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Abstract	Broadband fixed wireless access systems are under development to deliver voice, data and video for residential and commercial applications. Interoperability between various vendors' equipment, other IEEE 802 IP systems, and protocols such as ATM will be imperative for commercial success of the standard. Interoperability must be maintained at the physical layer, MAC layer, and LLC layer. Transport of real-time voice and video requires isochronous communications, provided by a QoS mechanism, which must interoperate between various systems and applications. This document proposes considerations for interoperability at various layers.		
Purpose	The purpose of this paper will be to provide some definitions for interoperability at various layers to be included in the standard.		
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Release	The contributor acknowledges and accepts that this contribution may be made publicly available by 802.16.		

Contribution to the IEEE 802.16 Systems Document on the Issues of Interoperability and interface to MAC and LLC Protocol

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Abstract

Broadband fixed wireless access systems are under development to deliver voice, data and video, for residential and commercial applications. Interoperability between various vendors' equipment, other IEEE 802 IP systems, and protocols such as ATM will be imperative for commercial success of the standard. Interoperability must be maintained at the physical layer, MAC layer, and LLC layer. Transport of real-time voice and video requires isochronous communications, provided by a QoS mechanism, which must interoperate between various systems and applications. This document proposes considerations for interoperability at various layers.

Introduction

Interoperability at various levels must be considered when designing a broadband fixed wireless access networking standard. A standard, which is interoperable only at one or two levels, will assure commercial failure. This paper considers interoperability at various levels of a network system. The following areas are considered in this paper:

- Physical (RF) interface
- Machine Access Control (MAC)
- Logical Link Control (LLC)
- Quality of Service (QoS) mechanism

Physical (RF) Interface Interoperability

Broadband fixed wireless access systems will generally contain two component parts. At the center of the system is the hub (cell site) mounted on a tall tower or building. User/subscriber locations are distributed around the hub. The hub-to-subscriber connections form a point-to-multi-point configuration as illustrated in Figures 1 and 2. The system provides full duplex communication between the hub and multiple subscriber locations.

When the same vendor manufactures the hub and subscriber unit, interoperability is generally assured even with custom access protocols and modulation methods. When different vendors manufacture the hub and the subscriber unit, as is the case with conventional cellular telephone equipment, interoperability is assured by conformance to a standard requiring a common access protocol and modulation methodology. Conventional cellular telephones for TDMA applications conform to the TIA/EIA-627 standard and use the same channelization, slot timing and modulation technique. Conformance to the standard assures interoperability between vendors.

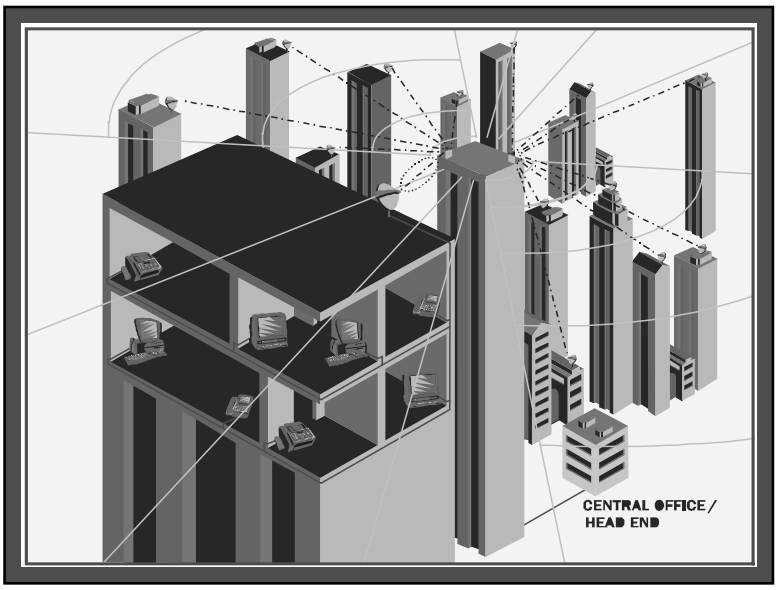

Figure 1, 802.16 System Showing a Hub Mounted on a Tall Building with Multiple Subscribers.

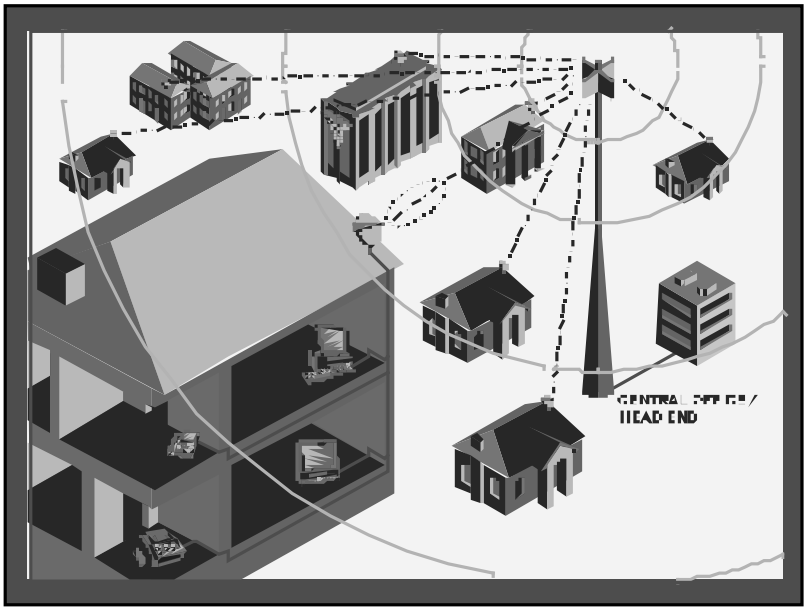

Figure 2, 802.16 System Showing a Hub Mounted on a Tower and Multiple Subscribers.

Access Protocol

A common method of providing multiple access is a major consideration in developing a network standard. This common access method is generally referred to as the access protocol. Some traditional methods of providing multiple access in a radio system have been:

- Carrier Sense Multiple Access with Collision Avoidance (CSMA/CA)
- Frequency Division Multiple Access (FDMA)
- Time Division Multiple Access (TDMA)
- Code Division Multiple Access (CDMA)
- Sectored antennas at the hub location and directional antennas at the subscriber locations.

Most systems will choose a single multiple access method or a combination of two or more methods.

Modulation

Modulation, or coding technology, is another consideration involved in interoperability. The modulation or coding method is the technique used to place digital information on a radio carrier. Modulation methods can be simple as is the case in Frequency Division Modulation (FDM) or can involve complex methods such as Quadriture Amplitude Modulation (QAM) or Quadriture Phase Shift Keying (QPSK). Modulation efficiency is described as coding gain, which is the number of bits that can be sent per Hertz of bandwidth. Coding techniques have been developed that will provide up to 128 bits per Hertz. However, the coding is limited by noise on the radio channel. Multiple modulation techniques can be used with the same device for a variable rate capability.

Machine Access Control (MAC) interoperability

By convention, every device that conforms to an IEEE 802 standard is programmed at the time of manufacture with a unique digital MAC address. The sending location and the receiving location MAC addresses are contained in the MAC frame header. When a device receives a frame of data, the MAC address tells it whether the data was destined for that location. MAC addresses are added to bridging tables by bridging equipment, allowing data to be forwarded from one IEEE 802 network to another even if they are different network types. IEEE 802.1 contains an explanation of this process. IEEE 802 MAC addressing will need to be included as part of the 802.16 standard.

Logical Link Control (LLC) interoperability

IEEE 802.2 Logical Link Control (LLC) is a methodology for detecting, correcting and re-transmitting data frames that contain errors. Sent frames are numbered consecutively. A Frame Check Sequence (FCS) is generated and added to the frame. At the receiving location, the FCS divides the data frame. When the remainder equals zero the frame checks and is used. If the result is anything other than zero, the frame is discarded and the receiver requests a replacement frame by requesting the frame number. This process is acceptable for transmitting data frames. The 802.16 standard will need to accommodate LLC interoperability between equipment. However, the LLC mechanism may not be acceptable for real-time digital voice and video due to the time required for retransmission. These applications require another error correction method.

Quality of Service (QoS) interoperability

Real time digital voice and video require a QoS mechanism. To operate properly, time-dependent services need a guaranteed maximum transition time through a network. Since applications vary in priority of service, several levels must be specified. Any method selected must also be compatible with current QoS systems such as ATM AAL 1 through 5. The standard must contain a QoS mechanism that is interoperable with other systems.

Conclusion

In order for the IEEE 802.16 standard to be commercially viable, it must define minimum interoperability in the following areas:

- a common access protocol with common channel bandwidth,
- a common modulation/coding method that is adaptable to several bit rates depending on the noise environment,
- at a minimum interoperability with IEEE 802.1 MAC mechanism,
- at a minimum interoperability with IEEE 802.2 LLC mechanism,
- interoperability with other data link control mechanisms,
- a QoS methodology compatible will current systems.

A workable standard must address all of these areas.