Project	IEEE P802.16 Broadband Wireless Access Working Group	
Title	Contribution to the 802.16 System Requirements Document on the Issue of The Network Topology of Point-to-Multipoint Radio Systems.	
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Re:	This is a response to Call For Contributions (802.16sc-99/12), Issue # 4, Topology	
Abstract	Broadband fixed wireless access systems are being planned for delivery of voice, data, and video services to subscribers. Point-to-multipoint radios have emerged as the principle approach to implementing these systems. This paper defines microwave point-to-multipoint radio systems in terms of network topologies so that appropriate protocols can be selected by the 802.16 working group.	
Purpose	The author offers the text and figures for inclusion in various 802.16 documents including the system requirements document.	
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Release	The contributor acknowledges and accepts that this contribution may be made publicly available by 802.16.	

Contribution to the 802.16 System Requirements Document on the Issue of The Network Topology of Point-to-Multipoint Radio Systems.

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Abstract

Broadband fixed wireless access systems are being planned for delivery of voice, video, and data services to subscribers. Point-to-multipoint (P-MP) radios have emerged as the principle approach to implementing these systems. Local area networks (LANs) use various protocols for different network topologies such as bus, ring, and star arrangements. This paper develops the topology of microwave point-to-multipoint radio systems so that appropriate protocols can be selected by the 802.16 working group.

Applications

Local area networks (LANs) implement various network topologies including rings, busses, and stars [1]. Carrier sense multiple access with collision detect (CSMA/CD, 802.3) LANs use a half-duplex bi-directional bus topology. Switched Ethernet uses a full duplex star topology. In some cases the media access control (MAC) and the logical link control (LLC) layers make assumptions about the network topology of the physical layer. Radio architectures have implied topologies, which place limitations on the protocol choices.

Radio systems that implement the 802.16 protocol deliver voice, video, and data services over a local coverage area of up to about 5 km. Radio architectures for providing these services include point-to-point (P-P) and point-to-multipoint (P-MP) configurations.

A P-P radio has highly directional antennas at both ends of a link and implements a symmetric full-duplex transmission system. A P-P station normally uses two frequencies (go and return). A P-P radio link emulates a passive two-terminal wire or fiber and is not capable of a distribution topology such as a buss, ring, or star without using equipment external to the P-P radio. A P-P radio is also not capable of performing multiplexing or inverse multiplexing function over the airway and there is no benefit for performing these functions within the radio.

A P-MP radio uses broad coverage antennas at the hub side of a link and highly directional antennas on the subscriber side of the link. A centrally located hub mounted on towers (Figure 1) or tall buildings (Figure 2) transmits information downstream to the subscriber terminals (sub). The hub radio is fitted with antennas that radiate in a broad azimuthal beamwidth. The sub radios use highly directional antennas pointed at the hub. The arrangement enables multiplexing and inverse multiplexing to be performed over the air-way and within the radio. With fixed P-MP antenna arrangements, direct sub-to-sub communication is not supported.

Radios with P-MP configurations implement full duplex circuits (Figure 3) using frequency division multiplexing (FDM), i.e. hubs transmit to a group of subscribers on some frequency (e.g. f_{d1}) while, at the same time, subs transmit on different frequencies (e.g. f_{u1} to f_{un}) back to the hub.

P-MP radios can also implement half-duplex circuits in which hubs and subs transmit, using time division duplex (TDD), on the same frequency.

In the downstream direction (hub-to-sub), P-MP systems often perform an inverse multiplex function by using synchronous time division multiplexing (TDM) methods. All subs tuned to a given frequency can receive a common signal from a hub. Hubs often transmit continuously to minimize the effects that modem frequency, symbol, and frame timing algorithms have on payload bit streams. The information in the downstream signal can be in a TDM format. Circuitry in each subscriber terminal de-multiplexes a high data-rate bit stream into one or more low data-rate streams destined for a particular sub. Data rates from 1 to 50 Mbps are often used downstream. In the downstream direction, the network topology can be described as a unidirectional bus.

In the upstream direction (sub-to-hub), the topology can be described as a unidirectional star arrangement on each frequency. Transmissions can be continuous or burst. Time or code division multiple access (TDMA or CDMA) may be used to allow multiple stations to share a frequency. For TDMA systems, only one subscriber terminal can transmit on a given frequency at a given instant of time. For CDMA systems, multiple subscribers appear to share a block of spectrum but each subscriber terminal transmits using a different spreading code. Synchronous or asynchronous TDM can be accomplished using TDMA or CDMA depending on the details of the respective algorithms. Because subs use a highly directional antenna that points toward the hub, sub-to-sub communication is not possible unless the hub retransmits the sub-to-hub transmissions. Peak data rates from the sub are typically from 1 to 10 Mbps.

Conclusion

Broadband fixed wireless access systems deliver voice, video, and data services to subscribers. Point-to-multipoint (P-MP) radios have emerged as the principle approach to implementing these systems. For local area networks, various protocols implement different network topologies such as busses, rings, or stars. Radio architectures have implied topologies that place limitations on the protocol choices. In the downstream direction (hub-to-sub), the network topology can be described as a unidirectional bus. In the upstream direction (sub-to-hub), the topology can be described as a unidirectional star arrangement.

References

[1] William Stallings, Data and Computer Communications, 5th ed., Prentice Hall, 1996.

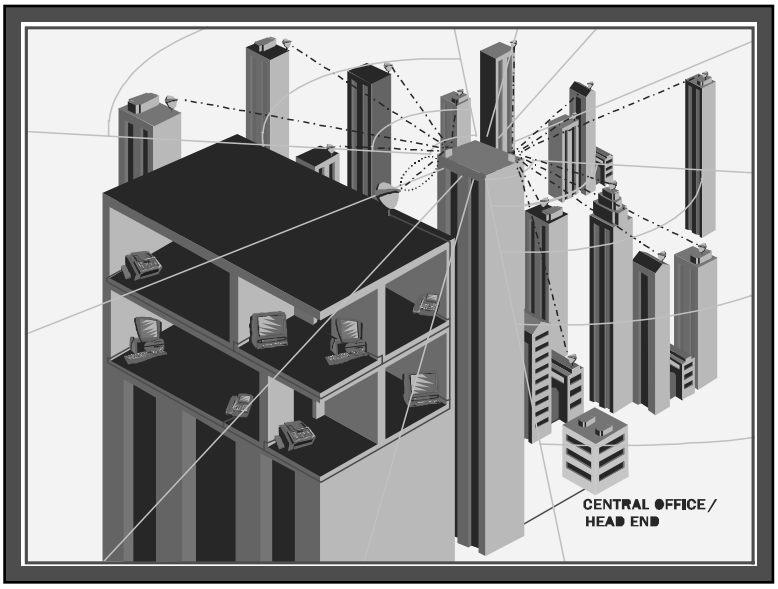

Figure 1, 802.16 System Showing a Hub Mounted on a Tall Building

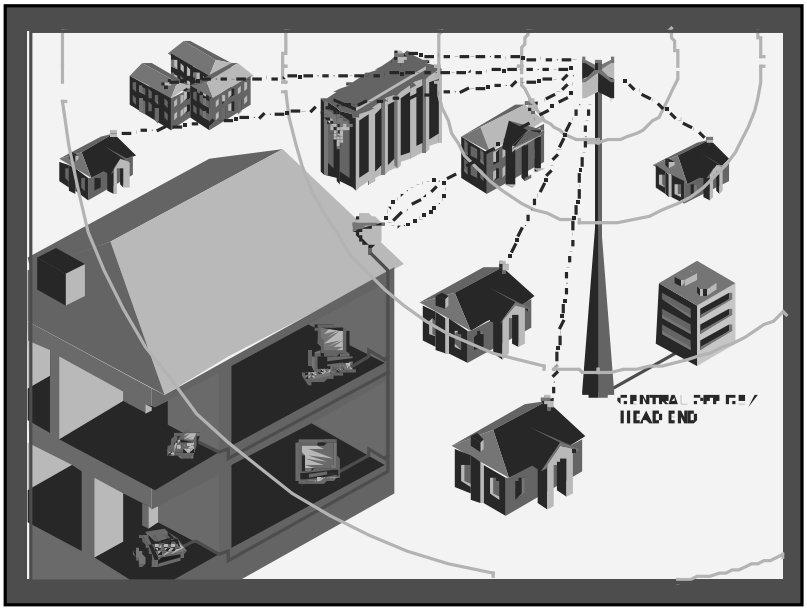

Figure 2, 802.16 System Showing a Hub Mounted on a Tower.

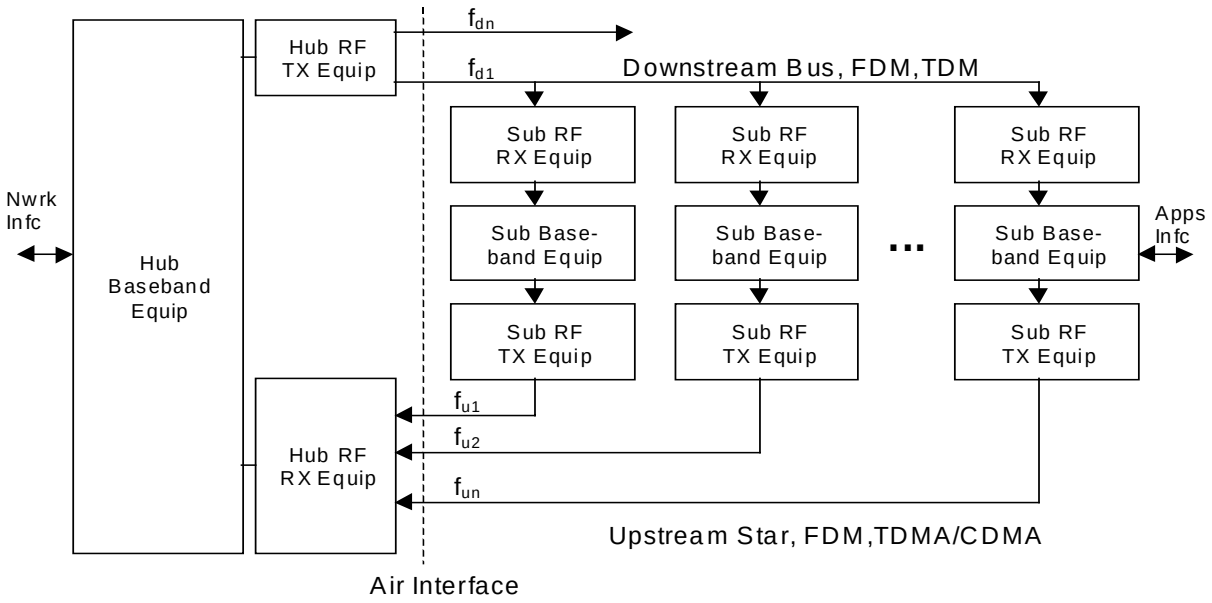

Figure 3, Network Topological View of Functions in a Point-to-Multipoint Radio System showing, at the Air Interface, a Unidirectional Bus Topology Downstream and a Unidirectional Star Topology Upstream.