# Market Opportunity: 802.16 and WiMAX


UCLA Anderson
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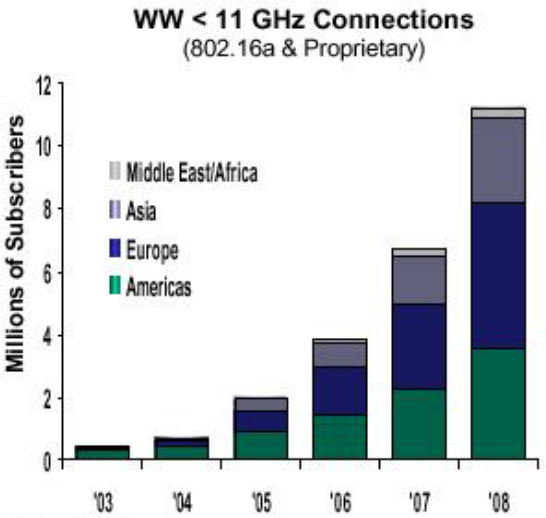
# Executive Summary

Broadband wireless access has garnered significant attention and industry momentum in 2003, thanks to the approval of the IEEE 802.16a standard in January 2003 and the marketing and compliance efforts of WiMAX (Worldwide Interoperability for Microwave Access). Standardization historically serves as a major catalyst in driving economies of scale, which lead to less expensive equipment for infrastructure providers and less expensive services for consumers. As such, standardized 802.16-based solutions should be more affordable and achieve more market penetration than existing proprietary broadband wireless solutions.

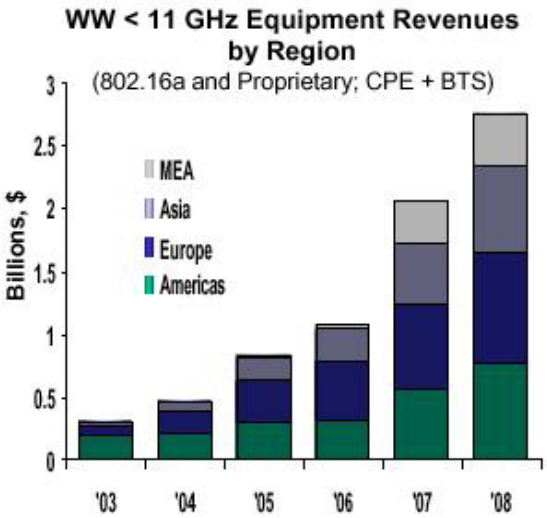
The first wave of fully compliant, 802.16-based products is projected to hit the market in late 2004. WiMAX will finalize the 802.16 system profile definitions and compliance tests in 4Q03, with production of 802.16-compliant network equipment commencing thereafter. Early adoption of "last mile" broadband connectivity is projected to occur first by enterprise campuses seeking to extend their wireless reach and small-office, home office (SOHO) customers seeking faster, more economical broadband access relative to existing alternatives. Opportunities to provide broadband access to consumers lacking broadband wireline access (e.g., cable, DSL) both worldwide and in the U.S. will follow.

Technology companies across the entire broadband wireless value chain are actively monitoring 802.16's progress, cognizant that 802.16 can revolutionize broadband wireless access. Some companies are already shipping products claimed to be 802.16-compliant, while other companies are taking a "wait-and-see" attitude to determine when to shift their resources to 802.16-based product lines. As 802.16 adoption ramps up, the companies best positioned to capitalize on the resulting market opportunity are those that play a leadership role within WiMAX, possess in-house broadband wireless expertise, and can leverage existing business and consumer relationships in the broadband wireless space.

# Market Opportunity




Assumptions
- 802.16a MAN standard is adopted
- $350 subscriber station
- 1 CPE = 1 Subscriber, even if multi-node
- LAN (Hot Spot) subscribers not considered "last mile"




**Source:** Intex Management Services research for Intel,12/02. Based upon April '02 report, "The WW Market for Broadband Wireless Access, 2002".

Adoption of 802.16 is projected to be a major driver spurring growth in broadband wireless access worldwide. According to Intex Management Services, the broadband wireless subscriber base will increase over 90% annually over the next five years, reaching a total of over 11 million subscribers in 2008.[1] Standardized 802.16 broadband services can be offered more economically and should attract far more customers than comparable proprietary services. Consequently, producers of 802.16-compliant base station and consumer premises equipment (CPE) will be best positioned to capture market share in the $2.7 billion market for broadband wireless equipment in 2008.[2]

These aggressive growth projections for broadband wireless usage are supported by two prevailing trends:

- **Widespread acceptance and deployments of wireless technology**: Using a wireless connection to access the Internet became commonplace in 2003. The convenience of wireless connectivity, combined with the relative ease of deploying wireless access points, drove adoption among both enterprises and consumers alike. In the first half of 2003 alone, over $800 million in 802.11-based WLAN equipment was sold.[3] In addition, over 16 million notebook PCs with embedded 802.11 NIC cards will be shipped to businesses in 2003.[4]

[1] Intex Management Services, "The WW Market for Broadband Wireless Access, 2002," April 2002.
[2] Ibid.
[3] Dell'Oro Group, "Wireless LAN Press Releases," May 13, 2003 and August 13, 2003.
[4] In-Stat/MDR, "The Wi-Fi Field of Dreams: If You Embed Wi-Fi, Infrastructure will Come," July 2003.

- **Increasing broadband penetration**: The number of consumer households worldwide with broadband access (cable, DSL, or broadband wireless) grew from 13.1 million in 2000 to 57.2 million in 2002, a CAGR of over 100%. With a projected 39% CAGR going forward, consumer broadband households will reach 154.3 million in 2005.[5] Growing consumer demand, along with the enterprise's ever-present need for broadband access and an increasing number of small offices / home offices (SOHO), will drive broadband penetration for the foreseeable future.

The market opportunity for 802.16 lies at the intersection of these two trends: capitalizing on the adoption of wireless for coverage areas exceeding 802.11's 100-meter range, and enabling cost-effective broadband access to areas lacking cable or DSL. Increasing demand for broadband and general acceptance of standardized wireless technologies bode well for 802.16's future prospects.

## 802.16a: Key Technology Features

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

- **Metropolitan area range**: 802.16a base stations can transmit and receive signals at a radius of up to 8 km. (Distances of 50 km are achievable if transmissions are focused in a single, well-known direction.) The 802.16a standard also supports multipoint backhaul, such that a remote location can be linked to the Internet backbone by passing data through a chain of base stations. This feature enables 802.16a to extend its coverage to remote regions lacking wireline access.
- **High throughput**: An 802.16a base station sector can achieve speeds of up to 70 Mbps, enough bandwidth to support 60+ T-1-style small business connections and several hundred DSL-style consumer connections. Because a base station can support up to 4-6 sectors, each tower has enough capacity to support a significant customer base with its coverage range.
- **Non-line-of-sight**: It is not necessary to establish a direct line-of-sight between the base station and the consumer premises equipment to send and receive 802.16a transmissions. This non-line-of-sight capability, a major upgrade from the 802.16c standard approved in 2001, 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 grant/request Medium Access Control (MAC) layer has built-in QoS that implement priority-based service levels. For example, network operators can guarantee T-1/E-1 access speeds for businesses while offering best-effort DSL speeds for consumers. 802.16a's QoS support also makes it a viable medium for transmitting voice and video in addition to data, giving network operators the opportunity to increase its enterprise footprint.

[5] eMarketer, "Broadband Worldwide," April 2003.

## Markets for Initial Adoption

We project that enterprise corporate campuses and the SOHO market will be early adopters of 802.16 in the next several years. Mainstream consumer adoption will eventually occur in remote areas but will lag until the cost of 802.16-based solutions drops in future product generations.

Enterprises, both large corporate campuses and SOHOs, are viewed as the best "beachhead" market for several reasons:

- **ROI from increased productivity**: Wireless connectivity generates a financial return on investment by enabling company employees to be more productive. Enterprises clearly see the value in wireless connectivity, as evidenced by the early adoption and proliferation of 802.11 access points in the workplace. These benefits will be even greater with 802.16 than it is for 802.11 due to its expanded coverage area. This focus on productivity differentiates enterprises with most consumers, who focus almost solely on price.
- **Higher willingness to pay**: Early generations of 802.16 equipment will be expensive because 802.16 semiconductor design and production will not yet have been perfected. We do not expect that consumers, even those without cable/DSL access, will pay these high initial prices given the slow adoption of high-priced proprietary broadband wireless to date. Enterprises, in contrast, are less price-sensitive and are more willing to pay for value-added wireless services.
- **Rapid provisioning for new campuses**: 802.16 is perfectly suited to provide broadband connectivity quickly and cost effectively for new corporate campuses or SOHOs, especially when compared to wireline T-1 access. Using 802.16, broadband access can be added to a corporate campus via a single base tower in a few days (rather than 3 months) and at a fraction of the cost of a dedicated T-1 line. This ability to get a new office up and running in short order is extremely valuable and is likely to generate significant enterprise interest.
- **Less existing competition**: There are few cost-effective methods to meet the high bandwidth needs of the SOHO market. A dedicated T-1 line is expensive, with $1,000 in installation costs and over $300 in monthly expenses. Cable/DSL installations running at 400 Kbps can't provide high enough speeds for productive multi-user business use. WISPs offering 802.16 broadband services can attract SOHOs given its lower price point versus T-1 lines (even for more expensive, first-generation 802.16 deployments) and faster broadband access versus cable/DSL.
- **Lower deployment barriers**: In early 802.16 enterprise deployments at large corporate campuses, the enterprise will likely deploy the network equipment, manage the base station, and utilize the bandwidth all on its own. By assuming control of the deployment value chain (network operator, WISP, and customer), enterprises can use 802.16 without depending on independent network operators to construct base stations and WISPs to sell bandwidth. Consumers, on the other hand, require that the entire wireless ecosystem be in place before 802.16 adoption can occur.

Only select enterprises will derive value from 802.16, primarily those that lack existing wired infrastructure (e.g., SOHOs, new buildings) or have a metro-scale campus where 100+ 802.11 access points are insufficient to blanket the entire campus (e.g., Microsoft's Redmond campus). The large majority of enterprises, which already have wired infrastructure or whose offices are too small to merit the construction of a dedicated base station, are unlikely to benefit from an early 802.16 deployment.

## Markets for Future Growth

As 802.16 chip prices fall in the years after first silicon is produced, price-sensitive customers will begin to adopt 802.16 now that solutions have dropped to an acceptable price range. In particular, countries that lack wired infrastructure as well as U.S. consumers that lack cable or DSL access are prime candidates for the second wave of 802.16 adoption.

The biggest long-term market opportunity for 802.16 is the international markets. Many countries currently lack the wired infrastructure to provide cable, DSL, or T-1 access to enterprises and consumers. While building out base stations to connect remote areas to the Internet backbone will require significant capital expenditures, providing broadband access through 802.16 is far more cost effective than building out wires to every customer.

The total addressable market for 802.16 worldwide is far larger than in the U.S. in terms of both magnitude and percentage of broadband penetration. Growth in broadband access through 2005 is projected to occur primarily in emerging regions of Asia and Latin America rather than in North America.[6]

**Broadband Households Worldwide, by Region, 2000-2005 (in thousands)**

| | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 |
|---|---|---|---|---|---|---|
| Asia-Pacific | 5,822 | 12,469 | 24,226 | 36,691 | 50,488 | 67,355 |
| Latin America | 119 | 492 | 881 | 1,467 | 2,321 | 3,255 |
| North America | 5,493 | 13,930 | 20,619 | 28,493 | 35,591 | 42,590 |
| Western Europe | 1,633 | 6,218 | 11,520 | 19,536 | 29,289 | 41,121 |
| **Total** | **13,067** | **33,109** | **57,246** | **86,187** | **117,689** | **154,321** |

*Source: eMarketer, March 2003*

India is a prime example of a country that can use 802.16 to compensate for its lack of telecommunications and cable infrastructure. Of the approximately 181 million households in India, there were only 3.2 million paid Internet subscribers in June 2002.[7] India has a teledensity (telephones per 100 inhabitants) of 4.4 in March 2002, according to India's Department of Telecommunication. The shortage of telephones, coupled with the national telecom operator VSNL holding a near monopoly in India's telecom market,

[6] eMarketer, "Broadband Worldwide," April 2003.
[7] Ibid.

points to stagnant growth in DSL services within India. Also, the majority of India's cable network is of poor quality and requires upgrading. The cable operators' lack of capital and the high cost of cable modems will prevent cable Internet from taking off. These circumstances, combined with the high density of its population and the price sensitivity of its consumers, make India an excellent market to deploy 802.16 technologies for broadband access. The WiMAX Forum is presently working with the Indian government to free up licensed spectrum in India that can be used on an unlicensed basis for 802.16.

China is also an excellent case where 802.16 can drive significant growth in broadband access. With a relatively little fixed-line infrastructure and a patchy cable network, broadband access is not widely available in China at this time. Estimates from multiple sources indicate strong growth in China's broadband access going forward via technologies such as Ethernet to the home, DSL, cable modems, and fixed-wireless technologies including 802.16:

**Comparative Estimates: Broadband Households in China, 2000-2005 (in thousands)**

| | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 |
|---|---|---|---|---|---|---|
| BDA, 2001 | – | 2,000 | 4,500 | 10,100 | 18,100 | – |
| CNNIC, July 2002 | – | – | 2,000* | – | – | – |
| **eMarketer, March 2003** | **103** | **390** | **3,790** | **8.645** | **14.700** | **23,510** |
| International Data Corporation (IDC), 2001 | 68 | 437 | – | – | – | 8,300 |
| Norson Telecom Consulting, 2002 | – | 670 | 1,030** | – | – | – |
| Strategy Analytics, 2002 | – | 500 | 2,900 | 8,400 | – | – |
| Yankee Group, 2002 | – | 323 | – | – | – | – |

*Note: *subscribers as of July 2002; **subscribers as of 30 March 2002*
*Source: various, as noted, 2001-2003; eMarketer, March 2003*

Within the U.S., a large population exists that still lacks access to broadband connectivity, whether by cable or DSL. The table below, based on data from the Federal Communications Commission, shows that 16.1% of the U.S. zip codes did not have access to broadband service as of June 2002.

**Access to Broadband in the US, 2001 & 2002 (as a % of zip codes with high-speed lines in service)**

| | June 2001 | June 2002 |
|---|---|---|
| No access | 22.2% | 16.1% |
| 1-3 providers | 50.2% | 47.9% |
| 4+ providers | 27.5% | 35.9% |

*Source: Federal Communications Commission (FCC), December 2002*

The FCC also reports that broadband access existed in 99% of the most populated zip codes but only 50% of the least populated zip codes in June 2002, reflecting the fact that populations in rural areas are still underserved in terms of broadband access.[8] WISPs can offer broadband access by chaining 802.16 base stations to extend to remote areas where cable/DSL coverage is not economically feasible. WISPs looking to deploy 802.16 will initially target markets with a sufficient density of potential subscribers to support expansion into these areas.

As for potential applications in future product generations, 802.16's quality of service support makes it a viable channel for enterprise voice as well as data. This dual voice and data capability will enable 802.16 to expand its enterprise footprint by allowing companies to use wireless transmissions for their data and telecom needs and eliminate expensive wiring installations at new corporate offices.

## Economics of Broadband Wireless

Standardized 802.16 technologies will change the economics of broadband wireless access from the perspective of both network operators and customers. To understand the magnitude of these changes, we first examine the expenses and price structure of proprietary broadband solutions and then estimate the end-to-end impact of substituting 802.16 solutions in their place.

Sample financials for running a Wireless ISP (WISP) based on proprietary technologies provide a starting point for analyzing the underlying economics of broadband wireless. Airspan, a network equipment provider who sells proprietary solutions to Wireless ISPs, projects that WISPs can break even in 13-14 months[9] based on several key assumptions (see Appendix A for full financial model):

- Capacity per base station radio: 3 Mbps
- Oversubscription ratio: 10-to-1
- Throughput per user: 400 Kbps
- Hardware and operational costs: $750-$825 per year
- Consumer subscription price: $45 per month

The current WISP model centers on the consumer market for several reasons. First, the base stations radios have limited bandwidth capacity so T-1 speeds of 1.5 Mbps cannot be supported. Second, consumers do not require bandwidth guarantees, so WISPs can oversubscribe customers at a 10-to-1 ratio relative to available bandwidth to improve the bottom line.

The adoption of 802.16 enables WISPs, armed with more bandwidth capacity, to target enterprises and small office / home office (SOHO) customers, who demand better service

[8] eMarketer, "Broadband Worldwide," April 2003.
[9] Airspan, http://www.airspan.com, 2002.

but are more lucrative. As such, 802.16 changes several key assumptions that radically alter the WISP financial model:

- Capacity per base station radio: 70 Mbps
- Oversubscription ratio: 2-to-1
- Throughput per user: 1.5 Mbps
- Hardware and operational costs: $300 per year
- Enterprise subscription price: $100 per month

With these assumptions and the conservative presumption that WISPs will only focus on enterprises initially, WISPs running 802.16 can break even in three months when running at full capacity (see Appendix B for full financial model). Note that this break-even point ignores excess capacity that can support 300+ consumers at 400 Kbps, allowing for substantial upside to these projections.

Underlying this analysis is the snowball effect that occurs as proprietary technologies become standardized. First, broadband wireless adoption will increase due to reduced customer fear of being locked into proprietary implementations. Second, hardware and operational costs will fall once production and maintenance of standardized equipment is performed in higher volumes and outsourced to specialists. Third, subscriber prices will subsequently drop due to lower cost structures and increased competition among WISPs. Combined, these effects make 802.16 a clear threat to proprietary broadband wireless technologies.

## WiMAX Consortium

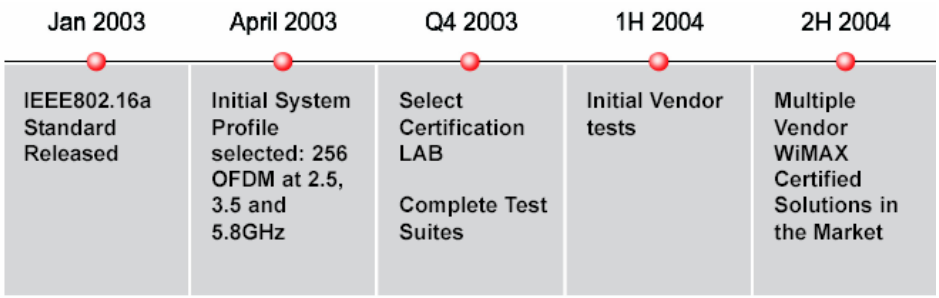
WiMAX (Worldwide Interoperability for Microwave Access) is a consortium of 46 companies driving industry standardization and adoption of 802.16.

| **WiMAX Forum Board (as of December 2003)** | | |
|---|---|---|
| Intel (Board Chair) | Ensemble Communications | Proxim |
| Airspan | Fujitsu | Wi-LAN |
| Alvarion | Nokia | |
| Aperto Networks | OFDM-Forum | |
| **WiMAX Forum Members (as of December 2003)** | | |
| Advantech | Gradiente Electronica | RF Integration |
| AirXstream | Inphi | SiWave |
| Analog Devices | L3 Primewave | SiWorks |
| Andrew Corporation | LCC | SR Telecom |
| Atheros | M-Web | Stratex Networks |
| China Motion Telecom | Microelectronics Technology | Telnecity Group |
| Compliance Certification Services | News IQ | TowerStream |
| Comtech AHA | Orthogon Systems | TurboConcept |
| CTS Wireless | Powerwave | VCom |
| Cushcraft | Radwin | Wavesat Wireless |
| Engim | Redline Communications | Winova Wireless |
| Filtronic | Remec | Yahoo! |

WiMAX plays a similar role for 802.16a as Wi-Fi did for 802.11b. WiMAX members are currently developing system profiles and test suites to ensure cross-vendor compatibility to create an implementation infrastructure around the IEEE's 802.16 technical specifications.

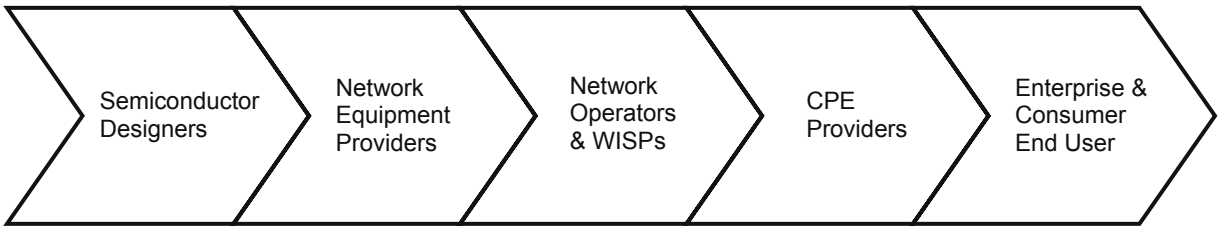
Major players in the proprietary broadband wireless space are actively driving and monitoring 802.16's progress, as evidenced by the fact that the companies in the WiMAX consortium represent 75% of proprietary 2-11 GHz broadband wireless access equipment. We expect that proprietary vendors will incrementally transition to standardized 802.16 equipment over time as chip prices fall and consumer demand increases.

Based on WiMAX's projected timeline, 802.16a test suites will be complete by the end of 2003, with WiMAX-certified solutions hitting the markets by the second half of 2004:



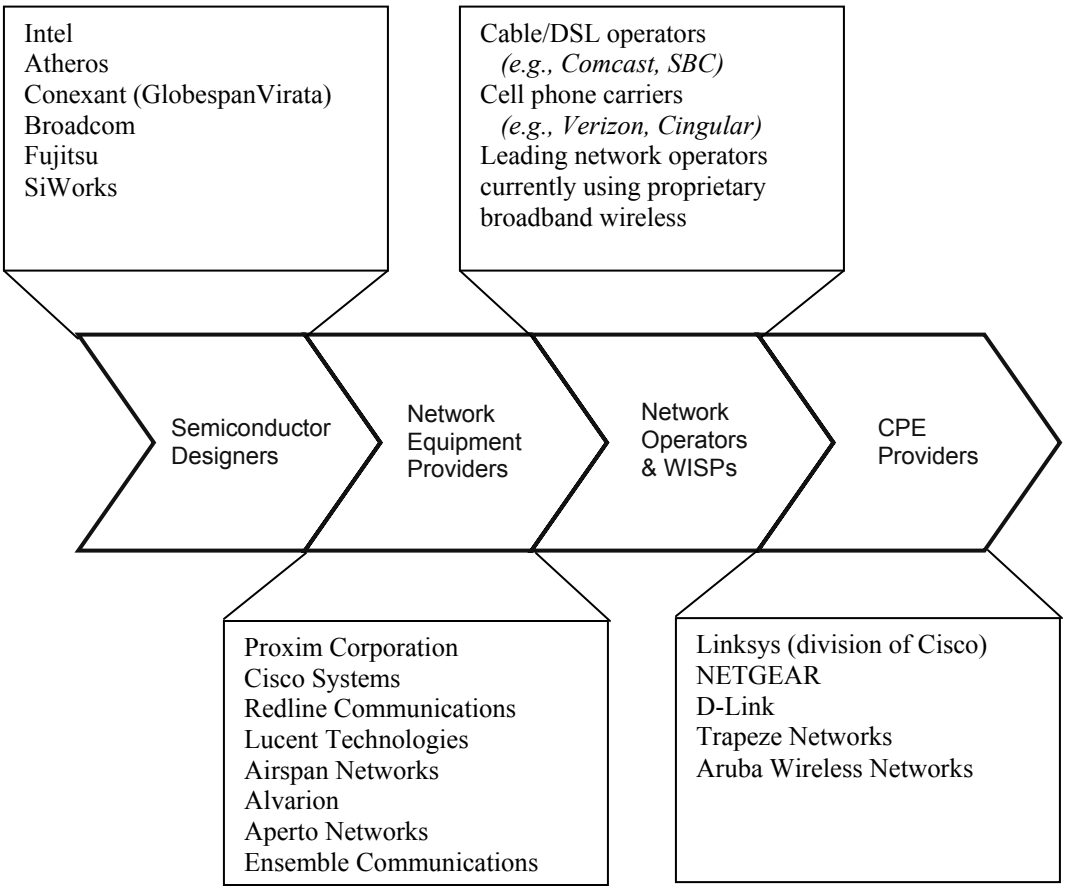

## Major Industry Players

Many companies stand to capitalize on 802.16's market potential in the coming years. We group these companies based on their role in the wireless value chain to understand the competitive landscape each faces:




Each link in the wireless value chain feeds a subsequent link. Semiconductor designers, for example, create the 802.16 silicon chips that will be used by network equipment providers and consumer premises equipment (CPE) providers in their products. Network equipment providers, in turn, sell their equipment to network operators and WISPs in order for them to operate their services. Lastly, the end user purchases and deploys the CPE and signs a contract with a WISP to gain broadband wireless access.

The following chart, broken down by value chain segment, provides an overview of companies we believe will be key players in bringing 802.16 solutions to market:




## Acknowledgements

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Atheros Communications
Cisco Systems
Proxim Corporation
Siemens AG

# Appendix A: Financial Model of Proprietary WISP

| | | |
|---|---|---|
| **Assumptions** | | |
| Capacity/Base Station Radio | 3 | Mbps |
| Actual Throughput/Base Station | 80% | |
| Actual Capacity/Base Station Radio | 2.4 | Mbps |
| Number of Subscribers/Radio | 60 | |
| Oversubscription Ratio | 10 | -to-1 |
| Throughput/User | 0.4 | Mbps |
| Subscription Fee Per Month | $ 45 | |

| **Costs** | *Varies by terrain, interference, demand, etc.* | | |
|---|---|---|---|
| Number of Radios/Base Station | 2 | 4 | 6 |
| Base Stations Costs* | $ 13,450 | $ 18,400 | $ 27,600 |
| Customers/Base Station | 120 | 240 | 360 |
| Base Station Cost/Customer | $ 112 | $ 94 | $ 88 |
| CPE Cost/Customer | $ 500 | $ 500 | $ 500 |
| NMS Software Cost/Customer | $ 10 | $ 10 | $ 10 |
| Hardware Cost/Customer | $ 622 | $ 604 | $ 598 |
| Operating Costs/Customer/Year | $ 200 | $ 180 | $ 160 |
| **Year 1 Hardware and Operational Costs** | **$ 822** | **$ 784** | **$ 758** |
| **Revenues/Customer/Year** | | | |
| Installation and CPE | $ 200 | $ 200 | $ 200 |
| Annual Fees ($45*12) | $ 540 | $ 540 | $ 540 |
| **Total Revenues** | | | |
| 12 months | $ 740 | $ 740 | $ 740 |
| 13 months | $ 785 | **$ 785** | **$ 785** |
| 14 months | **$ 830** | **$ 830** | **$ 830** |

* Includes radio, base station distribution unit, power supply

# Appendix B: Financial Model of 802.16-based WISP

| **Assumptions** | | | |
|---|---|---|---|
| Capacity/Base Station Radio | | 70 | Mbps |
| Actual Throughput/Base Station | | 100% | |
| Actual Capacity/Base Station Radio | | 70 | Mbps |
| Number of Enterprises/Base Station | | 60 | |
| Enterprise Oversubscription Ratio | | 2 | -to-1 |
| Throughput/Enterprise User | | 1.5 | Mbps |
| Enterprise Subscription Fee Per Month | $ | 100 | |

| **Costs** | *Varies by terrain, interference, demand, etc.* | | |
|---|---|---|---|
| Number of Radios/Base Station | 2 | 4 | 6 |
| Base Stations Costs* | $ 13,450 | $ 18,400 | $ 27,600 |
| Customers/Base Station | 120 | 240 | 360 |
| Base Station Cost/Customer | $ 112 | $ 94 | $ 88 |
| CPE Cost/Customer | $ 200 | $ 200 | $ 200 |
| NMS Software Cost/Customer | $ 10 | $ 10 | $ 10 |
| Hardware Cost/Customer | $ 322 | $ 304 | $ 298 |
| Operating Costs/Customer/Year | $ 150 | $ 130 | $ 110 |
| **Year 1 Hardware and Operational Costs** | **$ 472** | **$ 434** | **$ 408** |
| **Revenues/Customer/Year** | | | |
| Installation and CPE | $ 100 | $ 100 | $ 100 |
| Annual Fees (12 months) | $ 1,200 | $ 1,200 | $ 1,200 |
| **Total Revenues** | | | |
| 2 months | $ 300 | $ 300 | $ 300 |
| 3 months | $ 400 | $ 400 | $ 400 |
| 4 months | **$ 500** | **$ 500** | **$ 500** |

* Includes radio, base station distribution unit, power supply