem can be solved with the SDR assets using the so-called Over-The-Air Programming (OTAP) technique, which is „referring to is how to perform various methods of distributing new software in networks with wireless communication". [20]

Based on these examples, we can see that the SDR and the CR are solutions, with which we can improve the capability of our current wireless assets and networks. There are two different ways of use. In case of the first solution, these concepts provide the opportunity to have a higher performance by the actual assets, for example, a disaster relief radio network can observe the available and usable frequencies and is capable of changing the frequency automatically if it is need. The other way of use is the case of a faster development with less time and cost. When we are looking for the possible application of these concepts, we have to look for the possible use of these ways. In connection with the mentioned wireless networks, both types of enhancing solutions can be used. In case of implantation of different types of wireless technologies, we can use our assets in many different situations.

CONCLUSIONS

Based on the examples presented in the article, we can see, that the Software Defined Radio concept is a very smart, widely-used and researched solution. Using this possibility, we can combine and develop our current wireless equipment and networks. There are several new fields, in which has not been applied yet, but we have ongoing researches, and they are showing good results. As we see, the SDR and Cognitive Radio concept – used in the wireless equipment and networks – is an enabling technology, which has to be under further research to enhance the capability of our current wireless technology. If we would like to avoid the negative effects of the possible interference and the intentional jamming (as part of the electronic warfare), we can use the SDR and CR concepts. These wireless networks – based

on the analyzed concepts – can be used in different places, e.g. at airports, in office buildings, etc. If for some reason we can not use radiofrequency based wireless systems, there are other possibilities as well, e.g. the LiFi concept based wireless network.

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