ADVANTAGES OF MFSO TO RF WIRELESS COMMUNICATION SYSTEMS

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Abstract

Different wireless communication systems have been increasingly utilized in many applications over the last decades in providing a link between land, air or sea subscribers. One of the most promising among them is the system of Mobile Free Space Optics (MFSO). In this work a comparison analysis of the MFSO with the most rapidly developing mobile technologies, namely, technologies of Fourth Generation and LMDS is done. The achievements in the field in the last few years are summarized and it is shown the most important advantages of MFSO over other technologies. Other topics presented here are complete summary of the built MFSO devices over recent years and pivot-table for their feasibility. In conclusion, the issue of major hurdles and future development of MFSO is faced.

1. INTRODUCTION

FSO is laser based technology that provides wireless transmission of data on an atmospheric channel. It offers a very wide bandwidth, small size and weight, low price, huge unregulated license free spectrum, lack of electromagnetic interferences, excellent safety features. This makes it a major competitor of the developing fourth-generation systems, operating in the frequency range of 2 GHz to 11 GHz, as well as LMDS, located in the range from 10 GHz to 66 GHz [1]. Despite this advantages, FSO technology has a number of problems. The most significant of them are: limited mobility, line of sight (LOS) requirement between subscribers, influence of adverse weather conditions. An important issue about FSO systems is the eye safety measures at work. Due to the high intensity of the coherent laser source of light, there are certain limitations in the choice of its power, wavelength and beam divergence.

According to the above mentioned disadvantages there are different solutions to be built a mobile version of FSO system known as MFSO. MFSO systems are discussed in a lot of scientific papers due to improving their features such as modulation methods [2] working in different atmosphere conditions [3] and various types of adaptive control algorithms [4]. The main reason for this are its positive characteristics that make it not only desirable, but in many cases a compulsory decision, if there is a necessity of wireless communications. In this work we defend the above statement. As a result we have presented MFSO systems in all their crucial aspects.

2. TECHNOLOGY OVERVIEW

The necessity for high information capacity and security features determines the development of manifold wireless communication systems. The representative technologies with the greatest impact now and in the coming years are MFSO, WIMAX (Worldwide Interoperability for Microwave Access), LTE (Long Term Evolution) and LMDS (Local Multipoint Distribution Service). MFSO systems, based on stationary FSO technology, have possessed all its listed positive advantages as well as several new improvements. Acording to the lastest results, data capacity reaches to an amazing 2.5 Gbps on a link range of 100 km, using laser source in the near-infrared spectrum [5].

In contrast of this great achievement, MFSO systems are faced by number of challenges. The most important of them are mobile working in adverse weather conditions and constant LOS requirement. In order to enable **MFSO** communication in mobile environments, we introduce different hardware solutions. In many cases they must operate in condition of severe Mie scattering, expressing in different types of smokes, fogs and cloud fields. Another attenuation factor is atmospheric turbulence, which always plays a significant role in communications. [1].

Mobile **WIMAX** version 802.16m and **LTE** technologies are the main candidates for the fourth-generation systems. They provide relatively high information capacity. Acording to the most recent result the latest developed Release of WIMAX, WIMAX2, has peak data speed up to 330 Mbps (100 Mbps for mobile users). The LTE data rate is almost similar, reaching up to 300 Mbps (75 Mbps for mobile users). Coverage area of WIMAX cells is between 2 and 5 km while in case of LTE it is reaching to 10 km. The outstanding capability of both technologies is the lack of need for direct LOS. Major issue of WIMAX and LTE is because of propagation of radio signal in all directions which mean susceptibility to jamming, interference and saturation. Moreover, there is expensive licenses for network operation. **LMDS** technology is operating in the frequency range from 26 GHz to 29 GHz. This defines one of its main drawbacks. As in MFSO systems there is a need for LOS and they are strongly influenced by weather conditions. The cell is only up to about 2.4 km. The information speed is about 500 Mbps in both directions. In recent years the development of this system is suppressed by the fourth generation networks [6].

Figure 1 present summarised result of information capacity and radius of coverage for the compared technologies. As shown MFSO devices outstrips many times other systems in case of data rate feature. Although there is a limitation for the radius of coverage about 10 km this parameter is sufficiently competitive too and in some cases are possible far longer distances.

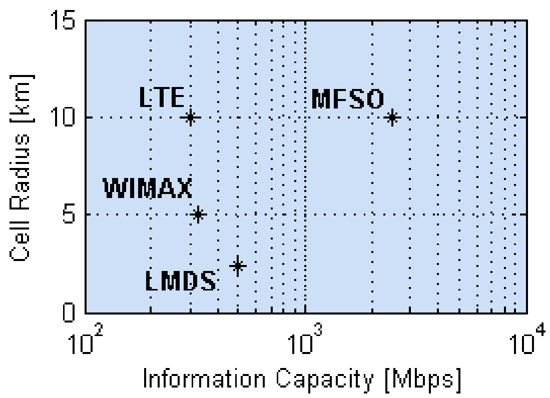

Figure 1. Comparison of communication technologies

3. MFSO SYSTEMS

The technical implementation of MFSO systems allows different types of architectures. Figure 2 shows the major achievements for connectivity between moving mobile platforms.

The structural scheme of Figure 3 provides a basic overview of general blocks of MFSO systems.

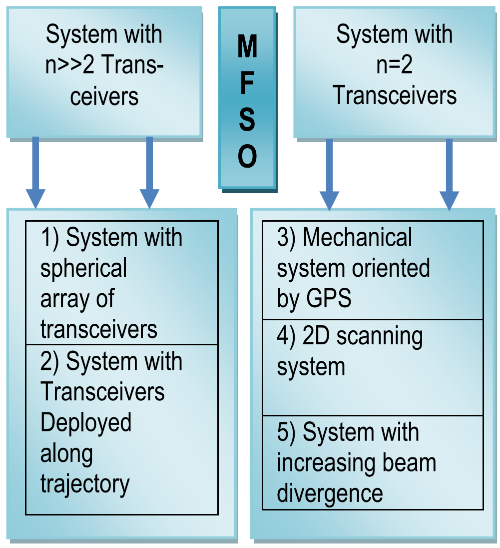

Figure 2. Classification of MFSO systems

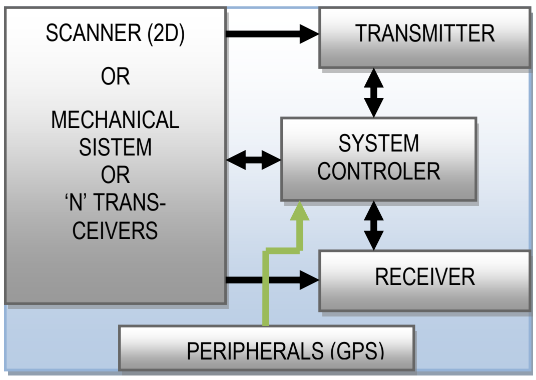

Figure 3. Basic architecture of MFSO systems

Special characteristics of individual MFSO system mainly arise from: technical realization; method for initial identification between communicating parties, ways for maintain connectivity. In the operation of each system usually are required three steps: acquisition, pointing, and tracking. In acquisition mode the two terminals try to locate each other. Pointing aims to achieve alignment between the antennas on the opposite pairs systems. Tracking is process in which there is a constant changing of direction of the laser beam transceiver due to the movement of the object.

System in Figure 2 are:

1) This system contains a number of spherical MFSO nodes. Each of them is built of hexagonal shapes and put together in a soccer ball arrangement. Thus they have 3D space coverage. Typically, each node has a auto-alignment circuit, whose task is to monitor the level of input signals and maintaining the communication link. In acquisition mode when there is absence or disconnection of signal, the system sends simultaneously search pulses in all directions. When some of other parties responded the communication link is established again and data transmission is restored. When more than one connection are aligned it must be use signal / noise ratio priority.

In this type of MFSO systems could be used different selection combining diversity schemes: MIMO, SIMO, MISO. Due to this multireceiving configuration, processing could be more complicated, but BER is reducing.

2) The proposed system is suitable for connection of moving platforms along a fixed terrestrial trajectory such as trains. The network is constructed of a large number of transceivers located along the track and another part of them deployed on the top of moving objects.

3) Typically are being used two MFSO systems located at both ends of the communication channel. The GPS signals control mechanical system for acquisition, pointing, and tracking presented by 2-dimensional rotating gimbal. The acquisition and pointing are made only once in the beginning of the communication session. The tracking continue all the time. The system uses small divergence angle due to aim to minimize the geometric loss.

4) This system is utilized in case of rapidly moving mobile platforms. It combines a powerful laser and two-dimensional scanning system based on two micro mirrors with size about 1 mm. The mirrors are steered from the device using electrostatic effect. The maximum angle is 25°. The receiver consists a short focus lens with wide field of view 1 rad x 1 rad and CMOS sensor with 1000 pixels. The system uses a special protocol for transmission and connection control. It includes three modes: rough acquisition, phase of precise pointing and periodical tracking, ensuring smooth communication.

5) These systems introduce the concept of increasing divergence of the laser transmissive beam, which is controlled by precise adjustment of the collimator. Here are the typical three phases of establishing a connection. In the process of acquisition both mobile parties of the system using optical radiation with a very extended range of coverage to establish a connection. The second phase is pointing, in which the radius of the beam is changing depending on the relative speed and distance between communicating platforms. The process of tracking includes additional mechanical device that rotates MFSO system in the right direction to ensure the communication link.

The specific feasibilities of the described MFSO systems is shown in Table 1.

Table 1. MFSO feasibilities

	MSFO system	Feasibility	Charch teristics
1	System with Spherical Array of Transceivers	Mobile Multi-Hop Ad-hoc Networks and MAN Networks	1 Gbps 200-300 m
2	System with Transceivers Deployed Along Trajectory	High-Speed Trains	1 Gbps 100 m
3	Mechanical System Oriented by GPS	Ground to Air Links	2,5 Gbps 100 km
4	2D Scanning System	Fast-Moving Terrestrial or Airborne Objects	1 Gbps 3 км
5	System with Increasing Beam Divergence	Ship to ship communication	1 Gbps 1-5 km

4. CONCLUSION

Mobile Free Space Optics systems are a viable alternative to communication devices of radio spectrum. With its numerous positive capabilities FSO technology has a chance to dominate almost over all modern mobile technics. Clear evidence is touched outstanding data speeds of 800 Gbps in its fixed wireless version. This shows the enormous potential of MFSO that even in these days reaches information capacity of 2 Gbps to which fifth generation technologies are aspiring, particularly future LTE-Advanced Release. Regardless of superlatives for MFSO Systems, RF systems also have their advantages. WIMAX and LTE technologies have almost no dependence on atmospheric conditions. They use radio signals in the frequence range, which defines no necessity of LOS. These and other challenges are addressed to mobile Free Space Optics system whose wide spreading feasibility is coming.

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