ISSN 2250-3153

A Robust Heterogeneous Network Structure with ROF and ROFSO for Better Link Availability

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Abstract- There are variety of applications where optical fibers are not feasible, to provide ubiquitous wireless services quickly and more effectively , then in such cases RoFSO links can be used to transmit signals. But inspite of its potential, such links are highly vulnerable to fluctuating atmospheric conditions and also dependent on the deployment surrounding characteristics in particular the weather conditions, severity and duration of the atmospheric effects have direct impact on the availability of the links as well as on the quality of RF signal transmitted over it. Whereas the Radio over Fiber (RoF) technology, as a means of transferring radio signals using optical fibers without changing radio format, has become a candidate for the common platform for wireless access networks. This technology provides a simplified and cost-effective radio access network and supports high-speed multimedia to satisfy the increasing demand when the radio spectrum is limited. It also helps to increase transmission capacity and distance of wireless. However, the applicability of this solution greatly depends on the availability of fiber cable infrastructure and installation costs. Therefore to have communication systems which has low cost, simple, is easy to install, and can be increasingly deployed to offer high-speed, broadband communications links with an ease to provide high-speed communications without the difficulty and cost of deploying optical fiber cable . A heterogeneous structure made up of RoFSO and RoF can be an attractive means for RF signal transmission, providing a versatile role of both wire and wireless system for an optical communication. This suggests us that if a compliance between the two , RoFSO and RoF is made that is the places where there is difficulty in deployment of the RoFSO then the RoF can be used and vice-versa, then there becomes lesser possibility of link failure and hence an improved availability of link can be achieved.

Index terms- Radio over Fiber (RoF), Free Space Optics(FSO), Radio on Free Space Optics(RoFSO).

I. INTRODUCTION

The development in various technologies has paved the advancement in photonics. The band of microwave and terahertz is always been an area of inquisitiveness due to the improved communication features as is outyeilded by it and is therefore been credited as the future of the next generation communication systems foundation. The promising technologies presently operating is Radio-on-Free-Space Optics (RoFSO) system which is conceived by combining Radio-over-Fiber (RoF) technique and free-space optical (FSO) communication technology using seamless connection of free-space and optical fiber. With this system it is possible to transmit simultaneously multiple RF signals representing different wireless services through free-space using WDM technique.

RoFSO system is a suitable platform for provision of ubiquitous wireless services. Free-space optics (FSO) systems are increasingly being considered as suitable alternative for transmission of optical and RF signals in situation where optical fiber deployment is not feasible. This can be made possible by utilizing FSO links designed by taking advantage of the emerging new generation FSO systems and advanced microwave and photonics technologies. The FSO rendering the merits of low costs ,high bit rate (10 Mbps to 2.5 Gbps) , providing the ease to set up a link in a few days, usage of the lasers which is safe to eyes being under limits; has enabled us to achieve connectivity solutions and has given 'Last-Mile' Network solutions along with it the most remarkable feature of establishing temporary network provision has been impulsive for the quick links setup in case of the difficult areas through which the communication is sought especially in military operative zones. Its GSM microcell connectivity is the topic of research for this paper since because cable digging, has increasingly becoming unpopular in cities, which is regulated by the local authority who may restrict re-digging frequency of roads and the cost may be prohibitive in some case, especially if a river or railway is in the way. The RF 2.4 GHz systems were typically running at 2-4 Mbps due to interference issues in the unlicensed frequency ranges but with the FSO providing 10 Mbps of throughput for less than unlicensed RF has introduced it as a strong contender in the heavily congested areas to be employed as a means of the communication. The interpretation of the technological advancement in wireless communication is best realized in terms of Radio over fiber(RoF) technology, since this technology lays an emphasis on the functionality which is simple and cost effective. Wireless network on the ROF technology has been proposed as the promising cost effective solution to meet ever increasing user bandwidth and wireless demand. As convergence of wired &wireless services ROF systems offers low attenuation loss large bandwidth immunity to radio frequency interference, easy installation ,maintenance and, reduced power consumption , Radio-over-fiber (RoF) systems are used to enhance the radio coverage of wireless applications and provide broadband services which makes RoF transport systems suitable for the long-haul microwave optical link.

II.RESEARCH

Among the different communication technologies, optical communications generally has the edge over baseband electronic or RF transmission systems whenever high aggregate bit rates and/or long transmission distances are involved. Both advantages are deeply rooted in physics: First, the high optical carrier frequencies allow for high-capacity systems at small relative bandwidths.Second, transmission losses at optical frequencies are usually very small compared to baseband electronic or RF technologies. Today's optical telecommunication fibers exhibit losses of less than 0.2 dB/km, Path loss,for typical RF attenuation (e.g. 2 GHz, 15 dBi antenna gains)Avg path loss in free space - > 68 dB for 1km , 118 dB for 10 km,Avg path loss in mobile radio (n=3.4, d_0=100 m) - > 82 dB/km, 146 dB for 10 km.

$$\overline{PL}_{\text{mobile-radio}} = \left(\frac{4\pi d_0}{\lambda}\right)^2 \left(\frac{d}{d_0}\right)^n$$

In free-space systems optical beams have much smaller divergence angles than in the microwave regime, at the expense of significantly exacerbated antenna pointing requirements. The narrow beam width favourably translates into the system's link budget, in particular in space-based systems where atmospheric absorption is less of a problem.

Therefore for a typical FSO , Typical optical attenuation (e.g. 1550 nm or 194 THz)clear atmospheric conditions -> 0.2 dB/km urban (because of dust) -> 10 dB/km,Rain -> 2-35 dB/km,Snow -> 10-100 dB/km,light fog -> 120 dB/km,dense fog -> 300 dB/km,maritime fog -> 480 dB/km.

III.LINK DESIGN

The RoFSO is broadband RF optical wireless communication link with fiber-optic technologies. It can provide universal platform for heterogeneous radio entrance network, in especially rural area with no fiber infrastructure. The developed RoFSO transceiver can directly connect multiple radio-on-fiber (RoF) signals from an optical fiber to the air, and can receive an optical signal from the air into a fiber core and the designing is supported by the FSO link .

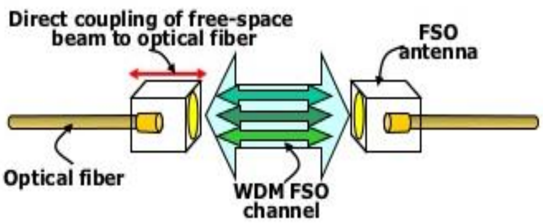

Fig. no.1 RoF and FSO operating together

At the network level a CS is connected to the numerous functionally, simple BSs via an optical fiber .The main function is to convert optical signal to the wireless one and viceversa ,almost all of

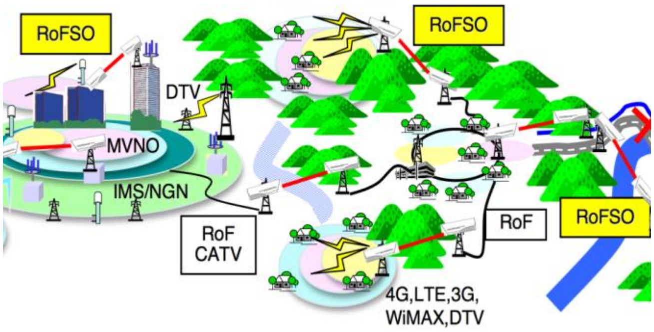

Fig. no. 2 Network of RoF with RoFSO

the processing including modulation ,demodulation coding , routing is performed at the CS that means RoF networks use highly linear optic fiber link to distribute RF signals between BS and CS. At the minimum the RoF consists of all the hardware required to impose an RF signal on an optical carrier , the fiber optic link and the hardware required to recover the RF signal from carrier.

The topic of research is the micro cellular system where each microcell radio port is to consist of a simple and compact optoelectronic repeater connected by an radio frequency fiber optic link to centralized radio and control equipment,which is located at a pre-existing macrocell site with much lower power level thereby the need for the expensive frequency multiplexes or high-power amplifiers which are currently employed at base stations gets eliminated. The limited coverage due to low antenna height greatly reduces the co-channel interference from other cells, hence RoF systems are proposed to be used extensively for enhanced cellular coverage inside buildings .A microcellular network can be implemented by using fiber-fed distributed antenna networks. The received Radio Frequency signals at each remote antenna are transmitted over an analog optical fiber link to a central base station where all the de-multiplexing and signal processing are done. Thus the overall network backbone is supported with the RoF, now as RF links complements FSO to achieve carrier class availability (99.999%) therefore at ranges less than 1 km, most FSO systems due to being having enough dynamic range or margin to compensate for scintillation effect is employed. Current estimates suggest that approximately 95 percent of corporate buildings are within 1.5km of a telephone or Internet Service Provider's fiber-optic infrastructure. But few of these companies are implementing a high-speed data solution. Connecting the last-mile usually involves laying new fiber-optic or copper cable which can be cost prohibitive thus here the Free Space Optic installations is required, which demands line-of-sight availability between the laser/receiver units which are called link heads.Dealing with simply the FSO may not completely solve the problem of last mile connectivity , therefore instead of installing the FSO alone we will be focussing on the deployment of the RoFSO , which is able to give the combined feature of the FSO and the RoF which assures the network infrastructure ,at the places where the coupling between the RoFSO and RoF to take place smoothly and along with that the enhanced link connectivity and improved speed which is gifted to it by the FSO part which is operational with the RoF ,in the RoFSO, will also be there.

A thorough pre-installation site evaluation must be done to ensure that the paths between the Free-Space Optic units are clear and will remain so for a number of years. The units can be mounted on building tops, sides and even behind windows.The units are full-duplex, meaning that data can flow in both directions simultaneously.It is due to the lasers which are of low power and do not constitute a risk to the naked eye or any bird or animal that might get in the laser's path which supports the RoFSO deployment within RoF infrastructure as safe and supporting for the links establishment. The various vendors offer multiple ways to connect the Free-Space Optics equipment to the LAN or WAN equipment including standard fiber based optical connectors, 10BaseT, 100BaseT, 1000BaseT and other connectors. The frequencies used by the lasers are between 750 and 1550 GHz that is a typical FSO transceiver transmits one or more beams of light, each of which is 5–8 cm in diameter at the transmitter and typically spreads to roughly 1–5 m in diameter at a range of 1 km, in addition, FSO installations capable of 99.9% or better availability typically have enough margin to compensate for large amounts of atmospheric attenuation and thus have more than enough margin to compensate for scintillation. For longer, lower-availability links,transceiver design features such as the use of multiple laser transmitters can substantially reduce the effects of scintillation. The systems including network layer operability also use routers to segment the Free-Space Optic links. Many solutions incorporate a partial mesh design so that if one link fails for any reason, a redundant path is almost immediately available.

IV. FUTURE SCOPES

As the free space optical communications offer broadband highly secure communication system in which a single wavelength can be used to cover a large area within the same room, taking advantage of the fact that optical signals cannot pass through opaque obstacle.Taking this most attractive feature into consideration , we envisage the proposed heterogeneous RoF based RoFSO system to achieve the rank of providing the secure cpommunication.This makes the way to non-LOS non-directed configuration, also known as diffuse,connectivity is possible even when obstacles are placed between the transmitter and receiver, because of the high reflectivity of walls.As an alternative design to wide angle transmitters often used in diffuse communications,quasi-diffuse transmitters create multiple narrow beams targeted in different directions.Thus the diffuse link (for connectivity) system can be applied at the end of the RoFSO link to be terminated by the FSO link which further gets converted to the Indoor diffused based FSO , when launched within the boundaries, instead of RoF. Although indoor diffuse or quasi-diffuse model is interesting; but the Inter-Symbol Interference(ISI) impairment and high path loss, resulting in relatively low bit rates (155 Mb/s), offers little advantage over RF approaches. Thus there still exists suitability of indoor diffuse or quasi-diffuse transmissions to provide connectivity to mobile users.

In order to further enhance the radio coverage and getting on making further improvement on the RoF based RoFSO network , we need to work on the having the non line of sight communication through the RoFSO part of this heterogeneous structure with the compliance of the indoor diffuse optical wireless to be made operational within the confined boundaries. This feature will bring on acceleration towards the better connectivity even if unlike what is desired for the FSO part of RoFSO to work , that is the line of sight availability, is not there , if this scheme is effectively deployed then the communication be made secure. Since because the interception of the data through the RoF part is hard to crack , whereas there is still a possibility of having the intruder to tap the signals down from the FSO section of the RoFSO , hence the indoor diffusion facilitates us with the opportunity to relay the signals in the area having higher possibility of intended interferences to counter with the transceiving of signals in the closed environments only.

Diffuse Links uses multiple reflections of the optical beam on surrounding surfaces such as ceilings, walls, and furniture.Therefore transmitter and receiver does not require to be directed one towards the other.It is robust to blocking and shadowing. However, even with these potential advantages over RF systems, current academic and commercial diffuse optical LAN networks still provide lower data rates than RF LAN, due to the optical power decreasing greatly as the signal diffuses from a medium. Any change in the position and/or orientation of transmitter and/or receiver changes the channel characteristic. Blockage and shadowing also will vary the properties of channel. There will be wide variation in the observed properties if the transmitter or receiver rotates. Effective design of an infrared wireless communication system is required Effective design of an infrared wireless communication system requires channel measurements under different conditions and optical configurations. These measurements give an idea about the distortions that are encountered in the actual application of these systems that is the experimental setup employed for conducting the FSO channel measurements and modelling needs to be worked upon.

V.CONCLUSIONS

Advanced radio access network architectures supporting heterogeneous configurations are attractive from RoFSO perspective. Heterogeneous configurations generally provide shorter link distances between network elements, but also provide features which enhances link reliability in face of inclement weather and temporary obstructions.The working together of the two technologies ,RoF and RoFSO with their supplementing and complementing features has a potential to bring about the momentum in the next generation communication system which tends to clear the hinderance of the last mile problem and provides a secure commununication.

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