Mobilizing Broadband using WiMAX
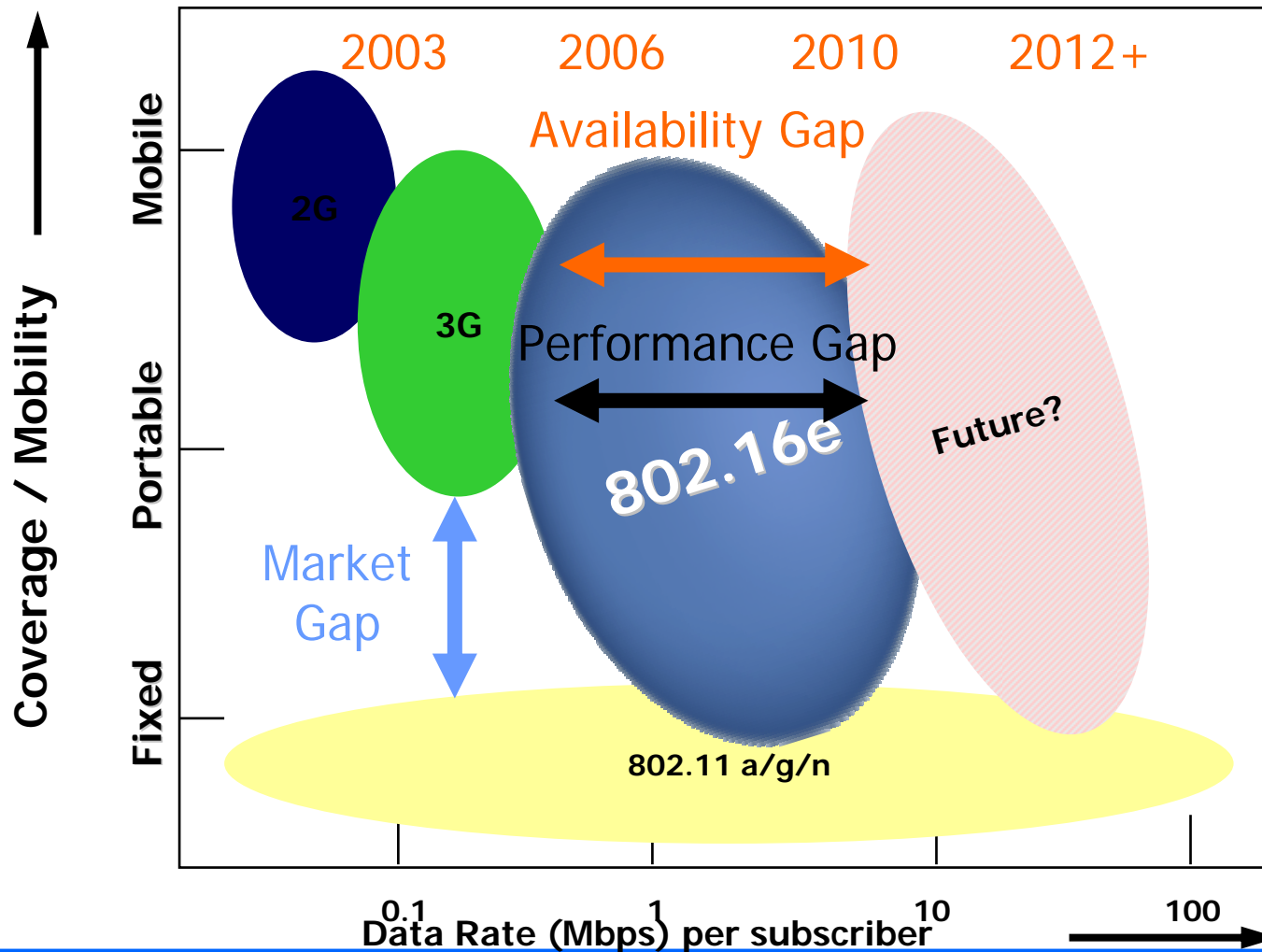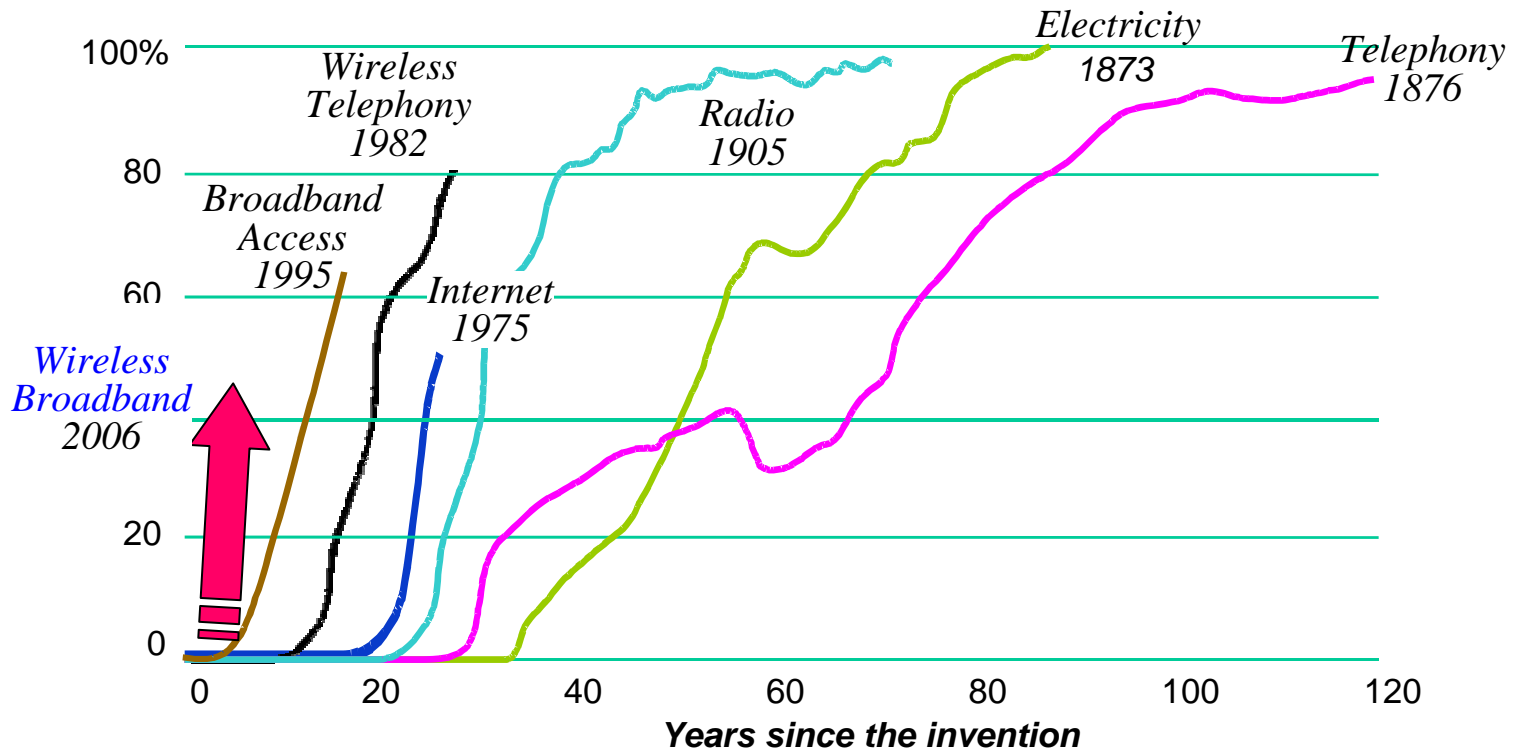
WCA – Nov 2006

Aditya Agrawal
Sr. Director of Marketing, Beceem Communications
Chair, Certification Working Group, WiMAX Forum

Broadband Wireless
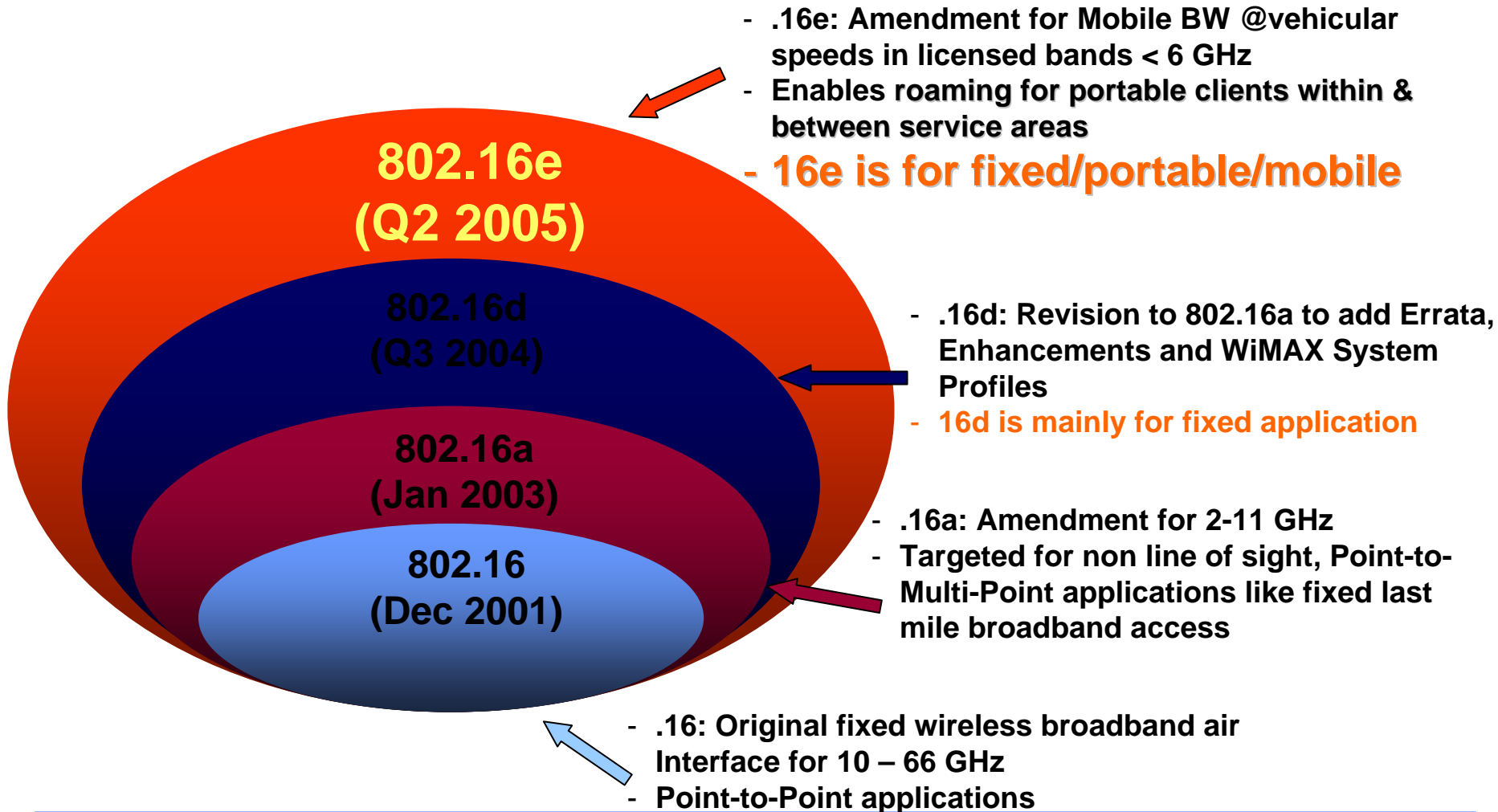# 16e Fills a Market Opportunity

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The Market Opportunity

Wireless Broadband has tremendous growth potential if ...

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802.16 Standards

802.16e (Q2 2005)

802.16d (Q3 2004)

802.16a (Jan 2003)

802.16 (Dec 2001)

- .16e: Amendment for Mobile BW @vehicular speeds in licensed bands < 6 GHz
- Enables roaming for portable clients within & between service areas
- **16e is for fixed/portable/mobile**

- .16d: Revision to 802.16a to add Errata, Enhancements and WiMAX System Profiles
- **16d is mainly for fixed application**

- .16a: Amendment for 2-11 GHz
- Targeted for non line of sight, Point-to-Multi-Point applications like fixed last mile broadband access

- .16: Original fixed wireless broadband air Interface for 10 – 66 GHz
- Point-to-Point applications

WiMAX Forum (350+ companies)

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Impact of Certification
On the Market for WiMAX
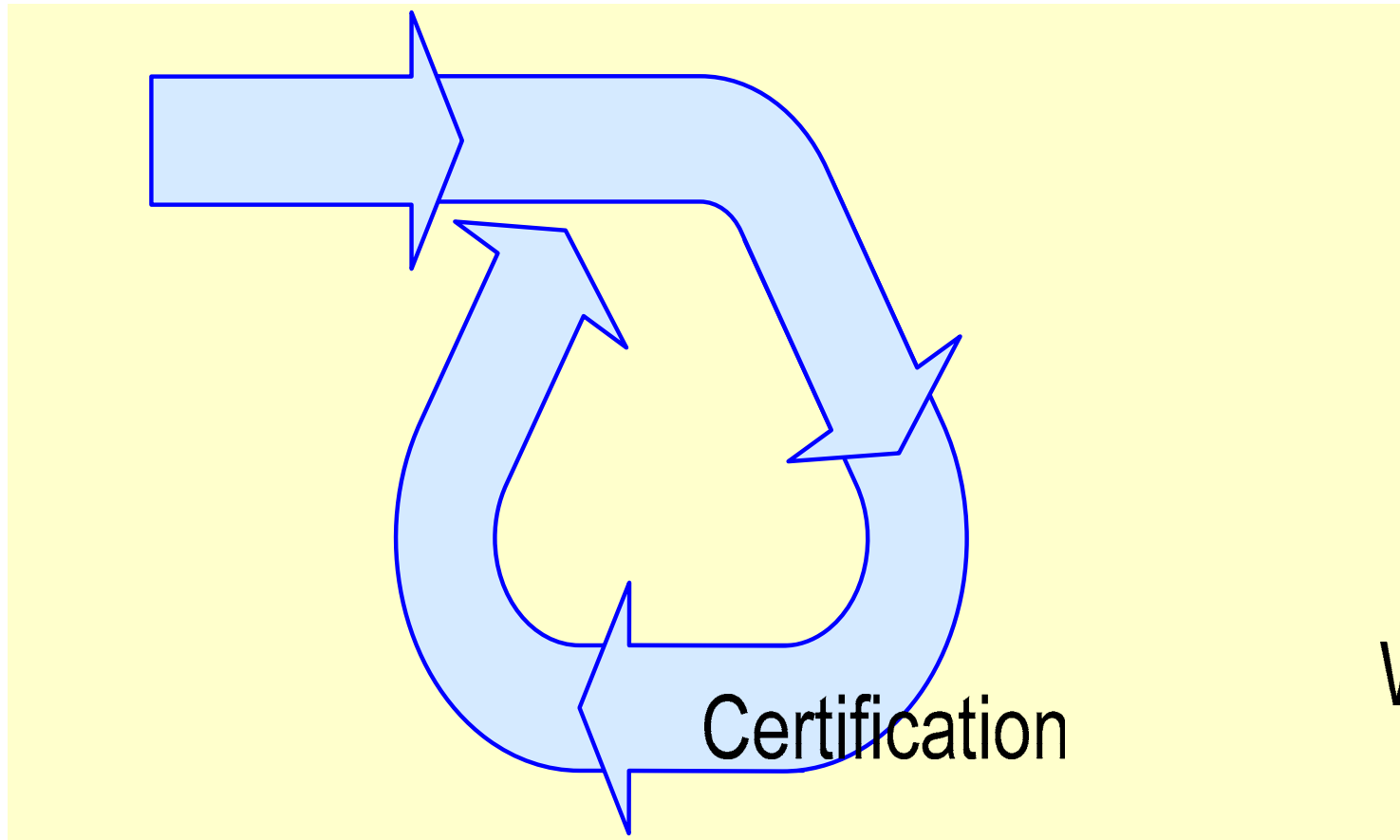
Certification

Worldw
marke

Mobile WiMAX Certification Roadmap
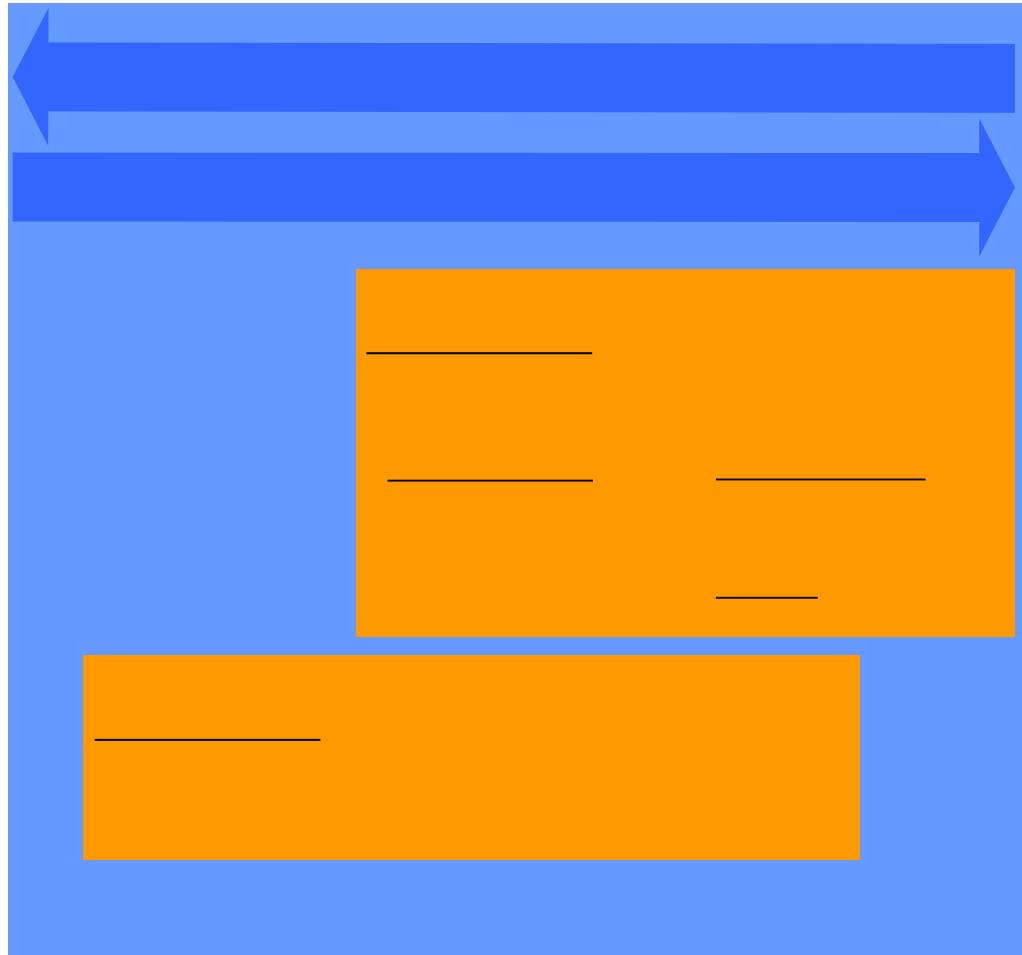
WiMAX Market Projections

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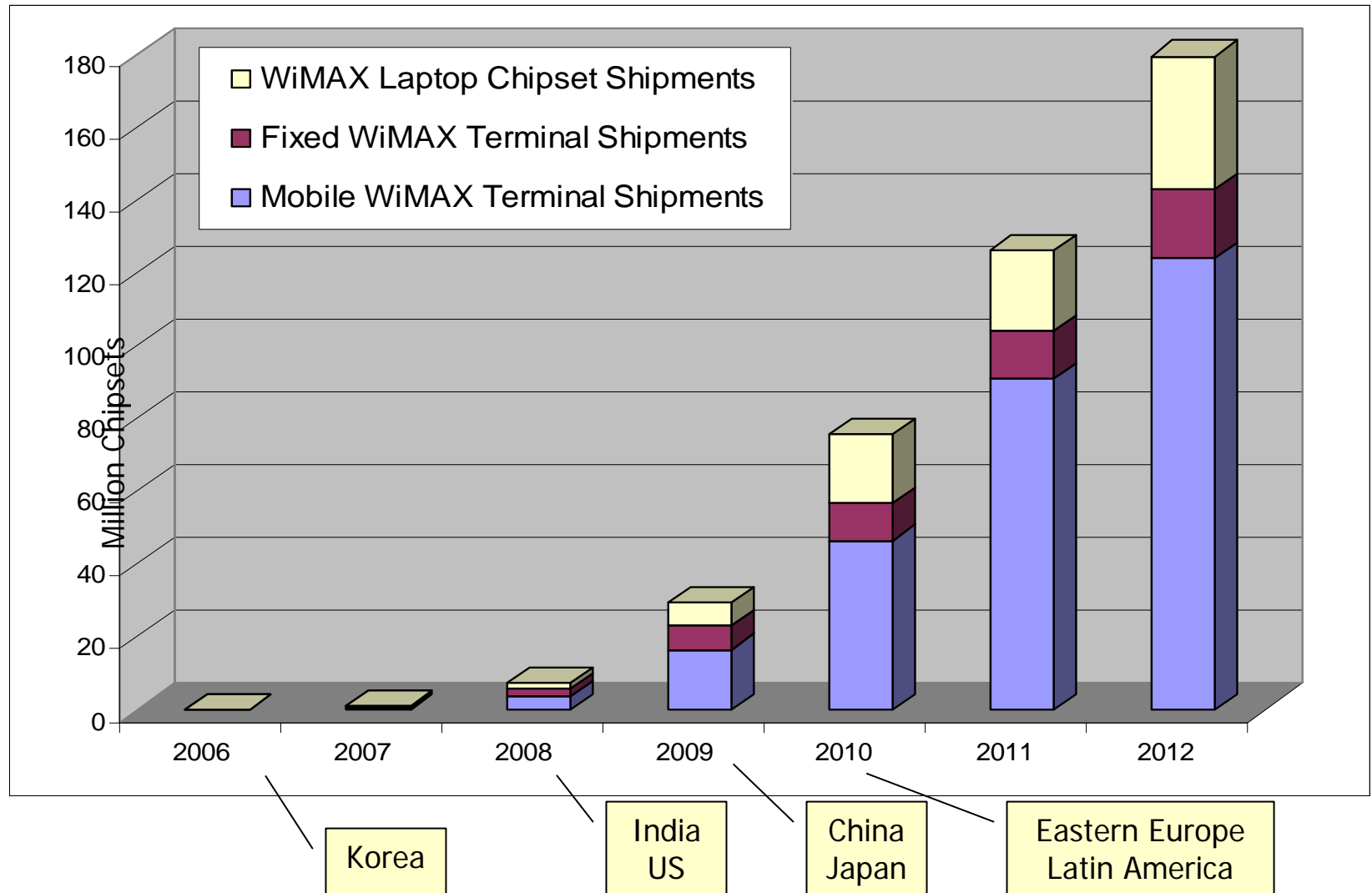
WiMAX Spectrum Opportunities

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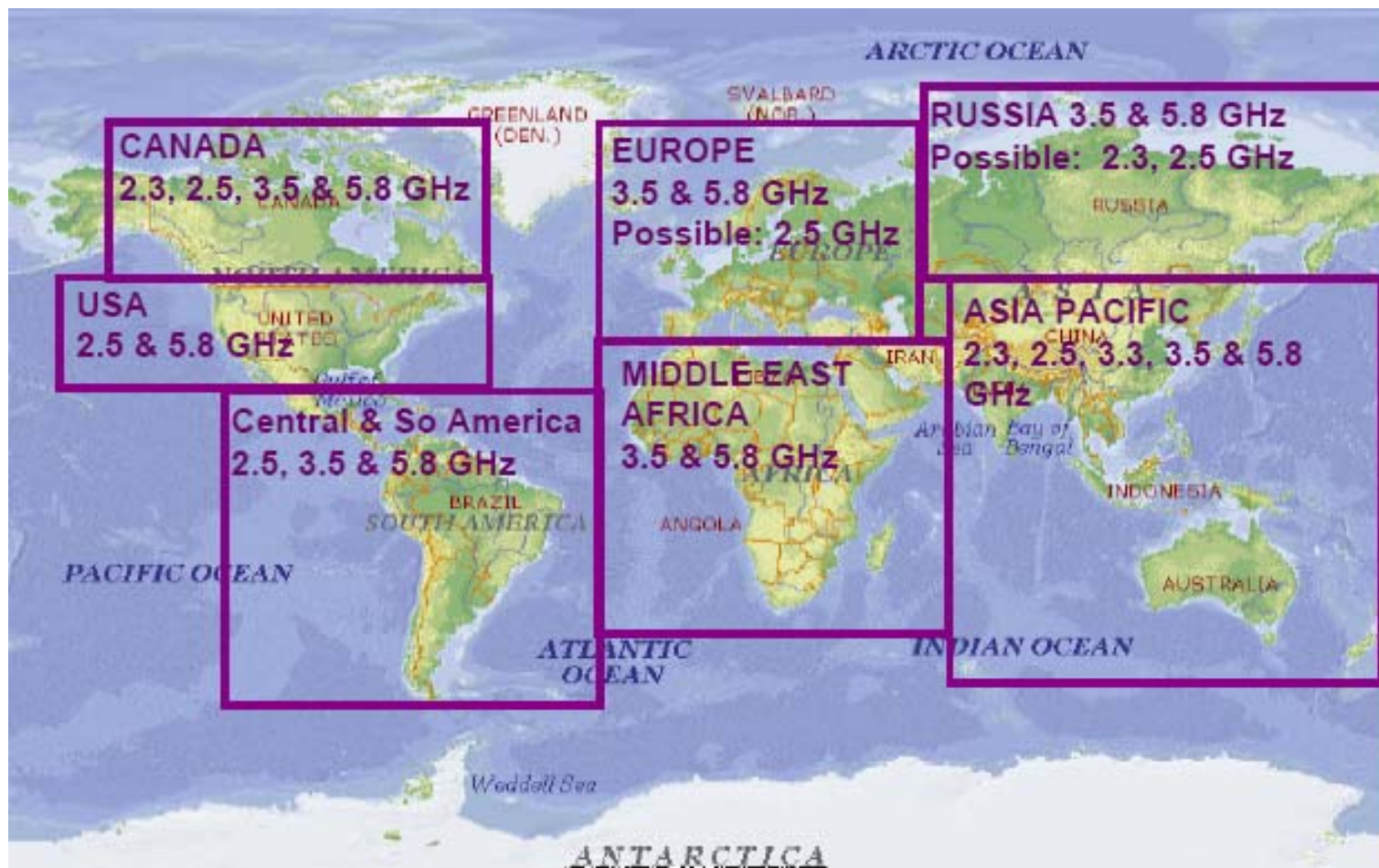
Mobile WiMAX Business Advantages

- ➢ Time to Market
  - First standardized OFDM based Mobile Broadband Technology
  - Trials and certification well underway, commercial deployments in 2007

- ➢ Global Footprint
  - 2.x GHz Spectrum in North America, Korea, Japan, South East Asia and India
  - Dual-mode devices exist already, enabling global roaming

- ➢ Vibrant Ecosystem
  - ~400 members in the WiMAX Forum
  - Innovation and competition at all levels

- ➢ Low IPR Royalties
  - Unfair, one-sided IPR schemes threaten adoptions
  - WiMAX OFDM IPR widely distributed and owners interested to avoid excessive, lopsided IPR regimes that are plaguing 3G

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Mobile WiMAX Cost Advantages

➢ Cost Advantages

  • Competition and innovation in the ecosystem drive down equipment cost

  • Global footprint increases economies of scale

  • Unparalleled network capacity leads to lowest network CapEx

➢ Revenue Opportunities

  • Supports fixed and mobile access

  • Enables rich multi-media, VoIP and Gaming

  • Drives device and application convergence

➢ Differentiation Advantage

  • WiMAX Service Providers are first movers

  • WiMAX Networks offer highest speed and lowest latency

  • Opportunity to offer premium applications and service bundling

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Mobile WiMAX Technology Advantages

➢ OFDMA
  - Offers best spectral efficiency (less interference than CDMA)
  - Allows for long range transmission from a mobile device
  - Ideal for interference management

➢ TDD
  - ideal for advanced Smart Antenna Technologies
  - Enables industry leading power efficiency

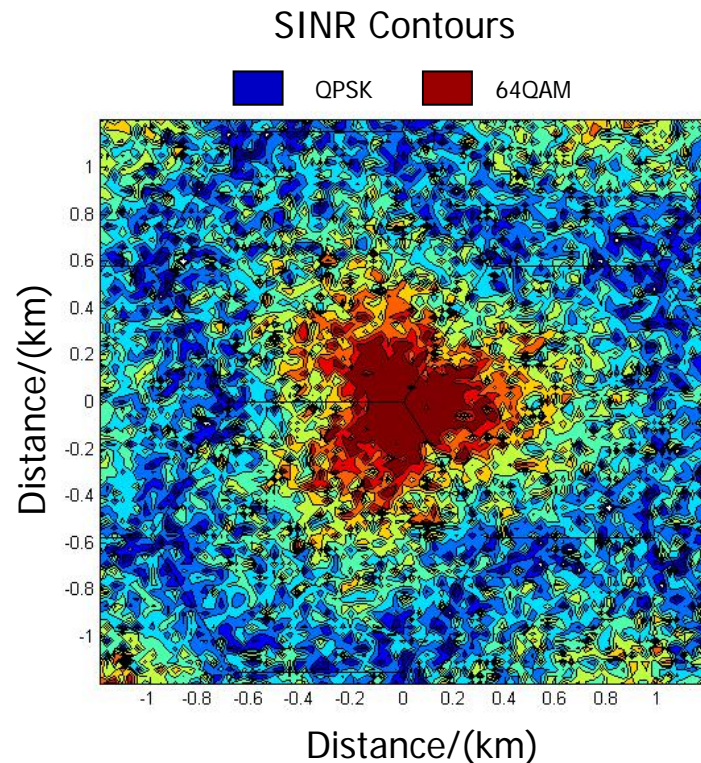➢ Smart Antenna Technologies
  - Optimal use of MIMO and beamforming techniques offers best possible spectrum efficiency
    - Significantly increases link reliability
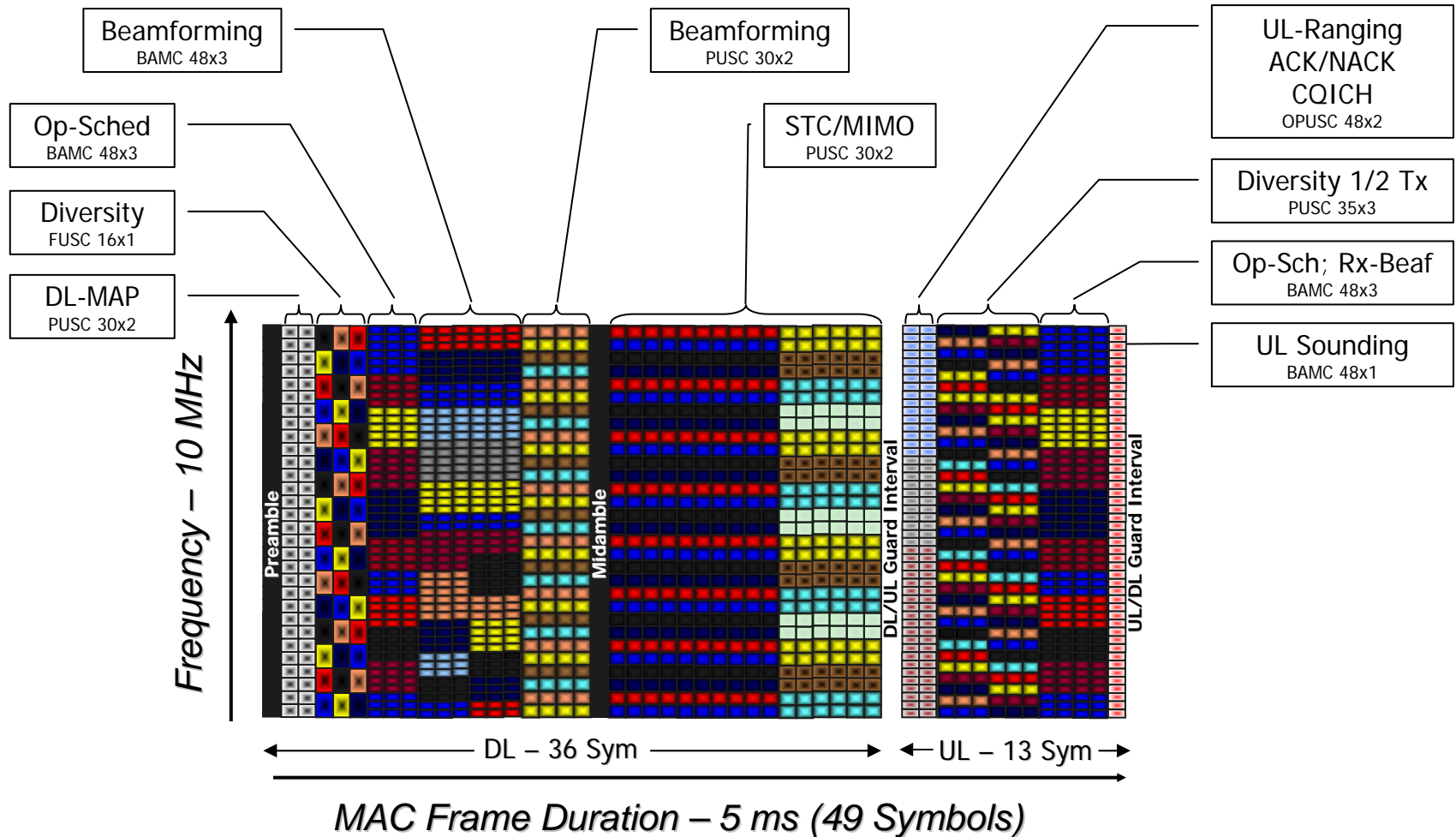   - High throughput during mobile system

➢ All-IP Network
  - Allows for QoS enabled fully mobile services
  - Supports voice, data, video, gaming, mobile Internet
  - Native IP with mobility support using IPV4 & IPV6

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Wireless Broadband isn't easy but it can be done!

➢ Data rate depends on signal quality

➢ Signal quality impacted by many factors

- Propagation loss over distance
- Delay spread (freq selective fading)
- Doppler spread (time selective fading)
- Angle spread (space selective fading)
- Interference (self, users in sector, users in other sectors)

➢ 16e uses advanced techniques to maximize signal quality

- OFDMA
- Diversity / Opportunistic scheduling
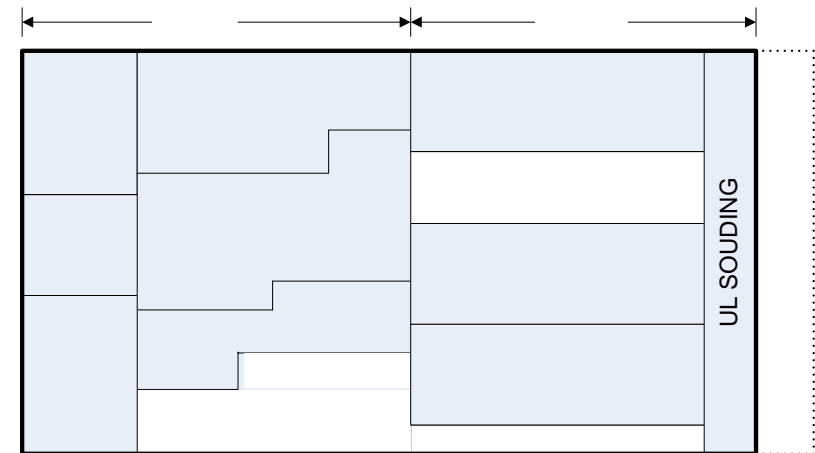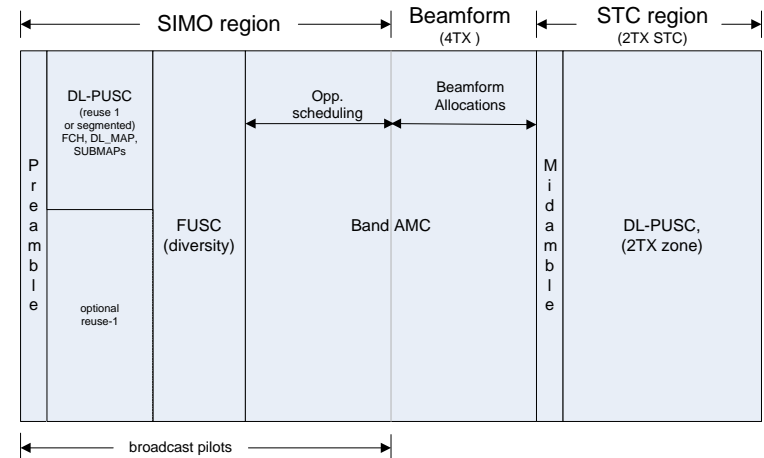- Beamforming / SM
- STC / SM

SINR Contours

QPSK   64QAM

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16e Airlink Zones

Beamforming
BAMC 48x3

Op-Sched
BAMC 48x3

Diversity
FUSC 16x1

DL-MAP
PUSC 30x2

Beamforming
PUSC 30x2

STC/MIMO
PUSC 30x2

UL-Ranging
ACK/NACK
CQICH
OPUSC 48x2

Diversity 1/2 Tx
PUSC 35x3

Op-Sch; Rx-Beaf
BAMC 48x3

UL Sounding
BAMC 48x1

Frequency – 10 MHz

Preamble

Midamble

DL/UL Guard Interval

UL/DL Guard Interval

DL – 36 Sym

UL – 13 Sym

MAC Frame Duration – 5 ms (49 Symbols)

14

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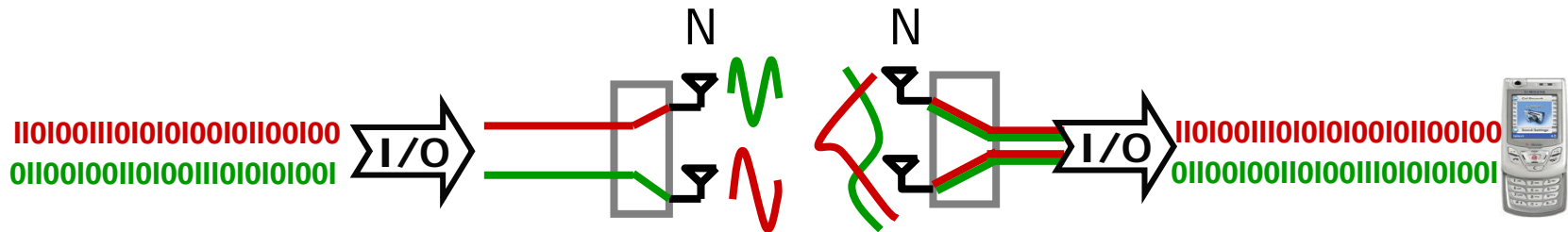
802.16e Frame Structure

- ➢ 10 MHz bandwidth - 1024 subcarriers
- ➢ 5 ms frame duration – 32 symbols
- ➢ Typical Downlink Frame Structure
    - • Preamble – 1 symbol guard time for transmission start
    - • PUSC zone – Broadcast MAP with DL/UL traffic and control assignments
    - • FUSC zone – for SISO/SIMO operation with 1 Tx and optional Rx diversity
    - • Band AMC zone – for:
        - • Opportunistic scheduling in SISO/SIMO configuration
        - • Beamforming in 4 Transmit antenna configuration
    - • Midamble – 1 symbol guard time for zone switching
    - • 2Tx-PUSC – for Space-Time Coding (STC) and/or Spatial Multiplexing (SM)
- ➢ Typical Uplink Frame Structure
    - • PUSC Control zone – for:
        - • Ranging (resource request for idle terminals)
        - • ACK/NACK retransmission and HARQ signaling
        - • CQICH Channel Quality Indicator CHannel
    - • PUSC Traffic zone – for:
        - • 1Tx, 2Tx and diversity transmissions
    - • Band AMC zone – for:
        - • For opportunistic scheduling and Rx beamforming
        - • UL channel sounding for downlink beamforming

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WiMAX Profiles

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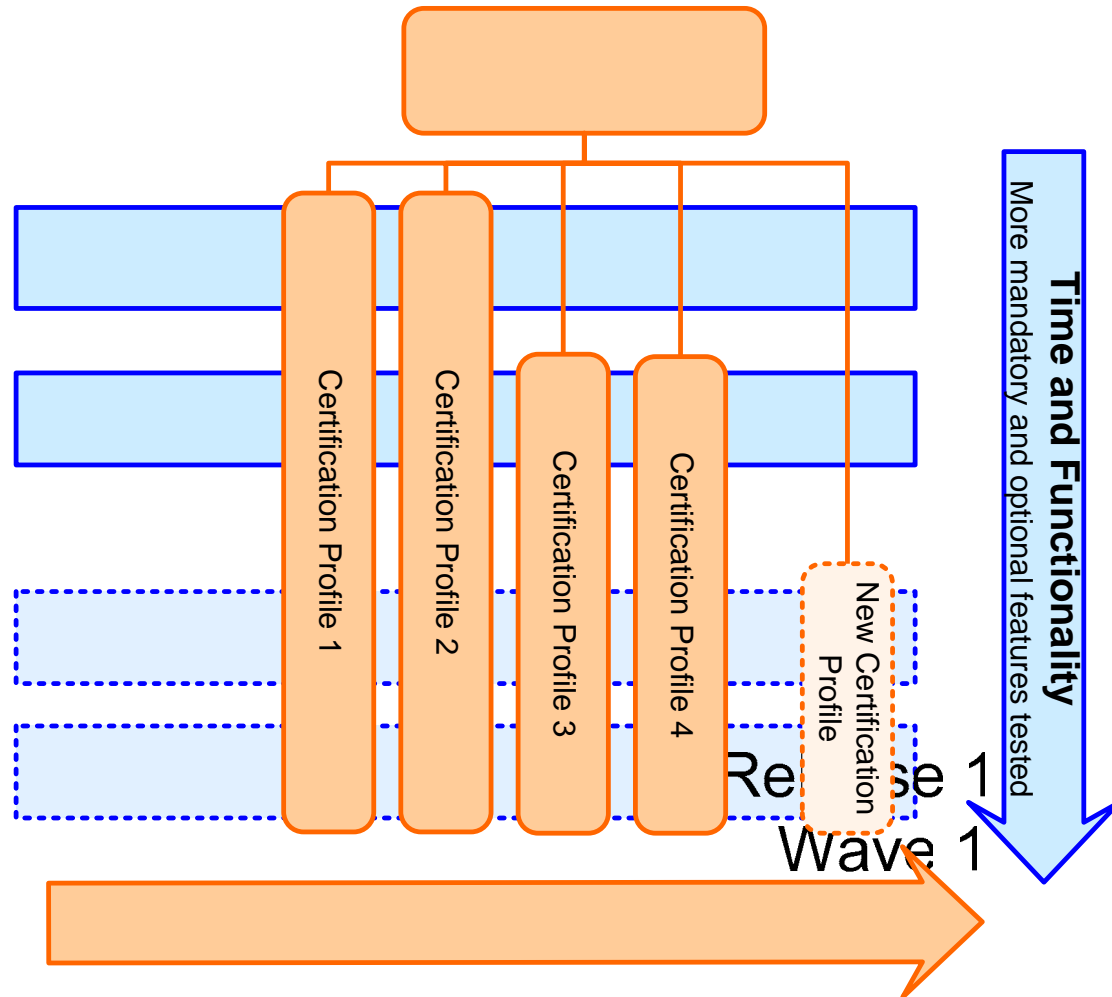
MIMO (Multiple I/P Multiple O/P)

➢ Tow signals sent over 2 independent Radio Links each to users with 2 Rx terminals, using the same resource allocation

- Spectral efficiency (throughput) improves proportional to N
- Coverage reliability improves proportional to Sqrt N

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Beam-Forming (Phased Array)
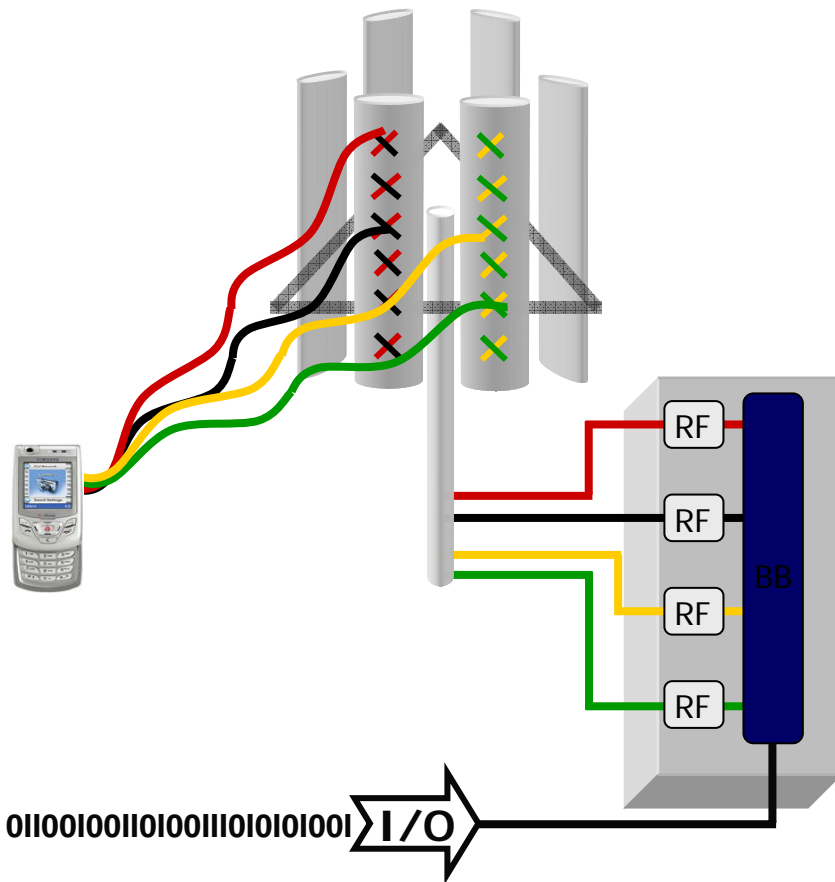
➢ Signal sent over 4 independent Radio Links with phase adjustments

  • Increases signal strength at receiver, good for low SNR and low mobility

OIIOOIOOIIOIOOIIIOIOIOIOOI I/O

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Terminal Supply Chain

HW & SW Components ➡ **Development Board** ➡ **Form factor Board/Prototype** ➡ **Commercial Terminals**
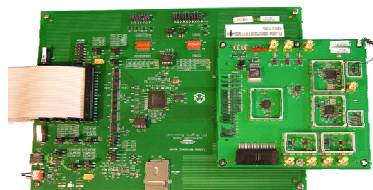

Components
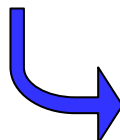–Processor
–Baseband/RF
–Power Mgmt
–Peripherals

Component SW
–Firmware
–HW drivers
–SW stacks

Application SW
–OS
–GUI
–Tools
–Codecs
–Graphics
–Browser

Reference Design
–Schematics
–Layout
–Component BOM
–Documentation

Manufacturing Blueprint
–Phone BOM
–Gerber files
–Molds
–Test tools

Supplier　　**Designer**　　**Developer**　　**OEM/ODM**

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Beceem – the Mobile WiMAX Chipset Leader

Beceem BBIC   Beceem RFIC   2 Rx

1Tx PA

Launched Jan 2006

- ➤ First and only commercially available terminal chipset that is utilized in mobile WiMAX trials around the World

- ➤ Strong customer relationships with leading OEMs and carriers

- ➤ Key Infrastructure partnerships

- ➤ Influential strategic investors (Samsung Ventures, Intel Capital, NTT DoCoMo Capital)

- ➤ IOT Development relationships with Motorola, Alvarion and Alcatel and others

- ➤ One of the 7 leading companies (Sprint, KT, Samsung, Motorola, Nortel, Intel & Beceem) in developing the Mobile WiMAX profile

- ➤ Co-Chair of certification group in WiMAX Forum

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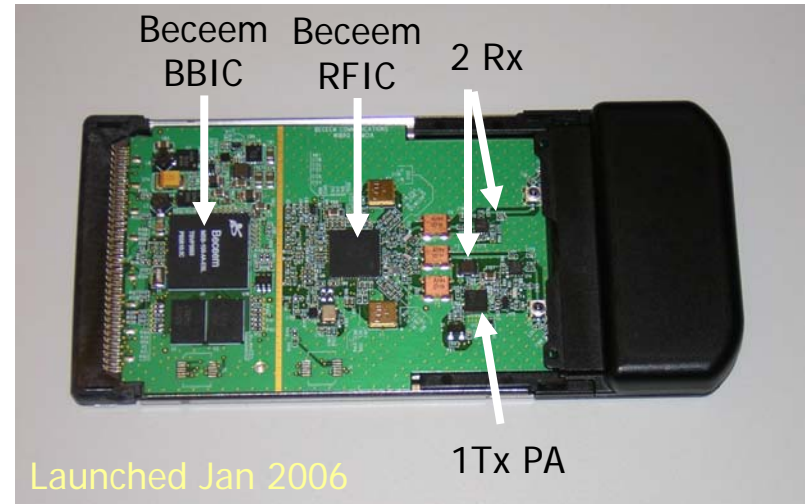
Staged Product Development Strategy

Stage 1	Stage 2	Stage 3

➢ Stage 1

- Develop separate baseband and RF chipset
  - Architect the solution for flexibility for standards fluidity and worldwide implementation
  - Hardware/ software partitioning for optimum power and cost but allow for in field upgrade of critical algorithms
- Reduce development risk elsewhere e.g. Fab

➢ Stage 2

- Integration of WiMAX functionality
  - SiP vs SoC ?
  - Tradeoffs between TTM, power consumption, footprint, cost
- What is optimal BOM?

➢ Stage 3

- Integration with other technologies
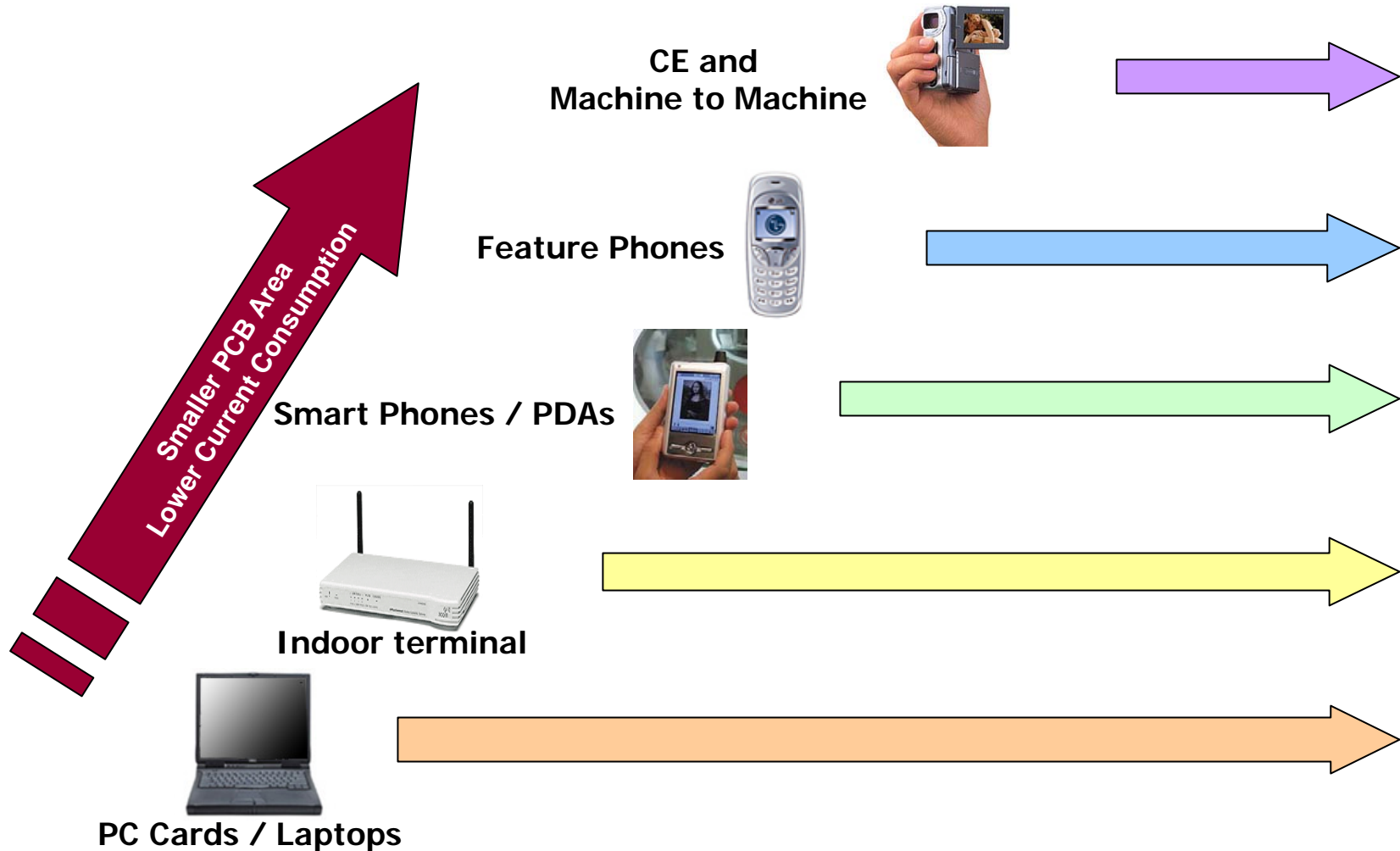 - WiFi?
  - Cellular
  - Bluetooth?

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WiBro Terminals Nov'05

WiBro Handset Nov'05

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Multimedia Internet Terminal Nov '06

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WiMAX Terminals

CE and
Machine to Machine

Feature Phones

Smart Phones / PDAs

**Smaller PCB Area
Lower Current Consumption**

Indoor terminal

PC Cards / Laptops

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Mobile WiMAX – the Time has Come
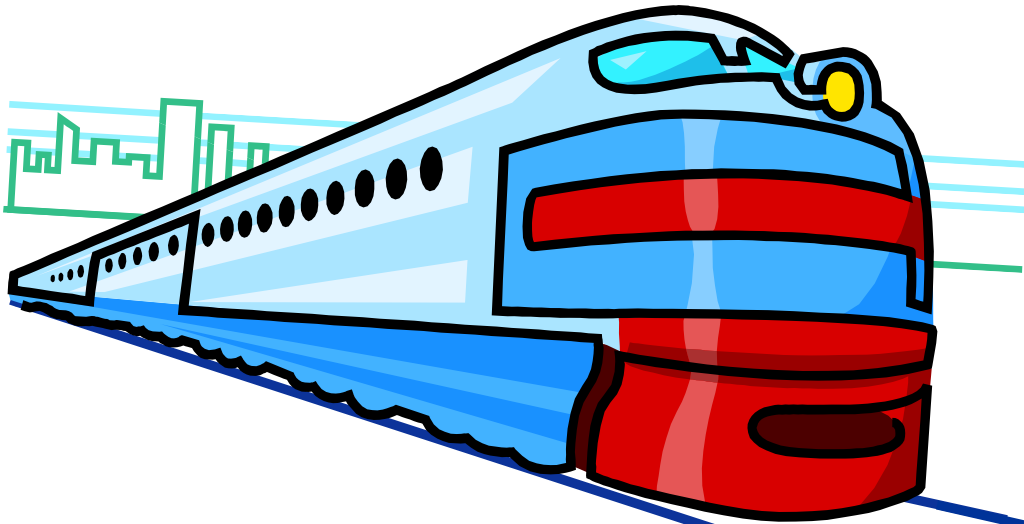
➢ Or keep on looking …

➢ Join the bandwagon

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