

Title:	WiMAX over RFoG : White Paper		
Revision:	1.2	Date:	25-Jan-09

WiMAX over RFoG
White Paper
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1 REVISION HISTORY

Table 1 Document Revision History

Revision	Date	Description	Author/Editor
1.0	Dec 24, 2008	Initial release	Kemal Ozdemir
1.1	Jan. 13, 09	First revision	Henry Hung
1.2	Jan. 25, 2009	Minor revision	Kemal Ozdemir

2 INTRODUCTION

The convergence of communication services, namely voice, video and data, are based on Internet Protocol (IP). Communications services based on IP are efficient, low cost and well defined. These digital services are delivered by fixed optical fiber networks (**fiber-based**), such as HFC, RFOG and GEAPON. Or they can be delivered via RF-based (**wireless**) networks that include 3G, WiFi and Edge networks.

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However, they are very different in their nature and operation principle. The wireless networks have the benefits of mobility, ease of connection and flexible installation. The fiber-based standards, like HFC, RFOG and GEAPON and its varieties, are highly reliable and offer broader bandwidth.

The current architecture of existing fiber-based and wireless systems is shown in Figure 1. With emergence of new wireless technologies, such as WiMAX, a million dollar question is whether the future communication networks will be leaning toward fiber-based or wireless. By analyzing the usage of communication networks, the existing and future application, the cost, and other factors, the CableShopper Inc (CSI) & QAMnet LLC (QNL) envision the convergence of fiber-based and wireless networks. Since these services are all IP based, the integration of different systems should be straightforward. In fact, we anticipate that the fiber-based connections to homes and business will continue; while the emerging wireless services will complement these systems as an additional connectivity that provide dynamic and mobile communication.

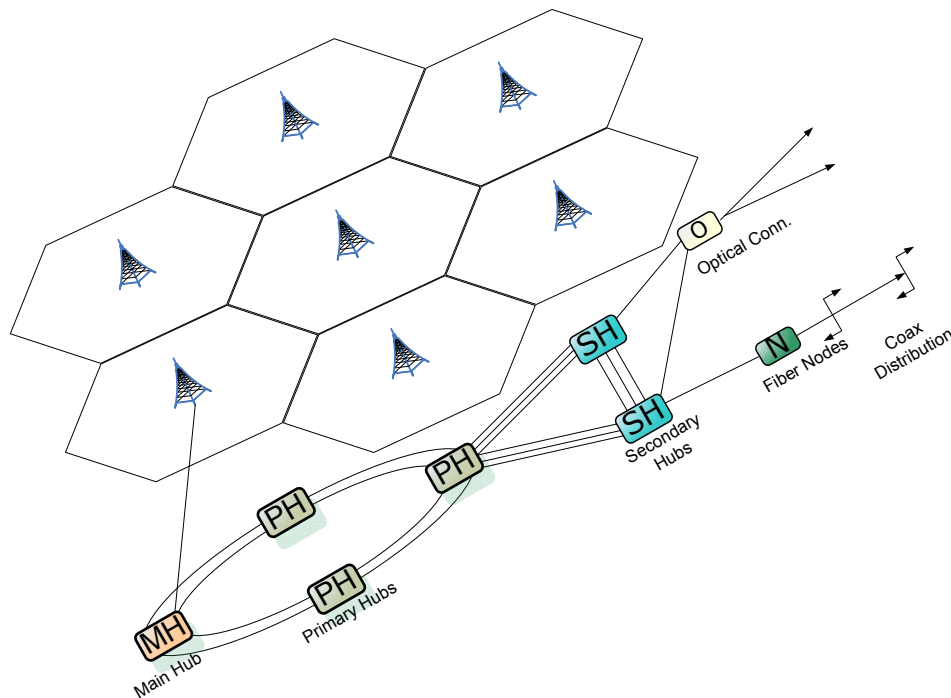


Figure 1 Existing Wired and Wireless Architecture

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3 THE NEED FOR WIMAX OVER RFOG

While wireless technology is evolving quickly, on the fiber-based side, the technology is also moving at a fast pace. Over the last 20 years, CATV services providers have installed HFC fiber infrastructure in most communities throughout North America. The recent introduction of RFOG or GEAPON based networks delivers high data rate and with FTTx architectures users can now benefit high data rates. One advantage of the FTTx architecture is that the fiber is now available to the last mile. A study performed by Roger's Communication Inc. wireless division of Canada shows that between 65% and 75% of the mobile calls are made within a reach of wire line phone [1]. Although this study is more towards the users relying more on wireless services, we extract another conclusion that wired infrastructure exists in 75% of the mobile communication points. We indirectly assume that for the 75% of mobile calls, there will be fiber lines available within one mile, or last mile.

While Figure 1 is a good representation of the overlapping of fiber-based and wireless systems, the fact that the existing fiber-based and wireless systems are decoupled for most of the coverage area makes the two systems very much independent from each other. The existing optical fiber infrastructure is rarely shared with the wireless systems. To implement a comprehensive all-WiMAX networks, a very significant capital investment will be required. The links between WiMAX base stations and the central router will be very costly to build. Moreover, failures other than RF at the wireless base stations require truck rolls and in most cases technical experts need to be on site for the problem resolution. Another significant issue is that the aggregation of data from WiMAX base stations to the router will limit overall data bandwidth.

If the WiMAX wireless base stations were to be located in a headend of HFC/RFOG networks, then this would significantly reduce the cost of infrastructure building. MSO companies have invested billions of dollars in installing optical fiber networks throughout North America. This design also brings many advantages to the operators; mainly the operating cost reduction due to the centralized maintenance and enhanced connectivity. Hence, it is desirable from an operator's point of view to have WiMAX base stations located at the headend. In this case, the fiber-based systems will be the optical conduit for the WiMAX wireless services. However, the question remains on how to bring the WiMAX base stations into the headend?

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With the wireless bringing the flexibility in mobile communication with now higher data rates, and fiber-based networks extending fibers down to the curbs or homes, and the user applications requiring mobile and fixed site (i.e. homes, business), it is natural to expect a system that enables the convergence of both fiber-based and wireless technologies that are easy to integrate and that complement each other. By using patented optical technology developed by QAMnet LLC [3] and [4], we can transmit wireless WiMAX channels along with HFC/RFOG channels in the existing optical fiber. This design enables the convergence of HFC/RFOG networks and WiMAX system into fully integrated communication networks.

With these points, we offer the following architecture that introduces the new systems as an overlay of the legacy HFC systems (See Figure 2).

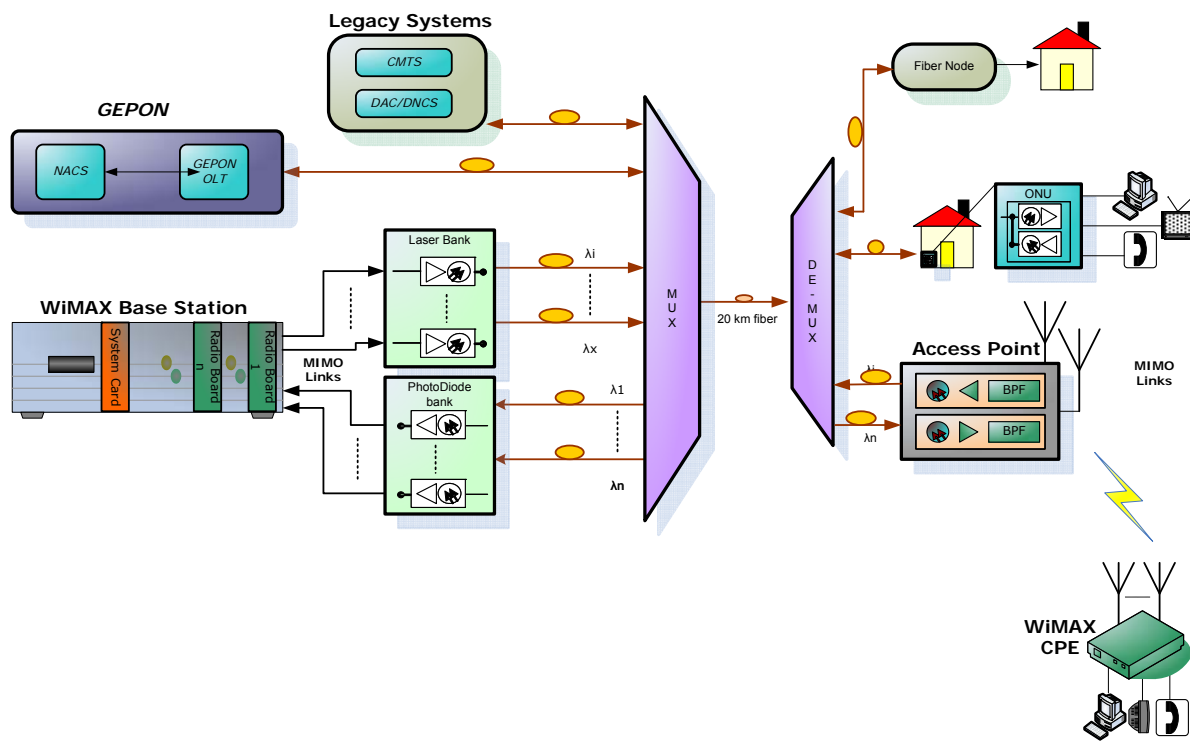


Figure 2 WiMAX over RFOG with legacy systems support.

The proposed architecture exploits existing fiber deployment and access points are placed in required places based on the need. It is anticipated that the proposed architecture co-exists with the existing broadband technologies like HFC/RFOG

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systems or GEAPON networks. Hence, the WiMAX over HFC/RFoG architecture is transparent to the existing system.

The key ingredients of the proposed architecture are the delivery of high frequency RF content over fiber and relocation of base stations intelligent equipment into the headend for control and data aggregation. The first item is described in detail in the technical aspect while the latter is discussed more in the next section.

It should be noted that the proposed architecture is not to replace the existing broadband solutions but rather to complement or providing the wireless connectivity as an additional link in the fiber-based system. Typical applications can be wireless access to the mobile users, areas without cable infrastructure, the use of WiMAX for the return path of existing broadband services, femto-cell applications etc. The application of the proposed architecture can be investigated for all these possible applications, but in the current paper, we will only concentrate on providing wireless access to the mobile users.

4 COEXISTENCE OF WIMAX WITH EXISTING ARCHITECTURES: A TECHNICAL ASPECT

- Henry to complete in terms of the system’s introduced CINR.
- Kemal then to use this number to ensure that WiMAX over RFoG is feasible by ensuring CINR required for WiMAX link is to support all the modulations.

5 BENEFITS OF THE PROPOSED ARCHITECTURE

The proposed architecture still keeps the wireless and fiber-based architecture coexistence as shown in Figure 3. The key to the proposed architecture is the transfer of intelligent WiMAX base station equipment to the headend. This way the most important capital of a base station is internally controlled and for troubleshooting there will be no need to send technical experts to the field. Moreover, data connection to other types of headend equipment like gateways and routers is much easier and low-cost compared to having the base stations on the field.

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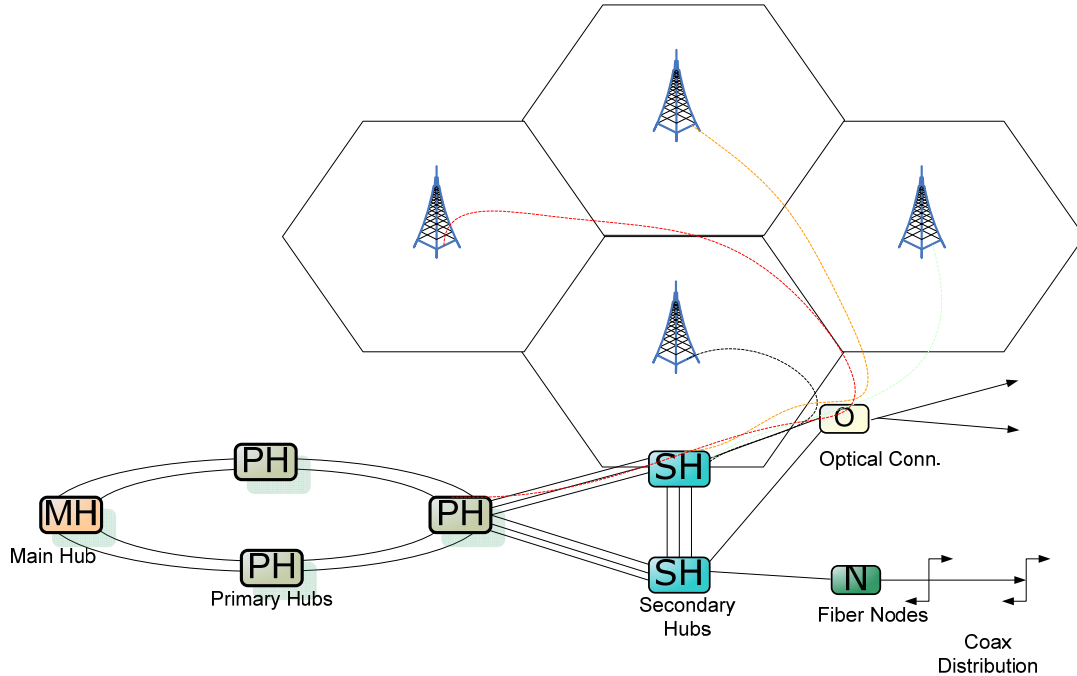


Figure 3 System Architecture of WiMAX over RFoG

Moreover, the towers now only carry the access points that are transceivers between optical and RF signals. Due to the use of different wavelengths in the optical domain and the access point being a dummy transceiver, FDD mode is well suited for the proposed architecture.

In terms of the cost savings, the followings are the key cost factors:

1. The elimination of base station housing to keep the devices. Hence, the elimination of heaters, AC units, and the outdoor base station enclosure, total which can be more than \$1K.
2. The trucks rolls are eliminated since most of the truck rolls are for the failures in base station chassis. Considering truck rolls for WiMAX to be anything between \$350 to \$500, this means at least \$500 saving per base station (Reference [2]).
3. A centrally co-located base stations for easy to configure, test, debug, and troubleshoot. Again truck rolls are saved with a centralized system.
4. Since fiber exists in many locations, the access points can be located at any convenient location while the base station stays in the headend.

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5. A significant saving also comes from not having to install a link, wireless or fiber-based, between base stations and Head End. Depending on the distance and type of installation, the cost per link can be up to \$100K.
6. Centrally located base stations will also make data aggregation much easier to realize.

Some of the risks with the proposed architecture are that now the headend becomes over-crowded with the equipment that more space would be needed. Also more equipment means more thermal management. However, it is believed that the benefits outperform these drawbacks, which can be mitigated.

6 CONCLUSION

WiMAX has set itself as one of the key IP based technologies for the future with the support of mobility. The users, on other hand, prefer to use wireless systems even due to their convenience. This white paper proposes an architecture that enables WiMAX systems to utilize the existing optical distribution systems and hence provide better coverage and mobility to wireless users. The proposed architecture centralizes base stations into headend and hence aims to eliminate the truck rolls.

7 REFERENCES

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- [3] U.S. Patent # 6,587,239 (Feb, 23, 2000) Optical fiber network having increased channel capacity
- [4] U.S. Patent # 6,583,901 Optical communications system with dynamic channel allocation

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