Wireless Local Loop

- **Wireless local loop** (WLL), is a term for the use of a wireless communications link as the "last mile / first mile" connection for delivering plain old telephone service (POTS) and/or broadband Internet to telecommunications customers. Various types of WLL systems and technologies exist.
  - Narrowband – offers a replacement for existing telephony services
  - Broadband – provides high-speed two-way voice and data service
Wireless Local Loop (WLL)

- Wired technologies responding to need for reliable, high-speed access by residential, business, and government subscribers
  - ISDN, xDSL, cable modems
- Increasing interest shown in competing wireless technologies for subscriber access

WLL Configuration
Advantages of WLL over Wired Approach

- Cost – wireless systems are less expensive due to cost of cable installation that’s avoided
- Installation time – WLL systems can be installed in a small fraction of the time required for a new wired system
- Selective installation – radio units installed for subscribers who want service at a given time
  - With a wired system, cable is laid out in anticipation of serving every subscriber in a given area

Propagation Considerations for WLL

- Most high-speed WLL schemes use millimeter wave frequencies (10 GHz to about 300 GHz)
  - There are wide unused frequency bands available above 25 GHz
  - At these high frequencies, wide channel bandwidths can be used, providing high data rates
  - Small size transceivers and adaptive antenna arrays can be used
Propagation Considerations for WLL

- Millimeter wave systems have some undesirable propagation characteristics
  - Free space loss increases with the square of the frequency; losses are much higher in millimeter wave range
  - Above 10 GHz, attenuation effects due to rainfall and atmospheric or gaseous absorption are large
  - Multipath losses can be quite high

802.16 Standards Development

- Use wireless links with microwave or millimeter wave radios
- Use licensed spectrum
- Are metropolitan in scale
- Provide public network service to fee-paying customers
- Use point-to-multipoint architecture with stationary rooftop or tower-mounted antennas
- Provide efficient transport of heterogeneous traffic supporting quality of service (QoS)
- Use wireless links with microwave or millimeter wave radios
- Are capable of broadband transmissions (>2 Mbps)
Protocol Architecture: PHY and MAC

- **Physical and transmission layer functions:**
  - Encoding/decoding of signals
  - Preamble generation/removal
  - Bit transmission/reception
- **Medium access control layer functions:**
  - **Govern access to the wireless transmission medium**
  - On transmission, assemble data into a frame with address and error detection fields
  - On reception, disassemble frame, and perform address recognition and error detection

Protocol Architecture: Convergence

- **Convergence layer functions:**
  - Encapsulate PDU framing of upper layers into native 802.16 MAC/PHY frames
  - Map upper layer’s addresses into 802.16 addresses
  - Translate upper layer QoS parameters into native 802.16 MAC format
  - Adapt time dependencies of upper layer traffic into equivalent MAC service
The 802.16 Physical Layer

For a typical value of 25 MHz worth of spectrum, QAM-64 gives 150 Mbps, QAM-16 gives 100 Mbps and QPSK gives 50 Mbps.

The 802.16 Physical Layer (2)

- Improved Bandwidth Allocation
  - Two techniques are used Frequency Division Duplexing (FDD) and Time Division Duplexing (TDD)
- Frame Bursting
- Error correction techniques

Frames and time slots for time division duplexing.
The 802.16 MAC uses a scheduling algorithm for which the subscriber station need compete once (for initial entry into the network).

After that it is allocated an access slot by the base station. The time slot can enlarge and contract, but remains assigned to the subscriber station, which means that other subscribers cannot use it.

In addition to being stable under overload and over-subscription (unlike 802.11), the 802.16 scheduling algorithm can also be more bandwidth efficient.

The scheduling algorithm also allows the base station to control QoS parameters by balancing the time-slot assignments among the application needs of the subscriber stations.

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The 802.16 Frame Structure

(a) A generic frame.  (b) A bandwidth request frame.
IEEE 802.16 Services

- Digital audio/video multicast
- Digital telephony
- ATM
- Internet protocol
- Bridged LAN
- Back-haul
- Frame relay

WiMAX Standards Roadmaps

802.16
10 – 66 GHz
LOS
Sep 2000

802.16a
2 – 11 GHz
NLOS
Jan 2003

802.16d
Similar to .16a
Errata
Jul 2004

802.16e
Some Mobility
2005

WiMAX = interoperable subset of this (< 6 GHz)

NOTE: IEEE 802.16 specifies only layer 1 & 2
Applications of 802.16

- **IEEE 802.16 Standards**

<table>
<thead>
<tr>
<th></th>
<th>802.16</th>
<th>802.16d/HiperMAN</th>
<th>802.16e</th>
</tr>
</thead>
<tbody>
<tr>
<td>Completed</td>
<td>December 2001</td>
<td>June 2004 (802.16d)</td>
<td>2005</td>
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<tr>
<td>Spectrum</td>
<td>10 - 66 GHz</td>
<td>&lt; 11 GHz</td>
<td>&lt; 6 GHz</td>
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<tr>
<td>Channel Conditions</td>
<td>Line of Sight Only</td>
<td>Non Line of Sight</td>
<td>Non Line of Sight</td>
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<tr>
<td>Bit Rate</td>
<td>32 – 134 Mbps in 28MHz channel bandwidth</td>
<td>Up to 75 Mbps in 20MHz channel bandwidth</td>
<td>Up to 15 Mbps in 5MHz channel bandwidth</td>
</tr>
<tr>
<td>Modulation</td>
<td>QPSK, 16QAM and 64QAM</td>
<td>OFDM 256 FFT QPSK, 16QAM, 64QAM</td>
<td>Scalable OFDMA 128 to 2048 FFT</td>
</tr>
<tr>
<td>Mobility</td>
<td>Fixed</td>
<td>Fixed</td>
<td>Portable</td>
</tr>
<tr>
<td>Channel Bandwidths</td>
<td>20, 25 and 28 MHz</td>
<td>1.75 to 20 MHz</td>
<td>1.75 to 20 MHz</td>
</tr>
</tbody>
</table>
Relation to Other Technologies

- Whether 802.16a will complement or clash with certain other technologies remains to be seen. For a while, at least, it will certainly be complementary to 802.11a, enabling Wi-Fi users to dramatically extend their distance from wired networks.

Portability (Mobility) in 802.16e

- New network reference model
  - New BS-BS interface (IB) and BS-server interface (A) defined, mobile subscriber station (MSS)
  - Authentication and service authorization (ASA) servers provide authorization, authentication, billing, management, provisioning and other services. EAP is defined for SIM cards, and other means of Authentication (Extensible Auth. Protocol).
Mobility in 802.16e – Layer 2

- Handover (HO) process defined in MAC including:
  - cell reselection
  - target BS scanning
  - network re-entry
  - HO decision and initiation and HO cancellation.
- MAC messages for each of the handover functions defined.
- Broadcast paging message defined.
- Neighbor topology advertisement messages defined.
- Option of using mobile IP provided.
- Full QoS supported. All four GSM/WCDMA classes.

Some Differences with 802.11

- MAC
  - 802.11: Contention-based MAC (CSMA/CA), basically wireless Ethernet.
  - 802.16: Dynamic TDMA-based MAC with on-demand bandwidth allocation.
- OFDM
  - 802.11a: 64 FFTs
  - 802.16d: 256 FFTs
- Spectrum
  - 802.11: limited channels in Un-license spectrum
  - 802.16: multiple channels in licensed & Un-license spectrum
## Comparison 802.11 and 802.16

<table>
<thead>
<tr>
<th>Technology</th>
<th>802.11</th>
<th>802.16</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Range</strong></td>
<td>&lt; 300 feet</td>
<td>&lt; 30 Mile (typical 3~4)</td>
</tr>
<tr>
<td><strong>Coverage</strong></td>
<td>Optimized for indoor short range 2.7 bps/Hz peak. &lt;= 54Mbps in 20MHz</td>
<td>Outdoor LOS &amp; NLOS 5bps/Hz peak, &lt;100Mbps in 20 MHz</td>
</tr>
<tr>
<td><strong>Data rate</strong></td>
<td>1-10 CPE CSMA/CA</td>
<td>1- hundreds CPE TDMA</td>
</tr>
<tr>
<td><strong>Scalability</strong></td>
<td>No QOS</td>
<td>On demand BW voice Video, data</td>
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</tbody>
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CPE: Customer Premise Chips