Cover Sheet for Presentation to IEEE 802.16 Broadband Wireless Access Working Group (Rev. 0)

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MMDS Background

History

Market

Spectrum

Technology

Platform

Standards

MMDS History

- Lottery of 1983 - launch of modern MMDS; protected service areas (PSA) 15 miles
- 94-95 Change of PSA to 35 miles
- BTA auctions 95-96
  - Ownership obtained in areas where there was no coverage
  - Others were grandfathered
- ITFS: Educational Services
  - Many local governmental and educational institutions
  - Eager to make deals to meet local needs (video broadcast)
  - Very interested in high speed Internet

MDS, MMDS, ITFS intended to serve the unserved with Entertainment and Educational Television.

FCC Progressively Opens Spectrum for Competition in Broadband

- In October 1996 Wireless Service spectrum was given the go-ahead to offer wireless Internet and digital video
- In March 1997 Wireless Service operators requested the ability to transmit two-way.
- After numerous delays, the FCC is expected to grant two-way licenses in 2000. Filings required with proof of non-interference.
- A number of two-way temporary licenses have been granted by the FCC. Trials and service underway.

Service Provider Consolidation

- Sprint and MCI Worldcom buy up spectrum holders
  - Sprint Purchases:
    - American Telecasting
    - PCTV

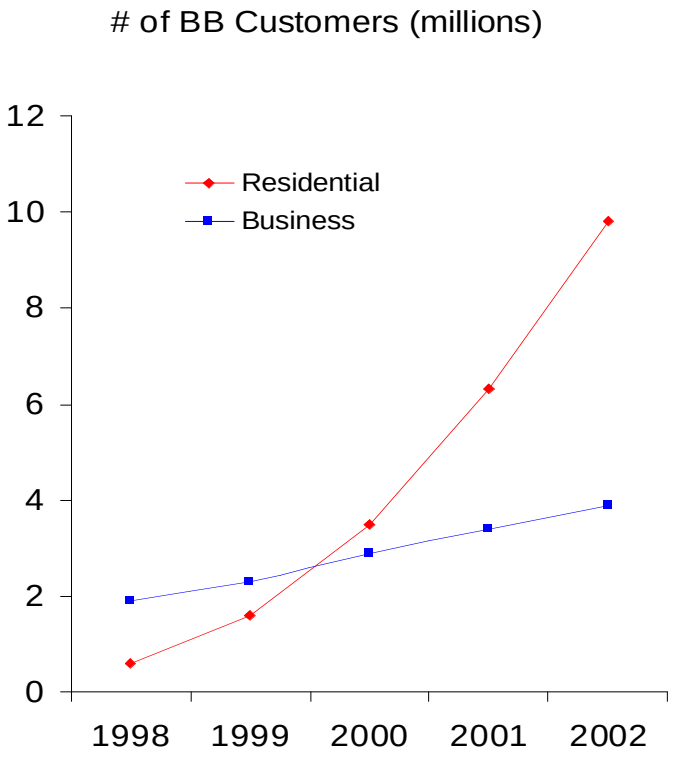
      ...
  - MCI Worldcom
    - Wireless One
    - CAI

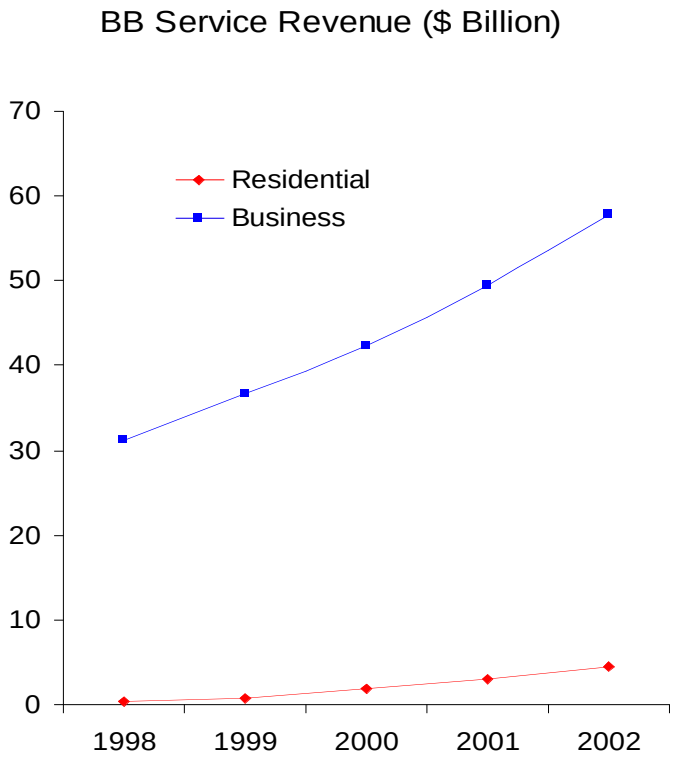
      ...
  - Major Independent
    - Heartland

- Sprint and MCI Worldcom merger in works.

Sprint an MCI Worldcom addressable market reported to be more than 60% US market.

The Opportunity:
Broadband Market Projections - US



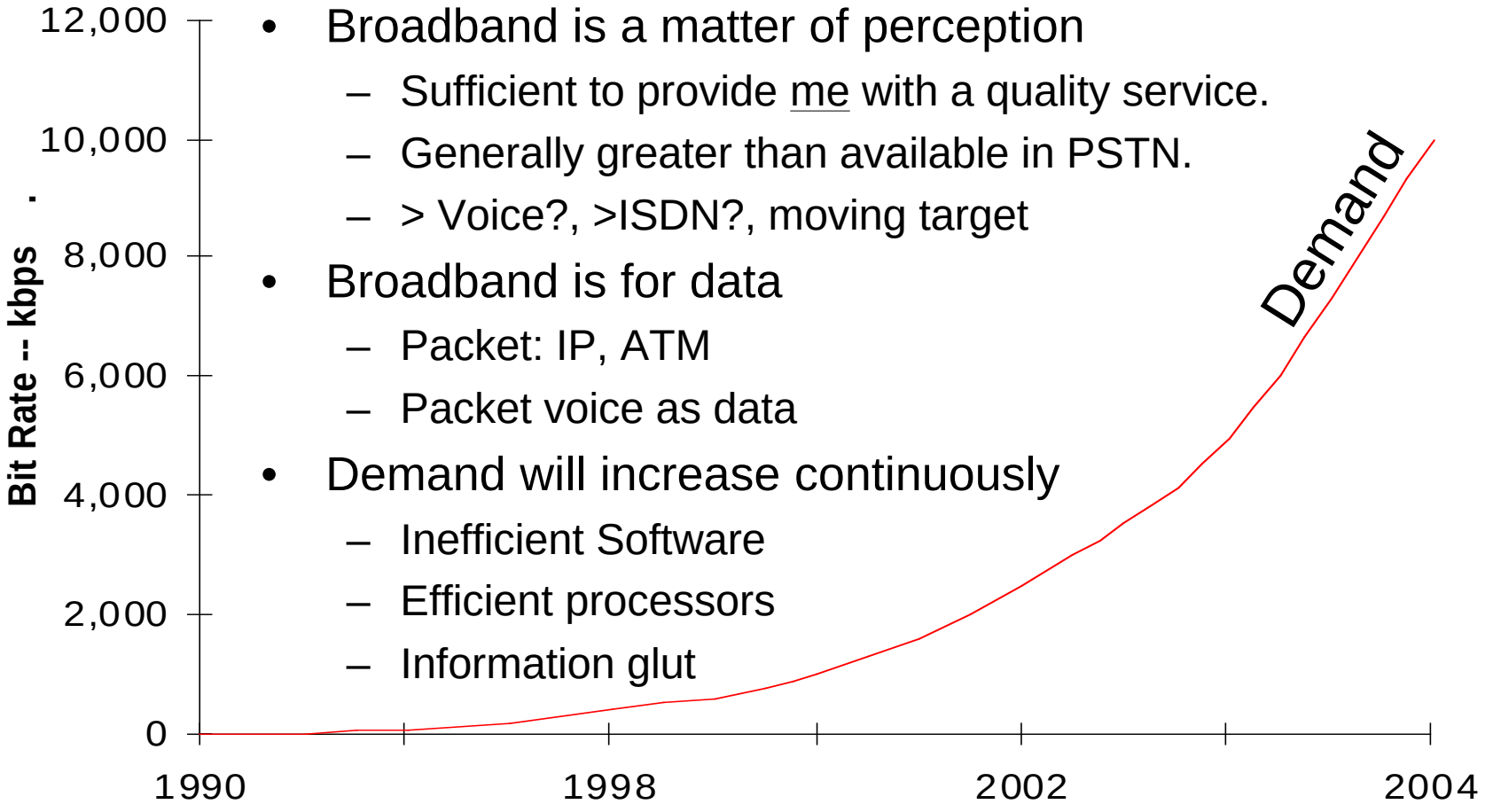


Source: The Strategis Group

Quantity favors residential, Revenue favors business.
MMDS positioned for both.

Broadband Demand

- Broadband is a matter of perception
  - Sufficient to provide me with a quality service.
  - Generally greater than available in PSTN.
  - > Voice?, >ISDN?, moving target
- Broadband is for data
  - Packet: IP, ATM
  - Packet voice as data
- Demand will increase continuously
  - Inefficient Software
  - Efficient processors
  - Information glut



Broadband is driving, Voice remains an essential service.

MMDS Target Markets and Services

- Target Markets
  - Small to Medium Business
  - SOHO
  - Residence (especially Technically Affluent Families, TAF)
  - Multiple Dwelling Units

- Target Services
  - High Speed Internet Access
  - Work at Home LAN extension
  - Virtual Private Networks
  - Video -- video conferencing to videophone
  - PSTN Voice: 2nd Line going to primary as customer attitude changes

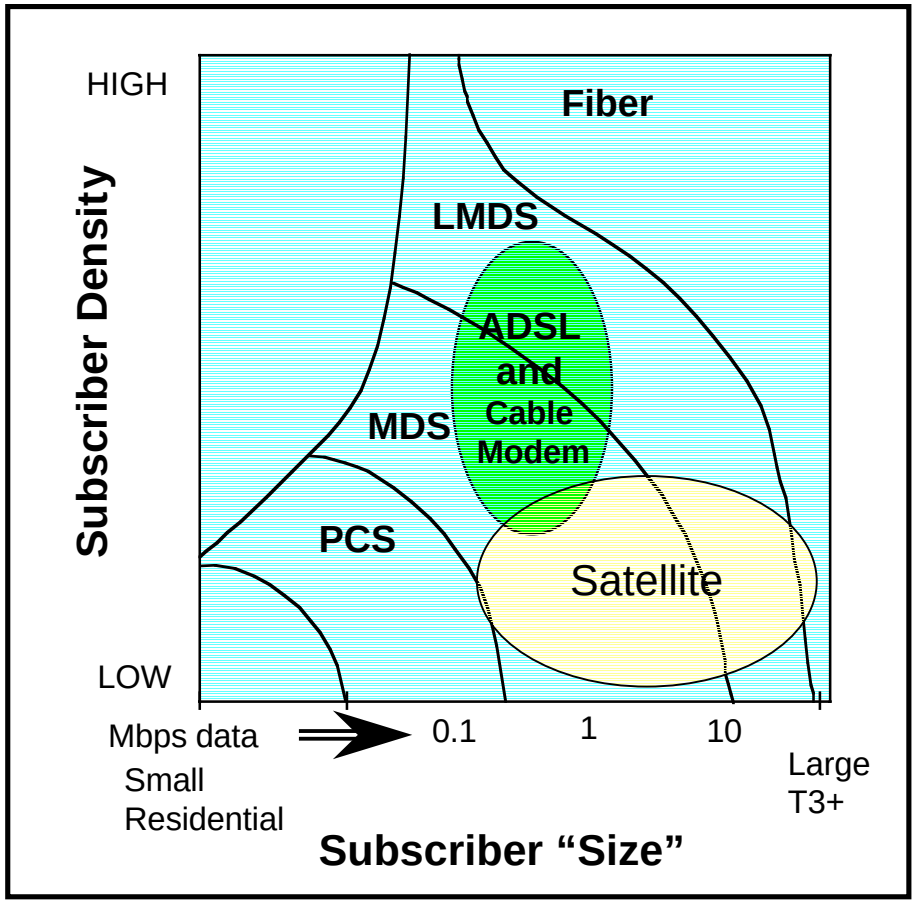
Telecommunications is moving from a circuit switched model with data pretending to be voice to a packet network model with voice pretending to be data.

MMDS Attributes

- MMDS Advantages
  - Broadband service
  - Large area coverage from hub
  - Short service activation cycle
  - Reach to unserved markets -- Outside ADSL and Cable service areas.
- Desirable System Attributes
  - Flexible access platform
  - Scalable/Migratable product
  - Spectrum efficient -- Optimize shared, limited resource
  - Manageable: Service volume administration and billing
- MMDS Solutions
  - Point to Multipoint
  - Statistical Multiplexing over the air
  - Packet based

Broadband Access Options

- Fiber Optics
- Point-to-Point Microwave
- ADSL
- Cable - HFC
- Point-to-Multipoint Systems
  - LMDS
  - MDS
- Satellites



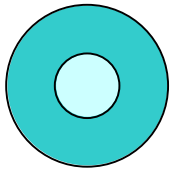
Technology and spectrum dictated by marketplace demands.

MMDS vs LMDS
Symbiotic Relationship

Low Band Microwave <10 GHz

- Narrow bandwidth allocations
- Largely unaffected by rain
  - Spans limited by earth's curvature -- >50 km
- Lower cost -- more experience, higher quantity

2-Way MMDS can serve lower density distributed market.



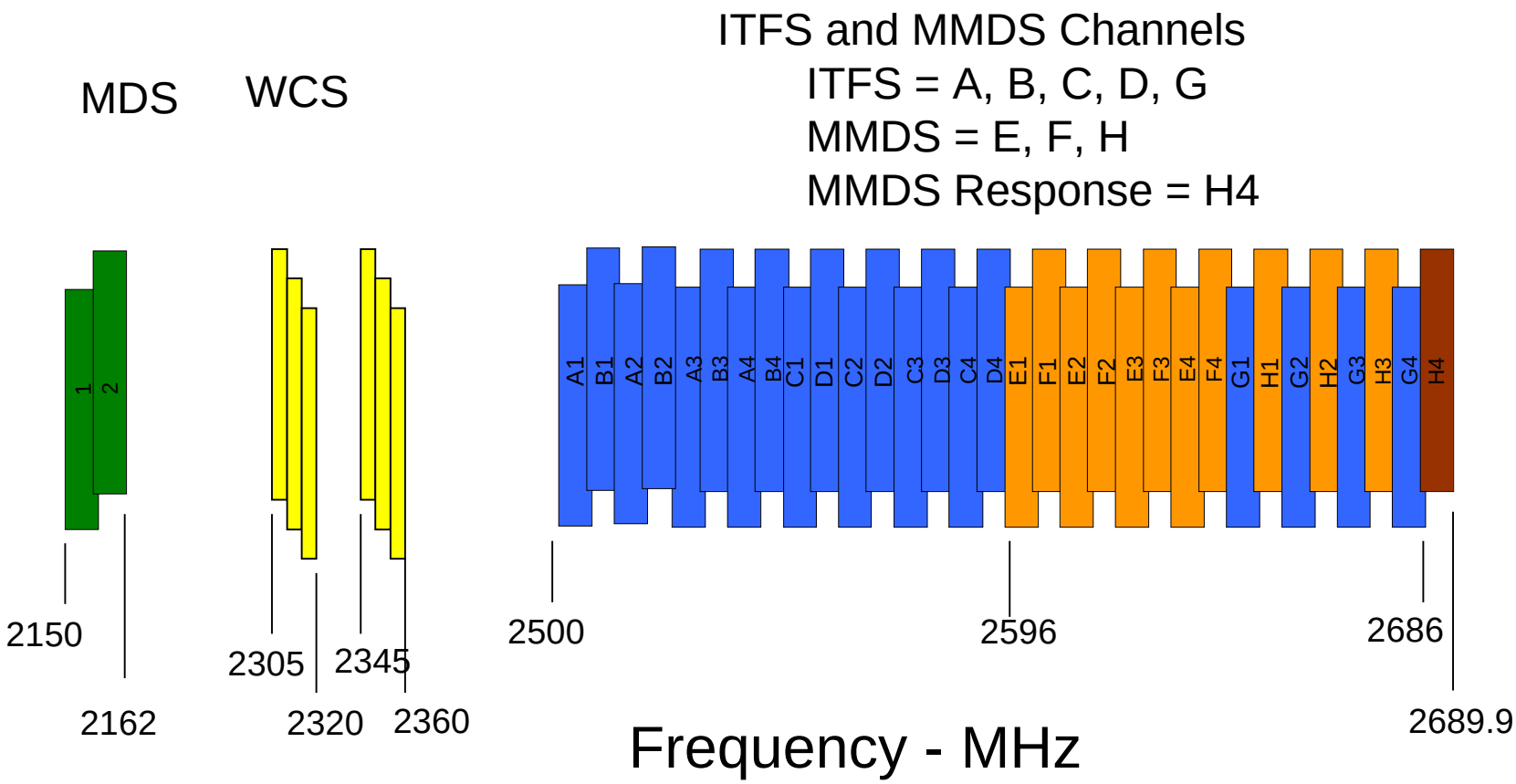
Microwave >10 GHz (Millimeter Wave)

- Wider bandwidth allocations -- up to 1 GHz LMDS
- Rain attenuation increases with frequency
  - Practical spans as short as 2 km at 38 GHz.
- Cost high -- but falling with experience and quantity.

LMDS: Service for high market density and/or high bandwidth

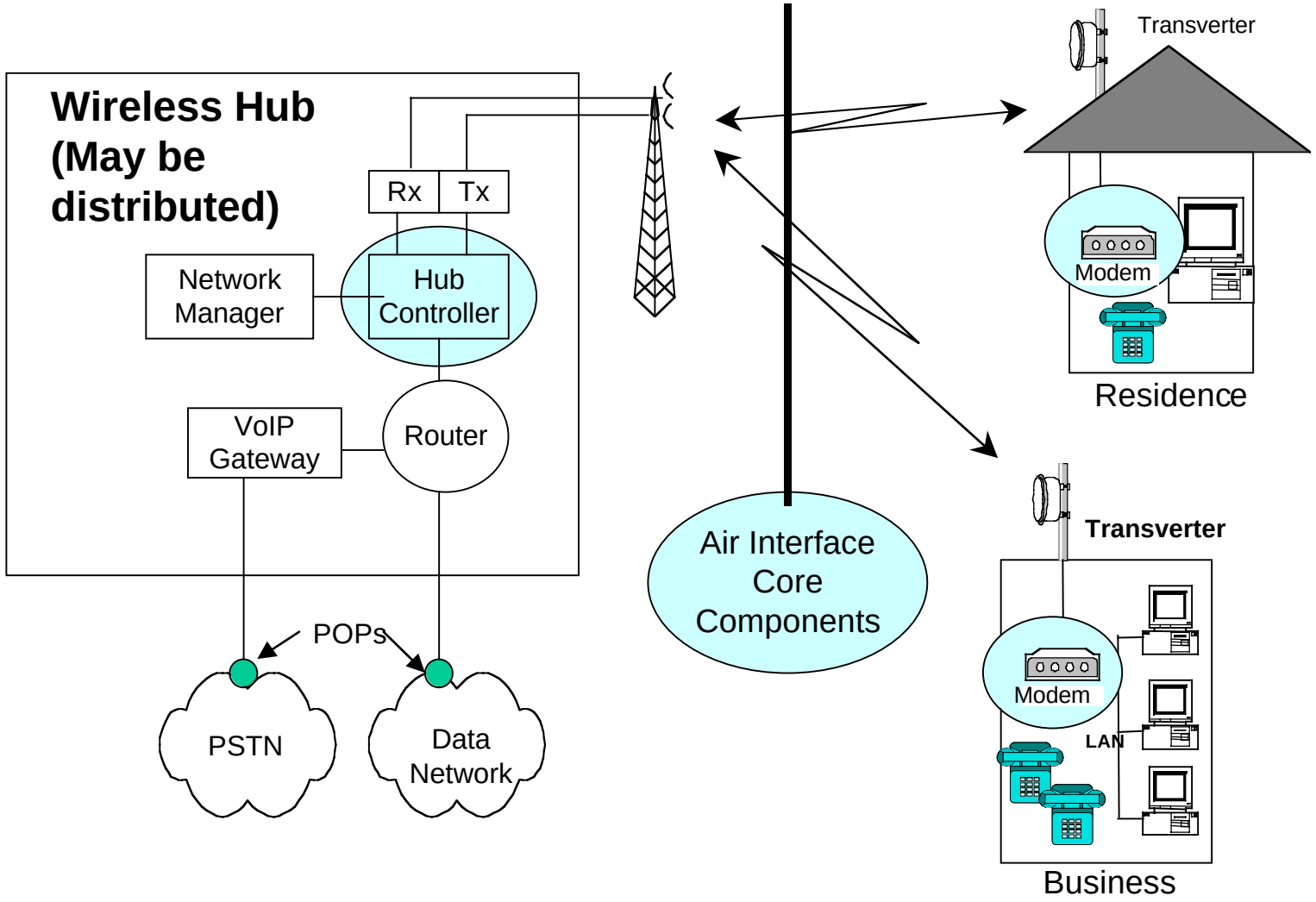
MDS Spectrum

ITFS, MDS, and MMDS Channelization - US Model



Note: WCS may be used to augment MDS.

Broadband Wireless Access System Model

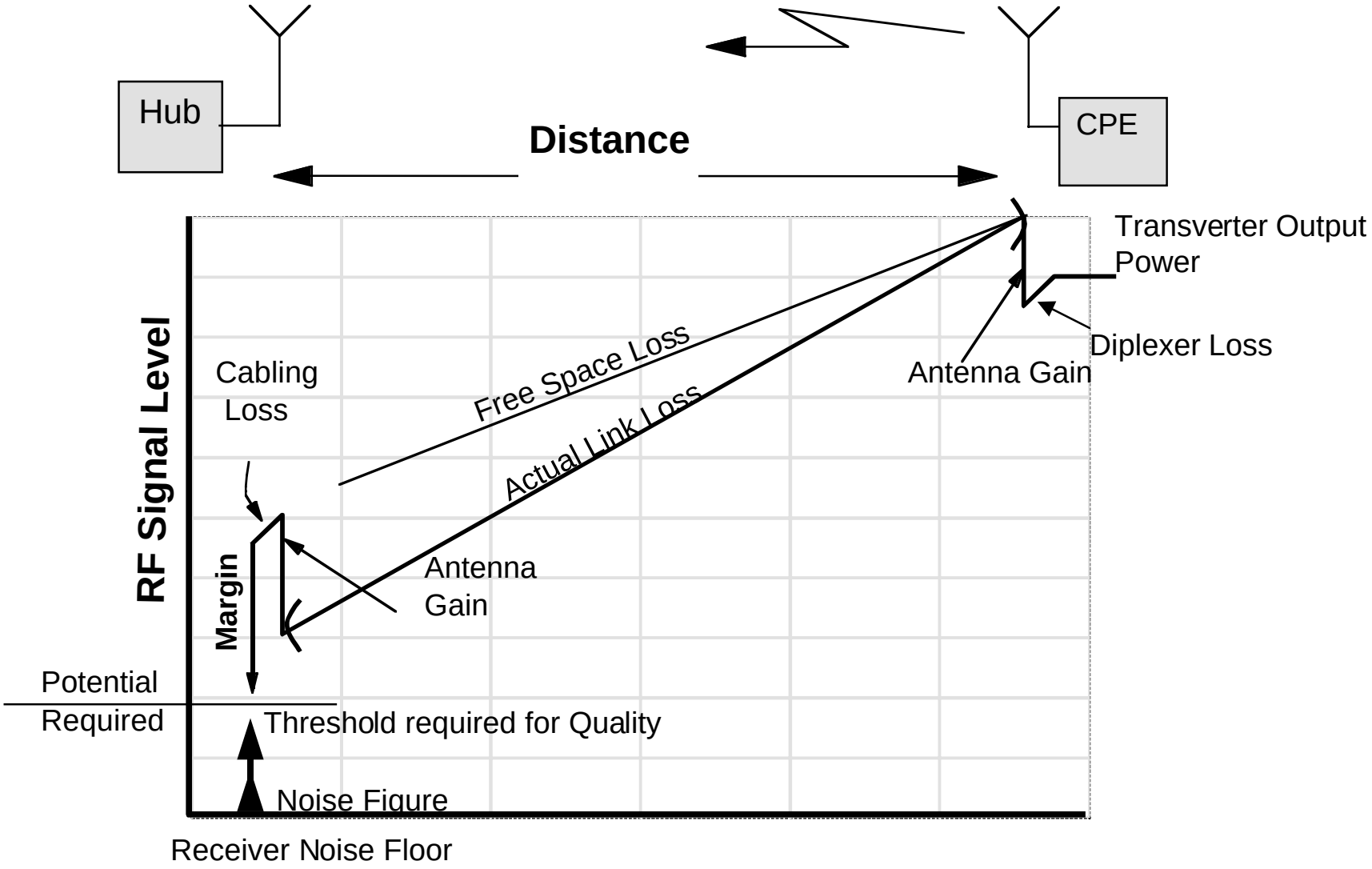


Access Methodology

- Multiple Access Options
  - FDMA -- Best suited to large pipe fixed bandwidth service
  - TDMA -- Best suited to Dynamic Bandwidth Allocation
  - CDMA -- Best suited to lower bit rate services in challenged environment. Magic is in frequency reuse -- not in individual spectrum efficiency.
  - OFDM -- Best suited for avoiding interference from discrete sources.
- Duplex Options
  - FDD (Frequency Division Duplex) -- Lower complexity
  - TDD (Time Division Duplex) -- Higher flexibility
- Protocol
  - ATM -- Best for transport and Quality of Service
  - IP -- Most services are IP. IP QoS under development

Best choice depends on service and environment.
Proposal: IP packet over TDMA/FDD.

BWA Link Loss/Link Budget



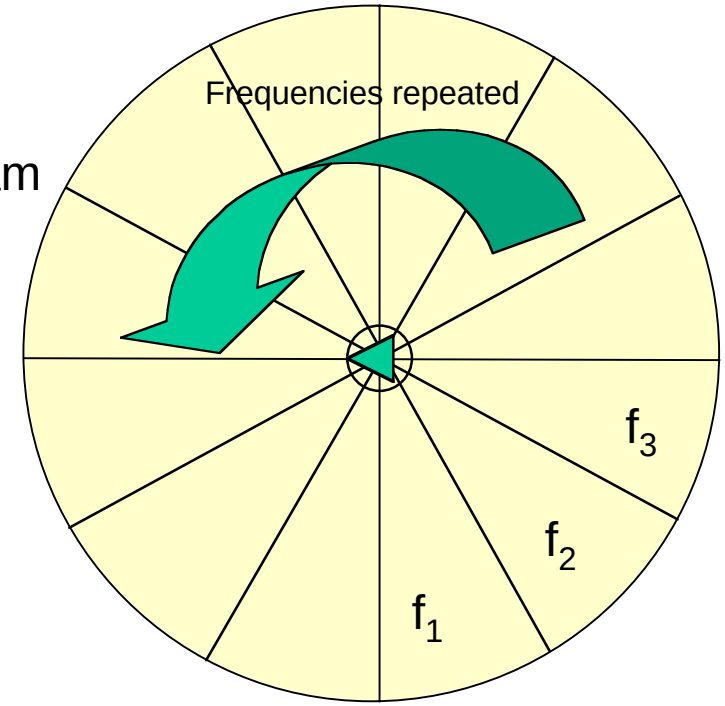
MMDS Coverage -- Options

- Coverage is determined by link budget, distance, terrain, and land use.
- Single cell layout -- Optimum network
    - Maximum reliable coverage range: 25 miles.
    - Flat terrain
    - High power CPE transmitters
    - High cell site antenna positioning
    - Advantage: Infrastructure, backhaul
- Multi-cell layout -- Useful for difficult terrain, very high density
    - Cell coverage range to suit capacity and terrain: 5-10 miles
    - May be adapted to terrain
    - Lower cell site antenna
    - Potential for higher level upstream modulation
    - Trade-offs may be made: spectrum, capacity, power
    - Multi-cell penalty: infrastructure, backhaul

Typical Super Cell

Definitions

- f_n=Frequency set
- Each set is 1 Upstream+1 Downstream
  - Other ratios may be preferred depending on service
- Reuse factor is 4x



Requirements

- High Gain Antennas
- Good Side Lobe Rejection
- Power Control

RF

- 6 BWA RF Channels Required

4 Sectored Multi-Cell Layout for Broadband Wireless Access

Definitions

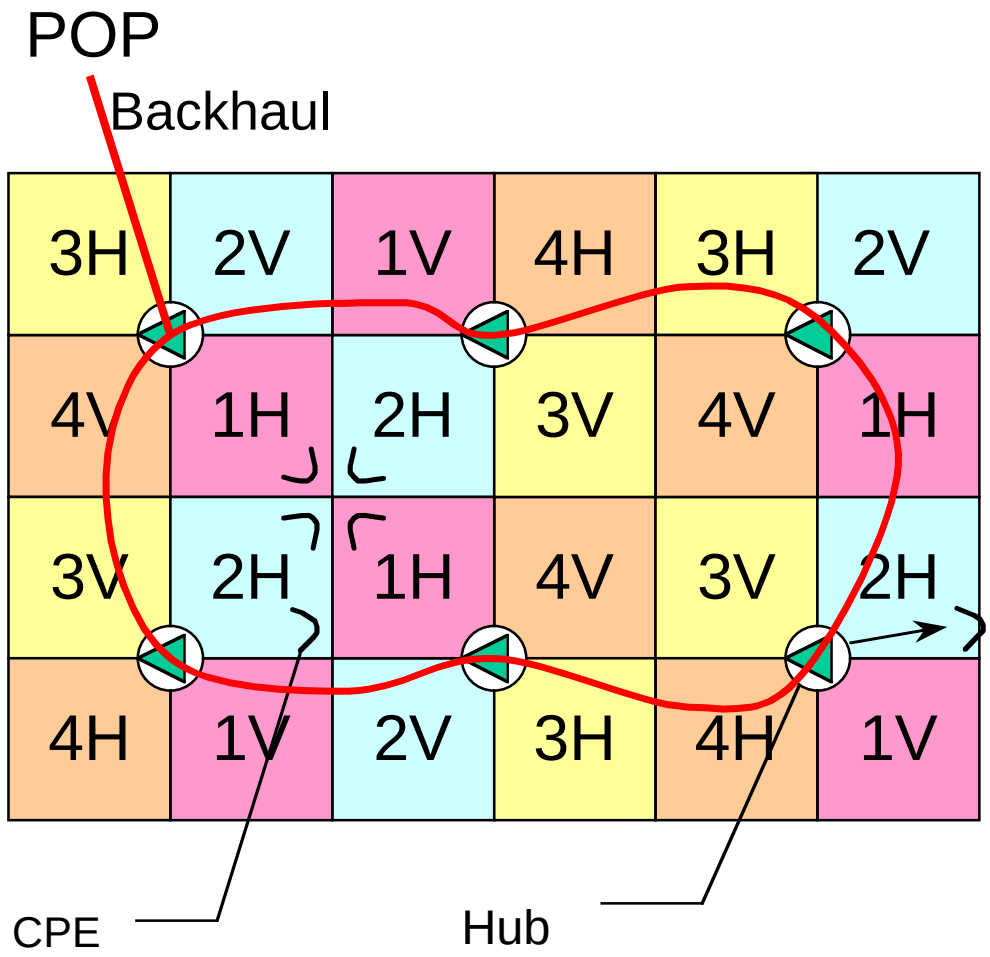
- 1V=Frequency set with Vertically Polarized Antennas
- Etc.

Requirements

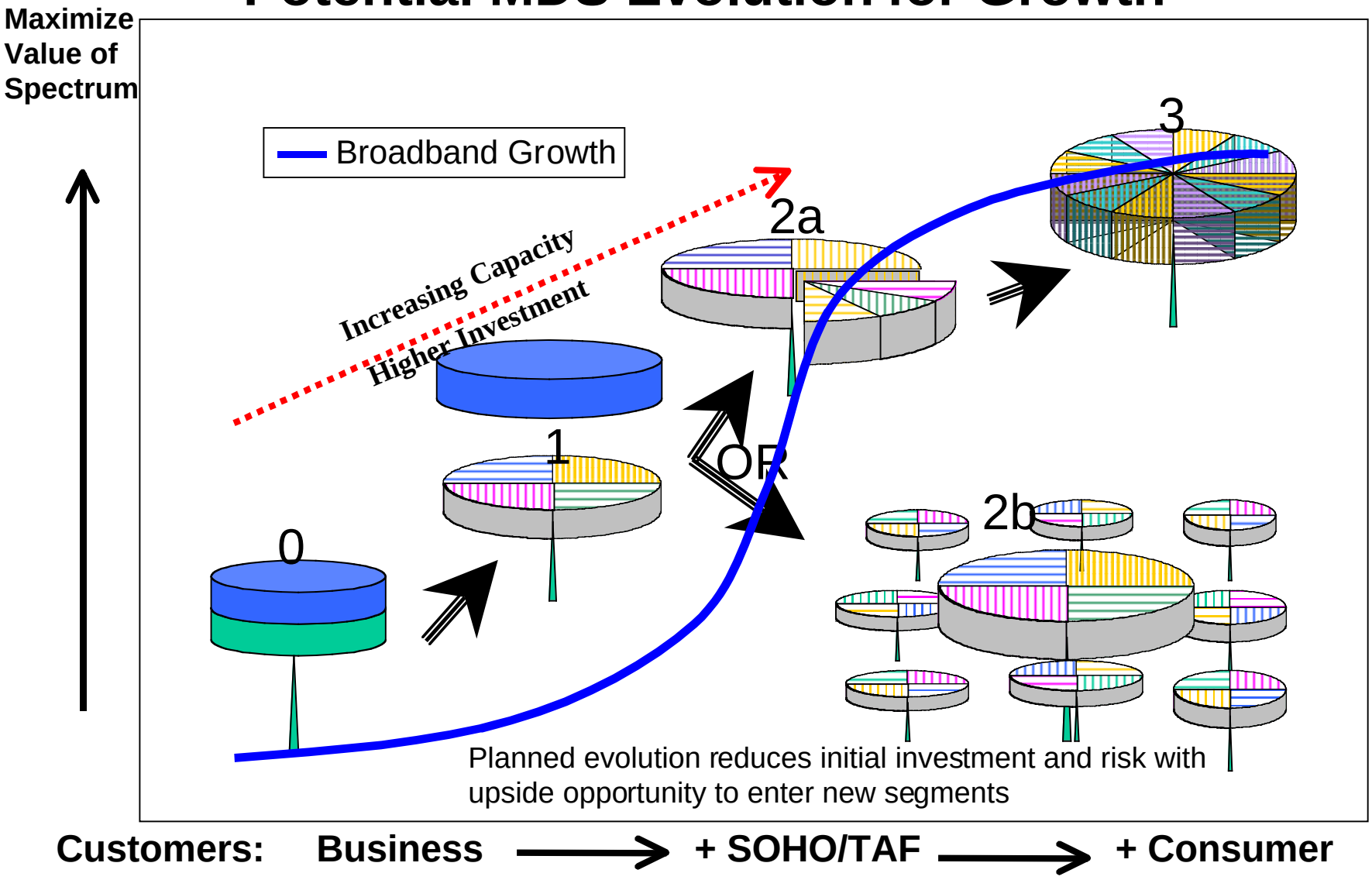
- High Gain Antennas
- Good Side Lobe Rejection
- Power Control

RF

- 8 BWA RF Channels min
- Frequency Reuse: 1/cell

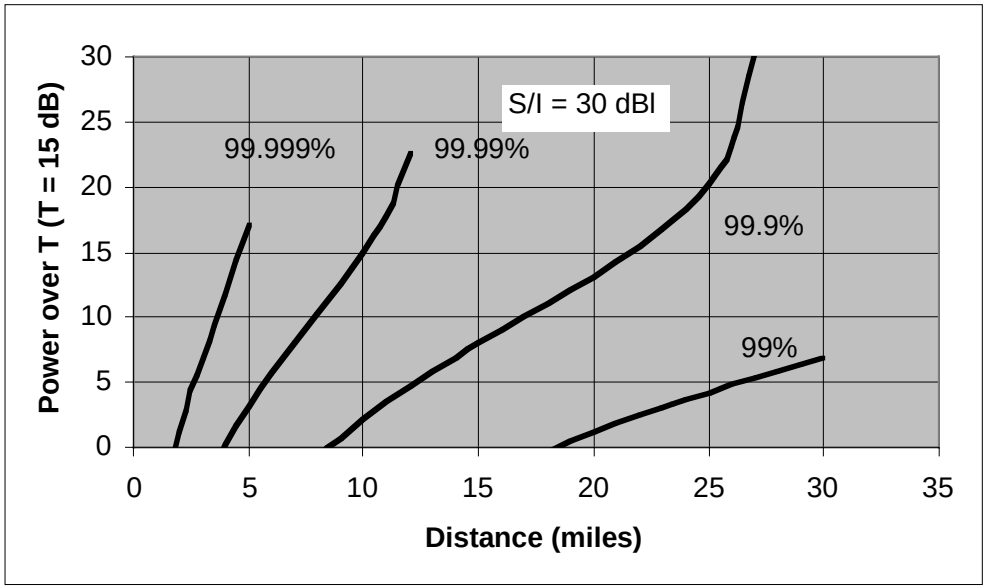


Potential MDS Evolution for Growth



Link Availability

- LMDS Link availability determined by distance and interference.
- Calculations based on works of Vigants and Barnett



- Example shown
  - Low interference
  - QPSK - 16QAM
- Example conclusions
  - High availability can be achieved at 5 miles
  - To achieve 4 nines availability at 10 miles requires operation 15 dB above threshold.

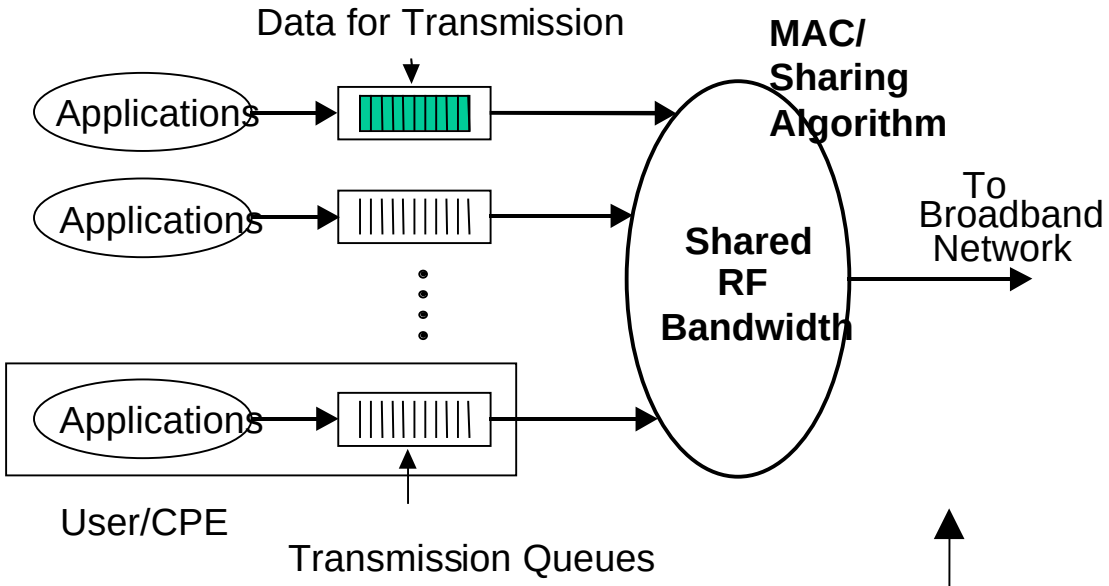
Availability primarily determined by distance from hub.
Reliability depends on redundancy, etc.

Quality of Service

- Data
  - QoS is the percent probability that the customer will perceive the file transfer rate specified by the provider during any session.
  - High level QoS requires prioritization of packet transfers
  - Service price options require bandwidth and QoS management
- Voice (VoIP)
  - Assumption: voice encoding will produce voice quality as required.
  - Transport must not reduce voice quality.
  - Prioritization required in packet transfer -- QoS management
- Providing QoS
  - Requirements
    - Scheduling of packets, compressed header, etc.
    - Traffic Engineering, operating within QoS capacity
  - DOCSIS 1.1 protocol provides hooks for QoS management
    - Scheduler algorithm and air interface enhancements required
    - Proposal: DOCSIS-based core for air interface protocol.

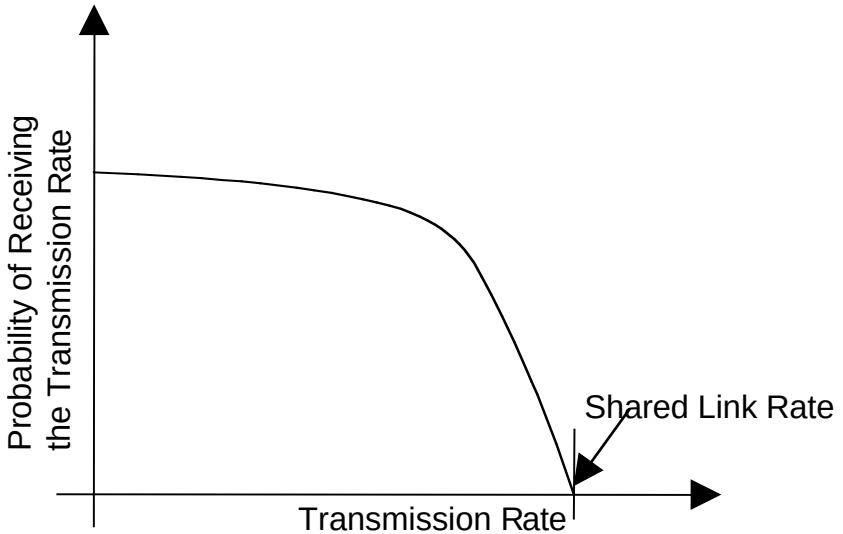
QoS is the business enabler for Sub10GHz BWA.

Traffic/Capacity Engineering



Access for multiple mixed services over one platform.

Sharing over platform depends on management and engineering.



Conclusions

- MMDS is on the verge of mass deployment.
- Success depends on competitive cost model and high quality service.
- Services include Internet, Voice via VoIP, and VPN
- Desirable product implementation :
  - TDMA/FDD
  - Multiple modulation rates -- QPSK to 64QAM
  - IP-centric
  - DOCSIS1.1 with wireless enhancements
- Products currently available with all or some of the essential characteristics.

An Air Interface Standard will lead to multiple suppliers and cost effective addressing of the mass market.