5 GHz, 802.16 and WiMax

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School on
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Wi-Fi Technology Overview
Agenda

-
- 802.16 standards
- WiMax
- Currently available 5 GHz systems

Band	Frequency Range (MHz)	Radio Requirement	Other Requirements
ISM	900–928	Spread spectrum FCC 15.247 U.S.	36 dBm; limited availability, U.S., Canada, Australia, and parts of South America
ISM	2400–2483.5	Spread spectrum FCC 15.247 in U.S.; ETS 300 328 in EU	36 dBm for point-to-multipoint in U.S.; 3-for-1 rule for pt-to-pt in U.S.; 20 dBm EIRP limit for EU
ISM	5725–5850	Spread spectrum FCC 15.247 U.S.	36 dBm EIRP
U-NII/ HiperLAN2	5150–5250	FCC 15.401 U.S.; TS 101 475 EU	23 dBm EIRP; indoor use only
U-NII	5250–5350	FCC 15.401	30 dBm EIRP
HiperLAN2	5470–5725	TS 101 475	30 dBm EIRP

Evolution of Broadband Wireless

From Wireless LAN to Access, from Proprietary to Standard Solutions

'00 01	'02 '03	'04 '05
Proprietary Solutions	**Proprietary**	**Standard-based 802.16a Solutions**
▪ **Data rate**: 2-11 Mbps peak ▪ **Chip sets**: use 802.11 RF and PHY or proprietary ▪ **Based on** 802.11, 802.11b	▪ **Data rate**: 6-54 Mbps peak ▪ **Chip sets**: OEMs forced to develop their own Silicon - Some use 802.11a RF & PHY ▪ **Air interface**: OFDM & S-CDMA approached ▪ **Based on 802.11a**	▪ **Data rate**: up to 72 Mbps peak ▪ **Chip sets**: Volume Silicon supplier ▪ **Standards**: Interoperable, carrier-class ▪ **Based on 802.16**

802.16 Standard: MAN Pt-Mp

- Base Station connected to the public Network
- Feeds Subscriber stations (SS)
  - Both Types of BS
  - SS Serves a building
- Multiple services with QoS

General Features

- Wideband Channels (20~28 MHz)
- Múltiple Access, TDM/TDMA
- Adaptive both Upstream and Downstream
- TDD, FDD o Half Duplex

Burst Adaptive Profile

- (Burst Profile)
  - Modulation and FEC
- Dynamically assigned according to the condtions of the link : Capacity and robustness interchange
- SS features are known at the time of the link

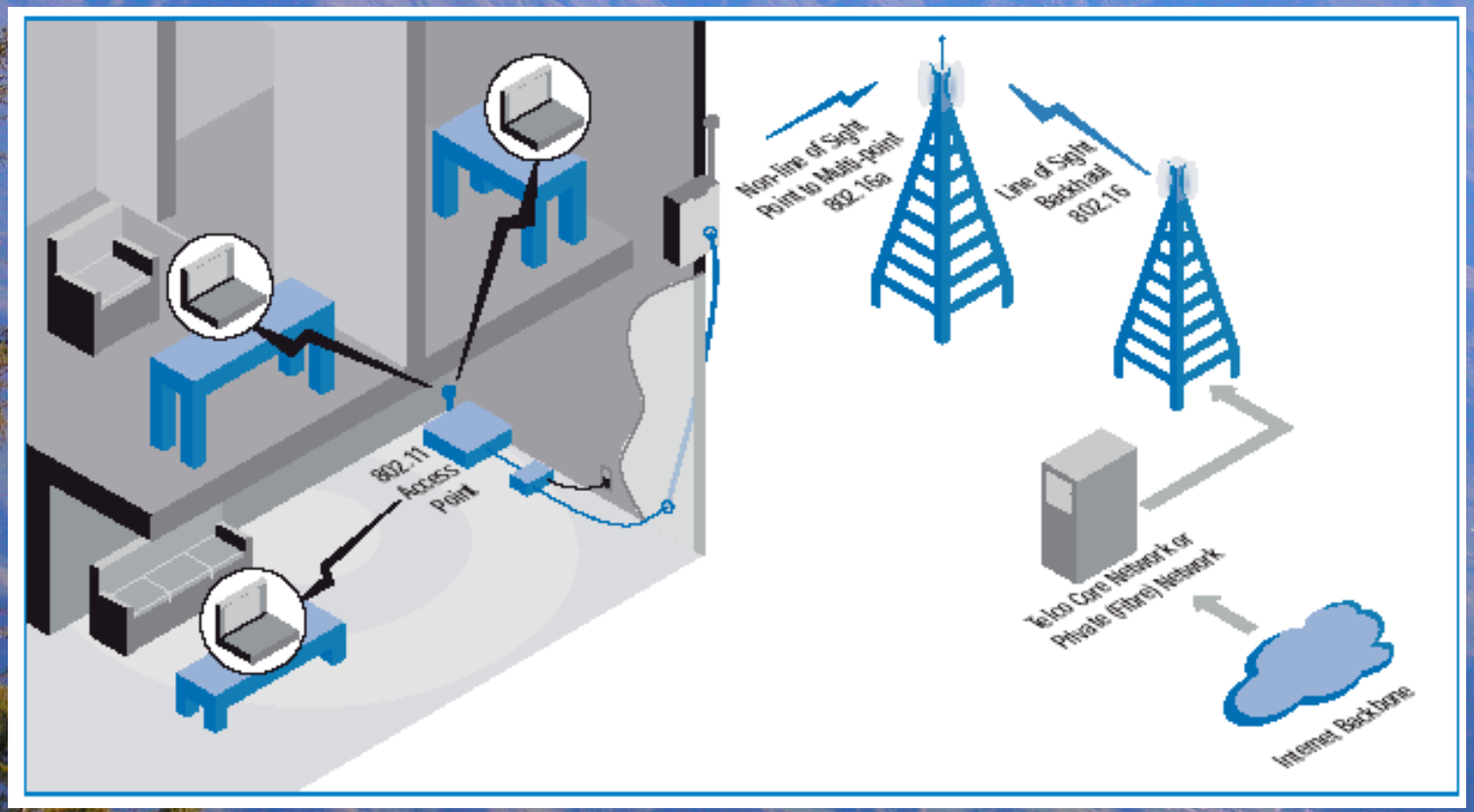
Duplexing Techniques

- Downlink a burst is provided at every SS
- Uplink every SS is provided with a variable length time slot

Completing WiFi, Completing the Wires

- 802.16 expands the reach of WiFi
  - Larger range and coverage
  - More performance and high level services
  - Connects 802.11 hotspots to the Internet
  - Connects 802.11 WLANs to the Internet
  - Last mile connectivity to wireless 802.11 home networks
- 802.16 expands the reach of the wires
  - A complementary broadband access solution
  - An alternative to cable and DSL

Both LOS and NLOS, P-P and PMP



802.16: Specifically Designed for the Outdoor MAN

	802.11	802.16	Technical
Range	Sub ~ 50 m indoor . (add access points for greater coverage)	Up to 40 km Average cell size 7 – 12 km	802.16 PHY tolerates greater multi-path delay spread (reflections)
Coverage	Optimized for indoor, short range	NLOS performance Standard support for advanced antenna techniques	802.16: 256 OFDM (vs. 64 OFDM); adaptive modulation
Scalability	Channel bandwidth is wide (20 MHz) and fixed -> Cell planning is constrained	Channel b/w is flexible to accommodate both licensed and license exempt bands -> easier cell planning	Only 3 non-overlapping 802.11b channels; 5 for 802.11a 802.16: limited by available spectrum
Bit rate	2.7 bps/Hz peak Up to 54 Mbps in 20 MHz channel	3.6 bps/Hz peak Up to 50 Mbps in a 14 MHz channel	802.16: MAC efficiency constant with PHY rate increase
QoS	No QoS support -> 802.11e working to standardize	QoS built into MAC -> voice/ video, differentiated services possible	802.11: contention-based MAC (CSMA) 802.16: scheduled MAC

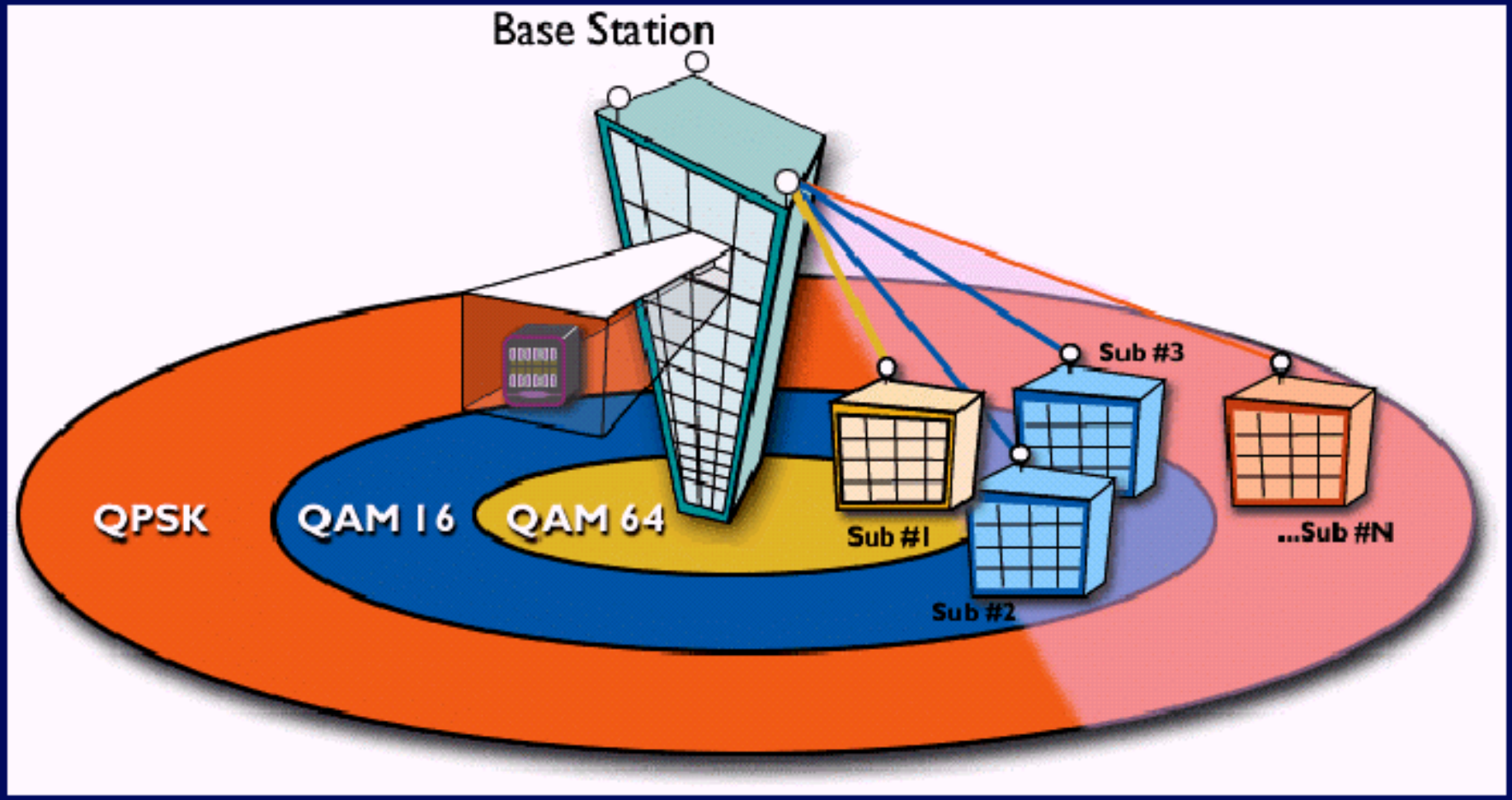
Quality of Service

The grant/request characteristics of the 802.16 Media Access Controller (MAC) enables an operator to simultaneously provide premium guaranteed levels of service to businesses such as T1-level service, and high-volume “best-effort” service to homes, similar to cable-level service, all within the same base station service area cell.

Coverage.

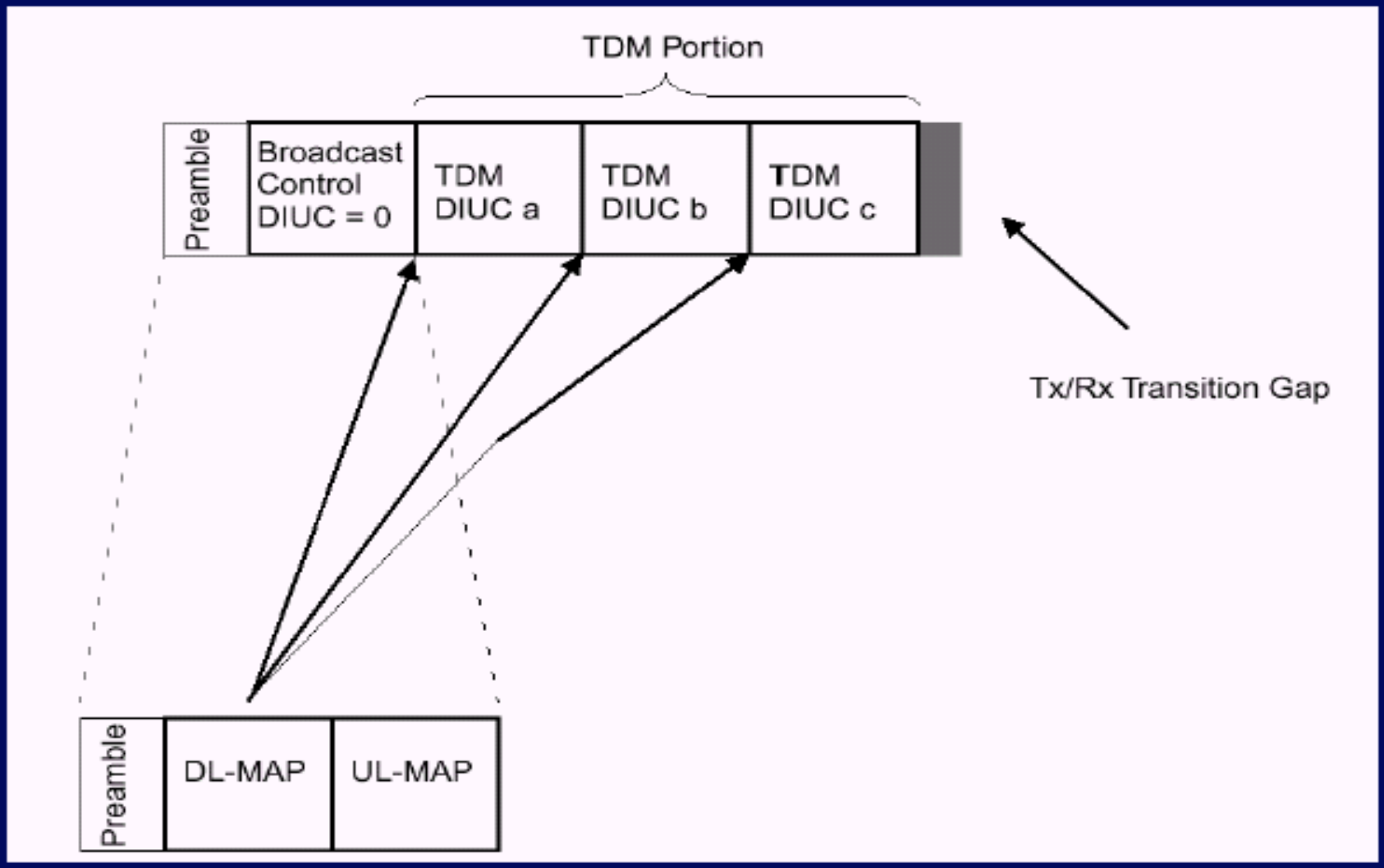
In addition to supporting a robust and dynamic modulation scheme, the IEEE 802.16 standard also supports technologies that increase coverage, including mesh topology and “smart antenna” techniques. As radio technology improves and costs drop, the ability to increase coverage and throughput by using multiple antennas to create “transmit” and/or “receive diversity” will greatly enhance coverage in extreme environments.

Physical Layer Adaptivity



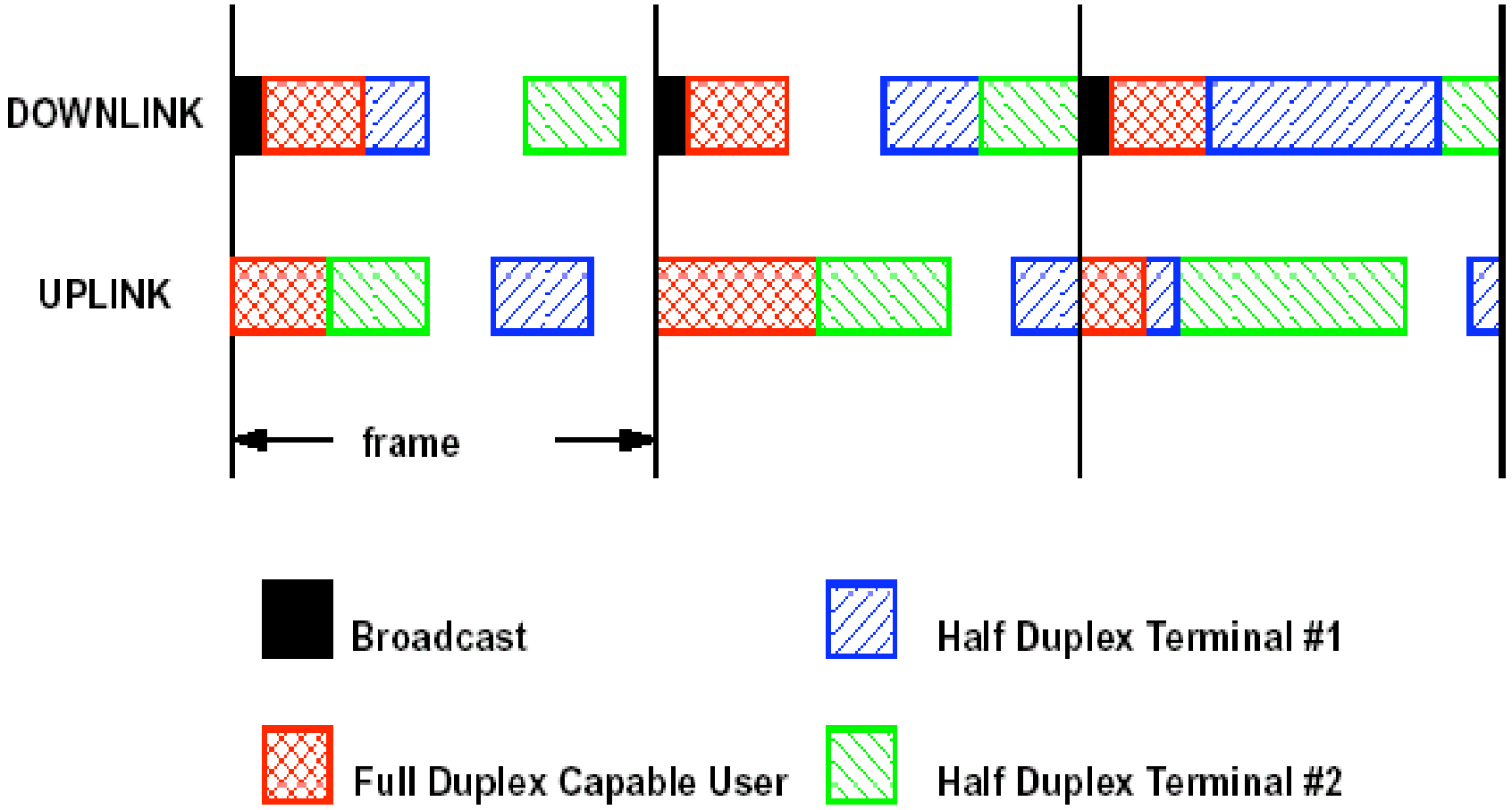
(burst-by-burst adaptivity not shown)

TDD



DIUC: Downlink Interval Usage Code

FDDD Frames


DOWNLINK
UPLINK
frame
Broadcast
Full Duplex Capable User
Half Duplex Terminal #1
Half Duplex Terminal #2

Transmission Rates

Channel Width (MHz)	Symbol Rate (Msym/s)	QPSK Bit Rate (Mbit/s)	16-QAM Bit Rate (Mbit/s)	64-QAM Bit Rate (Mbit/s)
20	16	32	64	96
25	20	40	80	120
28	22.4	44.8	89.6	134.4

Extensions for < 11 GHz

- OFDM Support
- ARQ
- 802.16b Mesh Mode
  - Optional Topology
  - Subscriber to Subscriber Communication

Worldwide Interoperability for Microwave Access

The Worldwide Interoperability for Microwave Access Forum (WiMAX) was formed with the following objective:

Promote the wide-scale deployments of fixed broadband wireless access networks operating above 2 GHz by using a global standard and certifying the interoperability of products and technologies.

WiMAX Founding Membership

- Early focus: 10-66 GHz
  - Nokia
  - Ensemble
  - Hughes Network Systems

Recently added: 2-11 GHz

- Alvarion
- Airspan
- Aperto
- Fujitsu
- Intel
- OFDM Forum
- Proxim
- Telnecity
- WiLAN

Worldwide Interoperability for Microwave Access (WiMax)

- Committed to develop products compatible with the 802.16a wireless standard
- effective at ranges of up to 30 miles and at speeds of up to 70 Mbps
- 802.16a modem currently costs about $1,000
- Members of WiMax, who include Intel,Nokia, and Fujitsu Microelectronics America, anticipate that price dropping to around $300 with 10k$ BS

- Point to Multipoint from 2.5 to 66 GHz
- one of the building blocks of the IEEE
- 802.16 standard is the concept of a “variable burst length,” a feature adopted to ensure a growth path from ATM networks to IP networks.

Throughput, Scalability, QoS and Security

By using a robust modulation scheme, IEEE 802.16 delivers high throughput at long ranges with a high level of spectral efficiency that is also tolerant of signal reflections. Dynamic adaptive modulation allows the base station to tradeoff throughput for range. For example, if the base station cannot establish a robust link to a distant subscriber using the highest order modulation scheme, 64 QAM, the modulation order is reduced to 16 QAM or QPSK, which reduces throughput and increases effective range.

Designed from the Ground Up for Metropolitan Area Networks

In January 2003, the IEEE approved the 802.16a standard which covers frequency bands between 2 GHz and 11 GHz. This standard is an extension of the IEEE 802.16 standard for 10 – 66 GHz published in April 2002. These sub 11 GHz frequency ranges enable non line-of-sight performance, making the IEEE 802.16a standard the appropriate technology for last-mile applications where obstacles like trees and buildings are often present and where base stations may need to be unobtrusively mounted on the roofs of homes or buildings rather than towers on mountains.

5 GHz long reach examples

- Airspan (NLOS)
- Alvarion
- Motorola Canopy
- Orthogon (NLOS)
- Proxim MP11a (NLOS)
- Redline AN50 (NLOS)
- UBT 100 (NLOS)
- WI-LAN Libra (NLOS)

Airspan's ASWipLL platform is a low-cost high-performance Fixed Wireless Access system designed to deliver high-speed data, Voice over IP (VoIP) and multimedia services to residential, small business and enterprise customers. ASWipLL is capable of delivering burst data speeds of up to 4 Mbps (3.2Mbps net) to each customer. ASWipLL introduces real-time adaptive modulation (2-, 4-, 8-level FSK) and auto retransmission request (ARQ); features that offer high quality services whilst maximising spectrum utilisation. ASWipLL is available in both licensed bands (700 MHz, 2.5GHz, 2.7-2.9GHz and 3.4-3.8GHz) and unlicensed bands (900MHz, 2.4GHz and 5.8GHz).

- AS4030 is a high-end Broadband Wireless system for access and distribution applications. AS4030 supports bit rates of up to 45Mbit/s per RF channel, with Base Station capacity of more than 180Mbit/s (using 4 RF Channels).

  AS4030 is typically used to to provide service to business applications and for Cellular / Backhaul Trunking. AS4030 can deliver just IP, or IP and E1/T1s services. AS4030 is ideally suited to providing service bundles to small and medium business consisting of a dedicated 2Mbit/s IP connection combined with a full or fractional E1/T1.

  AS4030 is based on robust OFDM technology of can provide service in Line-of-sight and Non Line-of-Sight deployment situations. AS4030 can operate in the presence of significant multi-path, found in urban environments

- Airspan's AS3030 is a high performance broadband wireless system designed to provide Point-to-Point (P-P) operation. It is a true high performance, high capacity, multi-service OFDM platform which has been designed to provide a reliable and economical solution for Operators, The AS3030 is capable of supporting up to 72Mbps over its air interface, using a 20MHz channel, equivalent to 49Mbps at the Ethernet level. The link can operate over a range in excess of 10km (NLOS) and 80km (LOS).

AS3030 operates in the licence-exempt 5.8GHz band and licensed 3.4 -3.7 GHz spectrum. It benefit from real-time adaptive modulation and Auto Repeat Request (ARQ); features that offer high quality connectivity whilst maximising spectrum utilisation. Thanks to its robust non-line-of-sight capability and remote management-through-web interface, AS3030 is remarkably easy and intuitive to install and use.

Alvarion BreezeACCESS VL

- Frequency
  - 5.725GHz – 5.850GHz
  - 5.47GHz – 5.725GHz
- 4 modulation types
  - BPSK, QPSK, 16QAM, 64QAM
- Channel BW: 20 MHz , TDD, OFDM
- Interfaces:
  - 10/100BaseT at both Sub. and Base Station
  - 3 CPE models, SW upgradeable
  - 6Mbps
  - 24Mbps
  - 54Mbps – will be released in the future

Alvarion's Extensive Access Suite

- Extended service Offering
  - Bridging functionality
  - 802.1Q VLAN support
    - Transparent bridging of tagged/untagged packets
    - Tagging outgoing packets (towards uplink), un-tagging incoming packets(downlink, from SU to LAN)
    - Allows for VLAN sharing between enterprise and SOHO users
  - QoS and SLA enforcement
    - QoS and prioritization according to ToS and 802.1p
    - …

alvarion
We're on your wavelength.

BreezeACCESS VL Specifications

- Frequencies : 5.47GHz – 5.725GHz , 5.725GHz – 5.850GHz
- Channel BW : 20MHz
- Output power (at antenna port)
  - AU : -10 to 21dBm, Adjustable in 1dB steps
  - SU: -10 to 21dBm, ATPC
- Receive nominal sensitivity

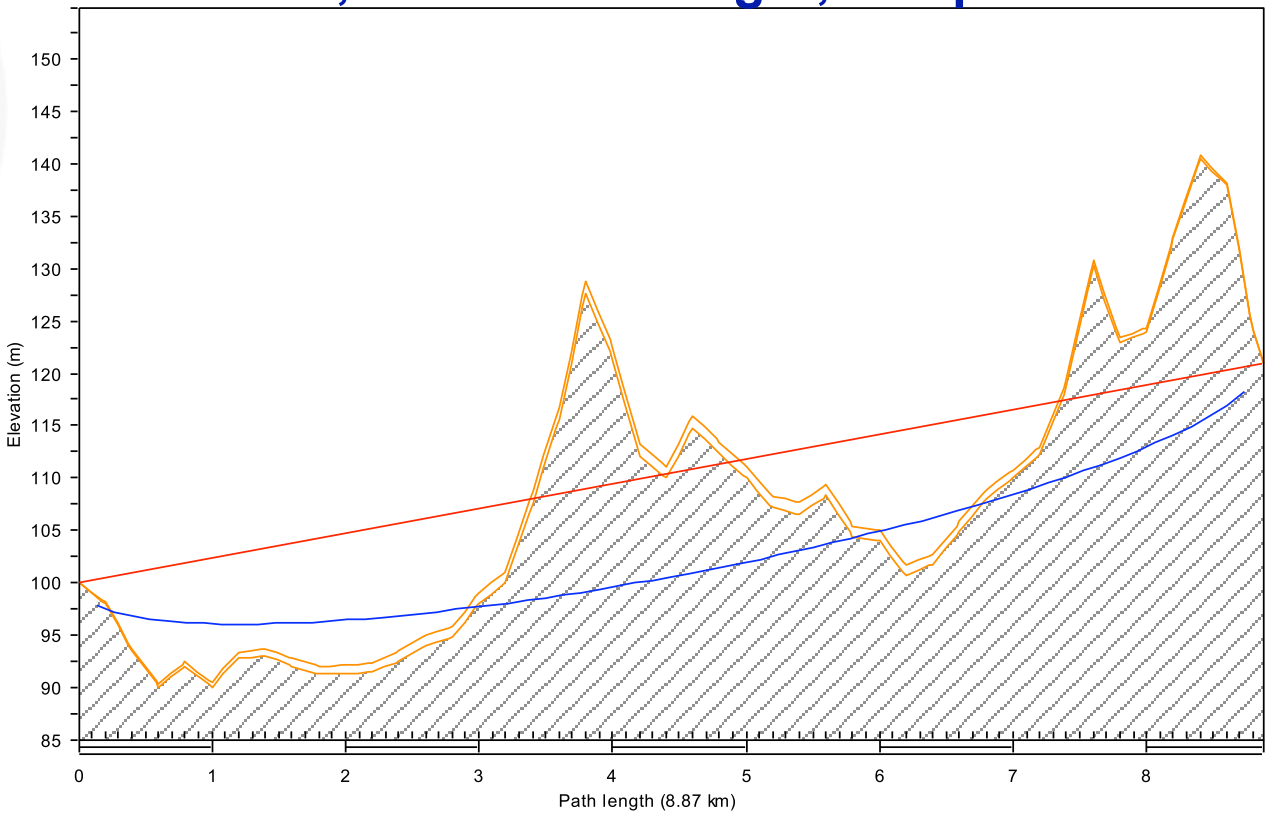
Rate	6Mbps	9Mbps	12Mbps	18Mbps	24Mbps	36Mbps	48Mbps	54Mbps
VL	-90dBm	-89dBm	-88dBm	-86dBm	-83dBm	-79dBm	-72dBm	-72dBm
802.11a	-82dBm	-81dBm	-79dBm	-77dBm	-74dBm	-70dBm	-66dBm	-65dBm

- SU Antenna: 21dBi
- AU Antenna:
  - 8dBi, 360^0 (5.8GHz only)
  - 16dBi, 60^0
  - 16dBi, 90^0
  - 15dBi, 120^0

alvarion
We're on your wavelength.

Ireland, Dublin

8.8 km, Non Line Of Sight, 7Mbps FTP !!!



Tallaght Square		Frequency (MHz) = 6700.0	ESB Sandyford	
Latitude	53 16 40.40 N	K = 1.33	Latitude	53 16 01.75 N
Longitude	006 21 40.20 W	%F1 = 100.00	Longitude	006 13 45.86 W
Azimuth	97.69°		Azimuth	277.79°
Elevation	100 m ASL		Elevation	121 m ASL
Antenna CL	0.0 m AGL		Antenna CL	0.0 m AGL

	Jul 17 03	


Pico Espejo, 4765 m, October 2002
alvarion

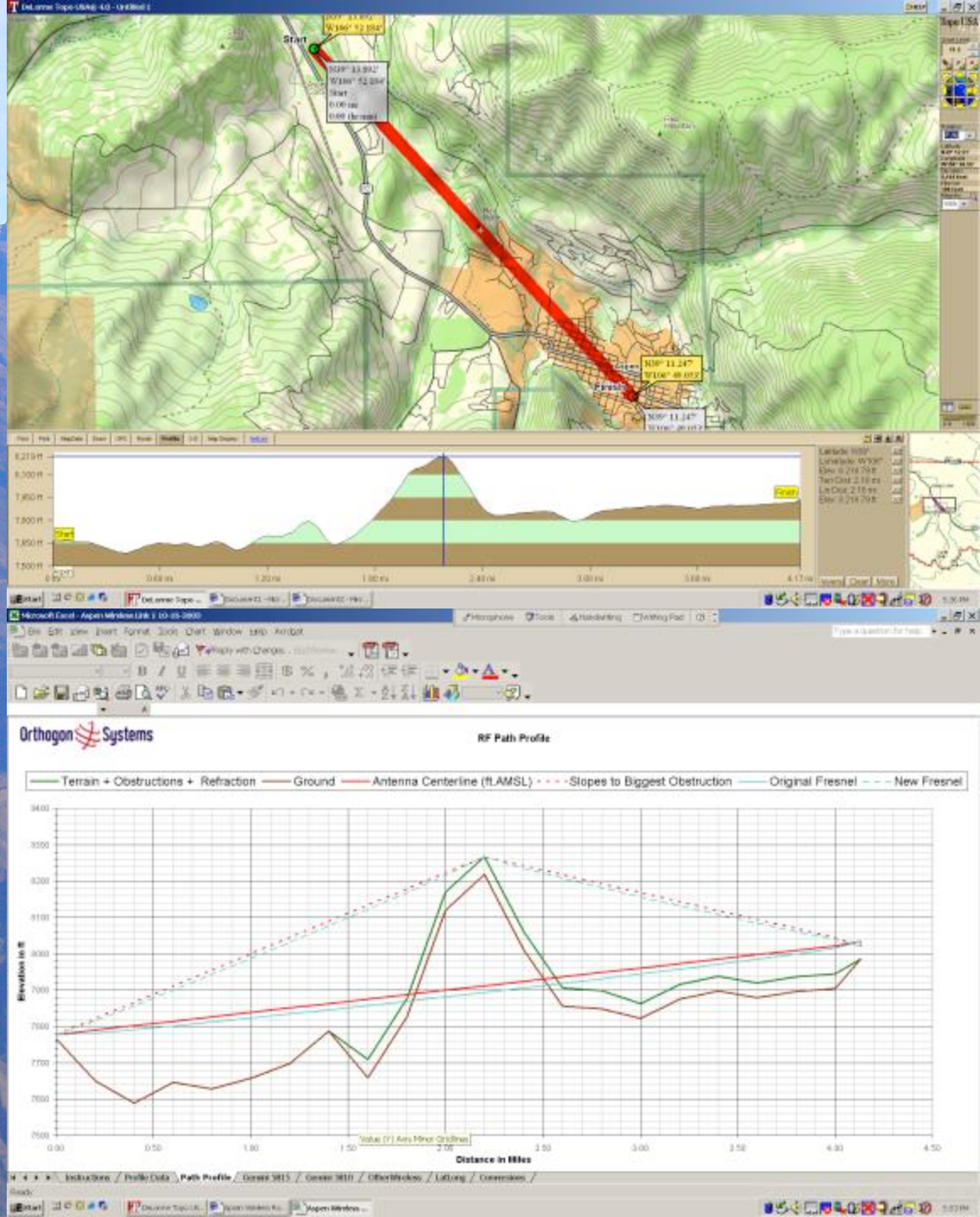
Motorola Canopy

10 Mbps, 20 Mps in PtP
60 degrees beamwidth BS
GPS Sincronization
3 dB S/N
Flexibility in antenna
Proprietary
PoE, Lightning arrestor
Weatherproof
Six non-overlapping frequencies
RSSI for all modules to display more consistent RSSI readings with temperature compensation
Audible alignment tone

Orthogon

- **Link Distance: 4.13 Miles**
- Height: 7985 feet
  Antenna Height AGL: 40 feet
  Obstructions Nearby:
  55' Opera House
- **Ending Point**
  Roadside
  Position: N39 13.201
  W106 51.722
  Height: 7766 feet
  Antenna Height AGL: 12 feet
  Obstructions Nearby:
  small ridge, trees
- **Major Obstructions**
  569 ft Butte and trees
- Free Space Path Loss:
  124.2dB
  Excess Path Loss:
  34.2dB
  Throughput Rate Upstream: 6
  Mbps
  Throughput Rate Downstream:
  Mbps
  Modulation QPSK ½ and BPSK ½
- Fade Margin: 0dB

02/23/2004



OS-Gemini

OS Gemini

The OS-Gemini enables true non-line-of-sight links, easily overcoming obstacles and terrains that render other wireless systems useless. Where other products are hampered by buildings, trees, small hills, or adverse weather, the OS-Gemini works around the obstacles to make its connection. Any potential interference is avoided by the OS-Gemini's automatic frequency selection, which always chooses a clear channel for communication. The OS-Gemini supports non-line-of-sight connections for up to 6 miles, with a user data rate of up to 23Mbps.

Orthogon Systems

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The OS-Gemini link comprises an integrated outdoor unit and a small indoor unit, along with the required mounting equipment. The OS-Gemini includes an embedded web server, to manage the link either directly or remotely. The outdoor unit can be positioned up to 200 feet (60 meters) from the indoor unit.

With shared data rates up to 75 Mbps, a single “sector” of an 802.16a base station provides sufficient bandwidth to simultaneously support more than 60 businesses with T1-level connectivity and hundreds of homes with DSL-rate connectivity, using 20 MHz of channel bandwidth. The 802.16 specification also includes robust security features and the Quality of Service needed to support services that require low latency, such as voice and video. 802.16 voice service can be either traditional Time Division Multiplexed (TDM) voice or Voice over IP (VoIP).

Proxim Mp11.a

Power over Ethernet
Max 36 W, Typ. 7.5W
Turbo mode gives 108 Mbps
rate adaptive to 6 Mbps
Max Out 18 dBm
Built in attenuator to control int.
Spanning tree protocol included
Radius support

Satellite Density	Large	Medium	Small	Mini	Micro
Receive Sensitivity Threshold	-99 dBm	-90 dBm	-85 dBm	-72 dBm	-66 dBm
Defer Threshold	-95 dBm	-85 dBm	-75 dBm	-62 dBm	-56 dBm

Supported Channels

Channel ID	FCC	ETSI
52	5.260	–
56	5.280	–
60	5.300	–
64	5.320	–
100	–	5.500
104	–	5.520
108	–	5.540
112	–	5.560
116	–	5.580
120	–	5.600
124	–	5.620
128	–	5.640
132	–	5.660
136	–	5.680

Channel ID	FCC	ETSI
149	5.745	–
153	5.765	–
157	5.785	–
161	5.805	–
165	5.825	–

Redline's AN-30

- The AN-30 supports voice, data and video on a single wireless link while reducing costs.

The AN-30 is a scalable license-exempt fixed wireless solution for quickly establishing point-to-point, wireless T1 or E1 connectivity. The AN-30 delivers 4 T1/E1 wireless links for full or partial line-of-sight (optical) conditions with up to 99.999% link availability.

- **Field proven OFDM technology**
The only T1/E1 solution utilizing OFDM technology. OFDM provides tolerance to multipath interference and tolerance to frequency specific fading

Long range
Links up to 50 miles. Enables remote locations to be connected and evaluates the cost of multiple links.

RF Datacom Inc.
UNII Band Terminal 54

System Features

Fast Ethernet Interface: 100BaseTx RJ-45

Range of up to 50 km with line of sight (LOS)

Non-line of sight (NLOS) range of up to 10 km

RF Datacommunication UBT-54

The RF Datacom UNII Band Terminal 54 (UBT-54) Fast Ethernet terminal IS configurable to operate as a point-to-point link or as point-to multipoint system, providing low cost and a scalable multi-service system capable of supporting backhaul and node access functions .
It can deliver a net data throughput of 54 Mbps, with non-line of sight (NLOS) capability to address challenging deployment environments.
operates in the unlicensed UNII band of 5.3 and 5.8 GHz and includes patented technologies to address any potential inter-cell interference issues.

RF Datacommunication UBT-54

In a point-to-point configuration, the UBT-54 is equipped with a narrow beam (9 degrees) to provide a high level of focus for long-range operations of up to 50 km with line of sight (LOS) conditions, and up to 10 km in non-line of sight (NLOS) conditions.

In a point-to-multipoint configuration, the UBT-54 is deployed with wider beam antennas at the base station, including 22.5 and 60 degrees, allocates bandwidth to each subscriber on either a best effort basis, or a pre-defined dedicated basis using QoS

UBT-54 Base Station Specs

Channel Size • 20MHz

RF Dynamic Range • > 50dB

Data Rate (Mbps) in 20 MHz channel • Up to 54 Mbps

Network Attributes • DHCP client / server /passthrough and VLAN

Modulation • Adaptive modulation automatically selects:

• BPSK • QPSK • 16 QAM • 64 QAM

Coding Rates • 1/2, 3/4, and 2/3

Quality of Service (QoS) •

UBT-54 Base Station Specs

System Range • 50 km line of sight (LOS) • 10 km non-line of sight (NLOS)

Total number of CPE's supported per base station • greater than 4,000

Network Services Supported • High speed data, all IP Layer 3 services

Chip Implementation at CPE • FPGA based MAC and PHY

Standards based • 802.16 compliant MAC

Duplex Technique • Time division dupled (TDD)

OFDM carrier profile • 64 point FFT

UBT-54 Subscriber Station Specs

CPE Capability • UBT-54 similar to base station

Modulation • Adaptive modulation automatically selects:

• BPSK • QPSK • 16 QAM • 64 QAM

Data Rate (Mbps) in 20 MHz channel • Up to 54 Mbps

IF Cable • Conventional Cable (RG 58)

• Maximum length 100 meters

• Diplexed IF (820 MHz), DC power, control

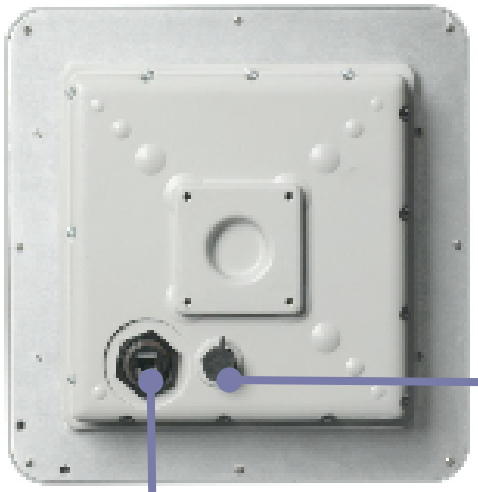
Technical Specifications WiLAN LIBRA

RF Frequency Range: 5.725 to 5.850 GHz	
Modulation Method:	W-OFDM
Wireless Data Rate:	32 Mbps (Raw)
User Data Rate:	24 Mbps (Effective)
Channel Size:	10 MHz
Operating Mode	TDD (Time Division Duplexing)
Modulation	16QAM, QPSK or BPSK
Physical:	Single unit, weather-proof design with integrated/separate antenna option
Weight:	2.5 kg/2 kg (integrated/separate antenna)
Antenna:	Integrated - 23 dBi
	Non Integrated - Up to 37 dBi
Output Power:	+ 17 dBm
Receiver Sensitivity:	- 75 dBm 16QAM @ 1 x 10-6 BER
Network Management: SNMP, TELNET, & Local RS-232 Port	
Network Features:	MBR, CIR & VLAN Compliance
Number of CPEs per AP:	2000 Software Limit

Integrated Platform

Front View

Rear View



1

2

3

Product Type: CPE & RD

1. 23 dBi Integrated Antenna
2. Standard RJ 45 Connector with Weatherproof Cap
3. Weatherproof RS 232 Connector

WMAN Standards

- IEEE 802.16a Standard
  - 256 FFT OFDM
  - Single Carrier
  - OFDMA
- ETSI HiperMAN Standard
  - 256 FFT OFDM
- Wi-LAN's Libra 5800
  - 256 FFT OFDM

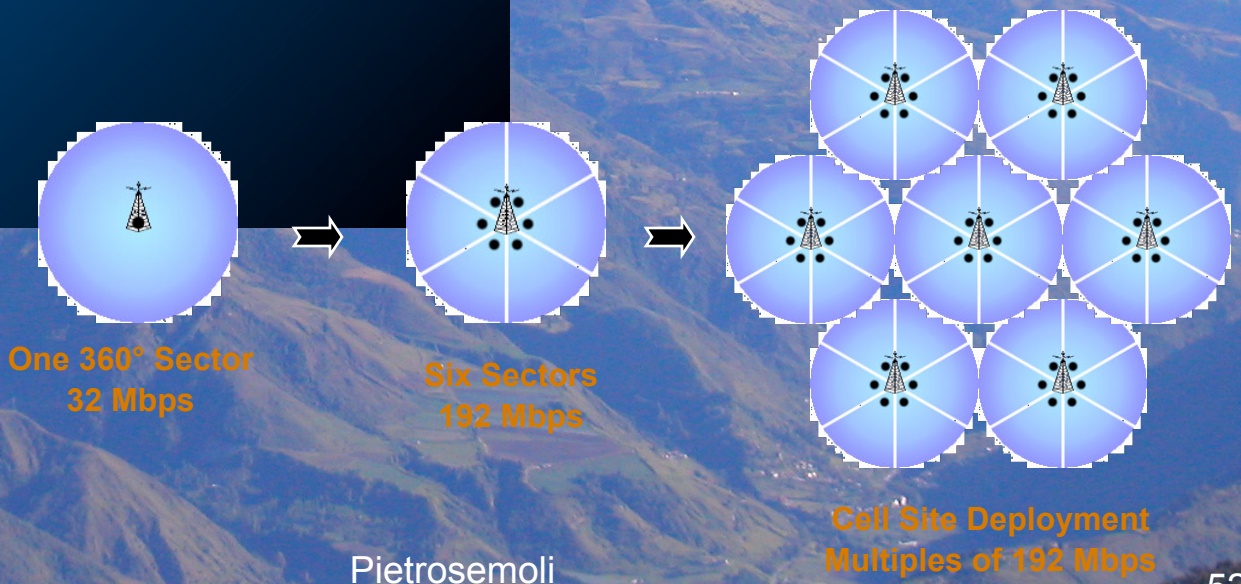
A True Wireless MAN Product!

High Security

- Physical Layer
  - Patented W-OFDM Technology
  - Configurable Centre Frequency
- Data Link (MAC) Layer
  - Proprietary RF Protocol
  - Remote Station ID
  - VLAN
- Network Layer
  - IP Address Filtering
- Network Management Security
  - Protected SNMP, FTP, ping, or TELNET Access
  - Password Protected User Menu

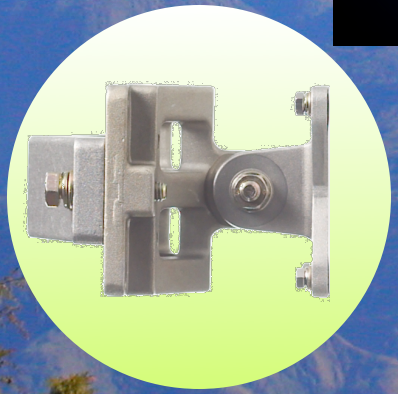
Scalable Capacity

- Configurable Modulation Scheme
  - 16 QAM, QPSK & BPSK
- 10 Non-overlapping Channels
- Selectable AP & CPE Antenna



Easy Installation

- Fully Integrated Design in Rugged Enclosure
- No Expensive & Rigid Cable Required
- PDA Installation Support
- Light Weight Form Factor
- Standard RJ-45 Connector
- Universal Mounting Kit with Pan & Tilt Capability



5 GHz Systems comparison

Manufacture	Wi-LAN	Proxim	Redline/Alvarion	Alvarion
Product	Libra 5800	Tsunami	AN-50 /Link Blaster	BreezeACCESS VL
Modulation	16 QAM	Up to 64 QAM	Up to 64 QAM	Up to 64 QAM
Technology	W-OFDM (256 FFT)	Single Carrier	64 FFT OFDM	64 FFT OFDM
Configuration	PtMP PtP	PtMP PtP	- PtP	PtMP -
Max. Range (Miles)	14 (PtMP) 25 (PtP)	3 (PtMP) 6/3 (PtP)	- 14/9 (PtP)	5 (PtMP) -
Raw Data Rate (Max. Mbps)	32 (PtMP) 32 (PtP)	20 (PtMP) 20/60 (PtP)	- 36/72 (PtP)	54 (PtMP) 54 (PtP)
Effective Data Rate (Max. Mbps)	24 (PtMP) 24 (PtP)	13 (PtMP) 13/39 (PtP)	 28/40 (PtP)	(PtMP) (PtP)
Channel Size (MHz)	10	20	20	20
AP Antenna	Selectable	60° Integrated	-	90° or 120°
Power Control	Yes	No	No	Yes
Integrated Antenna	9°, 23 dBi	10°, 21 dBi	5°/9°, 28/23 dBi	11°, 21 dBi
CPE Size	12x12x3 ½"	10x10x6.8"	-	12x12x2.8"
CPE Weight	5.5 lb	10 lb	-	Unknown
Physical Configuration	ODU	ODU	IDU/ODU	ODU
SNMP Support	SNMP	No	No	SNMP (Extra Cost)
VLAN	Yes	Yes	No	Yes
CIR/MBR	Yes	No	No	Yes


Questions?