Welcome to the Human Network.
WiMAX Overview
WiMAX Market Overview
Cisco WiMAX Solution
Cisco WiMAX Value Proposition & solution differentiation
Cisco WiMAX Security
WiMAX Forum Update
Cisco WiMAX Services and Applications

Atef Khatib
WiMax Business Unit
WiMax Overview
WiMAX

Worldwide Interoperability for Microwave Access
### 802.16 vs. 802.16-2004 and 802.16e-2005 Features

<table>
<thead>
<tr>
<th></th>
<th>802.16</th>
<th>802.16-2004</th>
<th>802.16e-2005</th>
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<tr>
<td><strong>Date completed</strong></td>
<td>December 2001</td>
<td>June 2004</td>
<td>December 2005</td>
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<tr>
<td><strong>Spectrum</strong></td>
<td>10-66 GHz</td>
<td>&lt; 11 GHz</td>
<td>&lt; 6 GHz</td>
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<tr>
<td><strong>Channel Conditions</strong></td>
<td>LOS only</td>
<td>NLOS</td>
<td>NLOS</td>
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<tr>
<td><strong>Bit Rate</strong></td>
<td>32-134 Mbps in 28 MHz channel bandwidth</td>
<td>Up to 75 Mbps in 20 MHz channel bandwidth</td>
<td>Up to 15 Mbps in 5 MHz channel bandwidth</td>
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<tr>
<td><strong>Air Interface</strong></td>
<td>TDMA with TDD and FDD</td>
<td>OFDM &amp; OFDMA with TDD &amp; FDD</td>
<td>Scalable OFDMA with TDD &amp; FDD</td>
</tr>
<tr>
<td><strong>Mobility</strong></td>
<td>Fixed</td>
<td>Fixed, portable</td>
<td>Nomadic portability, Full mobility</td>
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<tr>
<td><strong>Channel Bandwidths</strong></td>
<td>20, 25, 28 MHz</td>
<td>Scalable 1.5 to 20 MHz</td>
<td>Scalable 1.5 to 20 MHz</td>
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<tr>
<td><strong>Typical Cell Radius</strong></td>
<td>2-5 km</td>
<td>7-10 km</td>
<td>2-5 km</td>
</tr>
</tbody>
</table>

*Source: WiMAX Forum as of December, 2007*
Mobile WiMAX System Profiles

- Created by WiMAX Forum as guideline for Mobile WiMAX SS and BS conformance testing
- Comprised of subset of features from 802.16e standard
- 4 system profiles
  - PHY Profile
  - MAC Profile
  - Radio Profile
  - Power Class Profile
- Profiles contain
  - Mandatory features
  - Optional features
  - Performance requirements
- Guarantees Mobile WiMAX SSs and BSs configuration is built on a common baseline of functionality
WiMax Market Overview
Wimax has been declared as one of the 3G access options under IMT2000
European Regulators are adopting a “technology neutrality” for the 2.5 GHz band - TDD/FDD, Wimax/W-CDMA
In Norway the cost of 2.5 Ghz spectrum (Nov 07) was $0.047 per Hz
• 54M Wimax subs WW, 60% are mobile
• 55% of subscribers in Emerging
• US with 20% of WW subs
• Western Europe with 12% of WW subs
Reaching Critical Mass

2.7B people covered by WiMAX spectrum licenses today, estimated 4B as a result of ITU IMT-2000 inclusion
The Broadband Wireless Market

Why is WiMAX Important?

- WiMAX Leverages IP technologies throughout; a natural fit for Cisco
- WiMAX Enhances Cisco’s existing market-leading WiFi and WiFi mesh solutions

WiMAX (802.16e-2005) enables a wide range of fixed and mobile ‘any play’ services to deliver the Connected Life experience

Service Providers: Improved cost effectiveness with significant reductions in capital and operational expenditures
Faster time-to-market; no wires
Complements and extends existing cellular / broadband offerings
Governments: An efficient means to enable ‘Digital Inclusion’
Solution Overview
Cisco WiMAX Solution:
Based on WiMAX Forum Network Reference Model

MSS – Mobile Subscriber Station
NAP – Network Access Provider
NSP – Network Service Provider

ACCESS SERVICE NETWORK (ASN)
- Access gateway (ASN GW) – provides the micro-mobility anchor point and supports bearer services. Also supports the Foreign Agent.
- Base station (BS) – provides the radio dependent functions and has limited IP functionality

CORE SERVICES NETWORK (CSN)
- Home agent (HA) – provides the macro-mobility anchor point and supports bearer services, if roaming/mobility is desired.
- Other Network Elements such as AAA, DHCP servers and more are also in the CSN.
WiMAX ASN Profiles

- Three ASN Profiles have been specified in WiMAX Forum as a tool to manage diversity in ASN node usage and implementation
  - Release 1 of NWG Specifications on WiMAX supports 3 ASN
- Profiles:
  - **Profile A:**
    - Centralized ASN Model with BS and ASN GW in separate platforms through R6 interface
    - Split RRM: RRA in BS and RRC in ASN-GW
    - Open interfaces for Profile A: R1, R6, R4, and R3
  - **Profile B:**
    - Distributed ASN solution with the BS and ASN GW functionalities implemented in a single platform
    - Open interfaces Profile B: R4 and R3
  - **Profile C:**
    - Similar to Profile A, except for RRM being non-split and located in BS.
    - A big departure from the way things used to be done in the mobile radio world.
Product Overview
Network Fit: Access
Cisco E2E Mobile WiMAX Solution Architecture
Broadband Wireless Access (BWX) Products

BWX 8305 (P3) Basestation

BWX 2305 Basestation

Combinea

BWX 8326 Basestation Combiner

External GPS Unit (EGU-3)

BWX 8303 Basestation Timing System

BWX 360 Outdoor modem

BWX 350 USB modem

BWX 320 Desktop + VoIP modem

BWX 210 Desktop modem

BWX 120 PCMCIA modem

BWX 110 Desktop modem
Cisco Mobile WiMAX Certified Base Stations
(BWX 8305 & BWX 2305)

<table>
<thead>
<tr>
<th>COMPANY NAME</th>
<th>October 8, 2008</th>
<th>MP05</th>
</tr>
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<tbody>
<tr>
<td>COMPANY NAME</td>
<td>Cisco Systems Inc.</td>
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<td>CERTIFICATION PROFILE</td>
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<tr>
<td>PRODUCT NAME</td>
<td>Cisco</td>
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<tr>
<td>PRODUCT MODEL</td>
<td>Cisco BWX 8305 Base Station + TTA 2496-2620 MHz</td>
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<td>DEVICE TYPE</td>
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<td>CERTIFICATION NUMBER</td>
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<td>WiMAX Certification Body</td>
<td>Héctor Rubén Alba Díaz</td>
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<td>INTEROPERABILITY OPTIONS</td>
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Certificates can be found on the WiMAX Forum Web site:  [http://www.wimaxforum.org/kshowcase/view](http://www.wimaxforum.org/kshowcase/view)

- **Cisco** certification CSRL ver. 2.5.0 (2.5 GHz, 5 MHz)
- **Huawei’s** certification CSRL ver. 2.5.0 (2.5 GHz, 5/10 MHz)
- **Alcatel’s** certification CSRL ver. 2.4.0 (2.5 GHz, 5/10 MHz)
- **Motorola’s** certification CSRL ver. 1.9.0 (2.5 GHz, 10 MHz)
- **Samsung’s** certification CSRL ver. 1.6.0 (2.3 GHz, 8.75 MHz) or 1.9.0 (2.5 GHz, 10 MHz)
Cisco provides a full-range, industry-leading portfolio of IEEE 802.16e-2005 compliant products and technologies.

**Cisco BWX 8300/2300 series BTS**
- Software upgradeable for WiMAX 802.16e-2005 Wave 2 certification
- Unmatched radio link budgets
- First to support WiMAX Advanced Antenna Systems (AAS) for Beam-Forming

**Cisco BWX Antenna Systems**
- Multi-antenna configuration for beam-forming and MIMO
- Omni-directional and sector configurations
- Market-leading gain, reliability and availability

**Cisco BWX series Customer Premise Equipment**
- Zero-install, plug-and-play portable/mobile operation
- Sleek, appealing retail-friendly design
- Over-the-air activation
Cisco WiMAX RF Technical Leadership

The Only Commercially Deployed Smart Beam-Forming

Pioneering the Combination of Smart Beam-Forming with MIMO:

- Requires up to 50% fewer sites than competition
- Yields up to 50% savings in both OpEx and CapEx
- Enables the use of low powered consumer broadband devices (up to 4 times power reduction)
- Two to three times the network capacity

- Higher signal strength to both stationary and mobile users
- Enhanced indoor coverage / performance
- Improved roaming capabilities; fewer dropped signals
How Beamforming Works

- Signal from CPE bounces off of buildings & arrives at the 8-antenna system.
- Each antenna “sees” the signal a bit differently.
- All 8 signals are manipulated to have the equivalent effect of an antenna system with a very narrow beam pointing exclusively at that particular CPE.
Beamforming Concept

- Improved performance on uplink and downlink (9dB/18dB respectively)
- Reduces interference—allowing more capacity/better frequency reuse.
- Allows downlink and uplink power control per user (can increase the power without impacting other users)

Current Wireless systems
Low Capacity

Energy dispersed in all directions

Signal
Interference from other users

Energy directed to the intended user

Smart Beamforming
High Capacity
End-to-End
Mobile WiMAX Solution
Introducing Cisco Broadband Wireless

The industry’s first end-to-end IP NGN solution fully integrated and tested with Mobile WiMAX

Integrating both licensed and unlicensed access technologies into a converged IP service delivery architecture
WiMAX End-to-End System

Fixed and Nomadic Wireless Access

Fixed and Nomadic broadband wireless services aligned with the Mobile WiMAX Profile-C Network Reference Model

(Fixed and nomadic services are the current focus of the WiMAX Forum and system / device manufacturers)
WiMAX End-to-End System

Fixed, Nomadic, and Mobile Wireless Access

Fixed, Nomadic, and Mobile broadband wireless services aligned with the Mobile WiMAX Profile-C Network Reference Model and Mobile-IP

(Mobile broadband services are a future focus of the WiMAX Forum and system / device manufacturers)
Cisco Broadband Wireless Gateway
An Open Access Architecture

The Cisco Broadband Wireless solution conforms to the Mobile WiMAX Profile-C Network Reference Model

- All Access Services Network (ASN) functionality is open and distributed
- Radio-related functions such as resource management and handoff are provided by Mobile WiMAX basestations
- IP-related functions such as IP routing, IP Mobility, authentication, and traffic management are provided by ASN Gateways
Enables open Mobile WiMAX ASN architectures for maximum design & deployment flexibility

Built on the Cisco 7600 Series – the carrier-class converged services platform providing access to thousands of IOS features

The most powerful ASN-GW platform available – scalable from 5 to 45 Gbps

MPLS and IPSec VPNs enables secure residential and business services over a common infrastructure

Part of the Cisco Service Exchange Framework, enabling precise control over each subscriber’s quality of experience
Cisco Broadband Wireless Gateway
Platform Support

- BWG software will run on a service module in the 7600 Series Router
- Allows the system to rapidly scale by adding more service modules to meet traffic loads
- 7600 offers a variety of chassis configurations for different deployment scenarios
- A very robust and proven approach that has been used to support a variety of different applications in the mobile space
- A smaller “standalone”, 1RU high appliance based ASN-gw based on C7301 is available for Field/Demo trials
Mobile WiMAX Foundation Services
Example: Business Voice

Call Control
Flows to Enterprise call manager (CCM) and to PSTN if required. VOIP end-point.

Call bearers
Are switched in the ASNGW
Mobile WiMAX Foundation Services
Example: Residential High-Speed Internet Access

The R6 Control Plane
Handles user authentication and QoS/Service Flow assignment

The R6 Bearer plane
Residential Services uses both the R6 control and bearer plane.
Mobile WiMAX Foundation Services
Example: Multi-Access Roaming

Mobile IP Home Agent enables IP-based roaming across all mobile & wireless access technologies.
Cisco Value Proposition
Value Proposition

• **CAPEX/OPEX:**
Cisco’s 8-antenna solution is 35-50% more economical than 4 & 2-antenna
  ▪ 4 & 2-ant solutions are 55-110% more expensive than Cisco’s 8-ant
  ▪ Cisco cheaper than other WiMAX access product given for FREE

• **Coverage:**
Cisco’s 8-antenna coverage is 50-135% > 4 & 2-ant

• **Capacity:**
Cisco’s 8-antenna system capacity is 25%-115% > 2-ant
  ▪ Cisco BTS w/ BF-only = 2-ant. MIMO-only BTS + (25-75%)
  ▪ Cisco BTS w/ (BF+MIMO) = 2-ant. MIMO-only BTS + (55-115%)
Value Proposition Summary

- Cisco Solution: Most Economic by Far (<50%)
- Cisco Solution: Least Investment upfront, Scalable, Grow as you Go
- Coverage is Dominant
- 5 year Penetration Goal of 5% is Aggressive
- Site Cost Critical in BTS Product Selection
Business Case

- **BTS HW/SW cost** ≈ 20%-30% cell-site cost
  - Every cell-site eliminated ⇒ commensurate saving is ≈ 3x to 4x BTS cost

- Site\(^1\) (CAPEX+OPEX) per site (5 yrs) = $400K

- BTS (CAPEX) per cell-site (5 yrs) = $100K

- Total (CAP/OPEX) per cell-site (5 yrs) = $500K
Technology Summary

- BF is imperative to any successful wireless Broadband Wide Area Network (B-WAN) deployment

- BF central to:
  - Reduced network CAPEX/OPEX
  - Increased RF-Link budget / Coverage
  - Increased Capacity / throughput data rates
  - Indoor coverage (minimize need for Femto-cell)
  - Low-power handheld devices (uplink gain)
  - Frequency re-use (N=3, future N=1)
Profile C Value
Deploying Profile C: Revenue Growth Opportunities

- **Services Capability (Business & Residential Services)**
  - VLAN over the air and VLAN Stacking (Q-in-Q) for service differentiation (no VLAN stacking in Profile B)
  - Layer 2 bearer for site to site enterprise connectivity (transparent bridging) (L2 transparent bridge not available in Profile B)
  - VoIP using UGS and ERT-PS (only UGS supported in Profile B)
  - Tightly integrated QoS mapping from WiMAX to Carrier Ethernet to IP core (QoS features loosely integrated from core in Profile B)
- **Building services on BWG and SEF framework**
  - Traffic shaping and deep packet inspection using ISG
  - Leverage advanced IP services available on SEF platform (content filtering, policy management, user tracking, billing)
  - AAA Accounting on BS and BWG (no accounting in Profile B)
Deploying Profile C: Operational Efficiency Opportunities

- **Transport Efficiency (Business & Residential Services)**
  - Distributed bearer (Locally switched at BS to L2 Metro network)
  - Bearer based on Ethernet-CS at BS and CPE for enterprise transport

- **Subscriber Management**
  - Centralized subscriber management at AAA allowing single interface for billing, SLA management, accounting

- **Network Scalability**
  - Separate bearer plane for enterprise and residential allows greater flexibility in transport network scaling
  - Centralized control plane via BWG and AAA for subscriber scalability
Deploying Profile C:
Future proofing the network for Wave 2 features, third party CPE and mobility

- **Network Evolution on Profile C**
  - All new SW features only available on Profile C architecture
  - Evolution to third party CPE (WiMAX Wave 2) requires Profile C
  - Evolution to mobility requires Profile C

- **Subscriber Management/Authentication for third party CPE**
  - Profile C requires AAA for subscriber management and authentication
  - Third party CPE also require Profile C architecture for authentication and security

- **Operational Benefits**
  - Establish Profile C network architecture sooner will less risk by staging upgrade from 6.X -> 7.0 -> 7.1
  - Derisk major network overhaul with third party CPE, mobility and Profile C by doing staged roll out.
WiMax Security Update
WiMAX Solution Security and Authentication

Framework Overview

- **PKMv2 Framework**
  Mobile WiMax uses the Privacy and Key Management Protocol Version 2 (PKMv2) to manage all security, authentication and encryption schemes over the air interface.
  PKMv2 manages AK security using PKM messaging between BS and CPE.

- **Device and User authentication:**
  User authentication in Mobile WiMAX is done using EAP authentication schemes.
  Navini Mobile WiMAX solution supports EAP-TLS, EAP-TTLS and EAP-AKA etc.
  Device authentication done using X.509 certificates in WiMAX CPE.

- **Traffic Encryption:**
  Traffic encryption using 128 bit AES encryption scheme.
  AES encryption keys derives from EAP authentication and transported over PKMv2 framework.

- **Security context and associations:**
  All security and encryption contexts and associations maintained over mobility events and other network events.
WiMAX Authentication/security key exchange

- EAP is method used
- ASN GW is the authenticator and is agnostic to the EAP Method.
- The transport of EAP is done between the ASN GW and the Base-Station as a control exchange.
- The base-station functions as a EAP-Relay converting from PKMv2 to the EAP messages over to the ASN GW.
- The ASNGW is a EAP pass-through and any key generating EAP methods can be supported in the system.
- The ASN GW, following EAP authentication of the subscriber, will also compute respective Access Keys (AKs) for each Base-Station.
- The ASN GW will also cache the PMK for the duration of the authentication, and will recomputed additional AKs when the SS/MSS moves to another Base-station.
- Support for Un-authenticated user – 911 or Pre-paid for example

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<thead>
<tr>
<th>Supplicant</th>
<th>Authentication Relay</th>
<th>Authenticator</th>
<th>Authentication Server</th>
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</thead>
<tbody>
<tr>
<td>MS</td>
<td>BS (ASN)</td>
<td>NAS (ASN)</td>
<td>AAA Server (Home CSN)</td>
</tr>
</tbody>
</table>

- EAP methods such as EAP-TLS, EAP-AKA, EAP-TTLS
- EAP
- PKMv2
- Auth. Relay Protocol
- AAA Protocol
- 802.1X
- Auth. Relay Encapsulating Protocol
- UDP/IP
WiMax Forum Update
Mobile WiMAX Roadmap

- **2007**
  - Mobile WiMAX Rel 1.0 (802.16e)
  - 30mbs @ 30MPH

- **2008**
  - Mobile WiMAX Rel 1.5 (802.16e)
  - 100mbs @ 70MPH

- **2009**
  - Mobile WiMAX Rel 2.0 (802.16m)
  - 100mbs @ 300MPH

- **2010**
Mobile WiMAX Profile Release 1.0

Underlying Standards
Air Interface: IEEE802.16e-2005
Network: NWG Release 1.0/1.5

Specifications
Channel BW: 8.75 (Korea), 5, 10 MHz
Focus on TDD in

Modulation:
DL: 64QAM, 16QAM, QPSK
UL: 16QAM, QPSK

Peak Data Rates Per Sector/Per Carrier:

Specifications Completed
Products 2007-8
Mobile WiMAX Profile Release 1.x

Underlying Standards
Air Interface: IEEE802.16 REV2
Network: NWG Release 1.5

Enhancements
Extension to new Spectrum Bands
Enabling both TDD and (H)FDD with Maximum Commonality
Some Performance Improvement (Focus on Software Upgrades)
Enabling Network Release 1.5

Advanced Features
Applications
Higher VoIP Capacity
Enhanced LBS
Enhanced Multicast and Broadcast Services

Specifications 2008
Products 2009
Mobile WiMAX Profile Release 2.0

Underlying Standards
Air Interface: IEEE 802.16m
Network: NWG Release 2.0

Enhancements
Wider Band Channels (TDD & FDD in 5, 10, 20MHz)
Multiple Carrier Support
Higher Spectrum Efficiency/Capacity
Higher Peak And Average User Data Rates
Integrated Relay
Improved Mobility And Lower Latency
Improved MIMO (focus on higher order and multiuser MIMO)
Enhanced Inter-tech Handoffs/Coexistence With 3G and WiFi
Improved Power Saving

Applications
Multi-hop relay deployments

Specifications 2010
Products 2011
### WiMAX Network Standards Roadmap

#### Expected Timeline for Specifications

<table>
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<th>Release</th>
<th>Requirements</th>
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<td>Mobile and stationary WiMAX base spec: ASN, CSN mobility, Sleep/Idle modes, IPv4 &amp; IPv6 connectivity, Pre-provisioned/static QoS, Optional RRM, Network discovery/selection, IP/Eth CS support, Flexible credentials, pre- and postpaid accounting, Roaming (RADIUS only), 3GPP I-WLAN compatible IWK, Mobile Internet applications, 3 ASN profiles, Start of NWIOT (NCT/IIOT) specs</td>
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<td>IMS and PCC/Dynamic QoS, Telephony VoIP with emergency services, Lawful interception, MCBCS, Diameter based AAA, OTA APDO and device management, 3GPP SAE IWK, 3GPP2 IWK optimizations, Ethernet services, VLAN, DSL IWK, Multi-host support, Location based services, RoHC, Normative R8, Non-IMS/Universal Services Interface, NWIOT Release 1.5 (NCT/IIOT) and enabling IOT for retail devices</td>
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<td>Multimedia Session Continuity, Seamless WiFi-WiMAX handover, 3GPP/2 IWK (optimized HO), Network Management, Enhancements in Roaming, MCBCS, Emergency Services, IMS Support, Support for Relay (TBD), Second-gen. NWIOT framework</td>
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Last updated Oct 25, 2007
Cisco WiMax Services
## WiMAX Services

### Residential Services
- Internet Access
- Parental Control
- Residential Voice
- Walled Garden

### Business Services
- Managed Services
- L2 VPN
- L3 VPN (MPLS)
- Internet access and presence
- Backhaul of Hotspots

### Wholesale Services
- Internet Access
- Voice Services

### Consumer Services
- Internet Access
- Voice Services
# WiMAX Applications from fixed to mobile

<table>
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<th>Devices variant</th>
<th>Devices</th>
<th>Location Speed</th>
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<th>802.16e-2005</th>
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<tr>
<td>Fixed</td>
<td>Outdoor and Indoor CPEs</td>
<td>Single/Stationary</td>
<td>No</td>
<td>Yes</td>
<td>Yes</td>
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<td>Nomadic</td>
<td>Indoor CPEs, PCMCIA cards</td>
<td>Multiple/Stationary</td>
<td>No</td>
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<td>Portable</td>
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<td>Multiple/Walking speed</td>
<td>Hard handoffs</td>
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<td>Yes</td>
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<td>Simple Mobility</td>
<td>Laptop PCMCIA or mini cards, PDAs or Smartphones</td>
<td>Multiple/Low vehicular speed</td>
<td>Hard handoffs</td>
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<td>Full Mobility</td>
<td>Laptop PCMCIA or mini cards, PDAs or smartphones</td>
<td>Multiple/High vehicular speed</td>
<td>Soft handoffs</td>
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