

A REVIEW ON MOBILE TECHNOLOGY EVOLUTION, ROF AND ROFSO SYSTEM

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ABSTRACT

Mobile communications and wireless networks are developing at a wondering speed, with evidences of significant growth in the areas of mobile subscribers , mobile and wireless access networks, mobile services and applications. The worldwide revolution in mobile and internet technology have changed our way of living life. Every new technology has come to hide the drawbacks of previous technology.

This paper deals with the review and comparative analysis of Mobile Technology Evolution: First Generation, Second Generation, Third Generation, Fourth Generation , Radio over Fiber (RoF) and Radio on Fiber over optics (RoFSO) .

Keywords: *1G, 2G, 3G ,4G, RoF ,RoFSO.*

I. INTRODUCTION

The growth in telecommunication industry is very sharp during last little decades. The main contribution in this growth of industry is wireless mobile communication industry. The growth of this industry has experienced several generations. These generations are 1G, 2G, 3G, and 4G. Each generation have some standards, capacities, techniques and new features which differentiate it from previous generations. The last few years have witnessed a phenomenal growth in the wireless industry, both in terms of mobile technology and its subscribers. The ever-increasing demand for capacity and quality in wireless communication links has continued to inspire researchers to innovate new design methodologies and concepts over wireless systems and networks with the ultimate aim of achieving a next-generation network. Among the emerging technologies the RoF and RoFSO are described in this article. RoF technologies can realize a cost effective universal platform for future ubiquitous wireless services. RoF can be extended into RoFSO (Radio on Free Space Optics) which provide a free space for heterogeneous wireless services in Free Space Optics or millimeter wave radio.

II. EVOLUTION OF MOBILE NETWORKS

Mobile Cellular Network evolution has been categorized in to 'generations'. On a worldwide basis, ITU-R defines technology families and associates specific parts of the spectrum with these families. From the technology and standards angle, three main organizations have recently been developing standards relevant to

IMT requirements, and these organisations continue to shape the landscape of mobile radio systems as shown in Figure 1.1. The uppermost evolution track shown in Figure 1.1 is that developed in the 3rd Generation Partnership Project (3GPP), which is currently the dominant standards development group for mobile radio systems. Within the 3GPP evolution track, three multiple access technologies are evident: the ‘Second Generation’ GSM/GPRS/EDGE family was based on TDMA/FDMA; the ‘Third Generation’ UMTS family marked the entry of Code Division Multiple Access (CDMA) into the 3GPP evolution track, becoming known as Wideband CDMA or simply WCDMA; finally LTE has adopted, which is the access technology dominating the latest evolutions of all mobile radio standards.

Timeline Approx.

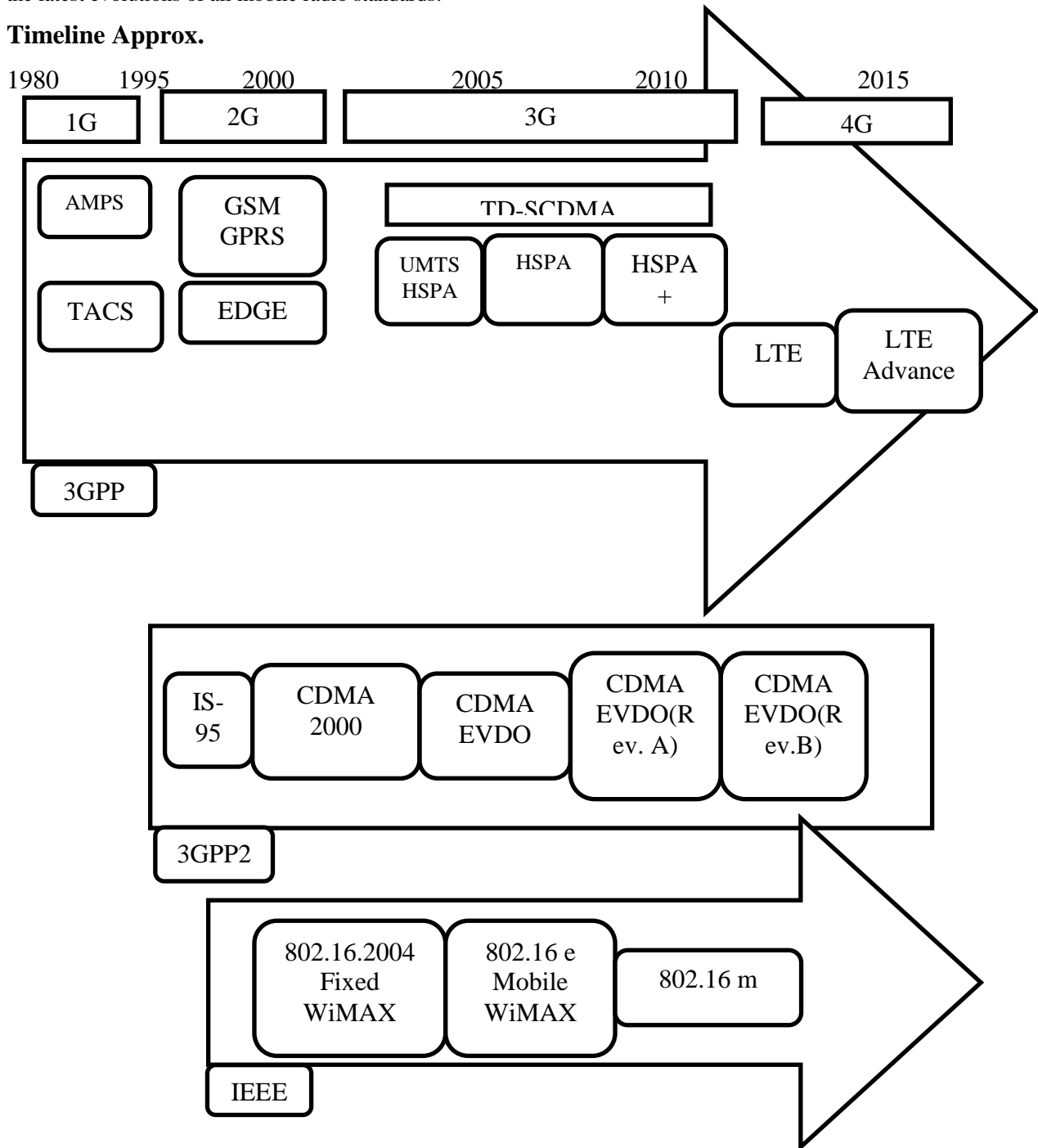


Figure 1. Approximate Timeline of the Mobile Communications Standards Landscape

The First generation of wireless telecommunication technology is known as 1G was introduced in 1980. Here basically, radio signals were transmitted in ‘Analogue’ form and expectedly, one was not able to do much other than sending text messaging and making calls. But the biggest disadvantage, however came in the form of limited network availability, as in the network was available only within the country. The 1G first generation mobile wireless communication system was analog system, which was based on a technology known as Advance Mobile Phone Service (AMPS)

3.1 AMPS

The AMPS system was frequency modulation radio system using frequency division multiple access (FDMA) with channel capacity of 30 KHz and frequency band was 824-894 MHz. The first generation has some specifications which are as following.

Genera tion	Data Capac ity	Technol ogy	Standar d	Multiple xing	Switchin g	Service	Main Networ k	Hand Off	Frequency
1G	2 Kbps	Analog Wireless	AMPS	FDMA	Circuit	Voice Only	PSTN	Horizo ntal	800-900 Mhz

IV. THE SECOND GENERATION

Second-generation (2G) mobile systems were introduced in the end of 1980s. Compared to first-generation systems, second-generation (2G) systems use digital multiple access technology, such as TDMA (time division multiple access) and CDMA (code division multiple access). Consequently, compared with first-generation systems, higher spectrum efficiency, better data services, and more advanced roaming were offered by 2G systems.

4.1 GSM

GSM (Global System for Mobile communications), initiated by the European Commission, is the second-generation mobile cellular system aimed at developing a Europe-wide digital cellular system.. The main objective of GSM is to remove any incompatibility among the systems by allowing the roaming phenomenon for any cell phone.

One of the basic aims was to provide a system that would enable greater capacity to be achieved than the previous first generation analogue systems. GSM achieved this by using a digital TDMA (time division multiple access approach). By adopting this technique more users could be accommodated within the available bandwidth. In addition to this, ciphering of the digitally encoded speech was adopted to retain privacy.

The table below summarises the main points of the GSM system specification, showing some of the highlight features of technical interest.

SPECIFICATION SUMMARY FOR GSM CELLULAR SYSTEM

Multiple access technology	FDMA / TDMA
Duplex technique	FDD
Uplink frequency band	890-915 MHz (basic 900 MHz band only)
Downlink frequency band	933-960 MHz (basic 900 MHz band only)
Channel spacing	200 kHz
Modulation	GMSK

GSM Network Architecture

The GSM network architecture as defined in the GSM specifications can be grouped into four main areas:

- Mobile station (MS)
- Base-Station Subsystem (BSS)
- Network and Switching Subsystem (NSS)
- Operation and Support Subsystem (OSS)

The different elements of the GSM network operate together and the user is not aware of the different entities within the system.

Mobile station (MS)

Mobile stations (MS), mobile equipment (ME) or as they are most widely known, cell or mobile phones are the section of a GSM cellular network that the user sees and operates. In recent years their size has fallen dramatically while the level of functionality has greatly increased. A further advantage is that the time between charges has significantly increased.

Base Station Subsystem (BSS)

The Base Station Subsystem (BSS) section of the GSM network architecture that is fundamentally associated with communicating with the mobiles on the network. It consists of two elements:

- **Base Transceiver Station (BTS):** The BTS used in a GSM network comprises the radio transmitter receivers, and their associated antennas that transmit and receive to directly communicate with the mobiles..
- **Base Station Controller (BSC):** The BSC forms the next stage back into the GSM network. It manages the radio resources and controls items such as handover within the group of BTSs and allocates channels .

PLMN, PSTN, ISDN (Public Network)

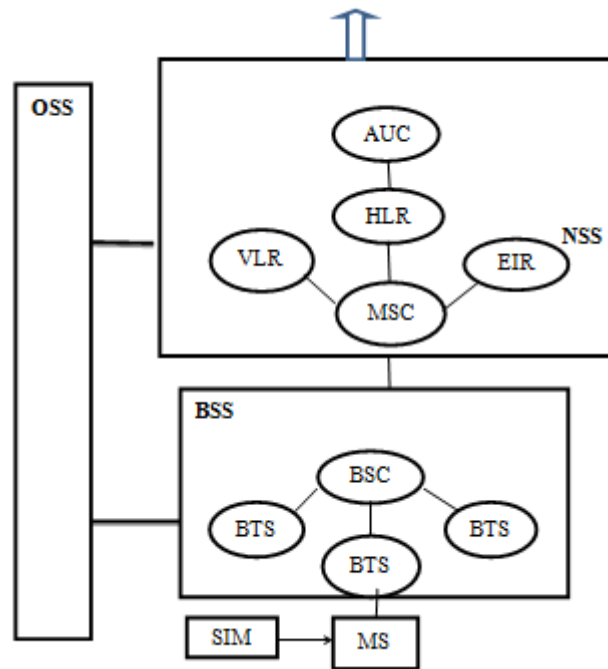


Figure 2. Overall Architecture for GSM.

Network Switching Subsystem (NSS)

It provides the main control and interfacing for the whole mobile network. The major elements within the core network include:

- **Mobile Switching services Centre (MSC):** MSC acts like a normal switching node within a PSTN or ISDN, but also provides additional functionality to enable the requirements of a mobile user to be supported. These include registration, authentication, call location, inter-MSC handovers and call routing to a mobile subscriber.
- **Home Location Register (HLR):** This database contains all the administrative information about each subscriber along with their last known location..
- **Visitor Location Register (VLR):** This contains selected information from the HLR that enables the selected services for the individual subscriber to be provided.
- **Equipment Identity Register (EIR):** The EIR is the entity that decides whether a given mobile equipment may be allowed onto the network. Each mobile equipment has a number known as the International Mobile Equipment Identity.
- **Authentication Centre (AuC):** The AuC is a protected database that contains the secret key also contained in the user's SIM card. It is used for authentication and for ciphering on the radio channel.

- **Gateway Mobile Switching Centre (GMSC):** The GMSC is the point to which a ME terminating call is initially routed, without any knowledge of the MS's location.

Operation and Support Subsystem (OSS)

The OSS or operation support subsystem is an element within the overall GSM network architecture that is connected to components of the NSS and the BSC. It is used to control and monitor the overall GSM network and it is also used to control the traffic load of the BSS.

4.2 IS-95

IS-95 was the first CDMA mobile phone system to gain widespread use and it is found widely in North America. Its brand name is cdmaOne and the initial specification for the system was IS95A, but its performance was later upgraded under IS-95B. Apart from voice the mobile phone system is also able to carry data at rates upto 14.4 kbps for IS-95A and 115 kbps for IS-95B.

IS95 specification summary

PARAMETER	DETAILS
Multiple Access Scheme	CDMA
Channel bandwidth	1.25 MHz
Data rate	14.4kbps for IS-95A & 115 kbps for IS-95B

V. THE THIRD GENERATION

Third Generation Technology was developed in order to face up to the new requirements of services what were coming, as high-quality images and video or to provide access to the Web with higher data rates. The data-handling capabilities of second-generation systems are limited and was necessary other mobile technology.

Although many proposals were submitted there were several that were considerably more important than others. These included:

- **UMTS / WCDMA:** The Universal Mobile Telecommunications System using wideband CDMA was the successor to the highly successful GSM system that was initially deployed around Europe, but was spreading rapidly worldwide.
- **CDMA2000:** This scheme was the successor to the cdmaOne system defined under Interim Standard IS-95 which was the first system to be deployed using CDMA technology.

5.1 UMTS

UMTS uses Wideband CDMA - WCDMA - as the radio transmission standard. It employs a 5 MHz channel bandwidth. Using this bandwidth it has the capacity to carry over 100 simultaneous voice calls, or it is able to carry data at speeds up to 2 Mbps in its original format.. A new introduction for UMTS is that there are specifications that allow both Frequency Division Duplex (FDD) and Time Division Duplex (TDD) modes.

The UMTS WCDMA system offered a significant improvement in capability over the previous 2G services.

PARAMETER	SPECIFICATION
Data rate	2048 kbps low range, 384 kbps urban and outdoor
RF channel bandwidth	5 MHz
Multiple access scheme	CDMA
Duplex schemes	FDD and also TDD

UMTS Network Architecture : The UMTS network architecture can be divided into three main elements:

1. **User Equipment (UE):** The User Equipment or UE is the name given to what was previous termed the mobile, or cellphone. The new name was chosen because the considerably greater functionality that the UE could have.
2. **Radio Network Subsystem (RNS):** The RNS is the equivalent of the previous Base Station Subsystem or BSS in GSM. It provides and manages the air interface for the overall network.
3. **Core Network:** The core network provides all the central processing and management for the system. It is the equivalent of the GSM Network Switching Subsystem or NSS. The core network is then the overall entity that interfaces to external networks including the public phone network and other cellular telecommunications networks.

TO PUBLIC NETWORKS.....

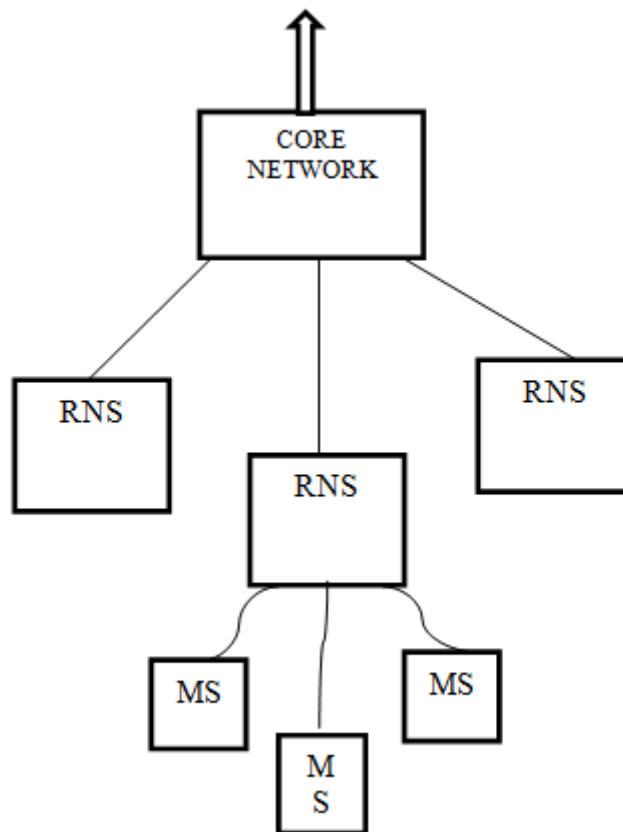


Figure 3.UMTS Network Architecture Overview.

LTE, Long Term Evolution, the successor to UMTS and HSPA is now being deployed and is the way forwards for high speed cellular services. In its first forms it is a 3G or as some would call it a 3.99G technology, but with further additions the technology can be migrated to a full 4G standard and here it is known as LTE Advanced. The UMTS cellular technology upgrade has been dubbed LTE - Long Term Evolution. The idea is that 3G LTE will enable much higher speeds to be achieved along with much lower packet latency.

LTE Network Architecture

The high-level network architecture of LTE is comprised of following three main components:

- The User Equipment (UE).
- The Evolved UMTS Terrestrial Radio Access Network (E-UTRAN).
- The Evolved Packet Core (EPC).

The User Equipment (UE)

The internal architecture of the user equipment for LTE is identical to the one used by UMTS and GSM which is actually a Mobile Equipment (ME). The mobile equipment comprised of the following important modules:

- Mobile Termination (MT): This handles all the communication functions.
- Terminal Equipment (TE): This terminates the data streams.
- Universal Integrated Circuit Card (UICC): This is also known as the SIM card for LTE equipments. It runs an application known as the Universal Subscriber Identity Module (USIM).

The E-UTRAN (The access network)

The E-UTRAN handles the radio communications between the mobile and the evolved packet core and just has one component, the evolved base stations, called eNodeB or eNB. Each eNB is a base station that controls the mobiles in one or more cells. The base station that is communicating with a mobile is known as its serving eNB.

The Evolved Packet Core (EPC) (The core network)

The evolved packet core communicates with packet data networks in the outside world such as the internet, private corporate networks or the IP multimedia subsystem. The interfaces between the different parts of the system are denoted U_u , S1 and SGi as shown in figure:

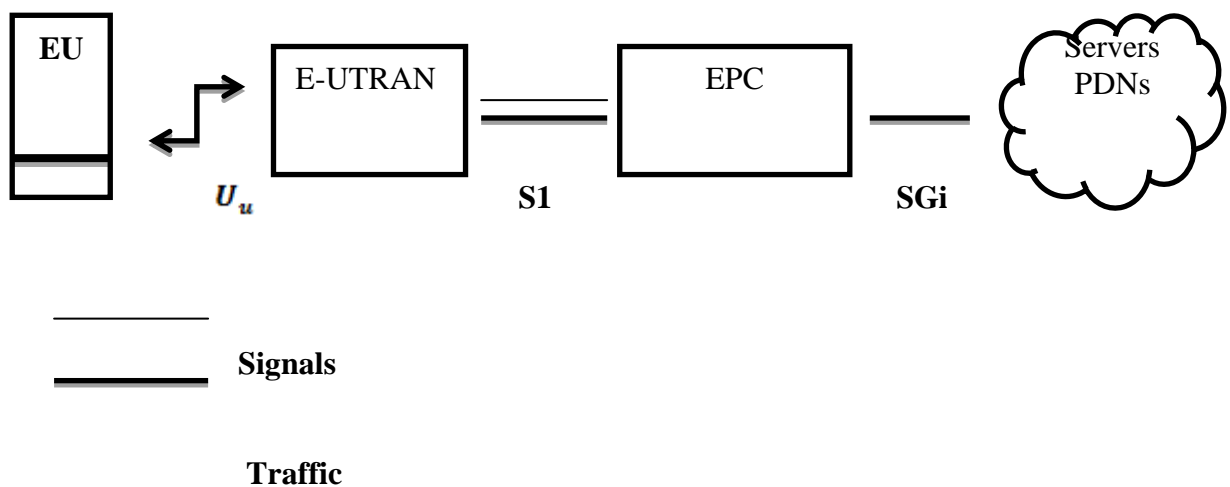


Figure 4. LTE Network Architecture Overview.

4th Generation mobile networks are believed to provide many value added features. In addition to all the 3G facilities, data transmission is believed to go through the roof with speeds ranging between 100MBPs to 1GBPS. Talking, surfing, conferencing, chatting, networking, partying, or whatever you want to do on your mobile phone.

6.1 4G LTE Advanced

With the standards definitions now available for LTE, the Long Term Evolution of the 3G services, eyes are now turning towards the next development, that of the truly 4G technology named IMT Advanced. The new technology being developed under the auspices of 3GPP to meet these requirements is often termed LTE Advanced.

The development of LTE Advanced / IMT Advanced can be seen to follow an evolution from the 3G services that were developed using UMTS / W-CDMA technology.

LTE Advanced key features

Some of the main headline aims for LTE Advanced can be seen below:

1. **Peak data rates:** downlink - 1 Gbps; uplink - 500 Mbps.
2. **Spectrum efficiency:** 3 times greater than LTE.
3. **Peak spectrum efficiency:** downlink - 30 bps/Hz; uplink - 15 bps/Hz.
4. **Spectrum use:** the ability to support scalable bandwidth use and spectrum aggregation where non-contiguous spectrum needs to be used.
5. **Latency:** from Idle to Connected in less than 50 ms and then shorter than 5 ms one way for individual packet transmission.
6. Cell edge user throughput to be twice that of LTE.
7. Average user throughput to be 3 times that of LTE.
8. **Mobility:** Same as that in LTE
9. **Compatibility:** LTE Advanced shall be capable of interworking with LTE and 3GPP legacy systems.

Table 1. Comparison Table for Different Generations

Technology	1G	2G	3G	4G
Design Began	1970	1980	1990	2000
Implementation	1981	1991	2001	2010
Services	Analog voice	Digital voice, short message	Higher capacity, data rates up to 2 Mbps	Higher capacity, completely IP-Oriented, multimedia, data to hundreds of megabits
Standards	AMPS, ETACS, NMT etc.	TDMA,CDMA,GSM	WCDMA, CDMA-2000	Single standard
Data Rate	NA	14.4 kbps	2 Mbps	>200 Mbps
Multiplexing	FDMA	TDMA, CDMA	CDMA	OFDM
Core Network	PSTN	PSTN	Packet network	Internet
Handoff	Horizontal only	Horizontal & Vertical	Horizontal & Vertical	Horizontal & Vertical

VII. RADIO OVER FIBER (RoF)

Radio-over-fiber (RoF) technology has emerged as a cost effective approach in which the central site and multiple number of remote sites are connected by using optical fiber. RoF technology is a technology by which microwave signals are distributed by means of optical components and techniques. If the application area is in a ‘Global System for Mobile communications network, then the central site could be the Mobile Switching Centre (MSC) and the remote site the base station (BS).. For a multifunctional RoF system, the choice of the electrical signal at the input depends on the type of functionality of the system. The electrical signal is modulated with the optical carrier signal. The modulated signal is carried over optical fiber link to the remote stations. Here, the original data is recovered from the modulated signal by using photo detector. Avalanche photo detector is commonly used. The benefits of the RoF system are low attenuation loss , large bandwidth, easy installation and maintenance operational flexibilities. Some of the Rof technology include mobile radio communication, satellite communications, broadband access Multipoint Video Distribution Services, (MVDS) Mobile Broadband System (MBS) and wireless LANs over optical networks.

VIII. RADIO OVER FREE SPACE OPTICAL (RoFSO)

Free Space Optics (FSO) is a line of sight technology which involves the transfer of data from one point to another point using optical radiation in free space . The intensity and phase of the optical carrier signal can be modulated based on the message signal. FSO provides the flexibility of wireless communication and the speed of fiber optic communication. An FSO unit consists of optical transceivers with a laser transmitter and a receiver

to provide full duplex connectivity between them. Each FSO unit uses a high power optical source and a lens that transmits the lights through the atmosphere to another lens receiving the signal. The advantages of FSO are high bit rate, ease of deployment, license free operation, high transmission security, full duplex transmission and protocol transparency. Shielding from electro-magnetic interference should also be mentioned as a significant advantage in saturated RF spectrum environments. Important features of FSO include huge modulation bandwidth, narrow beam size, low cost, easy implementation and unlicensed spectrum.

RoFSO is the technology in which it is possible to transmit and receive multiple RF signals simultaneously over FSO links using wavelength division multiplexing (WDM) technology. RoFSO can be used as a backup of RoF technology, in case of failure or absence of the fiber network . A simplified block diagram for radio over free space optical communication system is shown in Figure.

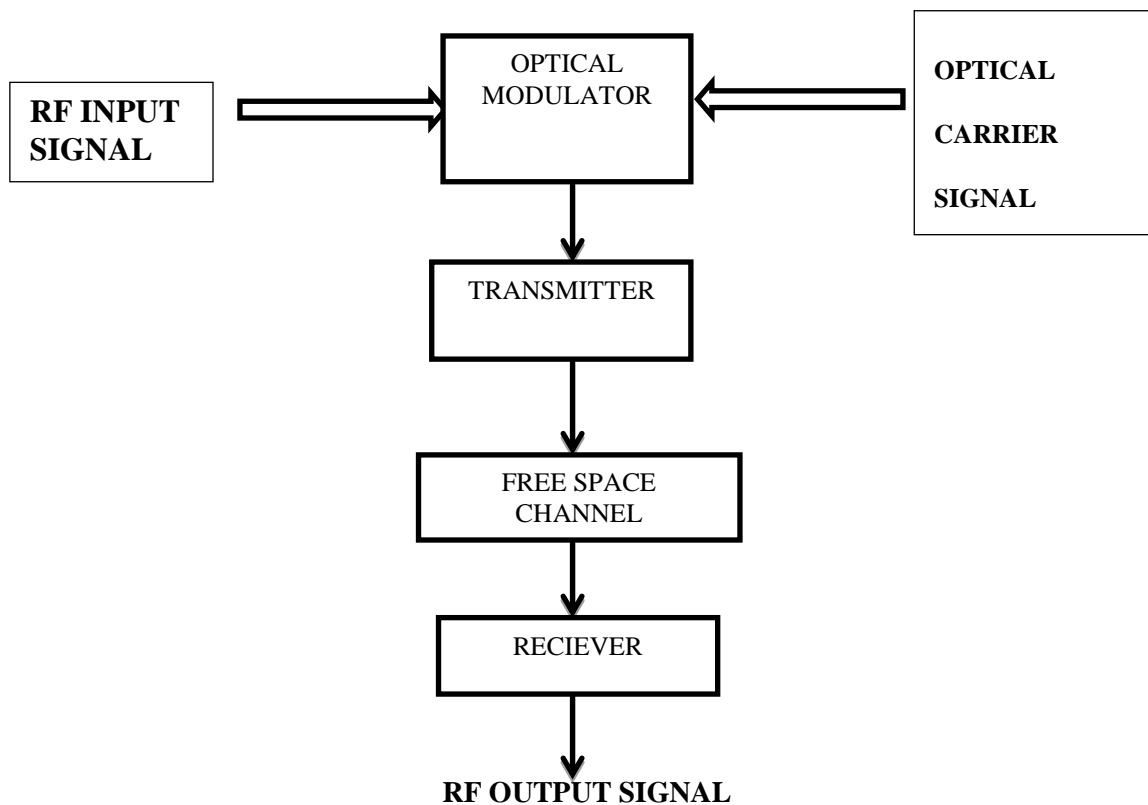


Figure 5. Block Diagram of RoFSO Communication System.

Table 2: Performance Comparison of RoF Using Multimode Optical Fibre and RoFSO as Signal Distribution Mechanisms.

Parameter	RoF	RoFSO
Attenuation (electrical) over 50m	0.1dB	20-40dB
3dB bandwidth over 50m	10GHz possible (typical commercial System 3GHz (approx..))	10GHz (limited by laser)
Maximum range	several km	50-100m
Estimate variable cable Cost	\$0.68/m	Nothing
Estimated capital equipment cost	\$420	\$500 (target)
Estimated installation Weight	<20kg/m	Nothing
Ease of installation	Moderate	High
Layout exibility	Low	High

1X. CONCLUSION

This paper given a close survey of development of mobile technologies and also the journey from 1G to 4G. Modern society is increasingly reliant on fast and ubiquitous access to wireless networks. As a result there is a huge demand on wireless networks and to avoid capacity shortfall, new strategies and technologies must be developed urgently. Therefore, attention must be turned to the design of wireless delivery infrastructure to enable further significant improvements in capacity. This is particularly important in indoor environments .

For this problem, the radio-over-fibre (RoF) technology, have been a popular infrastructure solution to improve coverage for wireless systems. RoF can be extended into RoFSO (Radio on Free Space Optics) which provide a free space for heterogeneous wireless services in Free Space Optics.

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