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Radio over Fiber (RoF): A New Approach to High Speed Access Network

Rajiv Chechi*
ECE Deptt., Haryana College of Tech. & Management (Kaithal), India

Mukhwinder Kaur
ECE Deptt., Haryana College of Tech. & Management (Kaithal), India
mukhvinderkaur24@indiatimes.com

Bhawna
ECE Deptt., Haryana College of Tech. & Management (Kaithal) India

Abstract: RoF (Radio over fiber) technology is emerging as an ideal technology for high speed access networks. This paper presents that wireless communication systems need a high density of remote antenna units (RAUs), high frequency carriers to have both high transmission capacity and wide signal coverage.. In this paper, main characteristics, basic design advantages, and network architecture are depicted with increased flexibility in resource management.

Keywords: - ROF, MIMO, WLAN, TDMA, CDMA, MA

I. INTRODUCTION

This document describes, and is written to conform to, author guidelines for the journals of AIRCC series. Radio over Fiber (ROF) is a technology which provides wireless access by sending signals in optical medium between main station and other base stations.[1] This technology has become important and major technology in wireless applications. The potential market in the multimedia services will be met by this ever growing ROF technology.

This technology is currently used in various applications telecommunication broadband systems, base stations optical networks to name a few. Ever increasing mobile subscriber base has pushed the mobile companies to provide better and enhanced capacity. Narrow band wireless systems cannot match this demanded capacity since they have low frequency operation [2] [3]. Capacity related issues in wireless systems can be resolved by providing small cells instead of large cells, frequency can be reused by using small cell sizes which will lead to enhanced spectral efficiency.

But implementation of smaller cell sizes has some cost involved with it; Cost of large number of base stations, to meet the service needs of these base stations, large number of feeder networks will be required as well. So the cost of base stations and the feeder networks becomes an important factor to allocated between Control station and the base stations. RF signal processing is centralized in one dedicated location by making use of single mode fiber. The architecture is discussed in brief.

II. WHAT IS RADIO OVER FIBER?

Radio over fiber is an amalgamation of wireless along with fiber optic networks. In Radio over Fiber technique, RF signals are distributed from a central location to Remote antenna units. Wireless signals are channelized between a main station and various other base stations in optical form.[2][4][5] Base stations transfer data to mobile stations which are within the range of that base station. In RoF optimal use of the transferring the signal is used by ensuring minimal loss during the transfer of RF signals to the remote antenna units. The signal processing is centralized in RoF, which offers a few advantages like ease of operation, ease in equipment sharing.

Low power radio access points ensure enhanced frequency reuse and better capacity of the system. RoF technology connects radio access points to control stations.[1] Rof technology's architecture consists of a network system which uses an antenna network, and at these antenna's – demultiplexing and signal processing is done by transferring the RF signals to the control stations via a optical fiber.

III. WORKING IN WIRELESS

Wireless network coverage for the end users in coming years will become an essential technology for communication network [5] to offer a wide range of broadband services, better and faster systems are required to offer faster data transmission. Historically RoF signals were used for transportation and mobility functions but nowadays RoF signals provide a vast array of functionalities beside their basic function which can facilitate the growing demand for increased capacity.

The major functions are data modulation and frequency conversion to name a few. Intensity Modulation and Direct Detection is the most basic form of RoF link, it's a simple method to transport RF signals over the fiber.[9] The electrical signal generated out of this process must meet the criterion needed by the wireless applications. Optical fiber link delivers the radio signals directly thereby eliminating the need of high frequency carriers at the antenna site.

A. Realization of Wireless Network Using ROF Double Multiple Access:

A network considered for the transfer via RoF comprises of the physical layer mainly poised of two sub-layers: conventional wireless layer and the optical layer. In its simplest form the optical layer will form a star network connecting a fiber to central location and base station. but in

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present times a large number of base stations are require because of heavy load [10] So if a fiber will be connected to more than one base station then an optical layer will act as a second multiple access (MA) system being independent from the regular wireless multiple access system.Different MA techniques that can be applied in the optical layer are sub-carrier multiplexing (SCM), TDMA, CDMA, WDM (wavelength division multiplexing).

Various services are operated by various radio frequencies, distinct RF Modulation scheme along with variable cellular structure. The services can be wireless, fixed or wideband or narrowband.

IV. DIFFERENT MULTIPLEXING SCHEMES IN ROF FOR WIRELESS

In this section different multiplexing schemes in field of ROF for wireless communication are explained in brief:

A. Wavelength Division Multiplexing in RoF Systems:

Wavelength division multiplexing has gained prominence in recent times for distribution of RoF signals. [12] WDM enhances the efficiency of fiber network's bandwidth, but spectrum utilization is not optimized in WDM hence alternate methods to improve spectrum efficiency have been proposed.

B. Sub-Carrier Multiplexing in RoF Systems:

Sub carrier multiplexing is a relatively new technique which is simpler and cheap way of expanding the optical fiber bandwidth in optical communication systems [11] SCM also supports mixed mode data traffic. One limitation of SCM is that being an analog modulation technique, it is prone to noise and distortions.

V. ADVANTAGES OF RADIO OVER FIBER

A. Less Attenuation :

Using an optical fiber results in much less attenuation as compared to other sources also use of optical fiber eliminates the use of repeaters. The attenuation losses of optical fiber is less than coaxial cable and twisted pair.

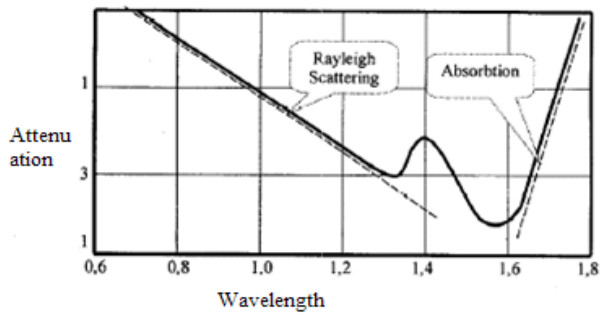

Figure. 1 Attenuation in optical fiber

B. Low Complexity

Remote stations are used under RoF technique, all the hardware can be arranged at on dedicated centralized location allowing the architecture to be simple.

C. Lower Cost:

As a result of simple architecture the cost of infrastructure is lower; maintenance costs are also lower for this technique as compare to other.

D. Large Bandwidth:

With the use of RoF technique the bandwidth is greatly enhanced with the reuse of frequency. The eminent bandwidth is the biggest advantage of fiber.

E. Easy Installation :

A RoF technique doesn't need all the equipment to be kept at the remote stations resulting in easy installation process. Thus they can be easily installed.

F. Flexibility:

RoF techniques increase operational flexibility for e.g.: Intensity modulation and direct detection technique may be operated as a linear system thereby making it transparent system.

VI. LIMITATION OF ROF IN WIRELESS

RoF links predominant in the market don't have much frequency ranges, the available systems are narrowband systems [8]. Numerous RoF links will be needed in case a system is supposed to carry multiplicity of services. There is a scope for a broadband solution which can fix this problem.

Most of the services have low carrier frequencies. Carrier frequency has not risen with the ever increasing need for increasing capacity, there is a great scope to increase the capacity of the systems or a broadband solution can be made available to tackle this problem.[12] [9].

a. Rof systems receive analogue signal from a Base station or from a receiver an then channelizes it to a remote antenna, during this course noise and distortion is added to the analogue signal which in turn limits the range.
b. Ensuring minimum data rates would be a major challenge for fiber networks.
c. High installation costs are a major bottleneck in the penetration of this network, reducing the length of the fiber used under the network might result in lesser installation costs.
d. Operational costs will also be relatively higher under this network as the numbers of transrecievers used are large to provide better mobile coverage.
e. Opto electronic interface is the other major issue in radio over fiber.
f. The dynamic range is limited and non linear distortions occur in it.

VII.FUTURE SCOPE OF RADIO-OVER-FIBER

Reach of the RoF is very good; it can access areas where other sources like wireless don't have any penetration [10] [13].

A. Fiber to the Antenna (FTTA):

Direct connection of an optical fiber with the antenna offer numerous advantages to the vendor by minimizing line losses and provide immunity against thunders. Optical connection ensures minimal line losses and decreased complexity by using light weight optical to Electrical convertor.

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B. ROF for MIMO:

By using several antenna sunder a single ROF cell, multiple-input multiple-output (MIMO) transmission technology can be put to use.

C. Access to dead zones:

We can use Rof to have wireless coverage in area where wireless backhaul link cannot exist. That zone can be inside a structure like Mountainous places, areas behind buildings, or secluded areas such jungle or a tunnel. [7]

VIII. CONCLUSION

Radio over fiber has evolve as an elemental technology for assimilation of broadband wireless and optically access networks and allows a adaptable access network capable of providing wireless connectivity to a variety of services and applications. RoF technologies can provide a range of benefits including the realization of a future proof architecture with the ability to support multiple radio services and standards. It provides an adaptable, reliable medium for distant interfacing with various distantly placed antennas by reducing system complexity with a centralized architecture.

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