Study of the Feasibility of Radio over Fiber Technology for WiMAX Systems

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Abstract—To meet the explosive demands of high-capacity and broadband wireless access, modern cell based wireless networks have trends, i.e., continuous increase in the number of cells and utilization of higher frequency bands. It leads to a large amount of base stations (BSs) to be deployed; therefore, cost-effective BS development is a key to success in the market. In order to reduce the system cost, radio over fiber (RoF) technology has been proposed since it provides functionally simple BSs that are interconnected to a central control station (CS) via an optical fiber. The well known advantages of optical fiber as a transmission medium such as low loss, light weight, large bandwidth characteristics, small size and low cable cost make it the ideal and most flexible solution for efficiently transporting radio signals to remotely located antenna sites in a wireless network. In addition to its transmission properties, the insensitivity of fiber optic cables to electromagnetic radiation is a key benefit in their implementation as the backbone of a wireless network. This paper will provide an overview of RoF technology, followed by the description of suitable architectures for the deployment of WiMAX networks employing RoF systems. Main issues and challenges in the deployment of WiMAX employing RoF technology will be discussed in detail after reviewing some experimental and theoretical work. Furthermore, a simulation model for IEEE 802.16e is studied and simulation results are shown.

Keywords—WiMAX; Radio over Fiber Technology; Broadband Wireless

I. INTRODUCTION

For the future provision of broadband, interactive and multimedia services over wireless media, current trends in cellular networks - both mobile and fixed - are 1) to reduce cell size to accommodate more users and 2) to operate in the microwave/millimeter wave (mm-wave) frequency bands to avoid spectral congestion in lower frequency bands. It demands a large number of base stations (BSs) to cover a service area, and cost-effective BS is a key to success in the market. This requirement has led to the development of system architecture where functions such as signal routing/processing, handover and frequency allocation are carried out at a central control station (CS), rather than at the BS. Furthermore, such a centralized configuration allows sensitive equipment to be located in safer environment and enables the cost of expensive components to be shared among several BSs. An attractive alternative for linking a CS with BSs in such a radio network is via an optical fiber network, since fiber has low loss, is immune to EMI and has broad bandwidth. The transmission of radio signals over fiber, with simple optical-to-electrical conversion, followed by radiation at remote antennas, which are connected to a central CS, has been proposed as a method of minimizing costs. The reduction in cost can be brought about in two ways. Firstly, the remote antenna BS or radio distribution point needs to perform only simple functions, and it is small in size and low in cost. Secondly, the resources provided by the CS can be shared among many antenna BSs. This technique of modulating the radio frequency (RF) subcarrier onto an optical carrier for distribution over a fiber network is known as “radio over fiber” (RoF) technology.

On the other hand, to meet the explosive demands of high-capacity and broadband wireless access, millimeter-wave (mm-wave) radio links (26 - 100 GHz) are being considered to overcome bandwidth congestion in microwave bands such as 2.4 or 5 GHz for application in broadband micro/picocellular systems, fixed wireless access and WLANs. The larger RF propagation losses at these bands reduce the cell size covered by a single BS and allow an increased frequency reuse factor to improve the spectrum utilization efficiency. Recently, considerable attention has been paid in order to merge RoF technologies with mm-wave band signal distribution. The system has a great potential to support cost-effective and high capacity wireless access. The distribution of radio signals to and from BSs can be either mm-wave modulated optical signals (RF-over-fiber) or lower frequency subcarriers (IF-over-fiber). Signal distribution as RF-over-fiber has the advantage of a simplified BS design but is susceptible to fiber chromatic dispersion that severely limits the transmission distance. In contrast, the effect of fiber chromatic dispersion on the distribution of intermediate-frequency (IF) signals is much less pronounced, although antenna BSs implemented for RoF system incorporating IF-over-fiber transport require additional electronic hardware such as a mm-wave frequency local oscillator (LO) for frequency up- and down conversion. These research activities fueled by rapid developments in both photonic and mm-wave technologies suggest simple BSs based on RoF technologies will be available in the near future. However, while great efforts have been made in the physical layer, little attention has been paid to upper layer architecture.
Specifically, centralized architecture of RoF networks implies the possibility that resource management issues in conventional wireless networks could be efficiently addressed.

II. RADIO OVER FIBER TECHNOLOGY

Radio-over-Fiber (RoF) technology entails the use of optical fiber links to distribute RF signals from a central location (head-end) to Remote Antenna Units (RAUs). In narrowband communication systems and WLANs, RF signal processing functions such as frequency up-conversion, carrier modulation, and multiplexing, are performed at the BS or the RAP, and immediately fed into the antenna. RoF makes it possible to centralize the RF signal processing functions in one shared location (head-end), and then to use optical fiber, which offers low signal loss (0.3 dB/km for 1550 nm, and 0.5 dB/km for 1310 nm wavelengths) to distribute the RF signals to the RAUs, as shown in Figure 1. By so doing, RAUs are simplified significantly, as they only need to perform optoelectronic conversion and amplification functions. The centralization of RF signal processing functions enables equipment sharing, dynamic allocation of resources, and simplified system operation and maintenance. These benefits can translate into major system installation and operational savings, especially in wide-coverage broadband wireless communication systems, where a high density of BS/RAPs is necessary as discussed above.

![Figure 1: The Radio over Fiber System Concept](image)

One of the pioneer RoF system implementations is depicted in Figure 2. Such a system may be used to distribute GSM signals, for example. The RF signal is used to directly modulate the laser diode in the central site (head-end). The resulting intensity modulated optical signal is then transported over the length of the fiber to the RAU. At the RAU, the transmitted RF signal is recovered by direct detection in the PIN photo detector. The signal is then amplified and radiated by the antenna. The uplink signal from the Mobile Unit (MU) is transported from the RAU to the head-end in the same way. This method of transporting RF signals over the fiber is called Intensity Modulation with Direct Detection (IM-DD), and is the simplest form of the RoF link.

III. BENEFITS OF RoF TECHNOLOGY

Some of the advantages and benefits of the RoF technology compared with electronic signal distribution are given below.

A. Low Attenuation Loss

Electrical distribution of high frequency microwave signals either in free space or through transmission lines is problematic and costly. In free space, losses due to absorption and reflection increase with frequency. In transmission lines, impedance rises with frequency as well. Therefore, distributing high frequency radio signals electrically over long distances requires expensive regenerating equipment. An alternative solution is to use optical fibers, which offer much lower losses. Commercially available standard Single Mode Fibers (SMFs) made from glass (silica) have attenuation losses below 0.2 dB/km and 0.5 dB/km in the 1.5 nm and the 1.3 nm windows, respectively. These losses are much lower than those encountered in free space propagation and copper wire transmission of high frequency microwaves. Therefore, by transmitting microwaves in the optical form, transmission distances are increased several folds and the required transmission powers reduced greatly.

B. Large Bandwidth

Optical fibers offer enormous bandwidth. There are three main transmission windows, which offer low attenuation, namely the 850nm, 1310nm and 1550nm wavelengths. For a single SMF optical fiber, the combined bandwidth of the three windows is in the excess of 50THz. However, today's state-of-the-art commercial systems utilize only a fraction of this capacity (1.6 THz). But developments to exploit more optical capacity per single fiber are still continuing. The main driving factors towards unlocking more and more bandwidth out of the optical fiber include the availability of low dispersion (or dispersion shifted) fiber, the Erbium Doped Fiber Amplifier (EDFA) for the 1550nm window, and the use of advanced multiplex techniques namely Optical Time Division Multiplexing (OTDM) in combination with Dense Wavelength Division Multiplex (DWDM) techniques.

C. Immunity to Radio Frequency Interference

Immunity to electromagnetic interference is a very attractive property of optical fiber communications, especially for microwave transmission. This is so because signals are transmitted in the form of light through the fiber. Because of this immunity, fiber cables are preferred even for short connections at mm-waves.

![Figure 2: RoF - Basic Structure of the System](image)
D. Easy Installation and Maintenance

In RoF systems, complex and expensive equipment is kept at the head-end, thereby making the RAUs simpler. For instance, most RoF techniques eliminate the need for a LO and related equipment at the RAU. In such cases a photo-detector, an RF amplifier, and an antenna make up the RAU. Modulation and switching equipment is kept in the head-end and is shared by several RAUs. This arrangement leads to smaller and lighter RAUs, effectively reducing system installation and maintenance costs. Easy installation and low maintenance costs of RAUs are very important requirements for mm-wave systems, because of the large numbers of the required RAUs.

IV. LIMITATIONS OF ROF TECHNOLOGY

Since RoF involves analogue modulation, and detection of light, it is fundamentally an analogue transmission system. Therefore, signal impairments such as noise and distortion, which are important in analogue communication systems, are important in RoF systems as well. These impairments tend to limit the Noise Figure (NF) and Dynamic Range (DR) of the RoF links. DR is a very important parameter for mobile (cellular) communication systems such as GSM because the power received at the BS from the MUs varies widely. That is, the RF power received from a MU which is close to the BS can be much higher than the RF power received from a MU which is several kilometers away, but within the same cell.

The noise sources in analogue optical fiber links include the laser’s Relative Intensity Noise (RIN), the laser’s phase noise, the photodiode’s shot noise, the amplifier’s thermal noise, and the fiber’s dispersion. In Single Mode Fiber (SMF) based RoF systems, chromatic dispersion may limit the fibre link lengths and may also cause phase de-correlation leading to increased RF carrier phase noise. In Multi-Mode Fiber based RoF systems, modal dispersion severely limits the available link bandwidth and distance. It must be stated that although the RoF transmission system itself is analogue, the radio system being distributed need not be analogue as well, but it may be digital (e.g. WLAN, UMTS), using comprehensive multi-level signal modulation formats such as xQAM, or Orthogonal Frequency Division Multiplexing (OFDM).

V. COST EFFECTIVENESS OF ROF TECHNOLOGY

Conventional BS drives the antennas over lossy electrical cable which necessitates the location of the BS very close to the antennas. This can create problems with acquiring suitable sites for coverage extension. It also increases the capital and operational expenses due to site purchasing or leasing, new BS installation and maintenance. Utilizing the idea of RoF and BS hostelling, one BS can control several RAUs and new BS is not required for coverage extension. The additional antennas can be served from the existing BS close to the cell tower. This dramatically reduces the requirements for cell site footprint and the cost of site acquisition. The electrical cables that drive the antenna are responsible for large amount power loss of the BS. The loss in these cables and their associated connectors can range from a typical value of 3db to as much as 10dB in extreme cases which means 50% to 90% of the radio transceiver’s output power is dissipated in cable transmission. All this extra power required to drive the electrical feeder cables means that higher output power amplifiers must be deployed. These high power amplifiers are more expensive and have poor operating efficiencies of around 10%, further compounding the problem of high energy consumption by BS. By feeding the RAUs with optical fiber, transmission to the antenna location can be made virtually almost loss-free except some small amount of loss in the short electrical cable connections between the RAUs and the antennas.

In the conventional BS, the power dissipated as heat by the low-efficiency amplifiers requires the BS enclosure to have sophisticated metal enclosures with climate control facilities such as air conditioning, which also increases the expenses. RoF offers large reduction in the amount of thermal energy dissipated by the system. This means that the RAU can be designed without the need for any expensive climate control facilities at the remote site. In addition, the BS hostel can be installed in the more benign environmental conditions of an indoor facility. From the above discussion, it is clear that RoF technology has lots of possibilities to reduce the capital and operational expenses. In order to check the feasibility of transmission of IEEE 802.16a based WiMAX data through optical fiber link, we have done the simulation study.

VI. APPLICATIONS OF ROF TECHNOLOGY

Some of the applications of RoF technology include satellite communications, mobile radio communications, broadband access radio, Multipoint Video Distribution Services (MVDS), Mobile Broadband System (MBS), vehicle communications and control, and wireless LANs over optical networks. The main application areas are briefly discussed below.

A. Cellular Networks

The field of mobile networks is an important application area of RoF technology. The ever-rising number of mobile subscribers coupled with the increasing demand for broadband services have kept sustained pressure on mobile networks to offer increased capacity. Therefore, mobile traffic (GSM or UMTS) can be relayed cost effectively between the SCs and the BSs by exploiting the benefits of SMF technology. Other RoF functionalities such as dynamic capacity allocation offer significant operational benefits to cellular networks.

B. Wireless LANS

As portable devices and computers become more and more powerful as well as widespread, the demand for mobile broadband access to LANs will also be on the increase. This will lead once again, to higher carrier frequencies in the bid to meet the demand for capacity. For instance current wireless LANs operate at the 2.4 GHz ISM bands and offer the maximum capacity of 11 Mbps per carrier (IEEE 802.11b). Next generation broadband wireless LANs are primed to offer up to 54 Mbps per carrier, and will require higher carrier...
frequencies in the 5 GHz band. Higher carrier frequencies in turn lead to micro- and pico-cells, and all the difficulties associated with coverage discussed above arise. A cost effective way around this problem is to deploy RoF technology. This greatly simplifies the remote transponders and also leads to efficient base station design.

C. Vehicle Communication and Control

This is another potential application area of RoF technology. Frequencies between 63-64 GHz and 76-77 GHz have already been allocated for this service within Europe. The objective is to provide continuous mobile communication coverage on major roads for the purpose of Intelligent Transport Systems (ITS) such as Road-to-Vehicle Communication (RVC) and Inter-Vehicle Communication (IVC). ITS systems aim to provide traffic information, improve transportation efficiency, reduce burden on drivers, and contribute to the improvement of the environment. In order to achieve the required (extended) coverage of the road network, numerous base stations are required. These can be made simple and of low cost by feeding them through RoF systems, thereby making the complete system cost effective and manageable.

VII. ROF BAASED WiMAX SYSTEM

In this section, some possible RoF deployment scenarios for WiMAX data transmission are proposed as a means for capital and operational expenses reduction. IEEE 802.16a standard based end-to-end physical layer model is simulated including intensity modulated direct detection RoF technology.

Due to the ever-increasing demand of wireless communication and mobility, various wireless communication systems have been developed and deployed. Worldwide Interoperability for Microwave Access (WiMAX) system is now closely examined by many companies for the last mile wireless connectivity to provide flexible broadband services to end users. The technology is based on the IEEE 802.16 and 802.16e standards. According to the WiMAX standard, the cell coverage can typically extend to 5km in the air, with higher data rate and more selectable channel bandwidth than 3G system. Radio-over- fiber (RoF) nowadays is a hot topic for integrating optical technologies with wireless systems. RoF deploys optical fiber, which has low loss and high bandwidth, to distribute radio frequency (RF) signals from central station (CS) or base station (BS) to remote antenna units (RAUs). For some applications, such as inside a long tunnel with many bends, the deployment of the wireless WiMAX is greatly hindered. Because of this, using RoF to carry the WiMAX signal is a good solution.

A. RoF Deployment Scenarios

Rapidly increasing demand for broadband services like high speed internet access and mobile multimedia forcing towards smaller radio cell size. Smaller cells imply that more antennas are needed to cover a certain area. Such an area may include the rooms in a residential home, a hospital, an office building, an airport lounge, or a conference site, etc. When it needs so many antenna sites, it becomes economically attractive to locate the microwave signal generation and modulation at a central BS from where the radio signals will be transmitted to the RAUs using RoF. The antenna units have to do the simple optical-to-electrical conversion, and to emit and receive the wireless signal. Centralizing the sophisticated signal handling process can bring many advantages in operating, maintaining and upgrading wireless networks. In WiMAX service provisioning, several approaches can be taken to utilize the benefits of RoF. Two particular deployment scenarios are given in Fig. 3 and Fig. 4.

Figure 3: In Building Deployment Scenario of WiMAX over RoF

Fig. 3 shows indoor WiMAX cells, inside the residential buildings, offices, underground subways, tunnels, or shadowed areas, are served by the distributed antenna systems, where the RAUs are fed by WiMAX over fiber links from the WiMAX BS via a control station. BS hosting can be another cost reducing deployment of RoF as shown in Fig. 4, where multiple macro cells are covered by a central BS and RoF links are used to feed the antenna in each cell. This type of deployment scenario results in lower capital and operational cost for the service providers.

B. Experimental Study Related to WiMAX RoF

In this section two different experiments related to check the feasibility of RoF for WiMAX are described in detail. Some of the good experimental results are summarized at the end of each sub-section.

a) Experiment for TDD Switching Architecture of WiMAX

Using time-division-duplex (TDD) is favored by a majority of implementations in wireless systems because of its advantages of providing flexibility in choosing uplink (UL)-to-downlink (DL) data rate ratios and having less complex transceiver design. However, it is worth to mention that the TDD system limits the transmission distance of systems.
The standard WiMAX signal generated from a commercial base station (BS) is applied to the RoF system. It is observed that the maximum effective transmission length of the WiMAX RoF system is mainly limited by the synchronization in the TDD mode and not by the signal-to-noise ratio (SNR).

TDD switch (SW) architecture is needed at the RAU in the WiMAX RoF link for switching between the UL and DL signals. In order to emit higher power for the RAU, leakage power from the DL may cause damage to the electronic components, such as RF amplifier, in the UL. A robust TDD switch architecture with self-detected switching in each RAUs is studied for the WiMAX RoF system.

The WiMAX signal access network using RoF is shown in Figure 5. In this RoF link, a head-end (HE), which consists of an optical-to-electrical (O/E) and an electrical-to-optical (E/O) modules, is used to connect to the BS. A remote antenna unit (RAU) will be used in each picocell.

In order to realize the WiMAX RoF system, an experiment is performed. Here, Figure 6(a) shows the proposed WiMAX RoF link connecting a HE and a RAU. The HE and RAU consist of a pair of E/O and O/E converters for converting electrical and optical signals. To characterize and analyze solely the performance of the WiMAX RoF system and to remove the atmosphere multipath fading effects of the signal, the antenna (ANT) in the RAU and mobile station (MS) are purposely removed. For the reported WiMAX-over-fiber system, the conventional antenna connecting to the base station via the electrical RF cable has been replaced by a pair of O/E-E/O converter and optical fiber. The detection of multipath fading signals in the conventional wireless antenna is the same as that by using the RAU. Since multipath fading issue has been considered in standard wireless WiMAX system, the multipath fading issue is not the main interest in this report. And this is the reason that the setup is simplified by focusing on the performance analysis owing to the optical fiber solely.

Hence, the RAU and MS are directly connected using high frequency electrical cables via a RF circulator (CIR), RF variable attenuator (VA) and a RF splitter (SP). According to WiMAX standard, for the TDD-based operation, there are two time gaps of transmit/receive transition gap (TTG) and receive/transmit transition gap (RTG) between DL-and-UL and UL- and-DL, respectively, as shown in Figure 7.

The maximum time gaps of TTG and RTG are 105 and 60 µs, respectively, in standard WiMAX system. Initially, the WiMAX signal access was for UL traffic. After ending gap time of RTG, the BS begins to transmit the DL signal. The signal switching can be achieved by using 1 X 2 RF switch (SW) in BS and control by MAC within the gap time of RTG, as shown in Figure 8(a). However, when using the WiMAX access in RoF link, as seen in Figure 8(b), the TDD switch design of the distributed RAU must complete the DL/UL signal switching within the gap times of TTG and RTG. Besides, the maximum WiMAX output power emitted from BS was 35 dBm. Thus, the higher launched power to the ANT at RAU is desirable in order to increase the emitted RF signal power in WiMAX RoF system. Furthermore, due to the intrinsic power isolation of RF circulator, the leakage power from the DL may cause damage to the UL components, such as the low noise amplifier (LNA). Thus, the RF switch design
in RAU must take into account the TDD signal operating and high leakage power.

**Figure 8:** (a) WiMAX TDD switching for DL and UL traffic of BS. (b) TDD switching of RAU in WiMAX RoF architecture

Figure 9 shows the proposed TDD switch in the RAU, which is used to solve the limited power isolation issue of typical high-speed RF device and the TDD operating (used in the experiment). Hence, higher RF power can be launched into the ANT in order to enhance the SNR, while preventing the leakage power may cause damage to the electrical components. The proposed RAU consists of a 1X2 switch (SW1), a 1X1 switch (SW2), a power amplifier (PA), a low noise amplifier (LNA), a delay element (DE), a detector (DT), a control circuit (CC), and a pair transceiver (E/O and O/E converter), as shown in Figure 9. Based on the WiMAX standard, the maximum WiMAX power can be amplified to 35 dBm. To avoid the leakage power of DL signal into the LNA in the UL, two switches: SW1 and SW2 are used to block the leaked DL power. In addition, the proposed TDD switch also needs to consider the signal transmission completely under the gap times of TTG and RTG in fiber link. Moreover, the proposed TDD SW design with self-detection not only avoids the higher leakage power, but also can synchronize the DL and UL data traffic. For IEEE 802.16e WiMAX, the maximum time gaps of TTG and RTG are 105 and 60 µs, respectively. The TTG frame is 105 µs, which equates to approximately 9km roundtrip over standard single mode fiber (SMF). This is the theoretical maximum transmission distance for the WiMAX RoF governed by the WiMAX protocol for waiting the acknowledgement signal. The maximum fiber length may be reduced when the switching or electrical to optical conversion delays are included.

**Figure 9:** The proposed RAU scheme.

SW1: 1X2 switch; SW2: 1X1 switch; PA: power amplifier; LNA: low noise amplifier; DE: delay element; DT: detector; CC: control circuit; ANT: antenna.

**VIII. WiMAX PHYSICAL LAYER SIMULATION MODEL**

Fig. 10 below depicts the Physical layer of 802.16a and a classical IMDD optical link model for transmitting the signal to RAU. The laser diode is modulated by the RF signal in the downlink path. The resulting intensity modulated optical signal is then transmitted through the single mode fiber towards a RAU. At the RAU end, the received optical signal is converted to RF signal by direct detection through a PIN photodetector. The signal is then amplified and radiated by the antenna. The Uplink signal is transmitted from the RAU to the BS in a similar way.

**Figure 10:** IEEE 802.61a Model with RoF using MATLAB

**A. Laser and Photodiode Mode**

The laser is usually a significant source of noise and distortion in an ROF link, and laser diode normally exhibits nonlinear behavior. When it is driven well above its threshold current, its input/output relationship can be modeled by a Volterra series of order 3 [6]. However, if the signal current dynamic range is within the linear region of the laser diode, it obviously will show linear response. In our present simulation we assume ideal linear characteristic of the laser diode. Output optical power versus current can be given as:

$$P_{opt} = \left( \frac{hf}{e} \right) \eta_L (I(t) - I_{th})$$  \hspace{1cm} (1)$$

where \(I(t)\) is input current of the microwave signal including the dc bias, \(I_{th}\) is diode threshold current, \(h\) is Planck constant, \(f\) is frequency in hertz, \(e\) is charge of an electron, and \(\eta_L\) is laser quantum efficiency [1]. The detection of transmitted light waves is performed primarily by the photo-detector. In most cases the received optical signal is quite weak and thus electronic amplification circuitry is used, following the photodiode, to ensure that an optimized power signal-to-noise (SNR) is achieved. The PIN photodiode and receiver total noise are calculated and superimposed over the ideal photodiode signal current. To evaluate the effect of noise...
added during the amplification process, a mathematical model explained in [1] has been used in our simulation. The noise in photodiode includes quantum shot noise $i_{sh}$, dark current noise $i_{dk}$, and the thermal noise $i_{th}$. The total current generated by the photodiode when optical power falls on it is expressed by

$$i_{total} = I_p + \sqrt{\langle i_{noise} \rangle^2}$$

(2)

Where $I_p$ and mean squared noise is given by:

$$I_p = \frac{\eta P_{opt} e}{hf}$$

$$\langle i_{noise} \rangle^2 = \langle i_{sh}^2 \rangle + \langle i_{dk}^2 \rangle + \langle i_{th}^2 \rangle$$

And

$$\langle i_{sh}^2 \rangle = 2eI_p B$$

$$\langle i_{dk}^2 \rangle = 2eI_d B$$

$$\langle i_{th}^2 \rangle = \frac{4kTB}{R}$$

Where $I_d = 25nA$, is assumed to be dark current obtained from the DSC10H PIN photodiode datasheet of Semiconductor, Inc. $B$ is the photodiode 3dB bandwidth, $B K$ is Boltzmann’s constant, $T$ is the absolute temperature (°K), and $R$ is the photodiode load resistor assumed to be 50 ohm for ultra wideband receiver.

B. Simulation results

In order to study the feasibility of transmission of WiMAX signals through single mode fiber by IMDD, the simulation was carried out using MATLAB. The model consisted of IEEE 802.16a end-to-end physical layer. More specifically, it modeled the OFDM-based physical layer for downlink, supporting all of the mandatory coding and modulation options. The laser and photodiode are modeled using (1) and (2), respectively.

Fig. 11 show the simulation results for bit error rate vs different SNR values for BPSK without RoF and with RoF. It can be noticed from the figure that the introduction of fiber introduces a high bit error rate because the amplifier is not used at the receiving end. But the introduction of RoF will enhance the coverage area without the need for additional Base Stations, thus reducing the cost of overall deployment. Similar results are obtained for 16QAM with 2/3 coding as shown in Figure 12. These results can be interpreted as same as for the BPSK.

IX. CONCLUSION

Objective of this study was to investigate RoF technology for the transmission of WiMAX signals to the RAUs and hence to suggest feasible RoF deployment scenarios to reduce the capital and operational expenses of the service providers. We studied the performances and limitations of standard WiMAX signal optimized for wireless communication to the commercial RoF system. Results show that the effective RoF transmission fiber length is limited to 8km SMF transmission due to the TDD framing in the connection using standard WiMAX signal. The study results imply that if the total length of the WiMAX RoF is 8 km, the distance between the MS and RAU should be very close. Furthermore, the simulation results obtained proved the feasibility of RoF for WiMAX system.

REFERENCES


