July’07

WiMAX

Worldwide Interoperability of Microwave Access

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What is WiMAX…

- Defined as **W**orldwide **I**nteroperability for **M**icrowave **Acc**ess by the WiMAX Forum .
- A standards-based technology enabling the delivery of last mile wireless broadband access.
- Without need for line-of-sight to a base station.
- While supporting different application classes at the same time.

WiMAX…not a new technology!!!

- A more Innovative and Commercially viable adaptation of a technology already used to deliver broadband wireless services around the globe.

Fixed WiMAX…

- The fixed version of WiMAX, based on 802.16-2004 .
- can provide **data rates up to 75 Mbps** per four-sector base station (18.7-Mbps) .
- Typical Cell Sizes :

  Urban & Suburban – 2-10 Kms

  Rural – 50 Kms
- Line-of-sight transmissions use **higher frequencies upto 66GHz.**
- Enough bandwidth to support over 60 Businesses and 100’s of Homes.

Mobile WiMAX…

- Systems built using 802.16e-2005 as the air interface technology.
- In this mode, WiMAX uses a **lower frequency range -- 2 GHz to 11 GHz** (similar to WiFi). Lower-wavelength transmissions are not as easily disrupted by physical obstructions -- they are better able to diffract, or bend, around obstacles.

WiMAX Network Description…

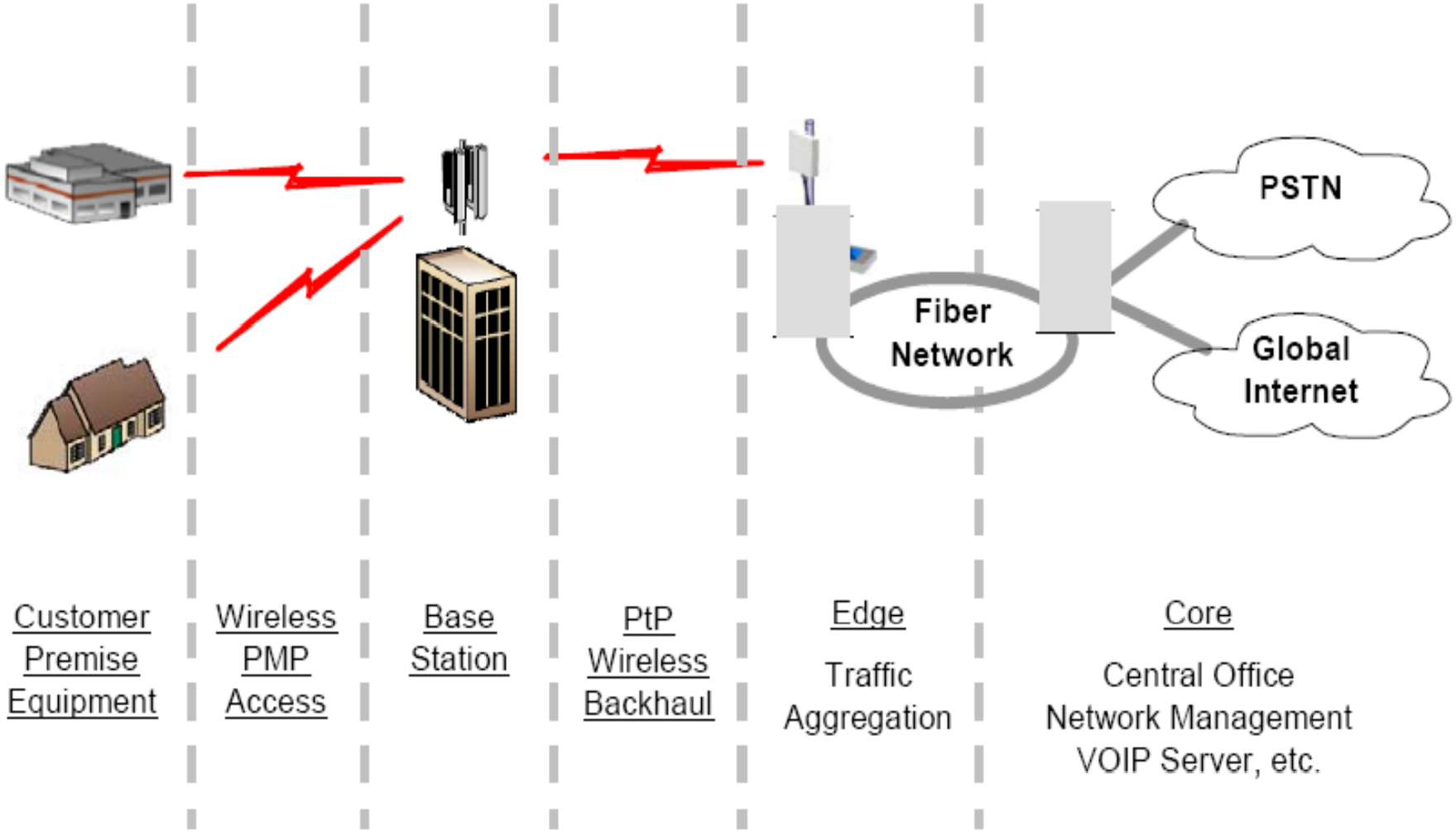


Figure 3: Network Description

WiMAX consists of Two parts…

1. WiMAX Base Station
2. WiMAX Receiver

WiMAX Base Station…

- Consists of indoor electronics and a WiMAX tower.
- Can cover up to 10 km radius.
- Several base stations can be connected with one another using high-speed backhaul microwave links to allow roaming to a WiMAX subscriber.

Base Station Architecture...

WiMAX BS architecture

- OFDM
  - Modulation technique, spread spectrum
  - Used in e.g DSL, WLAN, WiMAX
- MAC, control plane, user plane
  - Manage resources on the air interface
  - QoS
  - ARQ
  - Mobility Management
  - Radio Resource Management
  - Location
- PHY
  - OFDM
  - MIMO
  - Modulation

OFDM…

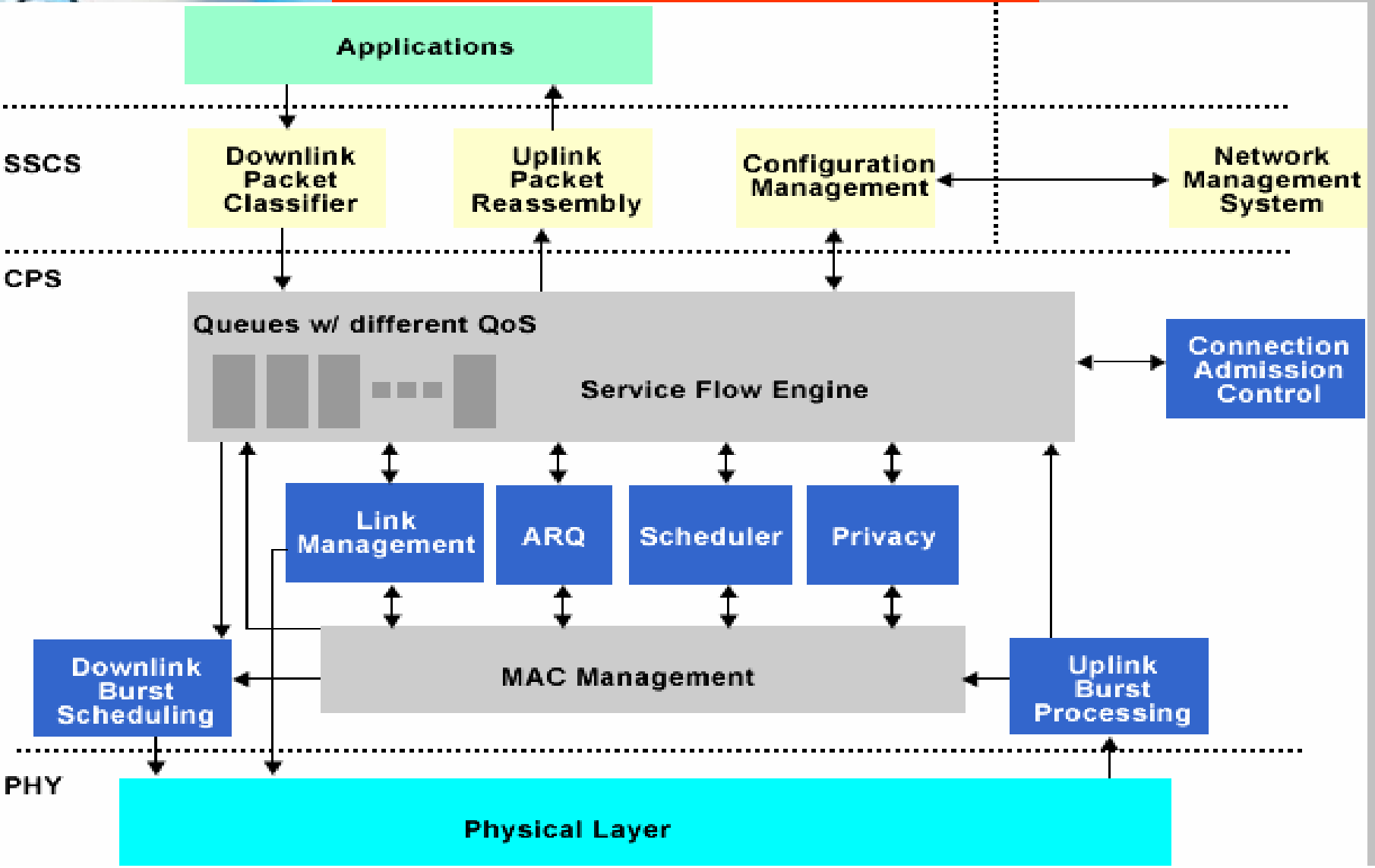
- A digital encoding and modulation technology.
- Achieves high data rate and efficiency by using multiple overlapping carrier signals.
- Key advantage over single carrier modulation schemes : the ability to deliver higher bandwidth efficiency. Hence, higher data throughput even in NLOS links suffering from significant degradation due to multipath conditions.

MAC Layer…

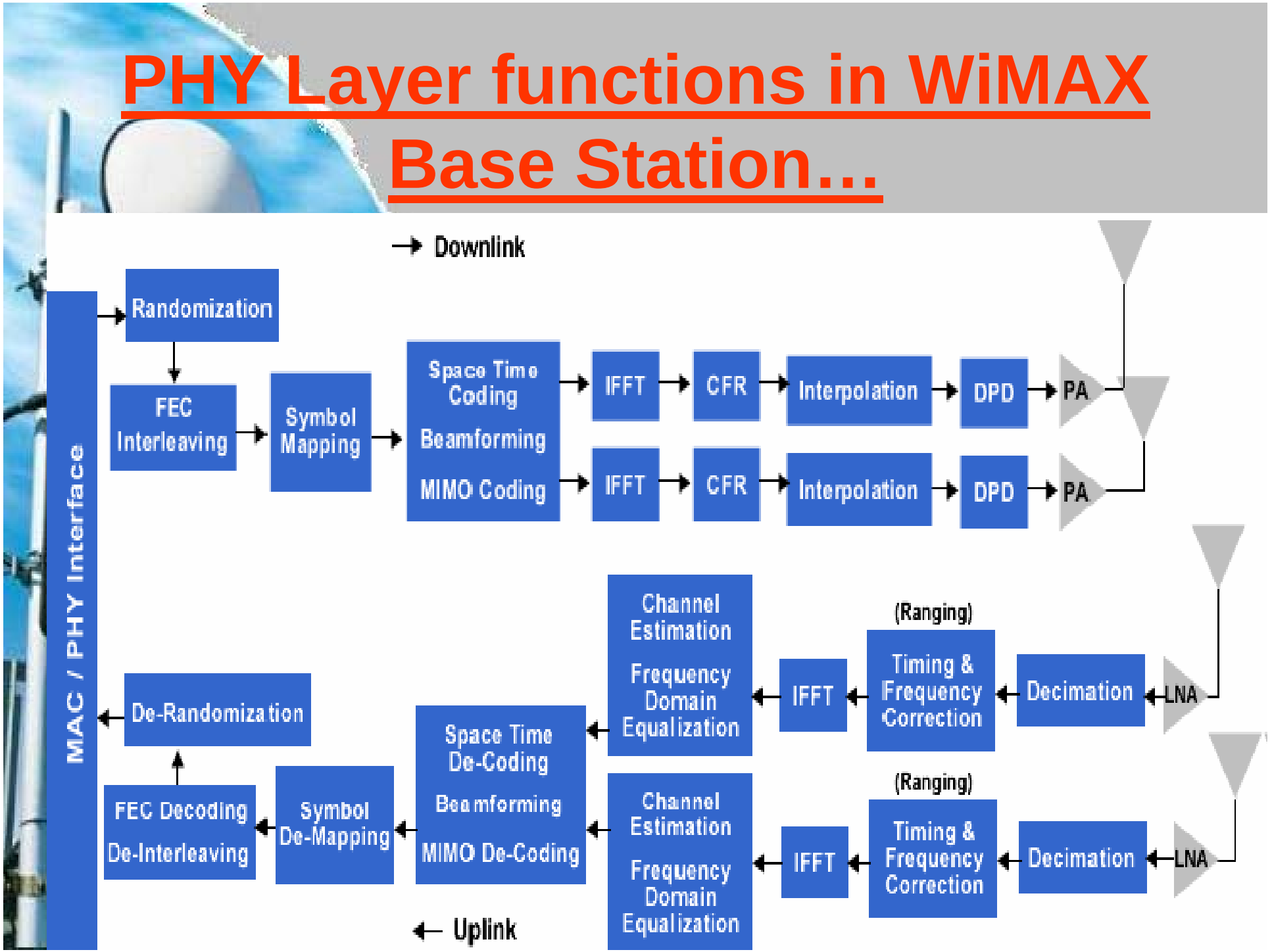
- Main focus is to manage the resources of the airlink in an efficient manner.

- Consists of three sub-layers:
- Service specific convergence sub-layer (SSCS) provides an interface to the upper layer entities through a CS service access point (SAP).
- The MAC common part sub-layer (CPS) provides the core MAC functions, including uplink scheduling, bandwidth request and grant, connection control, and automatic repeat request (ARQ).
- Privacy sub-layer (PS) provides authentication and data encryption functions.

Media Access Control(MAC) Layer Functions…



PHY Layer functions in WiMAX Base Station…



WiMAX Receiver…

- Is a digital baseband receiver that processes the I/Q data .
- The receiver and antenna could be a small box or PCMCIA card, or they could be built into a laptop the way WiFi access is today.

802.16 Standards…

1. 802.16a
2. 802.16
3. 802.16c
4. 802.16d
5. 802.16e

802.16a standard…

- First 802.16 standard.
- Approved in December 2001.
- Delivered a standard for point to multipoint Broadband Wireless transmission in the **10-66 GHz band** .
- Only a **Line of Sight (LOS)** capability .
- Uses a **single carrier (SC) physical (PHY) standard**.

802.16 standard…

- Delivered a point to multipoint capability in the **2-11 GHz band**.
- Also required a non line of sight (NLOS) capability, and the PHY standard .
- Extended to include Orthogonal Frequency Division Multiplex (OFDM) and Orthogonal Frequency Division Multiple Access (OFDMA).

802.16c Standard…

- A further amendment to 802.16 Standard.
- Delivered a system profile for the **10-66 GHz** 802.16 standard.

802.16d standard…

- Supports three physical layers (PHYs) .
- Mandatory PHY mode - 256-point FFT Orthogonal Frequency Division Multiplexing (OFDM).
- Other two PHY modes - Single Carrier (SC) and 2048 Orthogonal Frequency Division Multiple Access (OFDMA) modes.

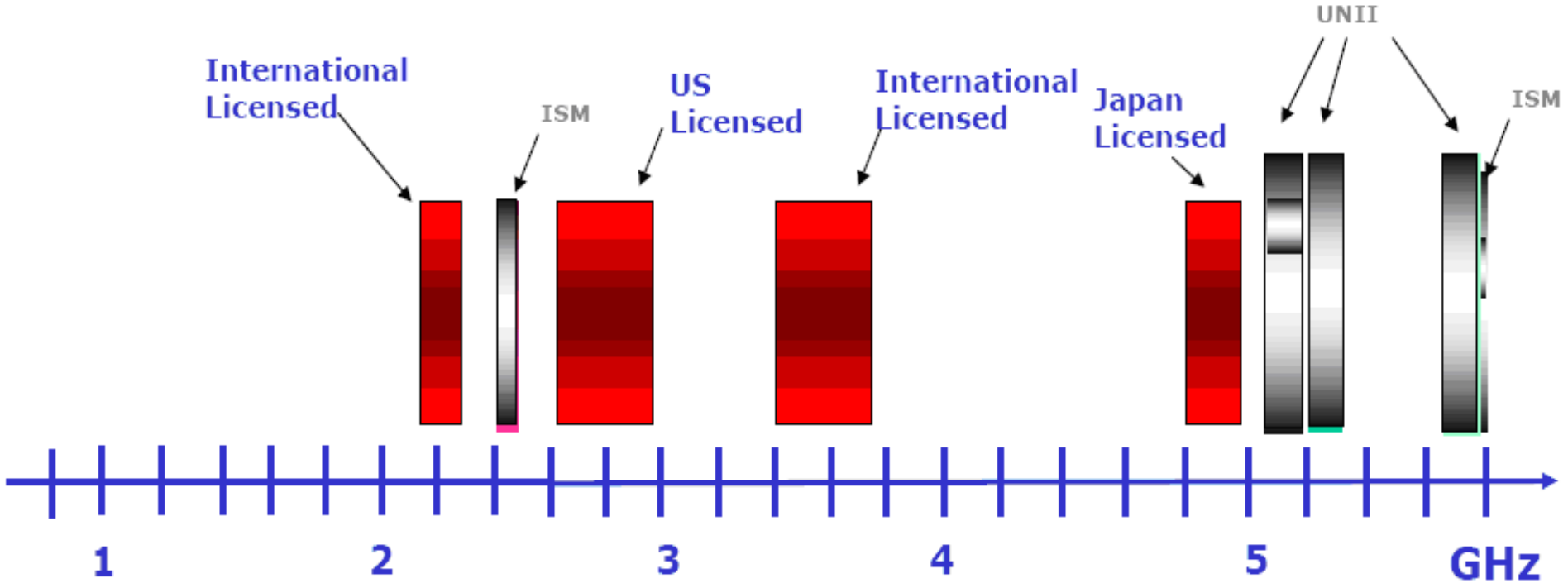
802.16e standard…

- Uses Scalable OFDMA to carry data .
- Supporting channel bandwidths of between 1.25 MHz and 20 MHz .
- With up to 2048 sub-carriers.
- Supports adaptive modulation and coding.
- Purpose is to add data mobility to the current standard .

WiMAX Forum…

- An organization formed in June 2001.
- Organization of more than 400 leading operators, communications component and equipment companies.
- Promote and certify the compatibility and interoperability of broadband wireless access equipment
- that conforms to the Institute for (IEEE) 802.16 and ETSI HiperMAN standards.

802.11/802.16 Spectrum…



802.16a has both licensed and license-exempt options

ISM: Industrial, Scientific & Medical Band – Unlicensed band

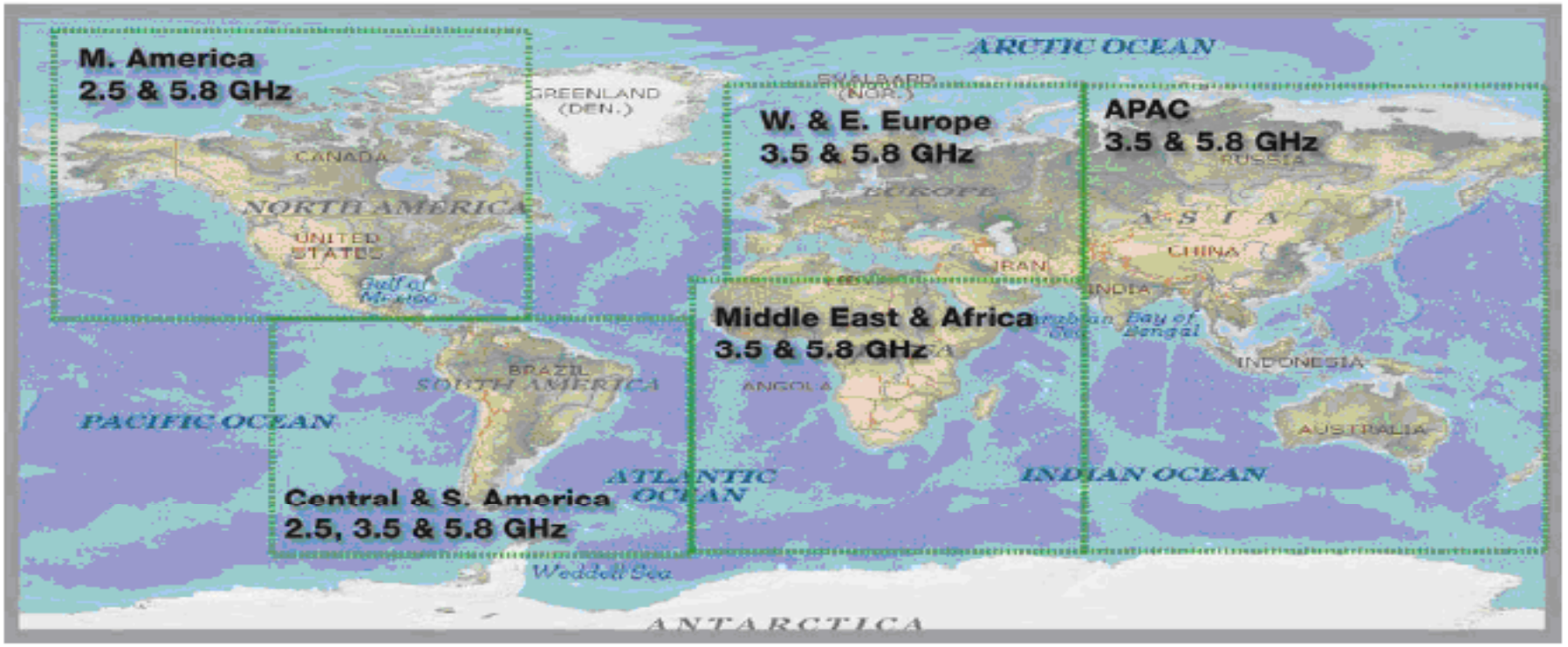
UNII: Unlicensed National Information Infrastructure band – Unlicensed band

Industry & Government aligning Frequencies…

- 3.5GHz will be global licensed frequency

Licensed Bands
2.5GHz (2.3-2.4; 2.5-2.7)
3.5GHz (3.3-3.8)

Unlicensed Bands
5.8GHz (5.25-5.85)



WIMAX OVERVIEW…

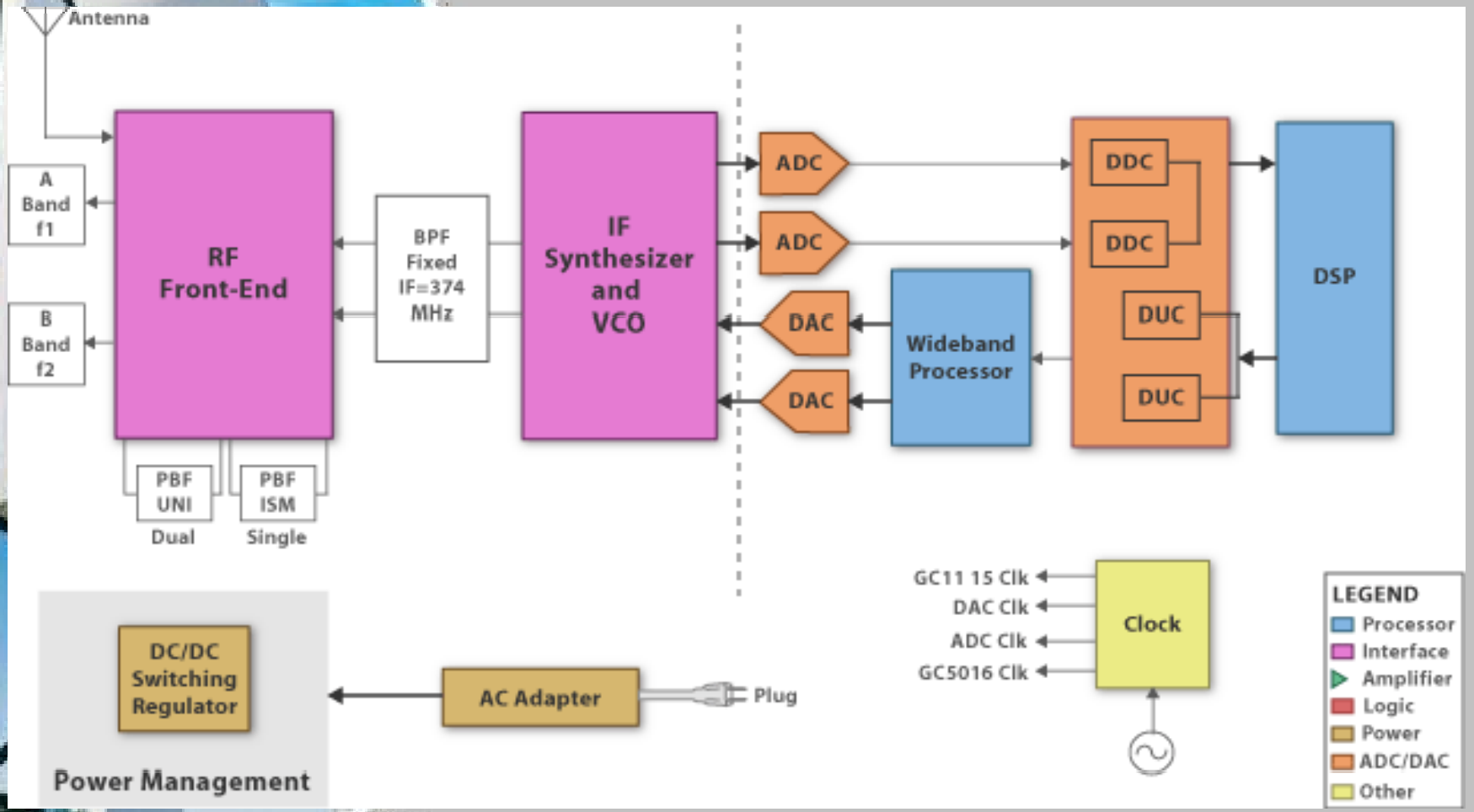
SYSTEM APPROACH

PROMINENT PLAYERS…

- TEXAS INSTRUMENTS
- INTEL
- WAVESAT
- SEQUANS
- FUJITSU
- NORTEL

TEXAS INSTRUMENTS

WIRELESS WIMAX INFRASTRUCTURE



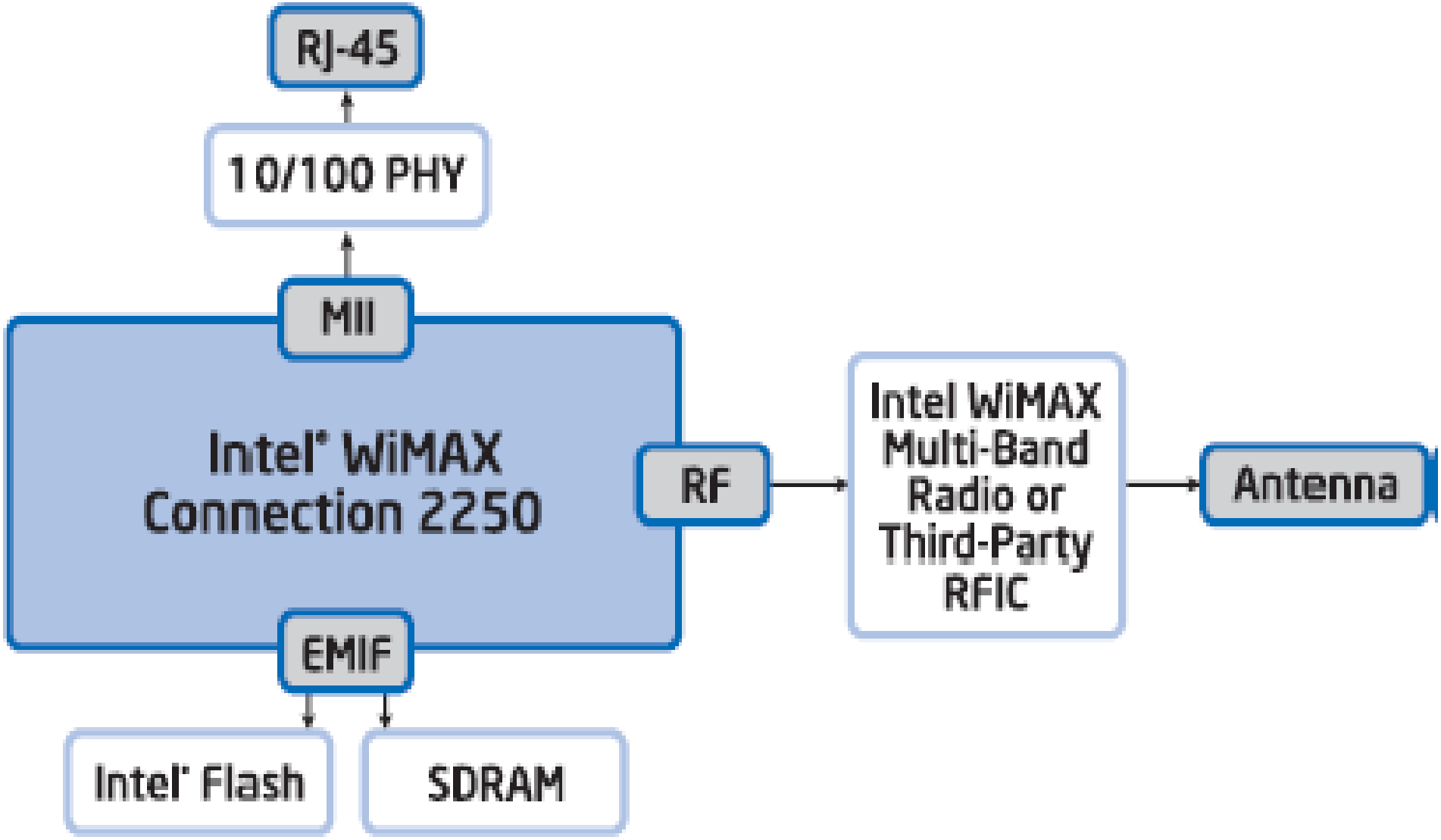
TI HARDWARE SOLUTIONS

- Rf Frontend Solution(**Trf2436**)-for Both 2.45Ghz & 5.6Ghz
- Transceiver Chip With Dual VCO & If Synthesizers (**Trf 2432**)
- ADC DAC Interface
- Baseband Processor
- Digital Up Convertors & Down Converters
- Integrated DSP Based Solutions

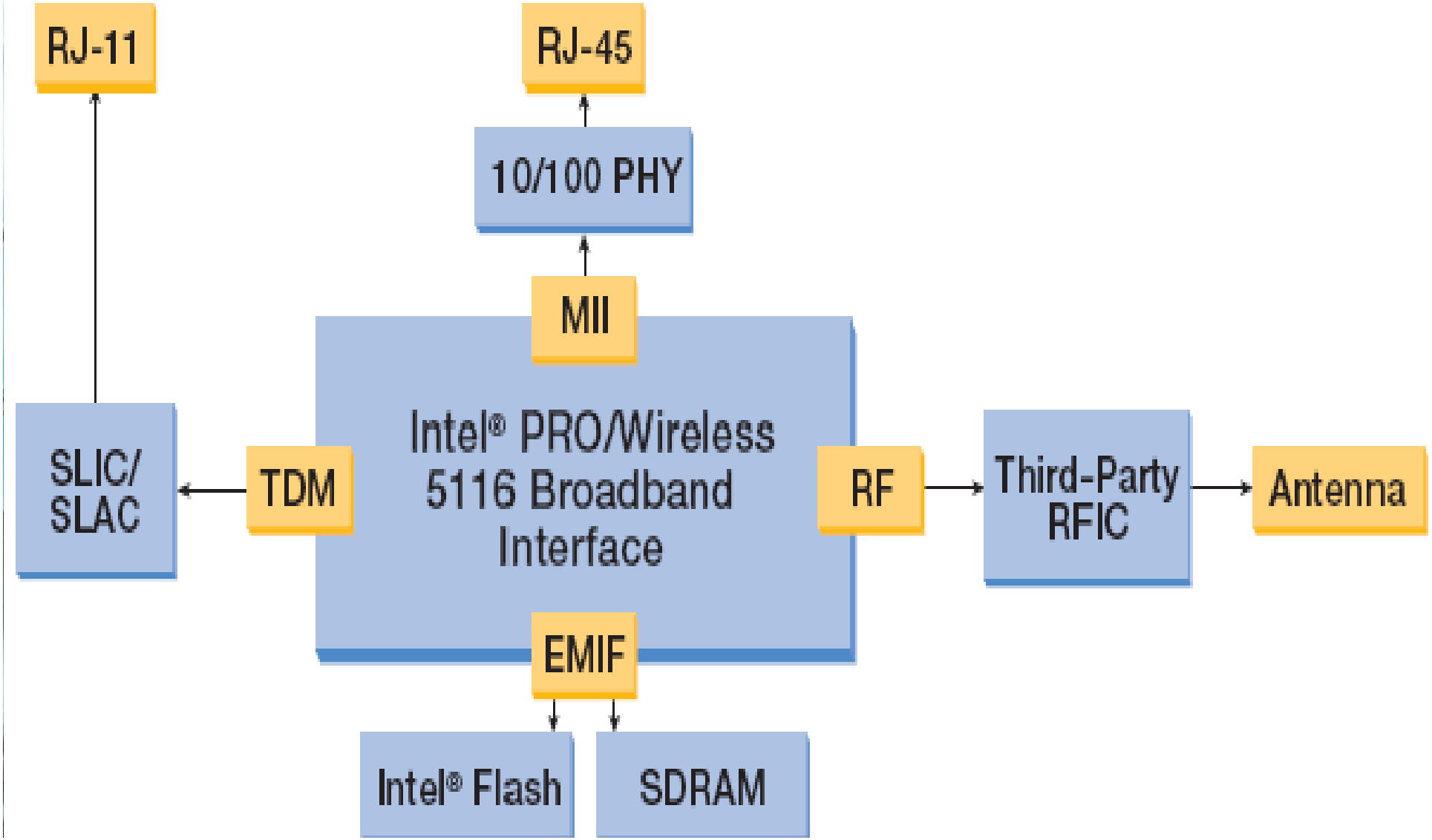
INTEL

- MOBILE WIMAX
- FIXED WIMAX

INTEL 2250-SoC FOR MOBILE WIMAX



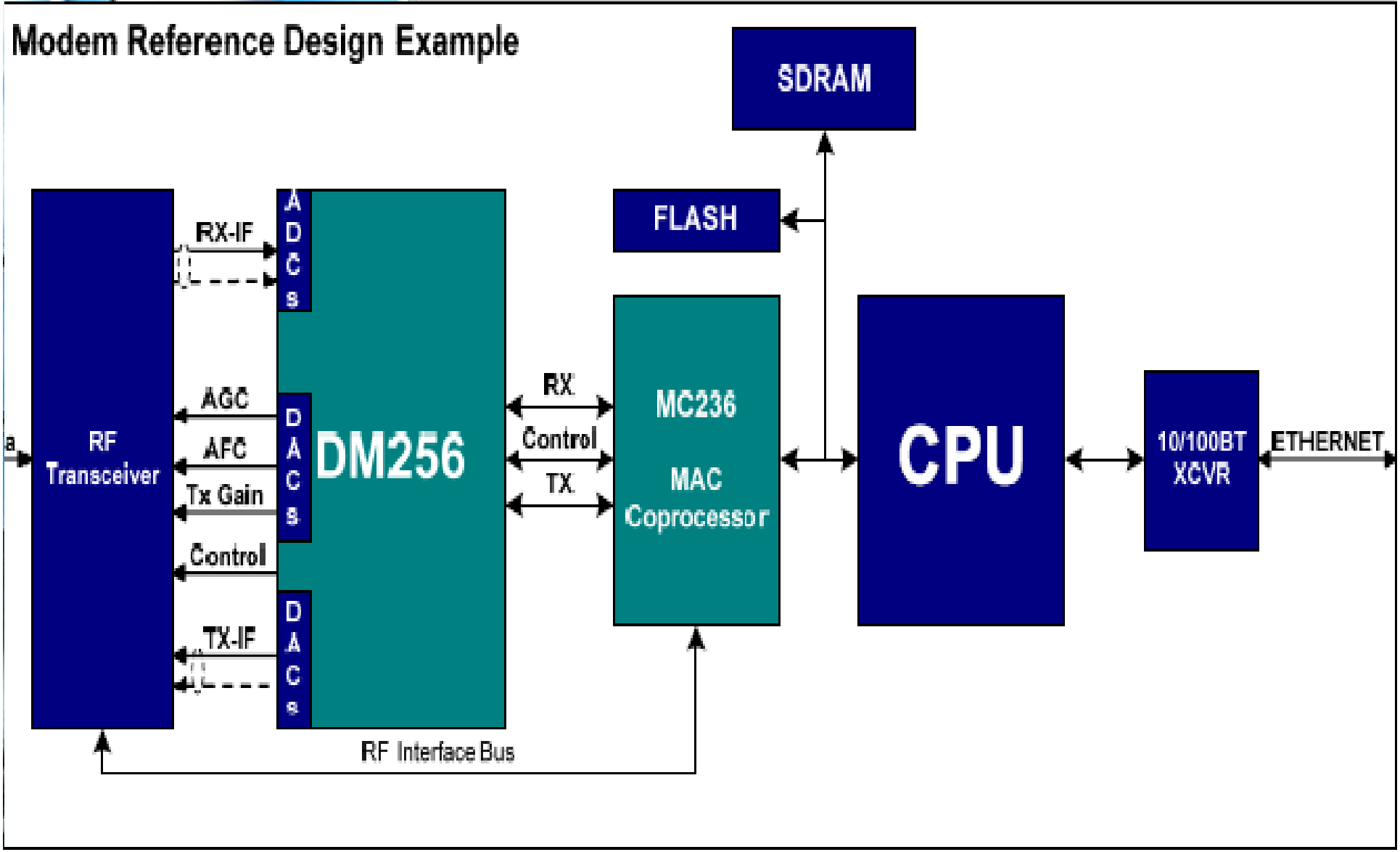
INTEL 5116-SoC FOR FIXED WIMAX



WAVESAT

The Evolutive DM-256 IC for implementation of IEEE802.16-2004 WirelessMAN-OFDM PHY layer protocol

WIRELESS INFRASTRUCTURE

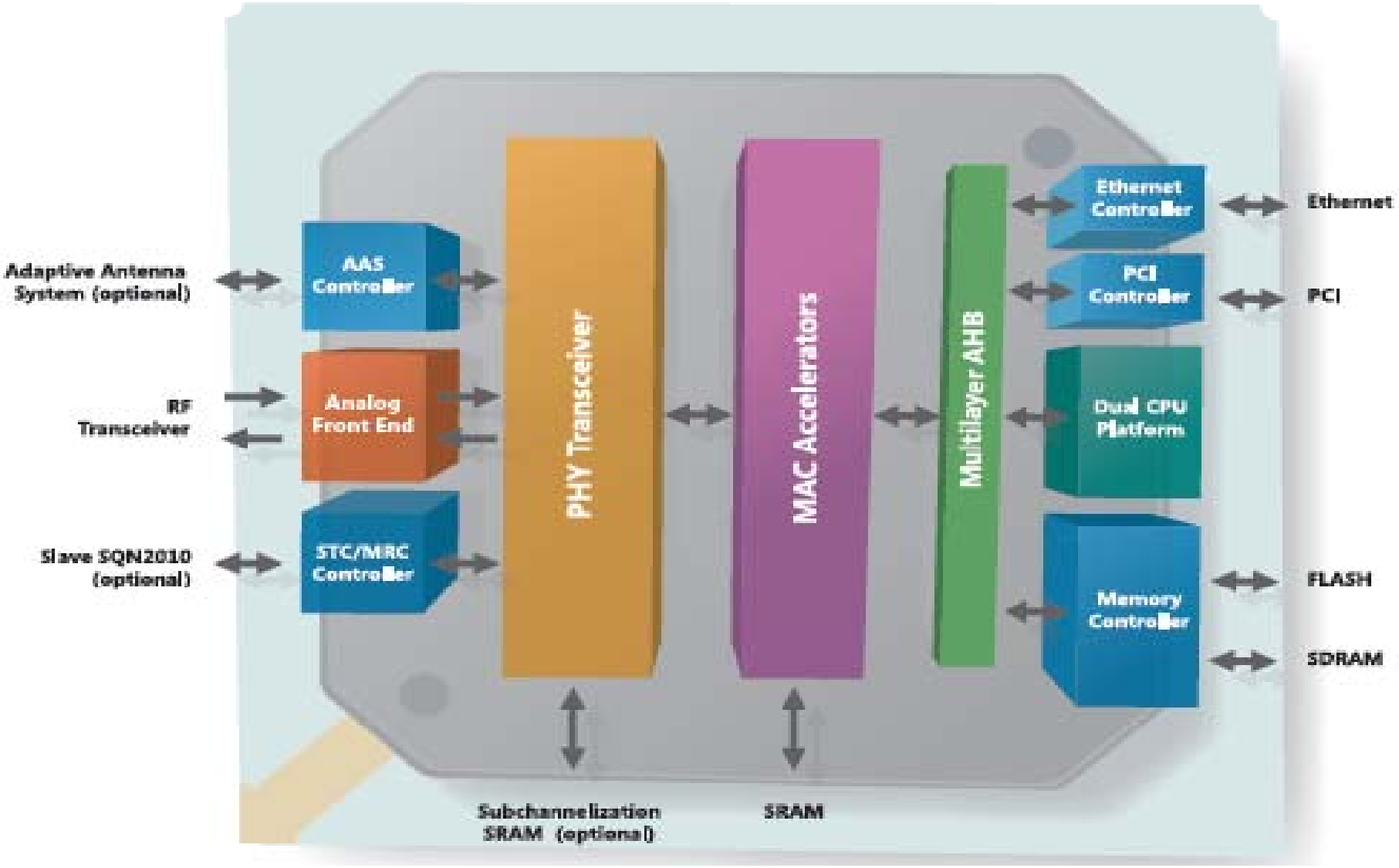


SEQUANS

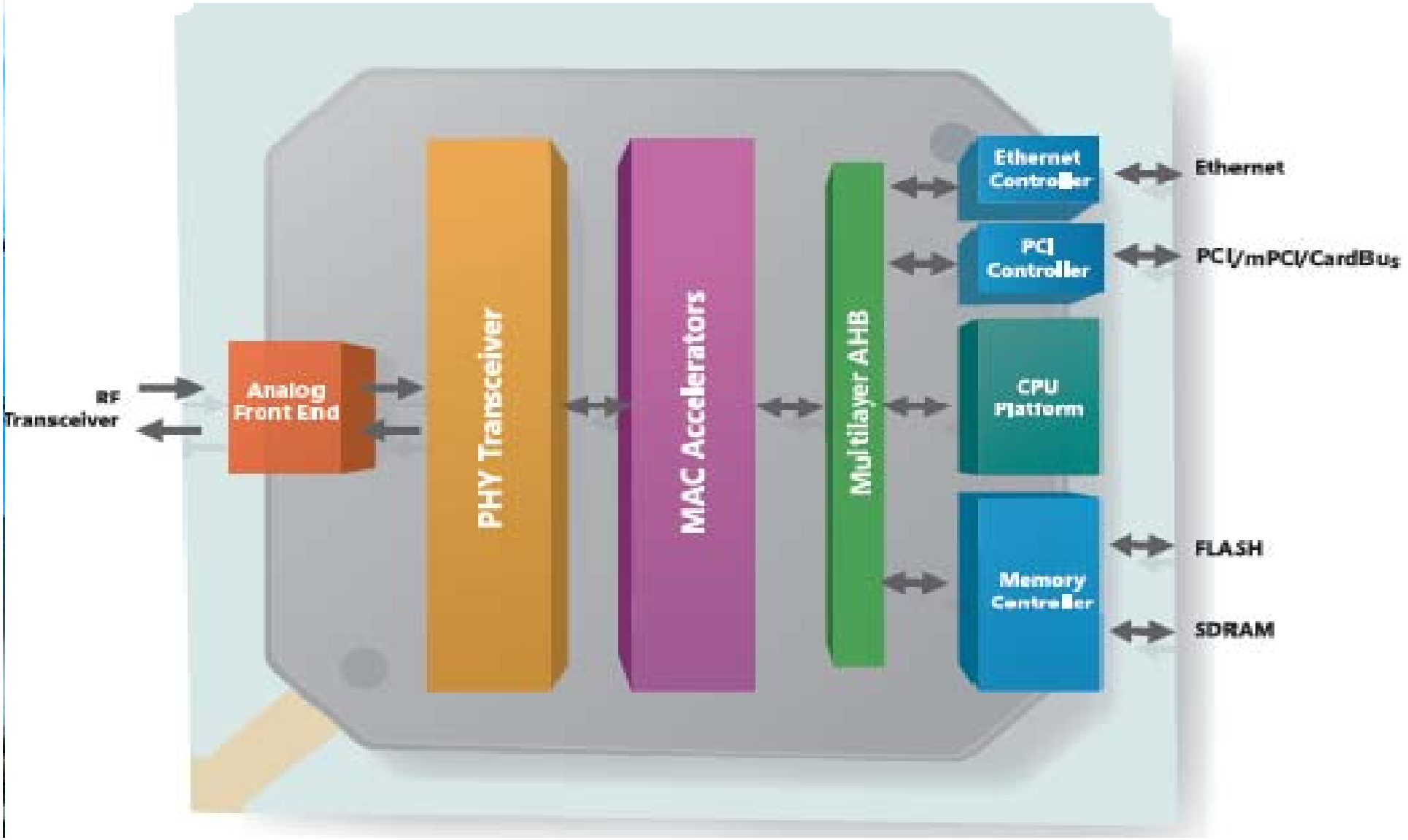
- MOBILE WIMAX
- FIXED WIMAX

FIXED WIMAX

SQN 2010 System On Chip for Wimax Base Station

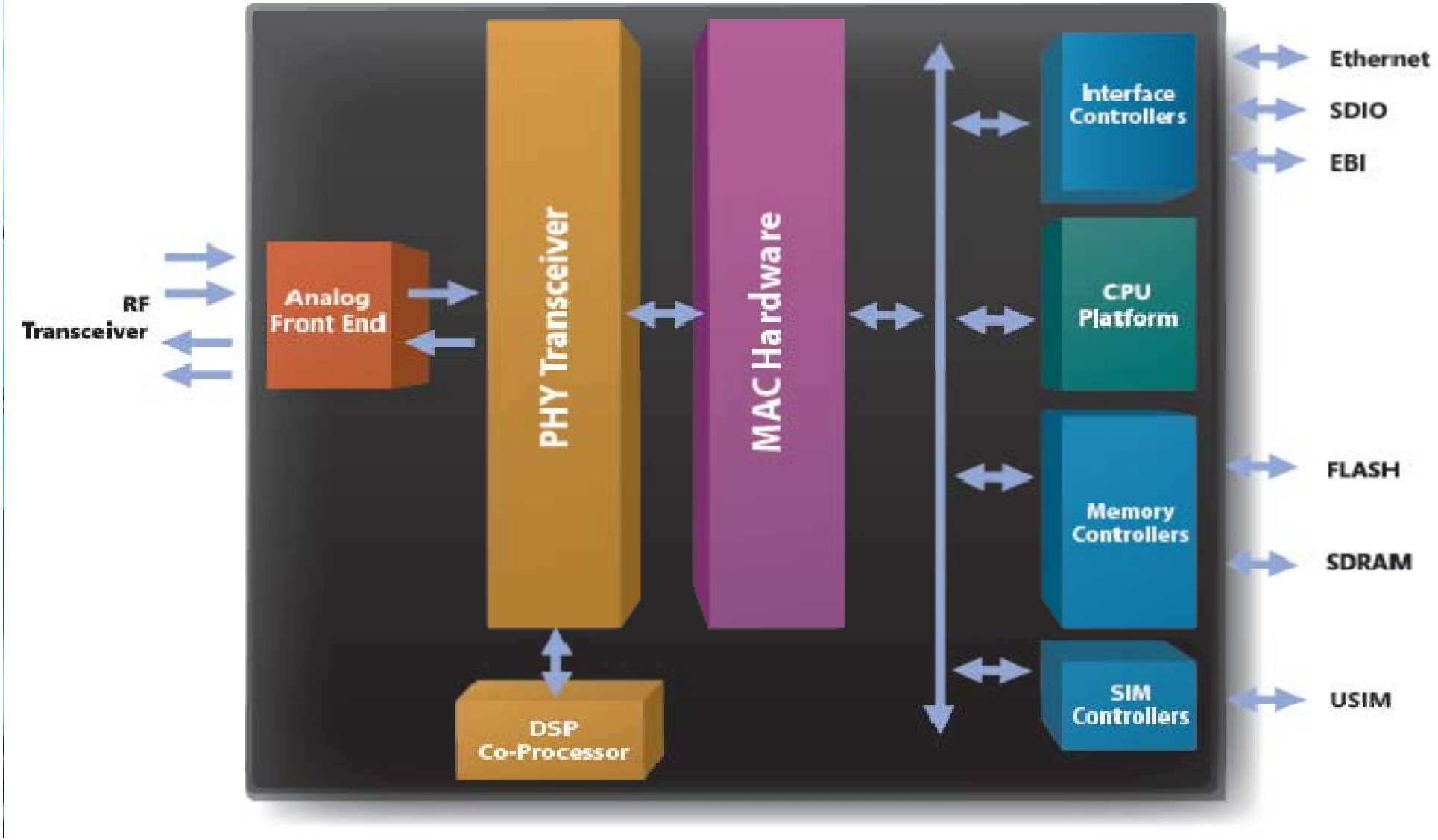


SQN 1010 System On Chip for Wimax Subscriber Station

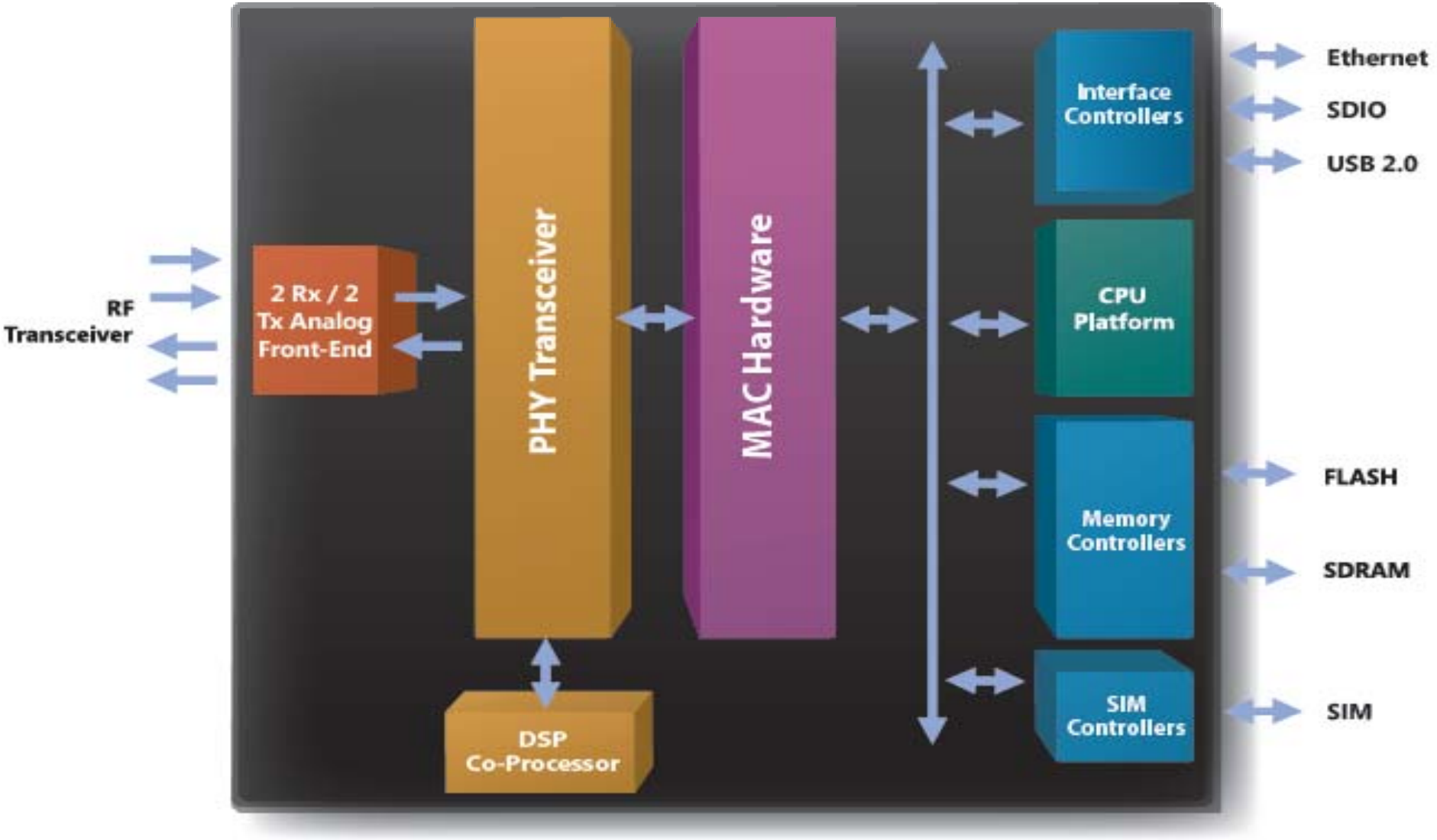


MOBILE WIMAX

SQN 1110 System On Chip for Wimax Mobile Station



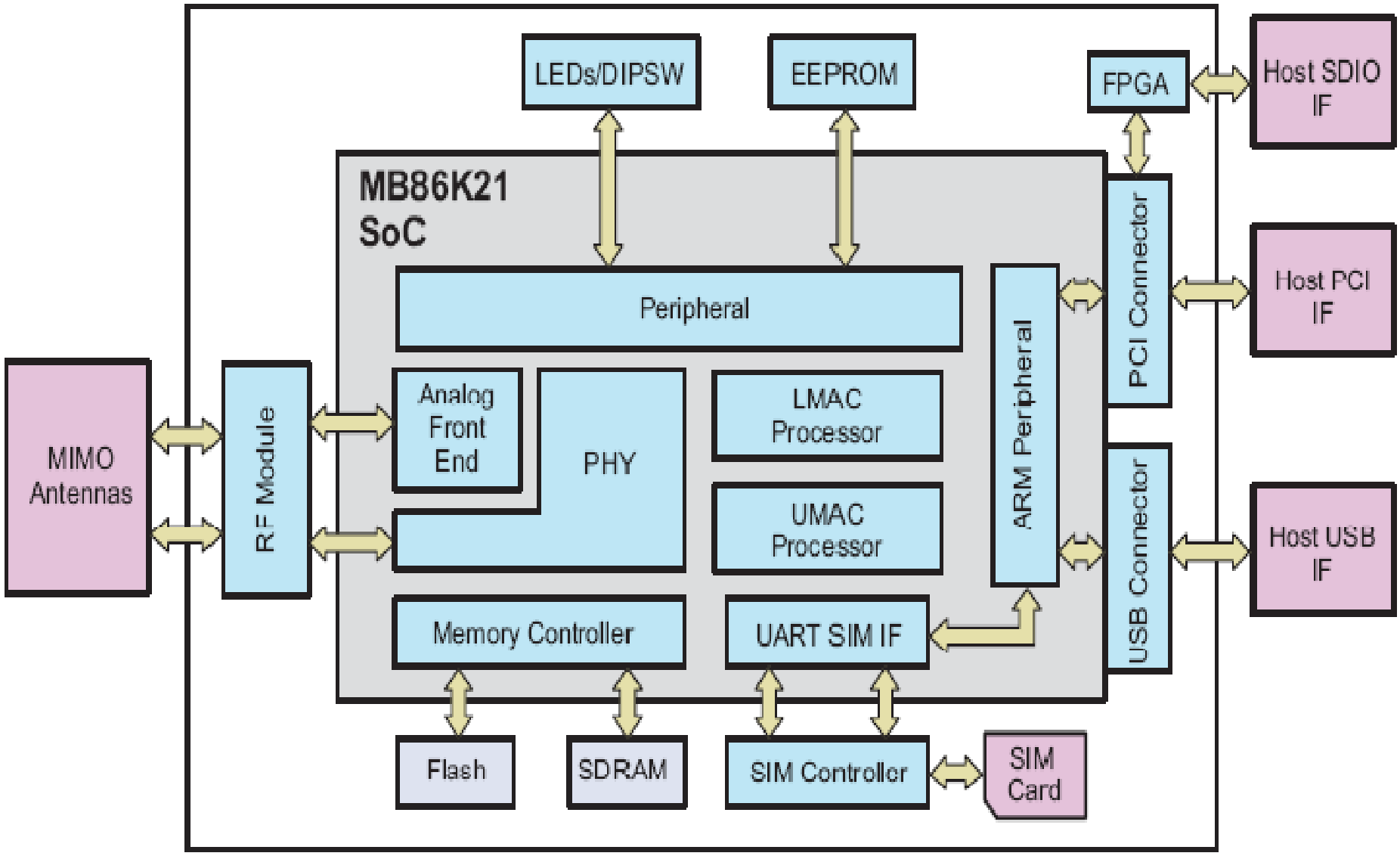
SQN 1130 PHY & MAC baseband solutions with mimo



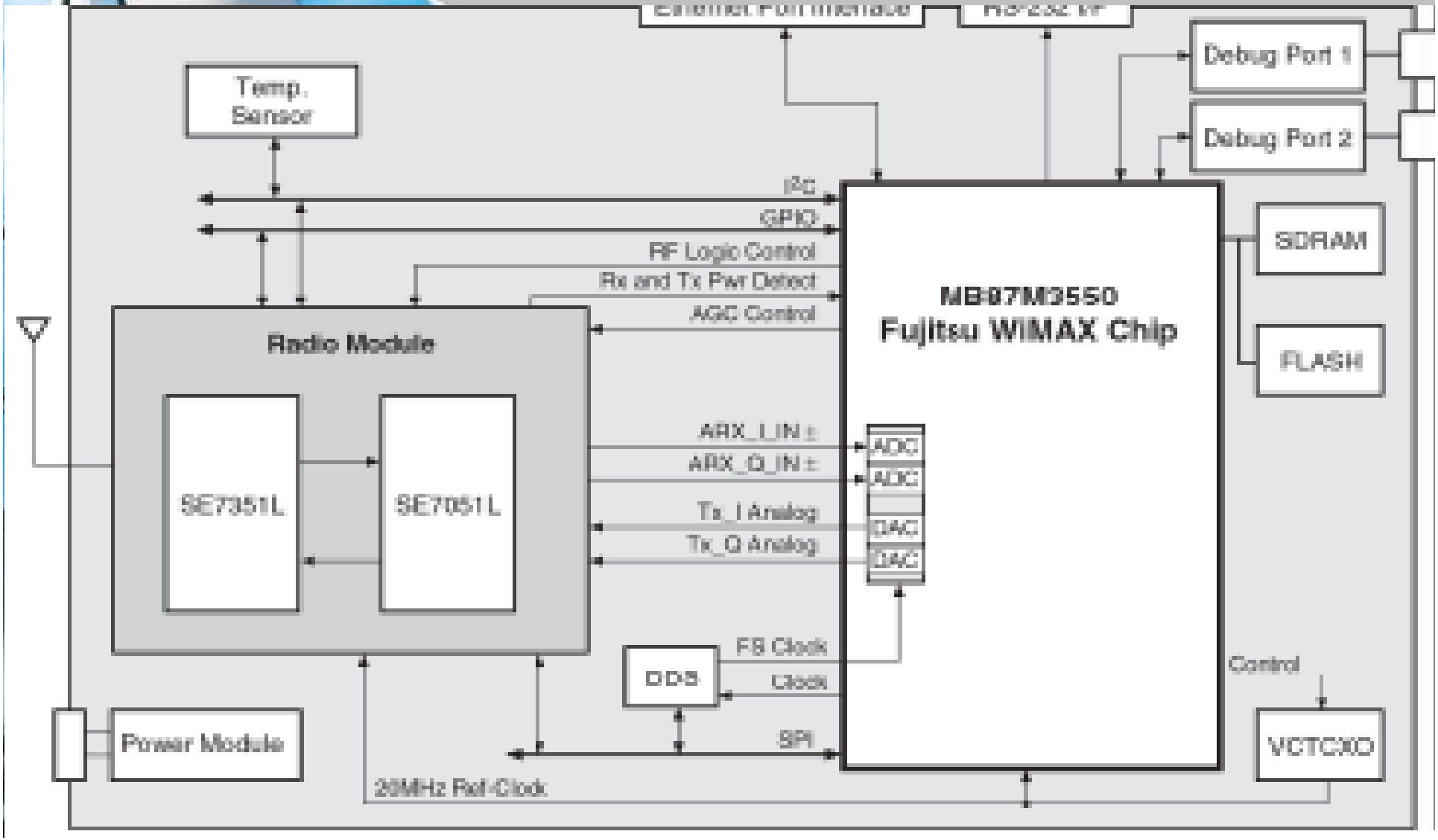
FUJITSU

- Mobile Wimax
- Fixed Wimax

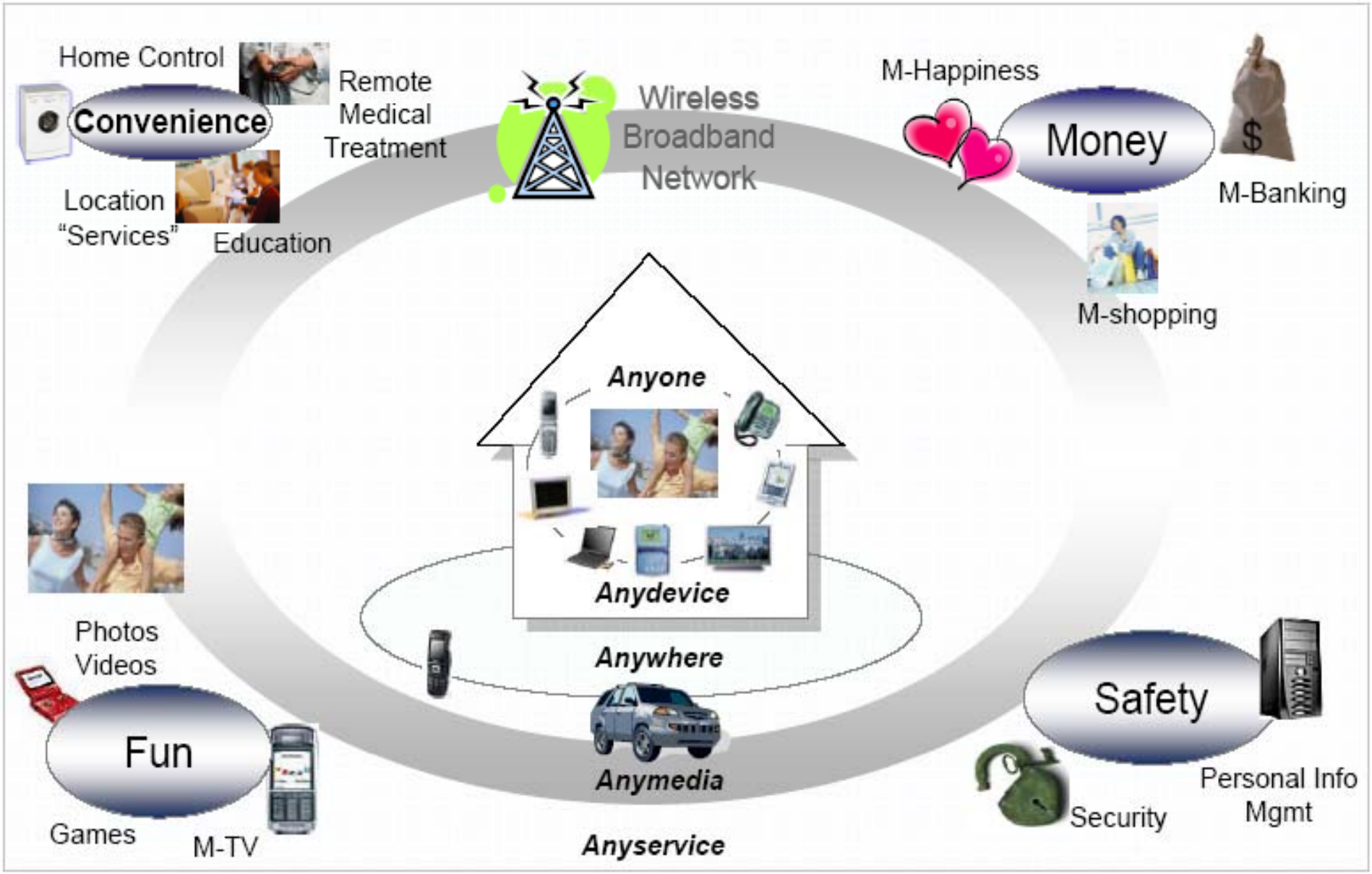
MB86K21
The Fujitsu 802.16e-2005 Mobile WiMAX SoC



MB87M3550.Fujitsu 802.16-2004 for Fixed Wimax



Broadband & its Impact…



Applications Of WiMAX…

1. Residential and SOHO High Speed Internet Access .
2. Small and Medium Business.
3. WiFi Hot Spot Backhaul.
4. Areas of low population density and flat terrain.
5. Interfacing with portable MP3 audio players and digital cameras.
6. Promoting Media Libraries and lessening Storage Requirements.

Applications…

Residential and SOHO High Speed Internet Access…

- Fixed WiMAX provides enough bandwidth to support over 60 Businesses and 100’s of Homes.
- An alternative, where not feasible to use DSL or Cable Internet.
- More reliable due to wireless nature of communication between the customer premises and the base station.

Applications…

Small and Medium Business…

- Well suited to provide the reliability and speed for meeting the requirements of small and medium size businesses .
- A diverse source of Internet connectivity as part of a business continuity plan .

Applications…

WiFi Hot Spot Backhaul…

- WiMAX backhaul provides full wireless solution to these wireless networks .
- Connecting Wi-Fi hotspots with each other and to other parts of the Internet .

Applications…

Areas of low population density and flat terrain …

- Particularly suited to WiMAX and its range.
- Useful in developing countries where reliability & quality of land-line communications infrastructure is poor.

Applications…

Interfacing with portable MP3 audio players and digital cameras…

- MP3 audio players & digital cameras rely on PC households to synchronize or transfer content.
- Mobile WiMAX connects these multimedia devices to the Internet providing convenience and valuable new services .

Applications…

Promoting Media Libraries and lessening Storage Requirements…

- Consumer electronics devices storing music and video content can lessen their storage requirements .
- By streaming media to the subscriber from home media libraries or e - commerce portals.
- Creates new revenue sources for the network operator .

Can Support Different Application Classes – at the Same Time…

- Interactive Gaming
- VOIP & Video Conferencing
- Streaming Media (Real Time)
- Web Browsing & Instant Messaging
- Media Content Download (Store & Forward)

Advantages Of WiMAX…

- **Spectral Efficiency**

✓ 802.16-2004 (fixed) spectral efficiency : 3.7 bit/s/hertz

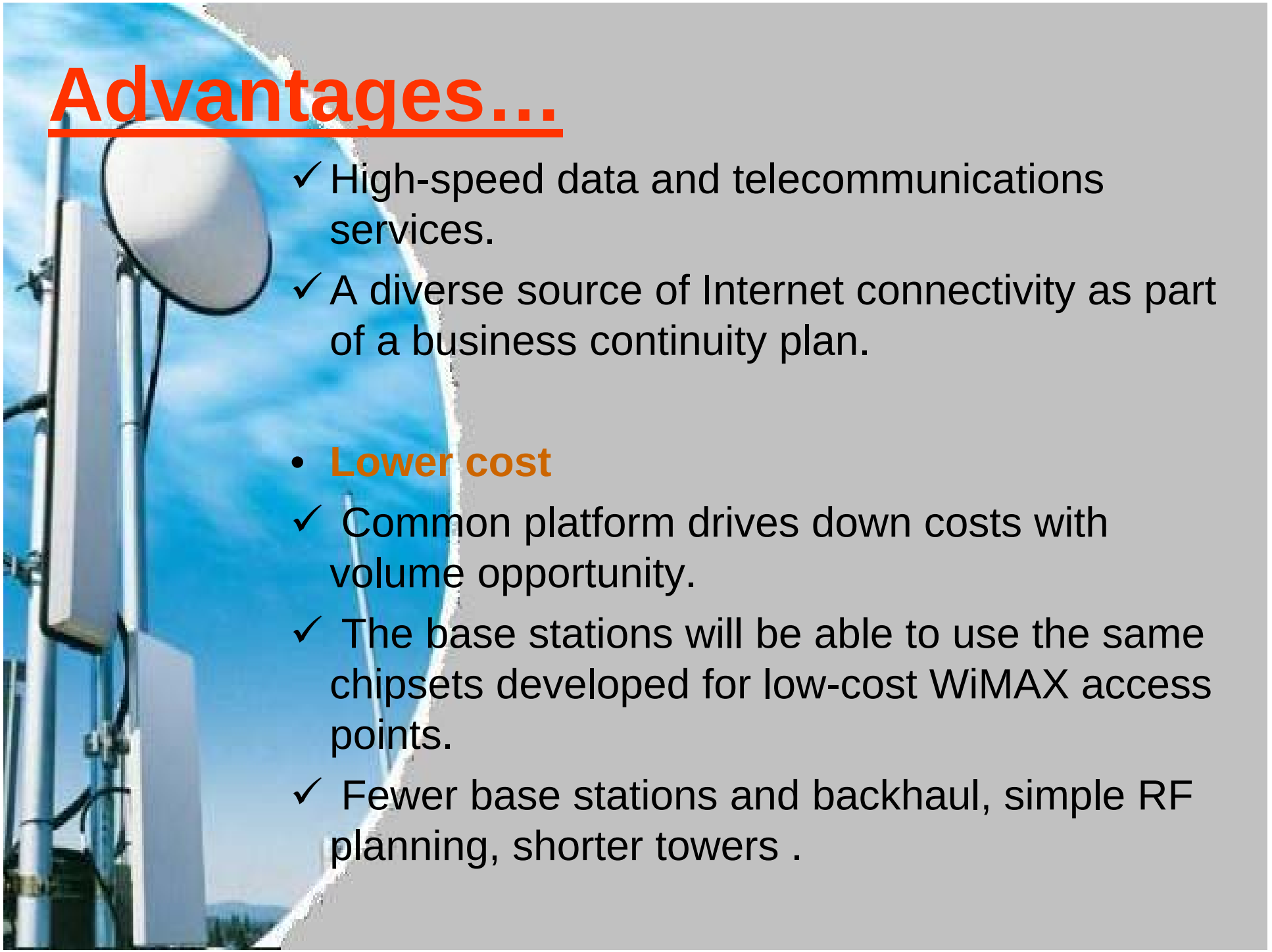
✓ WiFi : less than 1 bit/s/hertz .

- **Nomadic Connectivity**

✓ A wireless alternative to cable and DSL for last mile broadband access .

- **Enhancing Wireless Infrastructure**

✓ Can enhance wireless infrastructure of developing countries in an inexpensive, decentralized, deployment-friendly and effective manner.



Advantages…

- ✓ High-speed data and telecommunications services.
- ✓ A diverse source of Internet connectivity as part of a business continuity plan.

- **Lower cost**
- ✓ Common platform drives down costs with volume opportunity.
- ✓ The base stations will be able to use the same chipsets developed for low-cost WiMAX access points.
- ✓ Fewer base stations and backhaul, simple RF planning, shorter towers .

Advantages…

- **Wider Coverage**

✓ Provide excellent non line of sight (NLOS) coverage

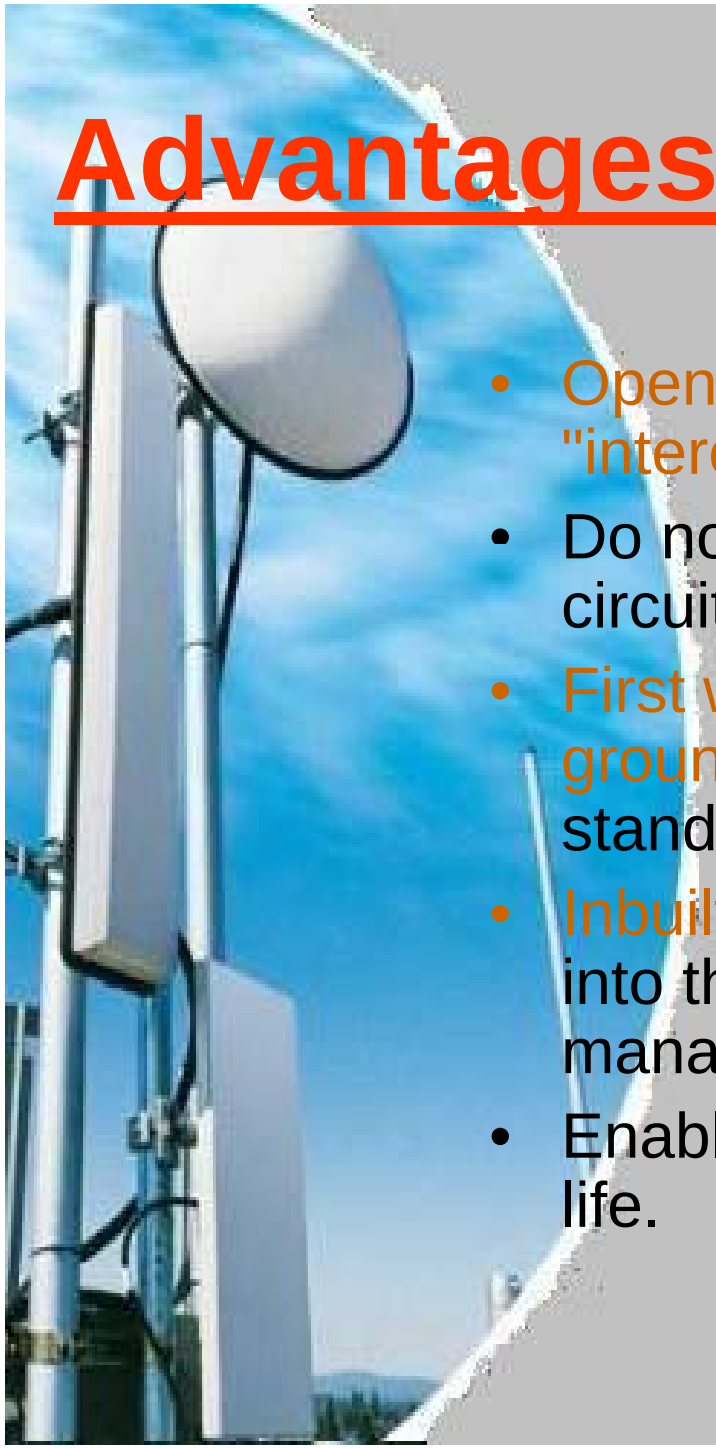
✓ Coverage of wider area

✓ Better predictability of coverage

- **Higher Capacity**

✓ Ability to deliver higher bandwidth efficiency .

✓ Higher data throughput .



Advantages…

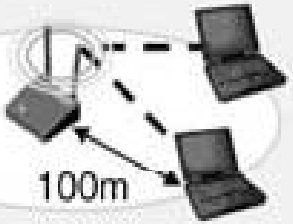
- Open standardization & system "interoperability“
- Do not rely on low data rate, high-latency, circuit-switched voice technology.
- First wireless WAN protocol built from the ground up for IP networking, the same standards that the Internet is based on.
- Inbuilt Quality of service (QoS) mechanisms into the WiMAX chipsets to support and manage multiple service flows.
- Enabling new applications that improve daily life.

Competing Technologies…

Existing wireless technologies

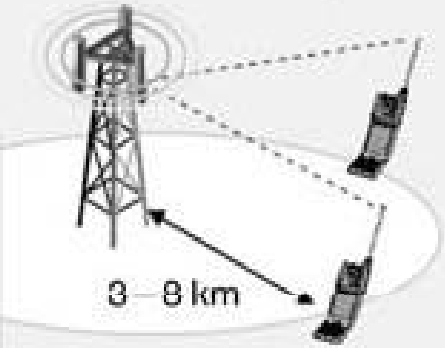
W-iFi (802.11)

- Point to multipoint
- Speed ~11–54 Mbps



2G, 2.5G, 3G

- Point to multipoint
- Speeds
  - 10–21 Kbps (2G)
  - 30–130 Kbps (2.5G)
  - 300–500 Kbps (3G)



New wireless technologies

802.16

- Point to multipoint
- Speed ~15–70 Mbps

802.20

- Point to multipoint
- Speed ~1.5 Mbps

Mobility & Coverage…

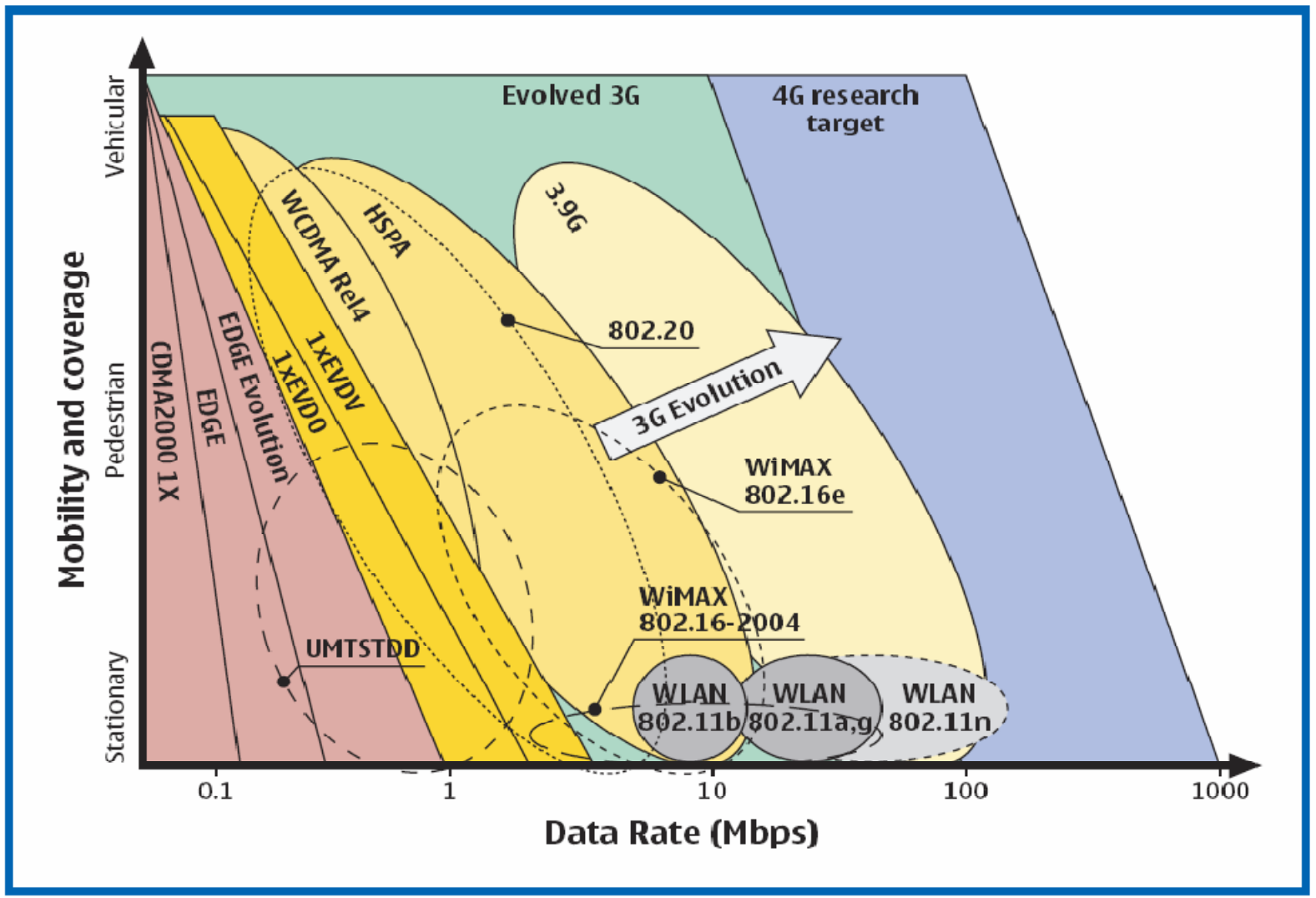
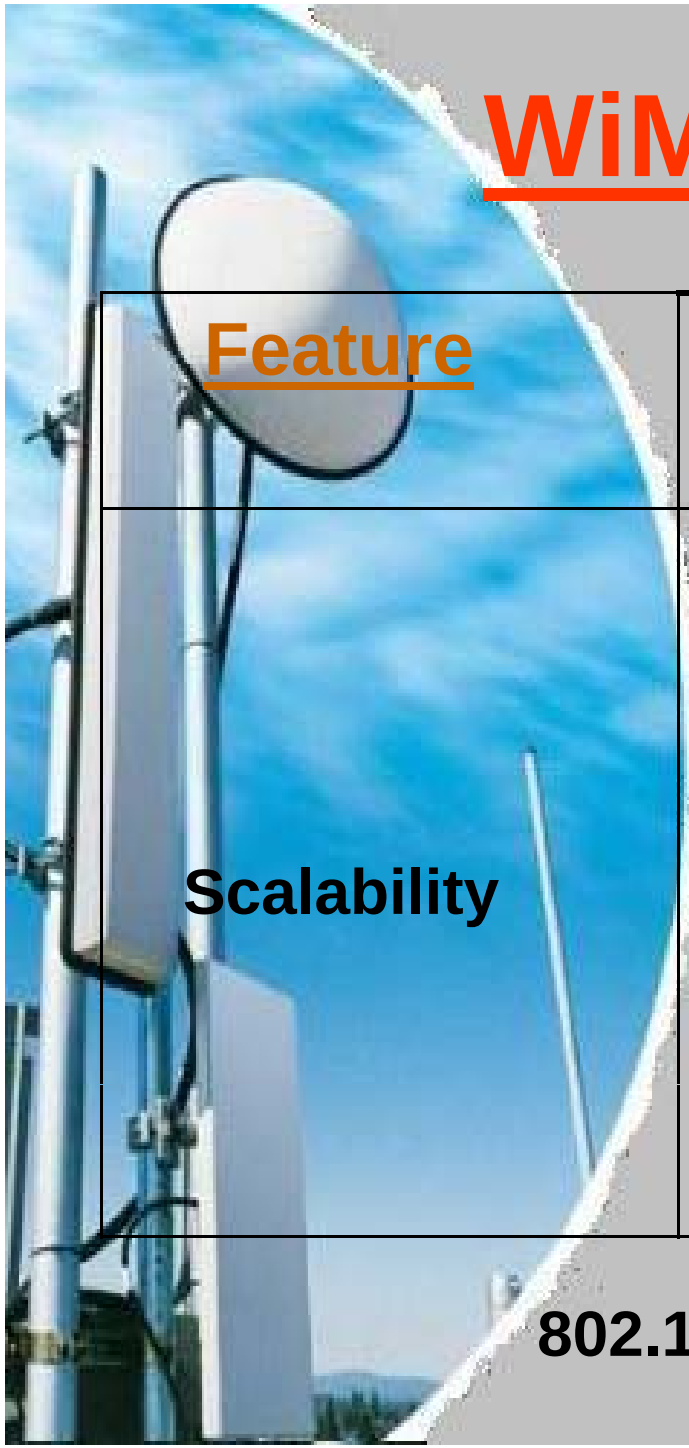


Figure 7. Mobility and coverage vs. the data rates of different radio technologies



WiMAX vs WiFi…

Feature	WiFi (802.11)	WiMAX (802.16e)
Scalability	•Wide (20MHz) Frequency Channels	•Channel Bandwidths can be chosen by the operator(e.g. for sectorization)1.5MHz to 20MHz width channels.
		•MAC Designed for scalability independent of channel bandwidth
	•MAC Designed to support 10's of Users	•MAC Designed to support thousands of users.

802.16e is Designed for subscriber density.

cond…

Feature	WiFi (802.11)	WiMAX (802.16e)
Relative Performance	**Channel Bandwidth:** 20 MHz **Maximum Data Rate:** 54 Mbps **Maximum bps/hz:** ~2.7 bps/Hz	**Channel Bandwidth:** 10,20 MHz ; 1.75,3.5,7,14 MHz ; 3,6 MHz **Maximum Data Rate:** 63 Mbps* **Maximum bps/hz:** ~5.0 bps/Hz

802.16e is Designed for Metropolitan performance.

Cond…

Feature	WiFi (802.11)	WiMAX (802.16e)
Range	•Optimized for ~100 meters •No “near-far” compensation •Designed to handle indoor multi-path (delay spread of 0.8 microsec)	•Optimized for up to 50 Km •Designed to handle many users spread out over kilometers •Designed to tolerate greater multi-path delay spread (signal reflections) up to 10.0 micro sec.

802.16e is Designed for Distance .

Cond…

Feature	WiFi (802.11)	WiMAX (802.16e)
Coverage	•Optimized for indoor performance •No mesh topology support within ratified standards	•Optimized for outdoor NLOS performance •Standard supports mesh network topology •Standard supports advanced antenna techniques

802.16e is Designed for Market Coverage .

Cond…

Feature	WiFi (802.11)	WiMAX (802.16e)
Quality Of Service (QOS)	•Standard cannot currently guarantee latency for Voice, Video •Standard does not allow for differentiated levels of service on a per-user basis	•Designed to support Voice and Video from ground up •Supports differentiated service levels: e.g. T1 for business customers; best effort for residential.
	•TDD only - asymmetric	•TDD/FDD/HFDD – symmetric or asymmetric

802.16e is Designed for Class Operation .

Risks For Embedding WiMAX in Consumer Electronics…

- **Current Mobile WiMAX chipsets do not meet acceptable levels** of power consumption and heat dissipation for integration into battery –powered handset devices.
- Large service networks do not yet exist for Mobile WiMAX.
- Spectrum allocations for WiMAX vary in each country .

Limitations Of WiMAX…

- **Tradeoff Between Bandwidth and Long reach**

✓ One can either have high bandwidth or long reach, but not both simultaneously.

- **Spectral Limitation**

✓ For use in high density areas, bandwidth may not be sufficient to cater to the needs of a large clientele, driving the costs high.

Limitations…

- **Lower Gain antennas in Mobile WiMAX Products**

✓ Antenna design of lower-gain due to omni directional (and portable) design.

✓ LOS environment-10Mbps at 10Km can be delivered.

But,Urban environment-10Mbps upto 2Km is possible.

✓ Use of higher-gain directional antennas lead to loss of practical mobility.

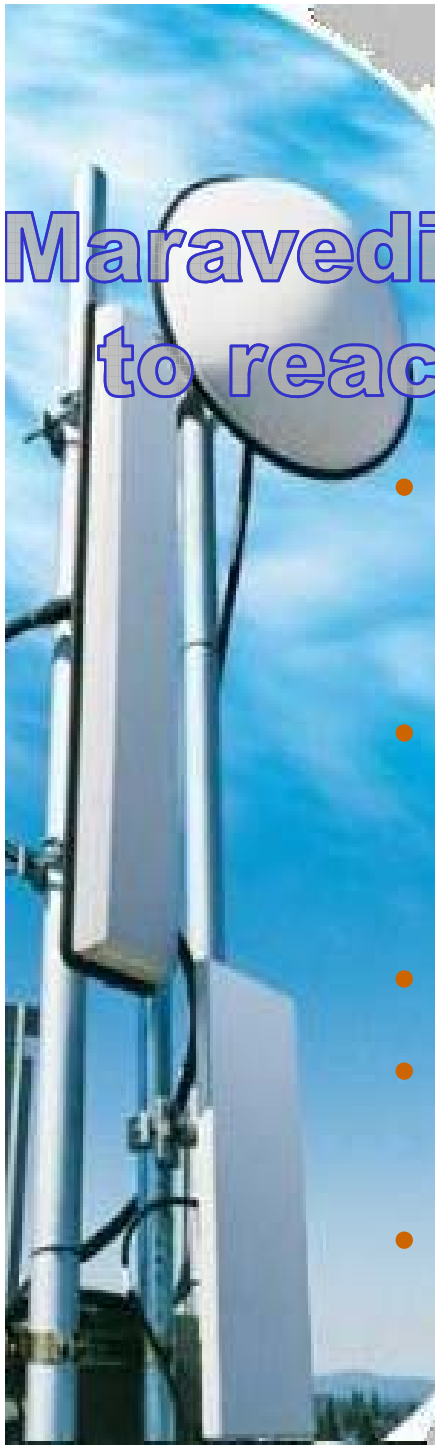
Limitations…

- **Bandwidth Sharing**

✓ Available bandwidth is shared between users in a given radio sector, so performance could deteriorate.

- **Spectrum Allocation Issues**

✓ No uniform global licensed spectrum for WiMAX.



WiMAX in India…

Maravedis predicts WiMAX subscribers to reach 13 million in India by 2012.

- Bharti TeleVentures, Reliance, BSNL and VSNL acquired licenses in 3.3GHz range & working on trials and modest commercial deployments.
- VSNL to install 2,000 WiMAX base stations & will spend INR45 billion (USD1.1 billion) over two years on the project .
- Motorola :BWA projects for state governments.
- Alcatel :joint venture with the C-Dot to focus on exclusive BWA/WiMAX solutions.
- Intel :working closely with the Indian Government in bringing the ”village entrepreneur” model.

Obstacles in India…

- **Shortage Of Spectrum**

✓ License holders need 20MHz of spectrum while they hold 12MHz or less.

- **Non-Availability Of Bandwidth**

✓ 3.5 GHz band (an internationally approved standard), is currently allocated to the Department of Space for INSAT downlink.

- **Need to Develop Low Cost End-To-End System**

Government Initiatives…

- Releasing some of the spectrum from the departments of Space and Defense.
- TRAI currently engaged in a critical public consultation.
- Initiating project to release 45 MHz of spectrum from the Department of Defense for 3G services.

WIMAX:
MARKET SIZE ESTIMATES

WiMAX Market Potential…

Industry analysts believe the WiMAX Market will be worth from $3 billion to $5 billion by 2009.

Monthly user averages from around 520 Mbytes in 2012 to 12 GBytes per month in 2020.

10 million BWA customers worldwide by 2008 .

Motivations For the WiMAX Markets…

- **Government endorsement of initiatives**

✓ South Korea's WiBro service

✓ Taiwan's M-Taiwan program

positive indicators for broadband wireless adoption.

- **New Revenue Sources**

✓ Mobile WiMAX connects multimedia devices(digital cameras,MP3 players) to the Internet, enabling new revenue sources for operators.

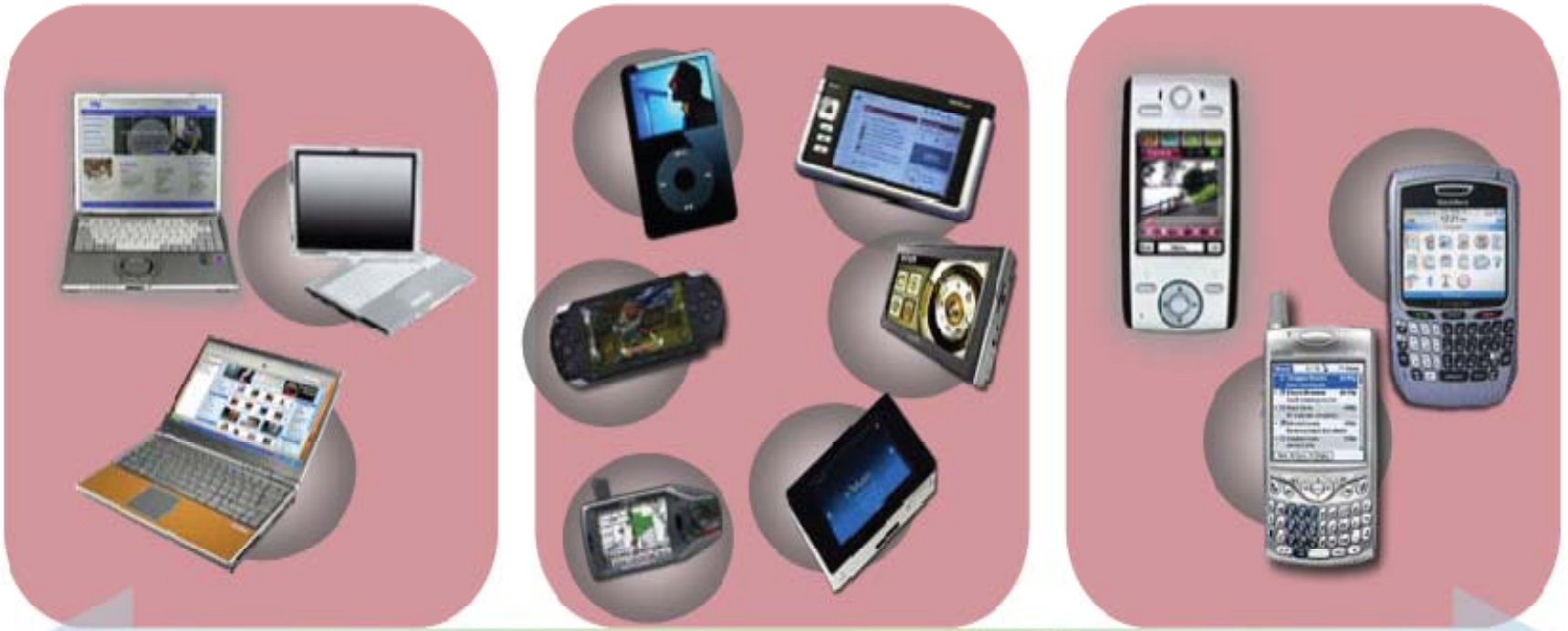
✓ Consumer electronics devices lessening their storage requirements by streaming media to the subscriber from home media libraries or e - commerce portals. New content can be leased to consumers.This leasing model creates new revenue sources for the operator.

Key Researches…

- The number of worldwide WiMAX users is forecasted to reach 14.9 million in 2009, creating over $13.8 billion dollars in service revenues for WiMAX market.
- North America- leading region in terms of the number of WiMAX licenses, with a total of 394 WiMAX license holders.
- Western Europe, WiMAX adoption slow due to the high levels of broadband penetration.

Large Potential WiMAX Device Market

100 Million + *100 Million +* *100 Million +*



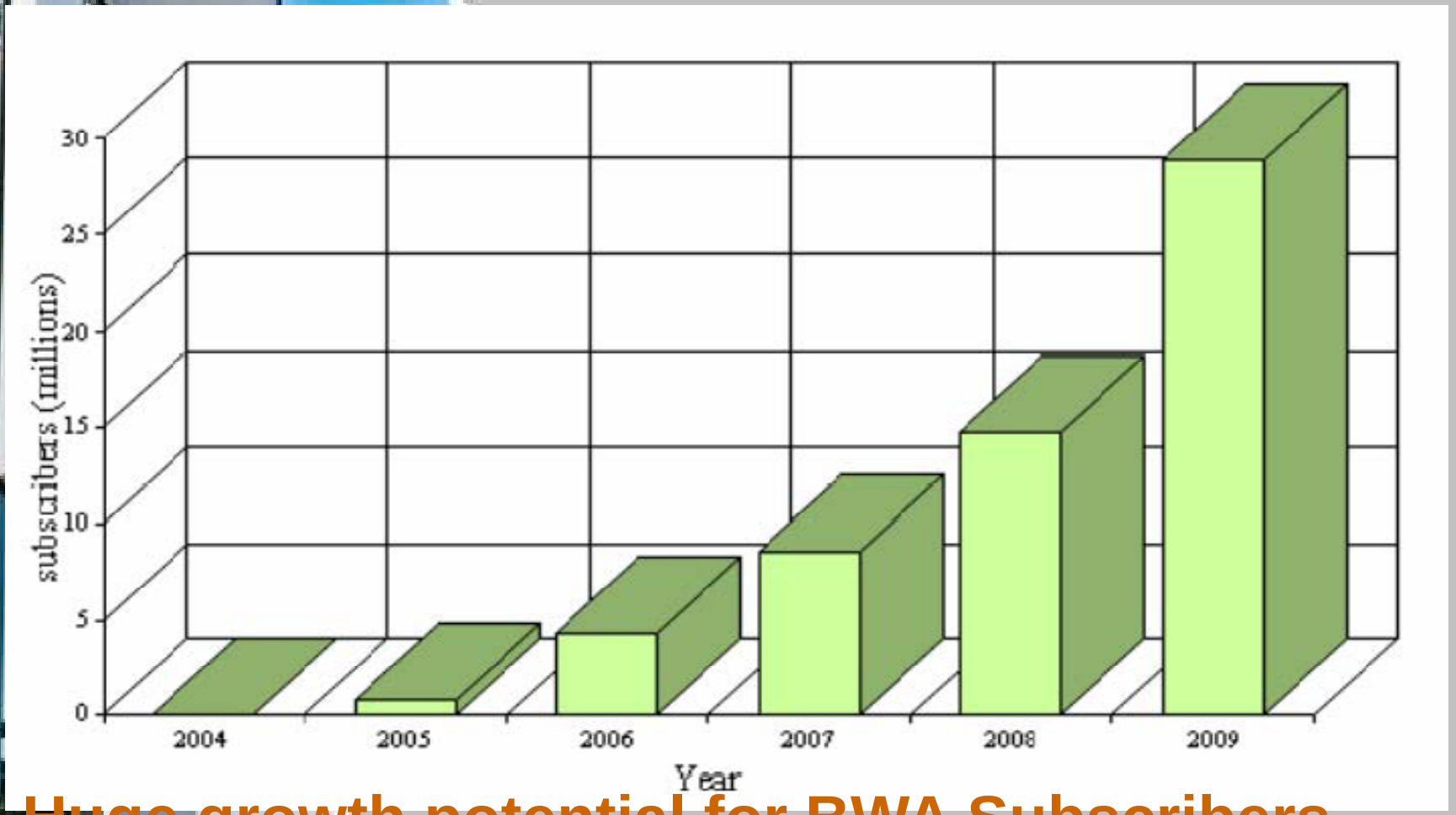
WiMAX Integration Across Multiple Segments

802.16e based WiMAX Devices Will Drive A New Embedded Mobile Internet Business Model

WIMAX STATS…

Source: Intel, Instat, Q3'06

WiMAX Penetration Rate…



Huge growth potential for BWA Subscribers

Market Share Analysis…

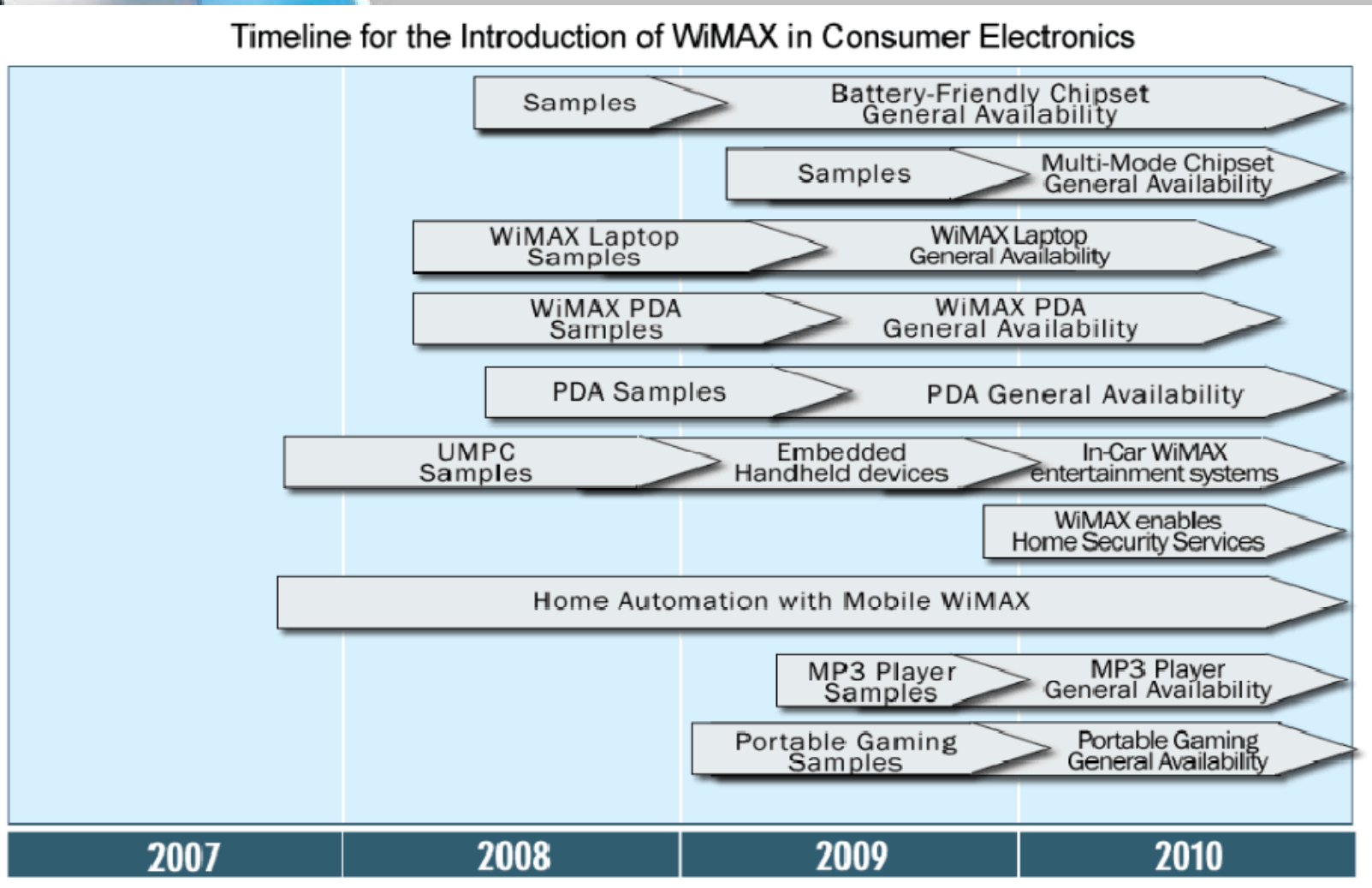
- Over 10,000 PMP BWA (sub 11Ghz) base stations and 1.2 Million CPEs installed worldwide providing 256Kbps+ broadband services to over 1.5 million subscribers.
- Alvarion -market leader with about 25% market share followed by SRTelecom with 12% and Proxim with 9%.
- ZTE -the market leader in the fast growing Chinese market with about 30%market share.
- Shipments of 802.16e will grow exponentially after 2007 to 1 million units andwill be dominated by Intel.

- The carrier and private networks market segments represented respectively 85%and 15% of the total market in 2006.
- The access and backhaul applications represented respectively 84% and 24% of total sales in 2006. However backhaul will represent 30% of equipment sales by2008 .
- Among Plug & Play, NLOS, portable systems, IPWireless is the leader in shipments and revenues, followed by a small group of companies which include Navini, NextNet Wireless, or SRTelecom (Angel) .

Future Developments in WiMAX…

- WiMAX II, 802.16m will be proposed for IMT-Advanced 4G.
- Goal to achieve 100 Mbit/s mobile and 1 Gbit/s fixed-nomadic bandwidth.
- WiMAX-m concentrating on MIMO-AAS, mobile multi-hop relay networking & related developments to deliver 10X & higher Co-Channel reuse multiples.

Timeline For WiMAX in Consumer Electronics…



WiMAX - The Future Ahead…

Emerging Technology Poised to Revolutionize the World!!


Thank You !!