WCA October 17, 2006 Meeting:

Advanced Wireless Architectures to Facilitate Convergence of Services

Part 2 – Radio Over Fiber Architecture

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Disclaimer:

All inferences, interpretations, and implications found in this report are the opinion of this author and do not in any way reflect a WCA position. The subjective statements by this author, if any, are expressed *in italics*.

Author's Notes clarify and provide background information on subject matter introduced by the speakers.

Introduction

The first part of this article dealt with different applications and approaches surrounding the deployment of wireless technologies. This article describes a Radio over Fiber Ring architecture that is being built and now in field trials. It combines the best of broadband wireless access networks with a high-speed fiber optic ring and backbone network. Both fixed and mobile wireless access might be offered in the future.

Radio-over-Fiber Architecture, Dr. Somnath Mukherjee, the Arasor Corporation

Arasor Corp's mission is to provide consumers with convenient and un-tethered access to the Internet through (combined) wireless and optical solutions. The company was started six years ago to develop optical components, but evolved to the hybrid wireless/fiber optic system three years ago. Hence, there is a three-year effort behind the present solution. At this time, most of the hardware design has been completed, but not quite all the software. The system is being field trialed in China and Australia. Service providers deploying this system will be able to offer users data rates from 100K bps to a few million bps. Both fixed and mobile wireless access will be provided, but only Fixed WiMAX will be initially offered.

The network architecture is predicated on the fact that fiber rings are and will continue to be prevalent in metro areas. **These fiber optic rings can carry huge amounts of traffic** and have deployed by most cable companies/MSOs in the U.S., Europe and Asia. Therefore, fiber optics is an excellent backhaul/ backbone technology. The **last mile** access technology is moving more and more to **broadband wireless**, which can offer both fixed access and mobility. Putting these technologies together, Dr. Mukherjee concludes, "Fiber backhaul with wireless access will be the network of future!"

Authors Note: To justify use of a fiber optic backbone in a metropolitan area network, it is important to understand the congestion and collapse behavior of wireless networks. Due to bandwidth limitations of radio waves propagating over extended distances, a wireless backbone network can easily become congested and collapse. This was one of the problems with the Aloha Net - the precursor to CSMA/CD used in the original coax Ethernet LAN. To handle an ever- increasing amount of traffic (particularly video) is exactly the reason that all the cable companies/MSOs, telcos, and ISPs have deployed fiber optic backbones.

Network traffic loads that might overwhelm a metropolitan area network with a wireless backbone (e.g. the Sandoval County Network) could be easily handled by the fiber backbone used in the Arasor network. Also, the fixed WiMAX access is an upgrade over WiFi access and backhaul.

Mukherjee proceeded to describe the network attributes. Arasor Corp. is focusing on network infrastructure and low cost, standards based CPE for both fixed and mobile broadband wireless access. The CPE will initially be based on IEEE 802.16-2004 ("Fixed WiMAX") and later on IEEE 802.16-2005 ("Mobile WiMAX"). The wireless network should support triple play services – voice, video, and data. It should provide security and low latency with varying levels of QoS. The wireless access network should be able to operate in both licensed and unlicensed bands. Data rates provided to users should be a multiple of 100 kb/s to several Mb/s per CPE.

The desirable features in such a network include:

- Flexibility: Ease of upgrades; Re-configurable dynamic capacity allocation
- Versatile: Multiple air interfaces and backhaul protocols
- Reliable (and secure)
- Scalable: Low initial investments (to "turn on the first subscriber"); Ease of expansion

Arasor Corp selected a **"Centralized Architecture"** to simplify operations and reduce costs. The system complexity is shifted from remote Base Station to equipment in a Central Office (CO) installation. The result was said to be "a future proof" system, where upgrades are only needed at the Central Office. This architecture supports simultaneous use of multiple access protocols (e.g. Fixed and Mobile WiMAX, WiFi, possibly IEEE 802.20, others). Because Base Station control functionality is moved to central office, OPEX is significantly reduced. CAPEX reduction results from lower site costs (power, space, cooling…) and use of indoor quality electronics. Finally, reliability is increased due to equipment being in an indoor environment (vs outdoor where temperature and external factors are a threat).

In this centralized architecture, the RF radio (analog) signal is transmitted through the fiber, hence the moniker "radio over fiber." Mukherjee stated that "Radio over Fiber" enjoyed several advantages over traditional fiber backhaul using digital transport:

- Ease of upgrade. Smooth handover to future technology
- Serviceability OPEX – reduced truck rolls
- Cost analysis CAPEX – less amount of hardened equipment
- Mix and match of protocols
- Synchronization of Data Symbols and RF from a common master clock
- Graceful degradation as opposed to catastrophic failure (sub-carrier based)

An analog implementation approach was claimed to be "generally simpler and more economical than direct digitization (of the RF signal)." The main issue was said to be impairments due to non-linearity. So Arasor Corp had made significant efforts towards impairment mitigation (Reed Solomon EC code corrects noise due to clipping, but not from Electrical/Optical non-linearity or from DID)

Fixed WiMAX (IEEE 802.16-2004) was chosen for IP transport over the access network. Reasons given were:

- NLOS operation with long range: OFDM and spectral efficiency through use of high level QAM
- Security
- QoS: Low latency; multiple SLA's possible, TDMA protocol
- Large (>100) number of simultaneous sessions per carrier
- Up gradable to mobile operation {802.16-2005} later
- Beam shaping for optimum coverage
- Space-time coding: Interference mitigation; increased throughput

The system implementation was described and illustrated (please see presentation slides, which may be downloaded from:

http://www.wca.org/year2006/media/WCAOCT2006_Mukherjee.ppt

Conclusions:

- Arasor Corp has developed a "Radio- over- Fiber first generation offering" which is now being field trailed. The development effort has taken place over the last three years.
- IEEE 802.16 – 2004 (Fixed WiMAX) access network is used to transport IP packets
- Multi-carrier Intermediate Frequency (IF) based optical transport is used over the fiber- each carrier has its own wavelength
- Time Division Duplexing (TDD) and Frequency Division Duplexing (FDD) are offered in both licensed and unlicensed frequency bands for the WiMAX network.
- Field trials are ongoing in China and Australia, which support three QOS based services: Video streaming, Video conferencing, and Voice over IP

During the Q and A session there were several questions related to the range of the radio (WiMAX wireless) transmission through fiber optic cable. The maximum distance was stated to be ~30 km when 1310 nm wavelength was used. In that scenario, the WiMAX signal would travel on a dedicated fiber, between the telco ring access point and the WiMAX antennas at the Base Stations.

Another question, by this author, dealt with the advantages of radio transmission directly (analog format) over fiber, rather then conversion from radio/RF transmission to the digital transport compatible with installed SONET rings (e.g. UPSR, BLSR, and RPR). Dr. Mukherjee replied that with the analog transport over fiber you could get mobility using wireless last mile and extended range for mobile clients. He stated that if the analog transport were to be used on a fiber ring already carrying digital traffic, it would require a separate wavelength for each direction of transmission.

Addendum: *The author was so intrigued by this radio over fiber system, that he has scheduled an in depth technical discussion with Dr. Mukherjee to discuss some of the telco related issues and proposed solutions for successful deployment.*

Next WCA Meeting:

Tuesday, 21 November 2006, 4:00pm to 6:00pm

"Wireless Semiconductors - Challenges & Solutions"

About the WCA

WCA founded in 1993, is a Silicon Valley-based, nonprofit corporation dedicated to the mutual benefit of Northern California companies and organizations involved in wireless communication technologies. WCA addresses over 2000 individuals and 350+ companies and organizations. The goals of the WCA are to promote education, networking and exchange of non-proprietary information; increase awareness of Northern California's vast wireless capabilities; and assist a broad spectrum of companies, including start-ups. The WCA organizes monthly meetings with presentations on a wide spectrum of topics including the technical and marketing aspects of wireless products and services, regulatory issues, wireless standards and investor-driven wireless market analysis. The WCA is run by an all-volunteer Board of Directors. **This author is also a volunteer.**