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# Survey: Radio over Fiber and Wireless Broadband Access Technologies

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***Abstract***

*This paper presents a survey on Radio over fiber for Wireless Broadband Access technology like WiMAX (Fixed and Mobile). Radio over Fiber has achieved an effective delivery of wireless and baseband signal, and has also reduces the power consumption. Whereas recent fast growing broadband access technology through wireless is WiMAX (Worldwide Interoperability for Microwave Access). In this survey, the Radio over fiber implements into wireless broadband access technologies like WiMAX. And also we will be carried out different keying and technical concept from the different methodology.*

## 1. Introduction

Network connectivity is categorized either as a backhaul or an access network. In the access network it provides last mile connectivity that connects the end users to the backhaul network which finally connect to the cloud. The recent wireless access network needs to increase coverage range and high data transmission of video, voice and multimedia services with the mobile and fixed users. Therefore for this reason, at the backbone of broadband access technology like WiMAX Base Station (BS), the recent network providers require high transmission bandwidth. So the RoF technology determines a key solution for satisfying this requirement. Since in the backbone wireless and fiber optic technologies, the RoF technology had high bandwidth optical system particularly.

Radio-over-Fiber refers to a technology in which light is modulated by the radio signal and is transmitted over an optical fiber link to wireless access. Each Radio signal in each cell are transmitted and received from mobile users via optical fiber by separate base station. In Radio over fiber System, signals are transported in optical form between a central station and base stations before radiating in the air. Each base station with at least one mobile station located in its range is adapted to communicate over radio link of base station. The main advantage of this equipment for serving multiple broadband networks like WiMAX, 3G, 4G and other protocols can be centralized in one place.

### 1.1 Radio-over-Fiber Technology

For increasing capacity, mobility and also decreasing costs in the access network using RoF architecture, the integration of microwave and optical networks is a ultimate solution. This architecture reduces complexity at the Base Station (BS) antenna side, and radio carriers which can be allocated dynamically to the different Base Station antenna into Sub Stations. If it is integrated into broadband technology, this system will offer data transmission capacities well standard to the present wireless network. Wireless LAN offers up to 54

Mbps and carrier frequencies 2.4 to 5 GHz, whereas 3G mobile networks offers up to 2Mbps in 2GHz, and 4G offers up to 40 Mbps with 2-8 GHz carrier frequencies. Recently wireless standard such as IEEE 802.16 Fixed and Mobile WiMAX offers 2-66 GHz.

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Radio-over-Fiber technology uses optical fiber links to distribute RF signals from Base Station to Remote Antenna Unit. RF signal processing functions such as frequency up-conversion, multiplexing and carrier modulation is performed in the antenna. Rather than optical fiber, Radio over fiber makes it feasible to centralize the RF signal processing function in one headend, which offers low signal loss between 0.5 dB /km for 1310 nm and 0.3 dB /km for 1550 nm wavelength. It distributes the signals to the Remote Antenna Units as shown in the following (see Figure 1).

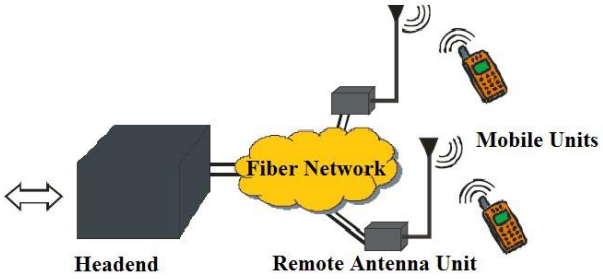


**Figure 1. Radio over Fiber System Concept**

**1.1.1 Architecture of RoF:** Radio over fiber transmission system are classified into two main categories

1. Radio Frequency over Fiber
2. Intermediate Frequency over Fiber

In RF-over-Fiber architecture, a data is carried over RF signal with frequency greater than 10 GHz. Before transmitting over the optical link it is imposed on a light wave signal. Therefore, wireless signals are optically distributed at high frequencies to base stations and then before being amplified and radiated by antenna it is converted from the optical to electrical domain at the base stations. Therefore no frequency up-down conversion is required at the base stations.

In IF-over-Fiber architecture, a data is carried over RF signal with frequency less than 10GHz. It is used for modulating light before transfering over the optical link. However the signal mush is up converted to RF at the base station before radiating through the air.

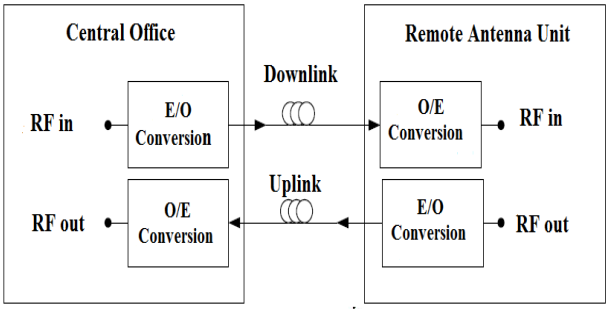


**Figure 2. Radio Over Fiber System Architecture**

A Radio over fiber system delivers the RF signal from the Central office to the Remote antenna unit through optical links, which consists of all the components required to transfer an electrical signal as shown in the Figure 2. This explains the Electrical/Optical conversion which can be done by direct modulated laser or by an external modulator at the output of Remote Antenna Unit.

 

**1.1.1 Applications of Radio over Fiber:** There are various applications of RoF technology which consist of mobile radio communications, satellite communications, broadband access, wireless LAN and mobile broadband system. The technical applications of RoF are Orthogonal Frequency Division Multiplexing and Coarse Wavelength Division Multiplexing.

**1.1.2.1 Wavelength Division Multiplexing (WDM) in RoF System**: Wavelength Division Multiplexing is combining light from different fibers with different wavelength on to a single fiber. It consists of DWDM, device that use optical multiplexing techniques to increase the capacity of fiber that can be use through Time Division Multiplexing.

On single fiber this system can achieve capacities over 1 Tbps. Also bit rate on a signal channel have risen from 10 Gbps to 40 Gbps. If we decrease the channel spacing in WDM to 50 GHz or 25 GHz, then it will be possible to transmit 100 of channels. Since the modulation bandwidth is always a small fraction of carrier frequency therefore, signal transmission of RoF signal is seen as inefficient in terms utilization of spectrum.

### 1.1.3 Benefits of RoF Technology

- Dynamic Resource Allocation
- Low Attenuation Loss
- Reduced Power Consumption
- Large Bandwidth

**1.1.4 Limitations of RoF Technology:** RoF technology involves analog modulation and detection of light. Therefore, in analog communication system and RoF technology, signal impairments such as noise and distortion are very important. These impairments limit the Noise Figure and Dynamic Range of the RoF links. The Dynamic Range is also important in mobile communication systems for signal received at the Base Station from the Mobile Units. That is the RF power received from a Mobile Unit is close to Base Station and also much higher than RF power received from Mobile Unit in which several kilometers away.

Single Mode Fiber based on RoF systems may limit the fiber link length and also increase the RF carrier phase noise. In MultiMode Fiber based on RoF system, model several limits that is available link, bandwidth and distance.

## 1.2 Wireless Broadband

The wireless broadband or wireless access technology that are classified into WiMAX, WiFi, mobile broadband, satellite based technologies and wireless network. The recent wireless broadband technology is for mobile and fixed that is The Worldwide Interoperability for Microwave Access. The standard of IEEE 802.16e for Mobile WiMAX and IEEE 802.16d for fixed WiMAX. The frequencies for broadband wireless communication system are given in the following table 1.

**Table 1. Frequencies for Wireless Broadband**

| Frequency | Wireless System |
|---|---|
| 2 GHz | UMTS/ 3G Systems |
| 5 GHz | IEEE 802.11 a WLAN |
| 2.4 GHz | IEEE 802.11 b/g WLAN |
| 2-11 GHz | IEEE 802.16 WiMAX |
| 28 Ghz | Fixed Wireless access – Local point to Multipoint (LMDS) |
| 17/19 | Indoor Wireless (Radio) LANs |
| 38 GHz | Fixed Wireless access |
| 57-64 GHz | IEEE 802.16 WPAN |
| 58 GHz | Indoor Wireless LANs |
| 10-66 GHz | IEEE 802.16 WiMAX |

From above table, WiMAX system to offer high capacity and carrier frequencies increases whereas cell size reduces. The IEEE 802.16 WiMAX range 2-11 GHz for mobility support. The IEEE 802.16 WiMAX range 10-66 GHz it's for fixed wireless broadband.

**1.2.1 Architecture of WiMAX:** WiMAX deals with both point-to-point as well as point-to-multi point networks. Point to Point networks can easily deploy and provide high speed data with minimum interference. This Point to Point network usually takes less operating and maintenance cost and also can provide direct services to the end users. On the other hand Point to Multipoint network can provide hundreds of services to subscribers within a single radio environment. Many subscribers use the single radio channel for its communication using multiplexing and queuing method.
The network topology of WiMAX in which two base stations are connected with P-P microwave link . Connections with Base station are usually made by fiber optic cable. High speed line of sight connection with the base station or the base station could provide point to multipoint link which is very cheap and work even in obstructed environment can be established by mounting the WiMAX subscriber station on the rooftop of the customer premises equipment.

**1.2.2 Applications of WiMAX:** There are various technical applications of WiMAX which supports several multiplexing concept. Digital modulation scheme OFDM is especially for broadcasting. It can handle delays between received signals and multipath propagation. At the mobile stations, the OFDM is sensitive to frequency changes. Also OFDMA is a version of OFDM for mobile communication environments. This is advantageous as modulation scheme for wireless communication technologies. It access for Mobile WiMAX is possible if they presents number of subscribers in 3G and 4G also.

 

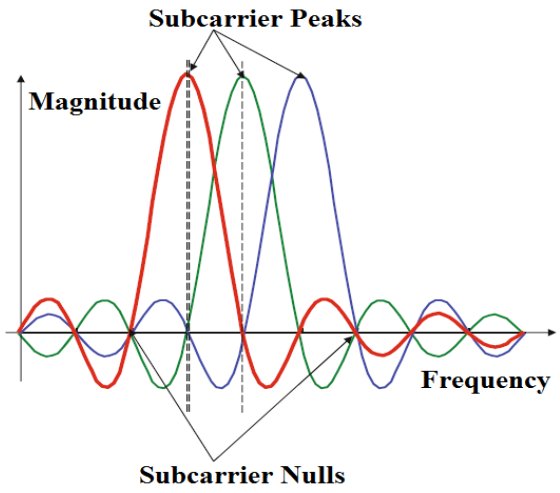


**Figure 3. OFDM Multicarrier System**

From the Figure 3, a property that allows the signals to be perfectly transmitted over a common channel and detected without interference is called orthogonal. In OFDM signal, the peak of one sub carrier coincides with the null of the other sub carriers. Therefore at the peak of spectrums overlaps no interference from other sub carriers.

### 1.2.3 Advantages of OFDM Systems

- OFDM can be used for high-speed multimedia applications with lower service cost. OFDM sub carriers do not interfere with each other.
- Dynamic packet access can be supported by OFDM. Smart antenna can be integrated with OFDM. MIMO system can also be obtained easily with OFDM.
- OFDM is more flexible for single frequency network in broadcast applications.
- OFDM transmitter simplifies the channel estimator for different modulator schemes.
- Its equalization is very simple compared to Single-Carrier systems.
- OFDM can protect energy loss at frequency domain.

## 2. Discussion

Radio over fiber is a flexible which is very cost effective technique that enables multiple functions. In this technique attenuation, dispersion and scattering are also reduced.

- It can improve bandwidth. Here frequency multiplexing is converted into OFDM which is a better solution for future for mobile broadband networks.
- DRoF and ARoF are the two methods which are very useful to the data transmission over RF.
- In this statement it is clear that the WiMAX RoF transmission is less then 40Km and it satisfy the lower cost of power consumption less than -30 dB. Due to this, it will increase the down link transmission of power consumption in the optical to electrical conversion in the access points.
- In uplink transmission it has low noise for the receiver.
- Relay system received optical power which is larger than -20dBm which is a practical power level.
- The up conversion technique from BS to CO is used. Here only Intermediate frequency signal is present over fiber in the front end, and receiver using transistor.
- OFDM conversion technique easily maintains the time and frequency domain. Data can be reduced while sending because the up conversion signal is less then 10GHz.

- To clarify both up and down conversion easily in future, it will implement in millimeter wave with RoF it.
- The Both WDM and OFDM are implemented easily into future broadband access technologies.
- In WiMAX Uplink and downlink transmission both are presented together. But in RoF both are not presented together.
- Increasing signal transmission for various fixed and mobile broadband systems such as UWB and WiMAX is possible.
- Radio over fiber link optimizes minimum and maximum power launched into the fiber. For long distance results SMF is advantages of MMF whereas for small distances MMF is better than SMF.

### 2.1 Comparison of Broadband Access Technology with RoF (WiMAX -RoF)

**Table 2. WiMAX with RoF**

| Parameter | 3G | 4G | WiMAX with RoF |
|---|---|---|---|
| Data throughput | Up to 3.1 Mbps | 40 Mbps | 75 Mbps |
| Frequency Band | 8-2.5 GHz | 2-8 GHz | 10-66 GHz |
| Services and Applications | CDMA | WiMAX2, LTE | Optical fiber into WiMAX |
| Network Architecture | Wide area cell based | Integration of wireless LAN and Wide are | Integration of fiber optical into WiMAX |
| Coverage | 2-3 km | 8 km | Upto 50km |
| Switching technique | Packet switching | Both Packet switching and message switching | Both Packet switching and message switching |

## 3. Conclusion

This paper provides the review of the progress RoF and WiMAX combination. Both enable different functionality whereas the multiplexing concept is coinciding. Therefore to carry out the OFDM of WiMAX and WDM of RoF keying concept is possible. It will support upcoming mobile generation in the world and the future broadband access technology. Also in the WDM-OFDM application it supports many broadband and mobile generation technologies. Additionally, Radio over fiber techniques merged with broadband access with optical networks like in the WDM, OFM and OFDM. From the literature table we observed that development of future WiMAX-RoF architecture and it will support many protocols in the optical and RF signals.

 

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