

## The Feasibility of Radio over Fiber Technology Application in 5G Mobile Technology Systems

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### Abstract

This paper consists of two parts: *I*. Introduction of Radio of Fiber technology & methodology, Radio over Fiber (RoF) is a promising solution for wireless access services by transferring the heterogeneous radio signal via the optical fiber link. However, RoF devices have nonlinear characteristics which create intermodulation products in system. *II*. It presents an overview of the fifth generation mobile networks with emphasis on current and future trends in the areas of wireless networking and networking services, and how to feasibility of RoF Technology Application in 5G Mobile Technology Systems.

**Keyword:** RoF, G1, G2, G3, G4, G5.

### Introduction

The exchange of information or communication with the users has become very easy and simple that just with a mobile phone we can be in touch with all of them.

5G technology is the abbreviation of the fifth generation mobile technology, Wireless communication has started in early 1970s. In next four decades, a mobile wireless technology has evolved from 1G to 5G generations. Fifth generation technology offer very high bandwidth that user never experienced before. The Fifth generation technologies offer various new advanced features which makes it most powerful and in huge demand in the future.

The fifth generation wireless mobile multimedia internet networks can be completely wireless communication without limitation, which makes perfect wireless real world – World Wide Wireless Web (WWWW). Fifth generation is based on 4G technologies. The 5th wireless mobile internet networks are real wireless world which shall be supported by LASCDMA(Large Area SynchronizedCode-

Division Multiple Access), OFDM (Orthogonal frequency-division multiplexing), MCCDMA (Multi-Carrier Code Division Multiple Access), UWB (Ultra-wideband), Network-LMDS (Local Multipoint Distribution Service), and IPv6. Fifth generation technologies offers tremendous data capabilities and unrestricted call volumes and infinite data broadcast together within latest mobile operating system. Fifth generation should make an important difference and add more services and benefits to the world over 4G. Fifth generation should be more intelligent technology that interconnects the entire world without limits. This generation is expected to be released around 2020.

### **1.1 Radio over fiber (ROF):**

Radio-over-Fiber (RoF), is a light technology modulated by the radio signal and it transmitted over an optical fiber link to wireless access. In the Radio signal in each signal in each cell are transmitted and received from mobile users by a separate base station via optical fiber. RoF is commonly used in wireless access. the RoF system transport wireless signals in an optical form between a central station and a set of base stations before using radiated in the air surface. Each base station is adapted to communicate over radio link with at least one user mobile station located in the range of base station. The advantage of this equipment for serving various broadband networks like 3G, 4G, 5G and other protocols can be centralized in one place. And the following sections to explain Radio over Fiber and wireless broadband access technology [1, 2].

Mobility as well as decreasing costs in the access network using RoF architecture. In this architecture can give several advantages such as reduced complexity at the Base Station (BS) antenna side, and radio carriers can be allocated dynamically to the different BS antenna into Sub Stations (SS). If it integrated into broadband technology, this system will need to offer data transmission capacities well standard to the present wireless network. That is Wireless LAN offering up to 54 Mbps and carrier frequencies 2.4 to 5 GHz, 3G mobile networks offering up to 2Mbps in 2GHz, and 4G offering up to 40 Mbps and 2-8 GHz carrier frequencies. In the recent day main wireless standard such as IEEE 802.16 Mobile. It needs to increase capacity frequencies more than 6GHz, which is indoor application the high operating system to access this network. [2, 3, 4]

Radio-over-Fiber technology is use an optical fiber links to distribute RF signals from BS to Remote Antenna Unit (RAU). In the communication system, RF signal processing

functions such as frequency up-conversion, carrier modulation, and multiplexing, is performed by the antenna. RoF makes it possible to centralize the RF signal processing function in one headend, then to use optical fiber, which offers low signal loss between 0.3 dB/km for 1550 nm and 0.5 dB/km for 1310 nm wavelength. It distributes the RF signals to the RAUs as shown in the following (see Figure 1).

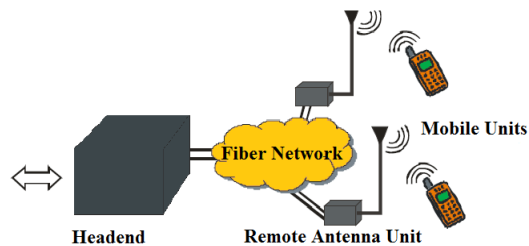


Figure 1: Radio over Fiber System Concept. [ 9]

If the system carries GSM and high bandwidth signals, for example RF signal is used to directly modulate, the laser and it send into Central Station. Finally the signal modulated over fiber that is Intensity Modulation with Direct Detection (IM-DD), and it in the RoF link [5, 6].

### 1.1.1 Architecture of RoF

RoF transmission system are usually classified into two main categories

- 1- RF-over-Fiber (Radio Frequency over Fiber).
- 2- IF-over-Fiber (Intermediate Frequency over Fiber).

In RF-over-Fiber architecture, a data-carrying RF signal with high frequency (greater than 10 GHz). It is imposed on a light wave signal before transmission over the optical link. Therefore, wireless signals are optically distributed to base stations directly at high frequencies and converted from the optical to electrical domain at the base stations before being amplified and radiated by antenna. As a resultant, no frequency up-down conversion is required at the various base stations.

In IF-over-Fiber architecture, a data-carrying RF signal with lower frequency (less than 10GHz). It is used for modulating light before being transported over the optical link. Therefore, before the air, the signal must be RF at the base station.

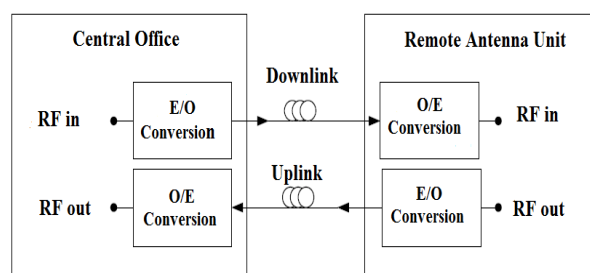


Figure 2: Radio over Fiber System Architecture. [9]

A RoF system delivers the RF signal from the CO to the RAU through optical links, an optical link being defined as consisting of all the components required to transfer an electrical signal over an optical carrier as in the figure (see Figure 2). In this diagram explained, the Electrical/Optical conversion can be done by direct modulated laser (or) by an external modulator at the output of RAU. [5, 6].

### 1.1.2 Benefits and Applications of Radio over Fiber Systems

- 1- **Low Attenuation Loss:** Electrical distribution of high frequency microwave signals either in free space or through transmission lines is problematic and costly.
- 2- **Large bandwidth:** Large amount of bandwidth can be offered in Optical fiber.
- 3- **Reduced Power Consumption:** Due to having simple Radio Stations, reduced power consumption is achieved.
- 4- **Dynamic Resource Allocation:** Radio over Fiber does offer operational benefits in terms of operational flexibility.
- 5- **Satellite Communications:** One of the first uses of Radio over Fiber technology was Satellite communications. [7]

## 2. Wireless Communication Networks: From 1G to 5G

Mobile communications and wireless networks are developing at an astounding speed, with evidences of significant growth in the areas of mobile subscribers and terminals, mobile and wireless access networks, and mobile services and applications. [8]

### 2.1 What features 1G has?

1G is the first generation cellular network that existed in 1980s. First generation refers to the analog “brick phones” and “bag phones” as they were first introduced for mobile cellular technology. (NMT, C-Nets, AMPS, TACS) are considered to be the first analog cellular technology cellular systems, which started early 1980s. There were radio telephone systems even before that. [8]

### 2.2 What features 2G has?

Fully digital 2G networks have replaced analog 1G, which originated in the 1980s. 2G networks first commercially began on the Global System for Mobile Communications, or GSM/CDMA, standard. 2G on GSM standards was first used in commercial practice in 1991 by Radiolinja, a Finish GSM operator that was founded on September 19, 1988 Improved by introducing the concept of digital modulation, which means converting the voice (only) into digital code (in your phone) and then into analog signals. [8]

### 2.3 What features 3G has?

3G is the current generation and third of mobile telecommunication standards. 3G supersedes 2G technology and precedes 4G technology. Current 3G systems have been established through ITU's project on International Mobile Telecommunications 2000 (IMT-2000). 3G technologies have enabled faster data transmission speeds, greater network capacity and more advanced network services. [8]

### **2.3 What features 4G has?**

In telecommunications, 4G is the fourth generation of cellular wireless standards. It is a successor to the 3G and 2G families of standards. In 2008, the ITU-R organization specified the IMT-Advanced (International Mobile Telecommunications Advanced) requirements for 4G standards, setting peak speed requirements for 4G service at 100 Mbit/s for high mobility communication (such as from trains and cars) and 1 Gbit/s for low mobility communication (such as pedestrians and stationary users). A 4G system is expected to provide a comprehensive and secure all-IP based mobile broadband solution to laptop computer wireless modems, smart phones, and other mobile devices. Facilities such as ultra-broadband Internet access, IP telephony, gaming services, and streamed multimedia may be provided to users. PRE-4G technologies such as mobile WiMAX and Long term evolution (LTE) have been on the market since 2006 and 2009 respectively, and are often branded as 4G. The current versions of these technologies did not fulfill the original ITU-R requirements of data rates approximately up to 1 Gbit/s for 4G systems. Marketing materials use 4G as a description for LTE and Mobile-WiMAX in their current forms. It uses OFDM in uplink and downlink. [8]

### **What features 5G has?**

The twenty-first century is surely the "century of speed", and achieves a high evolution in all the possible domains, especially in communication: a very large variety of services, software, equipments, possibilities etc. But this huge and colored offer also brings a complicated lifestyle and waste of time for the human beings, and needs to be integrated and achievable in a simple manner. Therefore, a new technology started to be delineated, that will provide all the possible applications, by using only one universal device, and interconnecting the already existing communication infrastructures—that is the fifth generation of the mobile communications standards—5G. [10].

Table 1: Comparative Study of various Wireless Generations [11]

1G	2G/2.5G	3G	4G	5G
<b>Start / Deployment</b>				
1970/1984	1980/1999	1990/2002	2000/2010	2000/2015-2020
<b>Feature</b>				
<ul style="list-style-type: none"> <li>• Make use of analog radio signals</li> </ul> <b>Services</b> Analog voice service, No data service	<ul style="list-style-type: none"> <li>• Used digital radio signals</li> <li>• Voice encoded to digital signals</li> </ul> <b>GSM:</b> supported digital voice service, SMS messaging, improved voice clarity comparatively secure <b>GPRS:</b> supported MMS, internet comm.	Fast data transfer rate, Improved spectral efficiency, greater network capacity. <b>Services:</b> Enhanced audio video streaming, video conferencing support, Web browsing at higher speeds, IPTV support	<ul style="list-style-type: none"> <li>• Converged data and voice over IP</li> <li>• Entirely packet switched network,</li> <li>• Higher bandwidth to provide multimedia services at lower cost (up to 100Mbps)</li> </ul> <b>Services</b> Enhanced audio, video streaming ,IP telephony, HD mobile TV	Simultaneous access to different wireless technologies - complete wireless communication (Wireless world wide web, WWW) <b>Services</b> <ul style="list-style-type: none"> <li>• Dynamic information access</li> <li>• Wearable devices with AI capabilities</li> </ul>
<b>Data rates</b>				
2k bps	14.4-6.4 kbps	2Mbps	200Mbps to 1Gbps	1Gbps and higher
<b>Standards</b>				
MTS,AMTS, IMTS	2G:GSM 2.5G:GPRS 2.75:EDGE	IMT-2000 3.5G-HSDPA 3.75G:HSUPA	Single unified standard LTE,LTE adv.Mobile WiMAX	Single unified standard
<b>WEB Standard</b>				
-----	www	www (IPv4)	www (IPv4)	Wwww (IPv6)
<b>Technology</b>				
Analog	Digital narrow	Digital	Digital	Proposed: Unified IP and

cellular Technology <b>Throughput</b> 14.4 Kbps	band circuit data, Packet data <b>Throughput</b> 20-20Kbps	Broadband Packet data <b>Throughput</b> 3G:200Kbps 3.5G:1-3 Mbps	Broadband Packet All, Very high throughput <b>Throughput</b> 100-300Mbp	seamless combination of broadband, Local area networks, wide area networks, personal area networks, wireless LAN
<b>Service</b>				
Mobile telephony (voice)	2G: Digital voice, SMS 2.5: Higher capacity packetized	Integrated high quality audio, video and data	Dynamic information access , wearable devices with AI capabilities	
<b>Technology</b>				
Analog wireless cellular technology used	Digital wireless network used	Digital Broadband network	Digital Broadband Packet	Proposed: unified IP and seamess
<b>Switching</b>				
Circuit	2G:Circuit 2.5G: Circuit for access network & air interface; packet for core network	Packet except circuit for air interface	Packet switching Message Switching	
<b>Handoff</b>				
Horizontal only	Horizontal only	Horizontal only & Vertical		
<b>Shortfalls</b>				
Low capacity, Unreliable handoff Poor voice links, Less secure	Digital signals were reliant on location & proximity, required strong digital signals to help mobile phones	Need to accommodate higher network capacity	Being deployed	Yet to be implemented



## Conclusion

1. Radio over Fiber (RoF) is a promising solution for wireless access services by transferring the heterogeneous radio signal via the optical fiber link.
2. The fifth generation wireless mobile multimedia internet networks can be completely wireless communication without limitation and offer various new advanced features which makes it most powerful and in huge demand in the future.
3. Mobility as well as decreasing costs in the access network using RoF architecture. This architecture can give several advantages such as reduced complexity at the Base Station (BS) antenna side, and radio carriers can be allocated dynamically to the different BS antenna into Sub Stations (SS).
4. Radio-over-Fiber technology is use an optical fiber links to distribute RF signals from BS to Remote Antenna Unit (RAU). In the communication system, RF signal processing functions such as frequency up-conversion, carrier modulation, and multiplexing, is performed by the antenna.

## Reference

- [1] Mazin Al Noor, Green Radio Communication Networks Applying Radio-over-Fiber Technology for Wireless Access, Ph.D Thesis, 2011
- [2]Christina Lim, Ampalavanapillai Nirmalathas, Masuduzzaman Backul, Prasanna Gamage, Ka Lun Lee, Yizhuo Yang, Dalma Novak and Rod Waterhouse. “Fiber-Wireless Networks and Subsystem Technologies” Journal of Lightwave Technology, Vol. 28, No. 4, Feb. 15, 2010.
- [3]Navid Ghazisaidi and Martin Maier, “Fiber-Wireless (FiWi) Networks: Comparative Techno Economic Analysis of EPON and WiMAX” IEEE Communication Society, 2009.
- [4] Anthony Ng’oma, Radio-over –Fiber Technology for Broadband Wireless Communication Systems, Ph.D Thesis, 2005.
- [5] Springer: “Mobile Broadband Including WiMAX and LTE” by Mustafa Ergen, E-Book, e-ISBN: 978-0-387-68192-4.
- [6] Wiley: “WiMAX Evolution Emerging Technologies and Applications” by Marcos D. Katz and Frank H.P. Fitzek. ISBN: 978-0-470-69680-4.

- [7] Sabit Farizma Iftekhar, Shanjida Hannan Popy, Radio Over Fiber Transmission By Sub Carrier Multiplexing, Thesis 2009.
- [8] Shivam Jaiswal,Ajay Kumar,and Neha Kumari, Development of Wireless Communication Networks: From 1G to 5G, in International Journal Of Engineering And Computer Science, 2014.
- [9] S. Prakasam, R. Karthikeyan, A Survey on Radio over Fiber (RoF) for Wireless Broadband Access Technologies, International Journal of Computer Applications (0975 – 8887) Volume 64– No.12, February 2013.
- [10] Prof. R. K. Jain, Sumit katiyar and Dr. N. K. Agrawal, Survey of Latest Wireless Cellular Technologies for Enhancement of Spectral Density at Reduced Cost, International Journal of Computer Science Issues, Vol. 8, Issue 3, No. 2, May 2011.
- [11] Roopali Sood, Atul Garg, Digital Society from 1G to 5G: A Comparative Study, International Journal of Application or Innovation in Engineering & Management (IJAIEM), Volume 3, Issue 2, February 2014.