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802.16 Network Planning Tool

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Introduction

Increasing demand for seamless high-speed Internet access at any time and place is driving the growth in broadband wireless services. However, the rapid growth of broadband wireless networks comes with scalability, interoperability and capacity problems. To plan for the future of broadband wireless networks, IEEE recently approved two standards, namely 802.16a [1] and 802.16c [2], under the umbrella of 802.16 solutions for broadband wireless access.

Advantages of 802.16-based systems are multi-fold: the ability to quickly deploy service, even in areas that are unreachable for wired infrastructure; lower installation costs; and highly reliable and truly scalable services. Further, the standardized 802.16 broadband services should be more affordable than comparable proprietary services offered by WISPs and hence should attain greater market penetration.

Market Opportunity

According to Intex Management Services [3], the broadband wireless subscriber base will grow faster than 90% annually over the next five years; eventually reaching over 11 million subscribers by 2008. The penetration of broadband wireless access is expected to correspond with increasing adoption of 802.16 solutions. Consequently, producers of 802.16-compliant base stations and consumer premises equipment (CPE) will have a dominant market share in the projected $2.7 billion market for broadband wireless equipment by 2008.

802.16-based services will initially target consumers lacking broadband wire line access (e.g., cable, DSL) and small-office, home office (SOHO) customers seeking faster broadband access relative to existing alternatives. These services will gradually expand to provide T1 and higher access speeds to small- and medium-sized enterprises.

802.16: The Technology

One of the requirements of broadband wireless access is non-line of sight communication. But it is infeasible to use higher frequency bands for non-line of sight communication. IEEE has thus approved two standards, namely 802.16a and 802.16c, under the umbrella of 802.16 solutions for broadband wireless access. 802.16a uses non-line of sight communication and operates in the 2-11 GHz frequency band. Here, base-stations are used to directly connect to the end-customer. 802.16c, which uses line-of-sight communication, operates in the 10-66 GHz frequency band and can be used in backhaul networks for connecting 802.16a base-stations with high-speed links over long distances. 802.16c can also be used in backhaul networks for cellular networks based on GSM/CDMA technology. Currently, expensive wired infrastructure is used by GSM/CDMA network providers for backhaul networks. Figure 1 below illustrates the entire 802.16 solution.

802.16: Key Technology Features

The IEEE 802.16 standard offers a number of key features that make it uniquely suited to providing broadband wireless access:

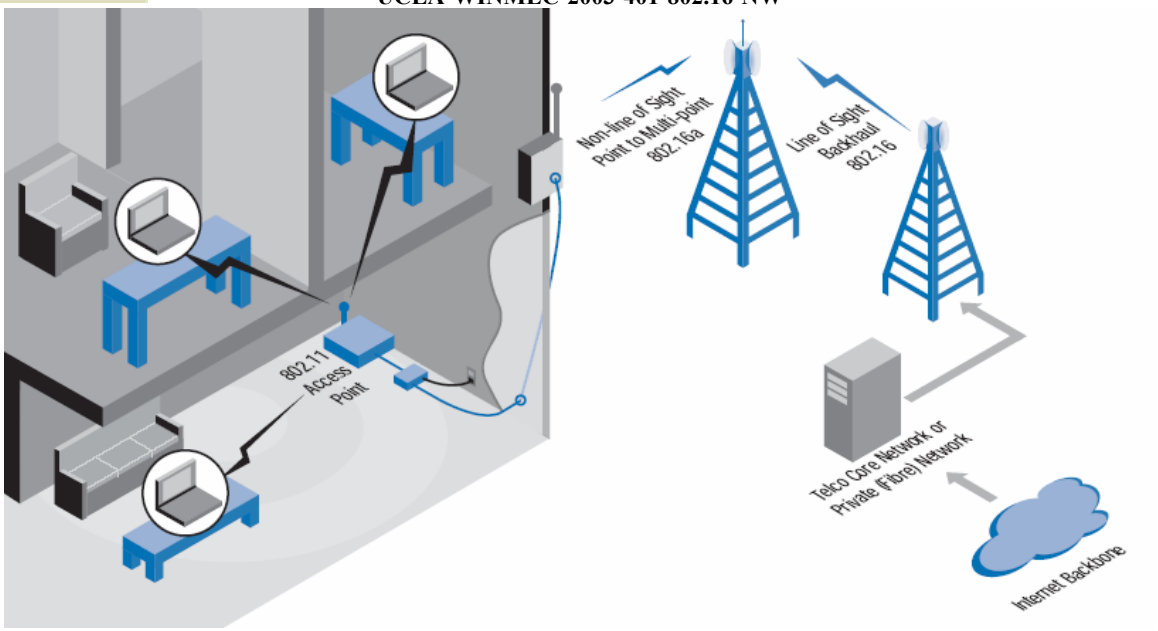

Figure 1: 802.16 for broadband wireless access (Source: Intel)

- **Metropolitan area range**: 802.16a base stations can transmit and receive signals up to a radius of up to 5 miles. Further, 802.16c-based solutions can form the long-distance backhaul networks, connecting 802.16a base-stations using line-of-sight communications.
- **High bandwidth**: An 802.16a base station sector can achieve speeds of up to 70 Mbps, enough bandwidth to support 60+ T1-style small business connections and several hundred DSL-style consumer connections.
- **Non-line-of-sight**: The non-line-of-sight capability enables 802.16a transmissions to penetrate obstructions like buildings and trees common to both urban and rural environments.
- **Quality of Service (QoS)**: 802.16a's built-in QoS support can help network operators guarantee bandwidths, thus making 802.16 a viable medium for transmitting multimedia in addition to data, resulting in more service opportunities for operators.

Deployment Issues

Deploying 802.16-based solutions involves determining the optimal placement and parameters of the hardware equipment while minimizing installation and operational costs so that system performance is maximized. In a competitive market, the system's performance and financial cost play a key role in determining the feasibility of any technological deployment. Wireless network planning thus forms an important component in determining the feasibility of 802.16-based deployment. Given that it is highly expensive to physically test out all possible wireless network configurations, there exists a need for a network planning software tool. Such a tool should ideally:

- Be integrated tool that can design the entire 802.16 solution. It must support planning for both 802.16a and 802.16c networks

- Support equipment from different vendors. Although 802.16 has been standardized, the supporting hardware differs widely (especially RF equipment like antennas).

- Take into account financial feasibility. The software must minimize deployment costs i.e. hardware investment and the operating costs.

802.16 Network Planning Tool

Modern wireless network design involves several inter-dependent factors such as coverage, traffic demand, topography, propagation characteristics and system capacity. The selection of the number of base-stations, base-station locations, power at base station and other design parameters have to be determined in the context of one another. Base-station locations can be chosen based on the coverage performance, traffic distribution, and propagation environments. However, coverage performance can only be determined only after the complete architecture of the wireless network (i.e. base-station and their parameters) has been specified. Lastly, wireless network planning is not a one time task as the design has to be continually updated based on the network scenario and hence such provision should be included in the design tool.

We have studied the problem of wireless network design in the context of cellular networks. In our earlier work [4], we had investigated the problem of placing base-stations and determining system parameters for GSM and CDMA-based systems. From our research, we developed a cell planning tool for designing wireless networks. In the current work, we wish to extend our tool to include 802.16 networks design.

Our 802.16 network planning tool will help determine the optimal location of base-stations (802.16a access points); determines channels, transmit powers and other system parameters for optimal system performance; and minimizes system installation and operation costs. It shall take into account the RF signal attenuation in the propagation path due to environmental factors and has provisions for capacity planning. Further, it will provide a user-friendly interface for choosing locations, transmit powers and other parameters of the 802.16a equipment before deploying them in the network.

Based on the previous knowledge of wireless network design [4], we propose the following flowchart for the tool as show in Figure 2. As can be seen from the flowchart the planning takes place in 3 phases. In the dimensioning phase, the network is dimensioned i.e. terrain considerations, environmental factors etc. in the form of digital maps are taken as input. In the planning phase, the actual design of the wireless network takes place. Finally in the optimization phase the design parameters of the network are further tuned by taking into account the field measurements and results from the performance analysis.

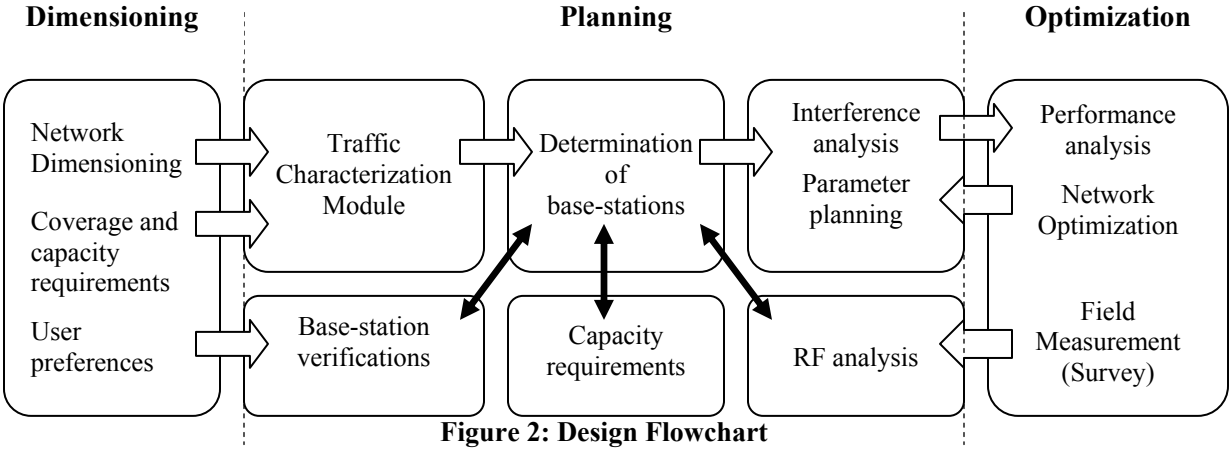

Figure 2: Design Flowchart

Acknowledgements

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