Fixed Wireless Broadband Access: Technologies and Standards

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ISART, Denver, CO
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The Broadband Internet Revolution

Digital Television

Data

Entertainment

Internet Driven

Video Telephony

Games

Telephony

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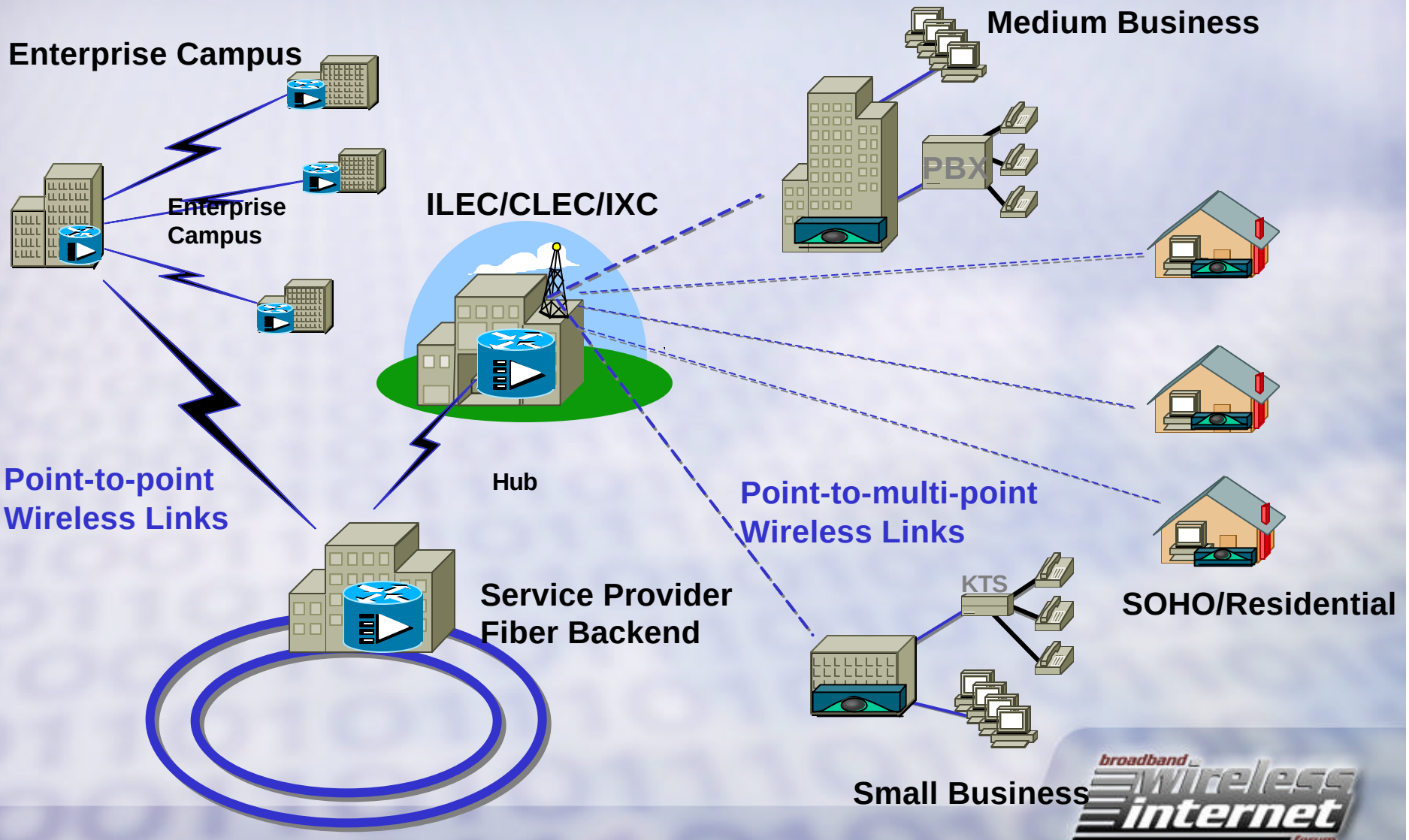
What are the Broadband Access Choices for the Future?

DSL	Cable	Wireless
good coverage distance destroys bandwidth upstream bandwidth an issue infrastructure upgrades	coverage is limited to residence build-out still required upstream bandwidth is limited	reach symmetric bandwidth higher upstream data rates speed of provisioning

Broadband Wireless Vision Into Reality

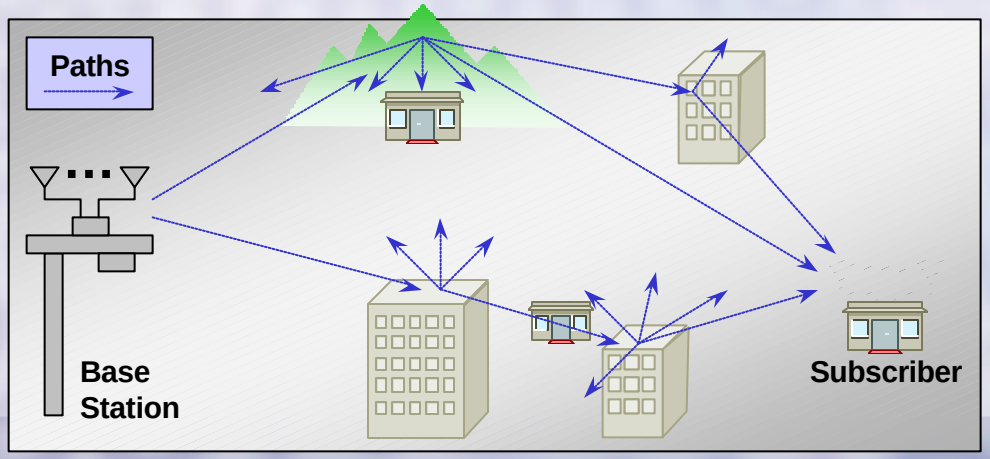


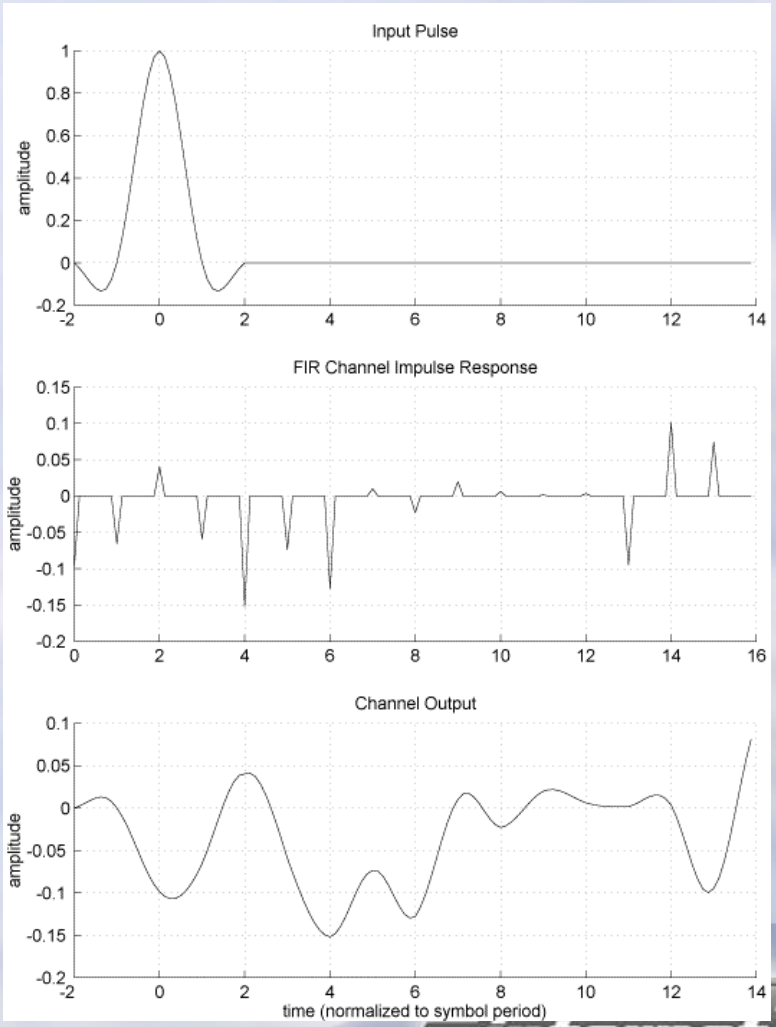
Broadband Wireless Access Layer System Needs

- 5 Mb/s to 20 Mb/s shared BW for consumers and business
- QoS managed, multiservice, bandwidth-on-demand MAC (Service Level Agreements)
- Standard, proven MAC
- High spectral efficiency and frequency re-use capacity
- Robust and simple to deploy
    - multipath tolerance & automated provisioning
- Low cost
- 3-20 mile range
- Easily ported to any frequency band

Multipath Wireless Communication

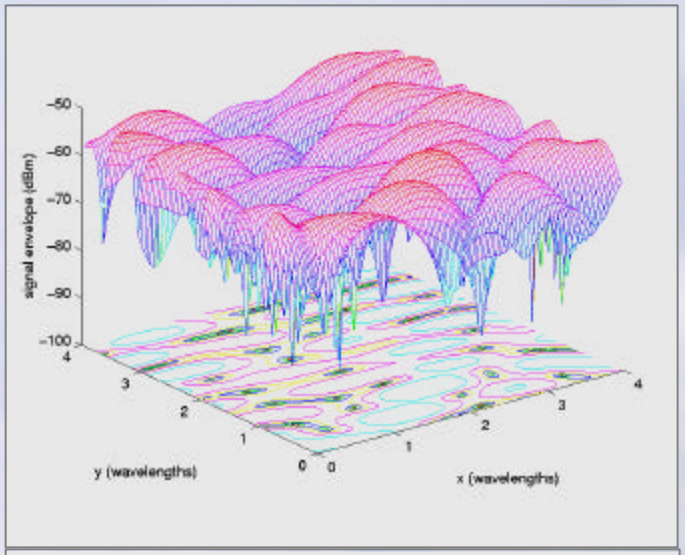
- Wireless communication involves multipath transmission
- Each path has an associated delay which causes intersymbol interference (ISI)
- Conventional wireless approaches exhibit degraded performance
- Other approaches designed to mitigate the effects of multipath:
  - Equalization
  - Direct sequence spreading
  - Adaptive space-time coding solutions

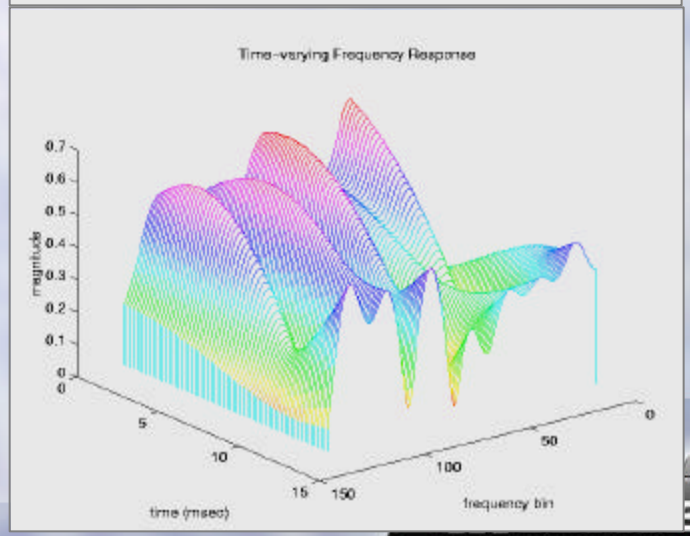




Effects of Multipath

- Spatial diversity
  - Standing-wave pattern between one transmit-receive antenna pair
- Time-variation
  - Motion in environment alters each standing-wave pattern
  - Motion in environment creates time-varying frequency response





Broadband Wireless Access Alternatives

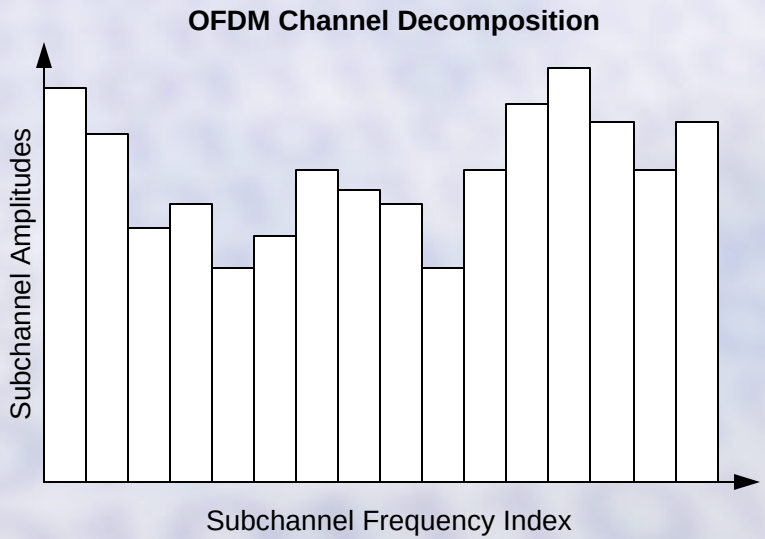
- CDMA (Space-Time CDMA)
- SCQAM (ST DFE)
- OFDM (MIMO [Vector] OFDM)
- Recent Enabling Factors
  - Systems on a chip complexity
  - New practical spatial processing techniques

Broadband Wireless Access Alternatives

- Not enough BW to offer broadband access with CDMA. High-speed CDMA is inefficient.
- SCQAM is not as robust, has lower spectral efficiency and is more expensive to make work
- Vector OFDM (VOFDM) has a very large link margin advantage and can be rigorously shown to be more cost effective than Space Time DFEs.

OFDM Concept

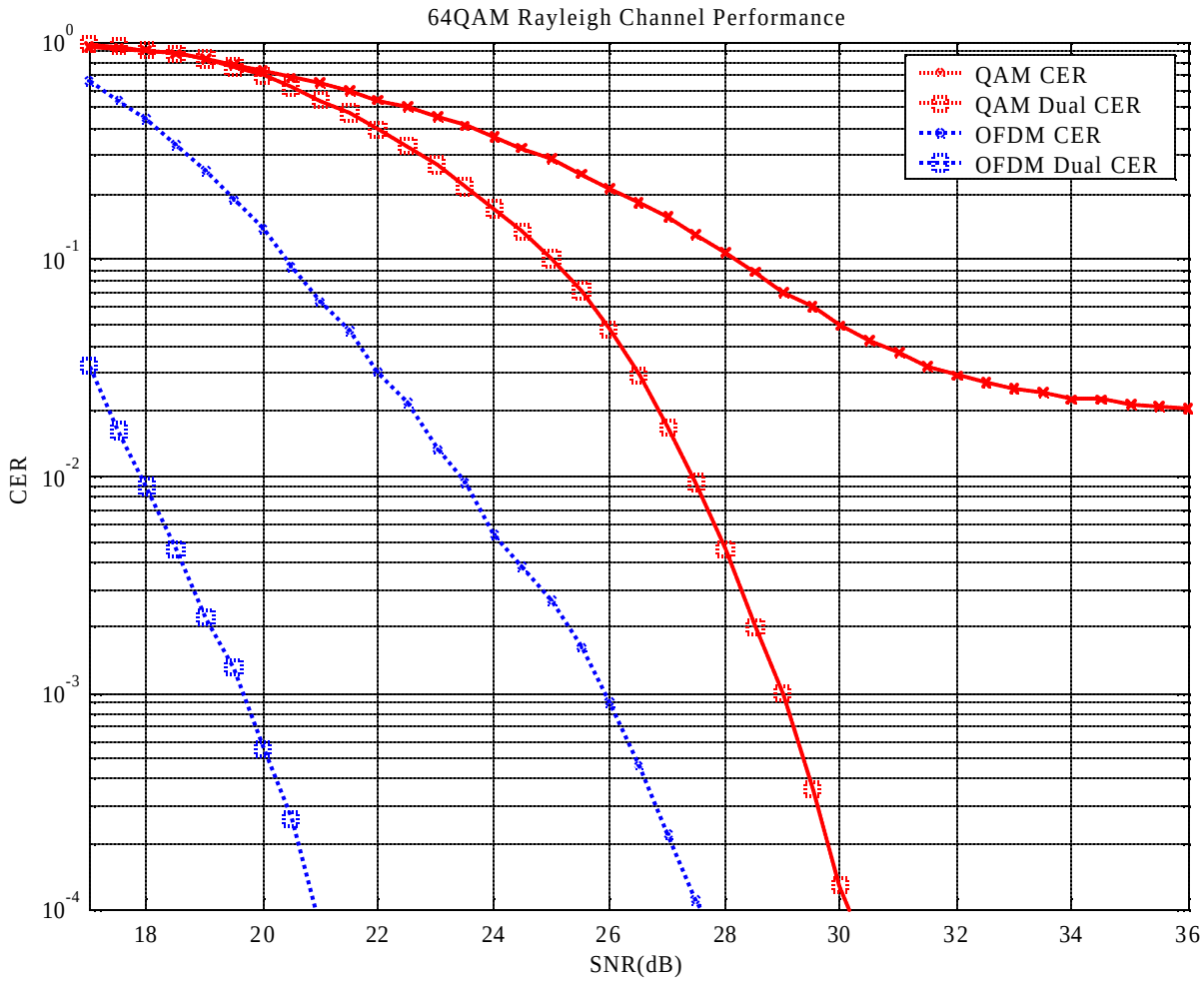
- OFDM decomposes ISI channel into many ISI-free narrowband channels for any time-limited channel.
- Exploits frequency diversity rather than inverting channel.
- BER performance improves with channel ISI (delay spread).



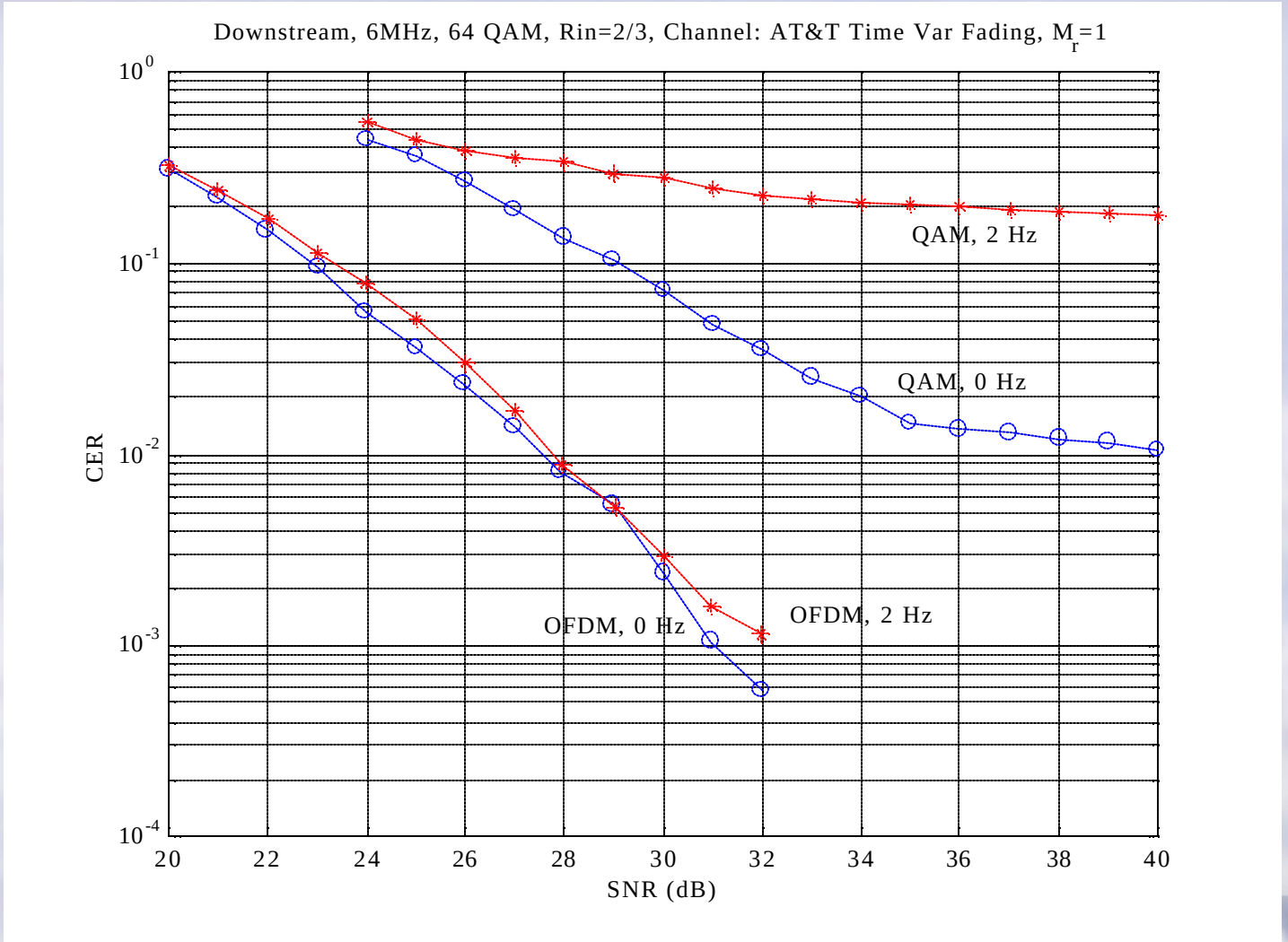
OFDM

- OFDM is composed of cyclic prefix and FFT operations
- Data at one frequency received independent of other data

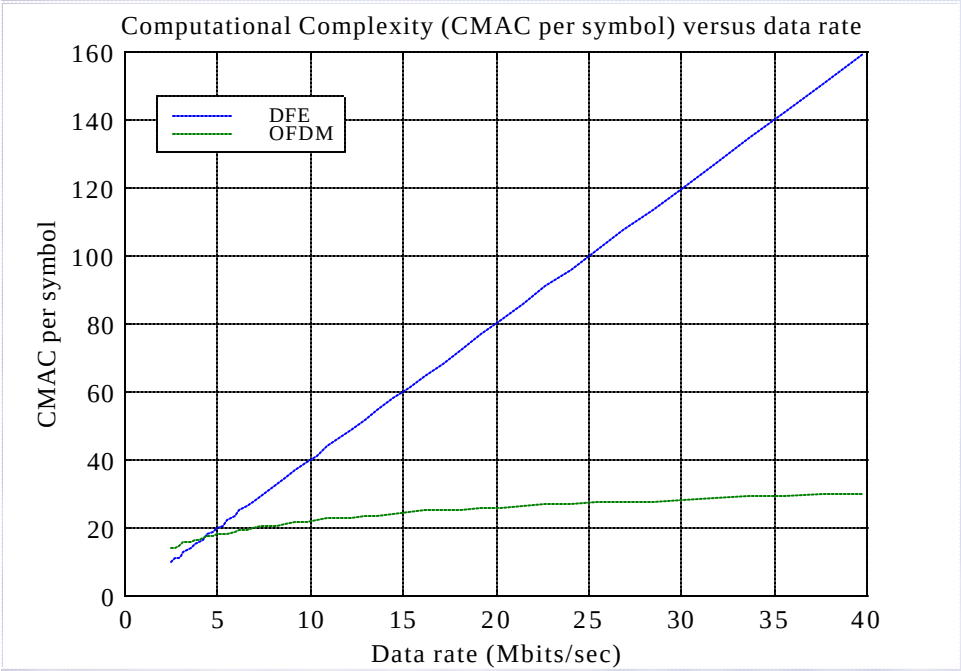
Upstream 64-QAM CER 1/2 ms Rayleigh Channel

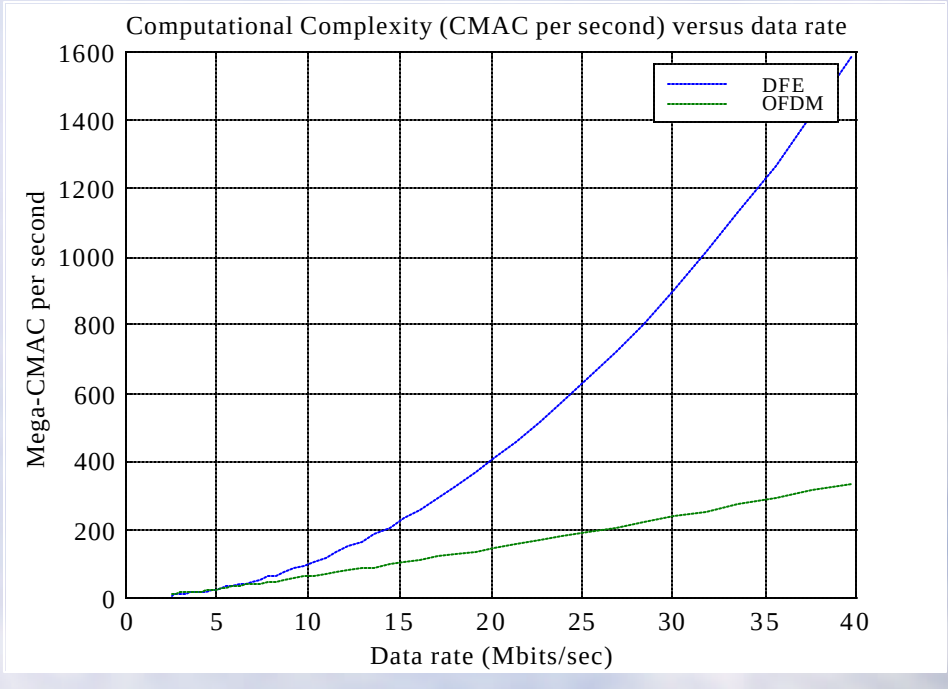


Downstream 64-QAM CER Ricean Channel



Better Performance with Lower Complexity



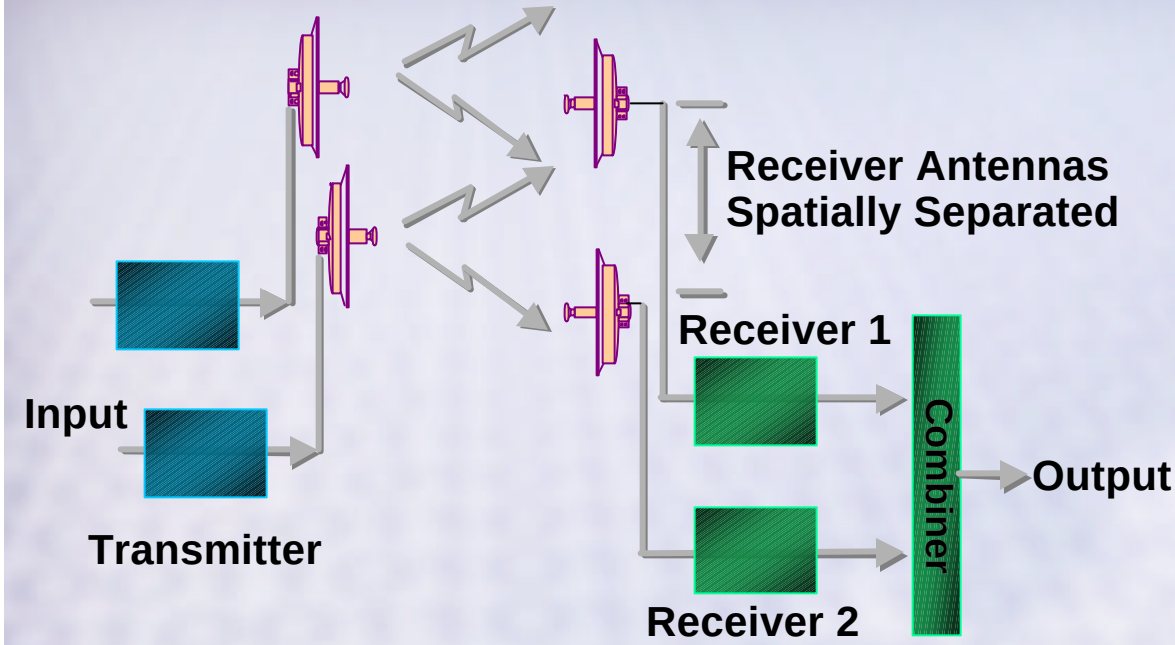


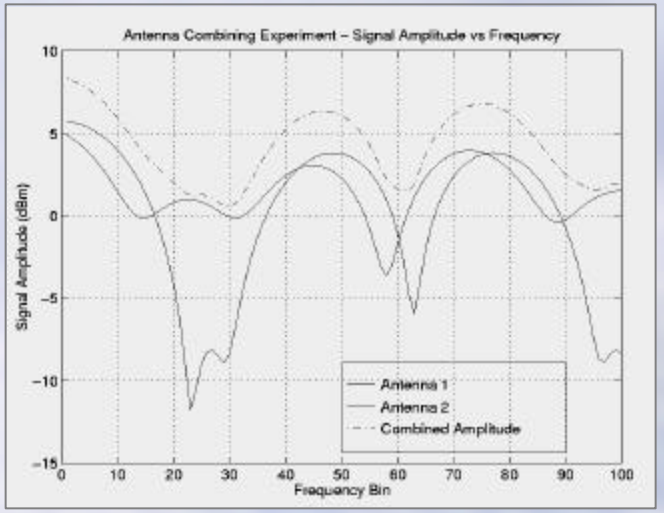
- For high sampling rates, computational complexity is lower than conventional space-time equalization structures
- Above example assumes: 2 μs delay spread, 16QAM, 20 μs OFDM burst length

OFDM Advantages

- Upstream processing
  - Robust burst-mode demodulation possible, even in severe delay spread environments
  - Higher spectral efficiency possible
  - Solves the upstream problem
- Downstream processing
  - Capable of operating in high delay spread environments
  - Capable of operating with time-variation
  - Dual antenna capability at lower complexity
- Interference-limited environments
  - Very robust to narrow-band interference
  - Interference cancellation possible with dual antennas

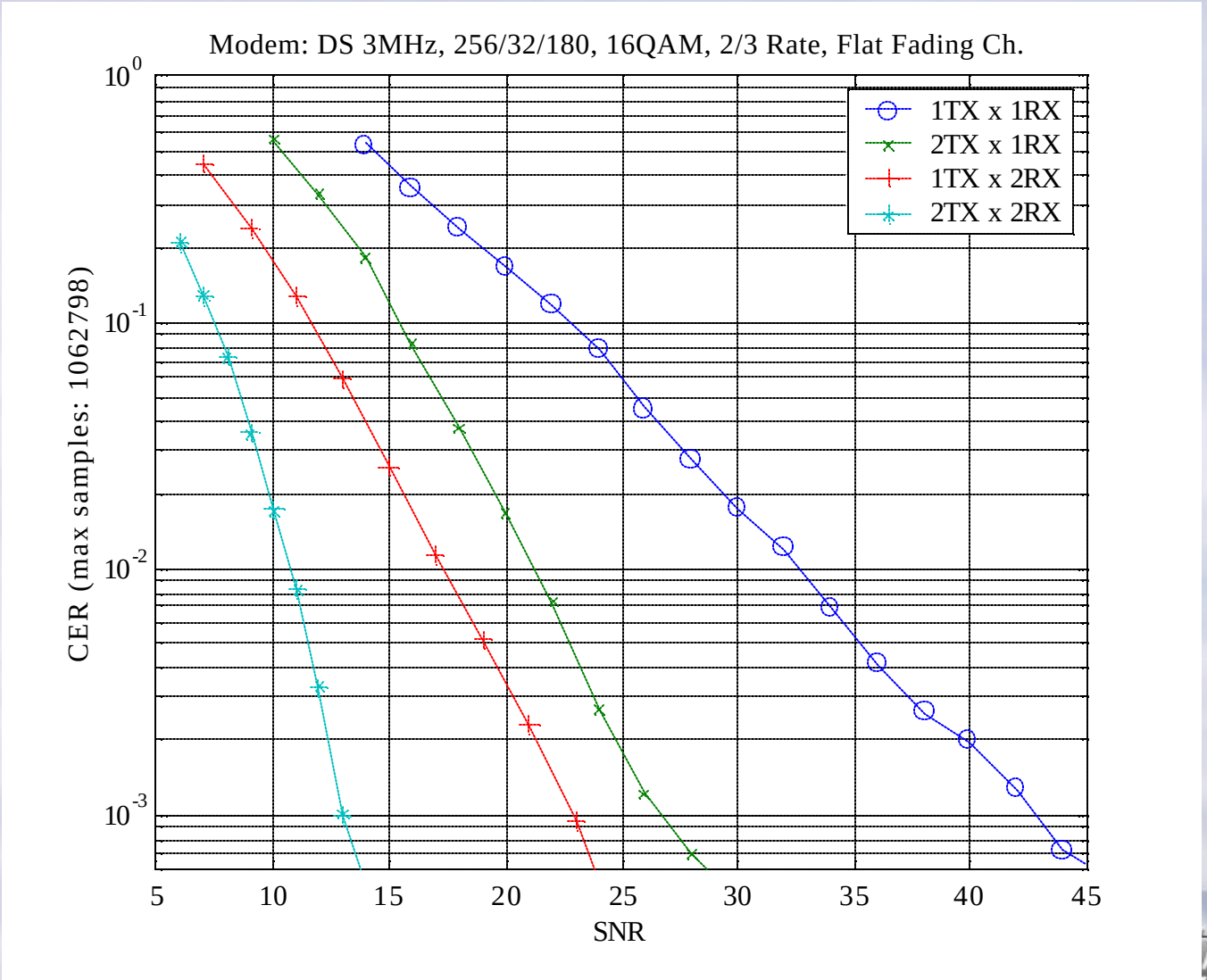
Spatial Diversity



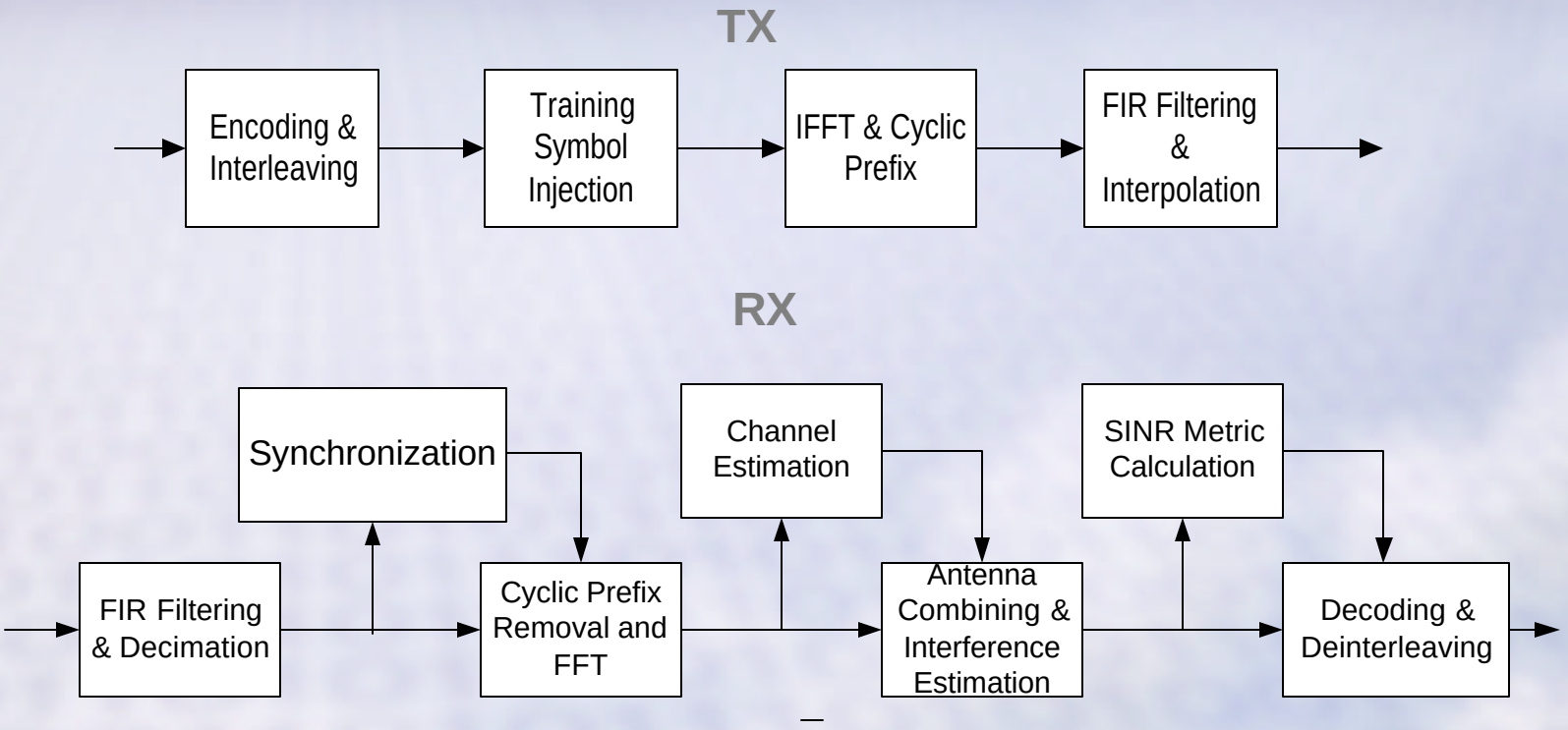


- In the presence of multipath fading, two received signals will have uncorrelated fading effects due to different path lengths
- Thus, a combined received signal will have a higher SNR that any of the individual signals
- The greatest processing benefits come from exploiting both frequency and spatial diversity

Spatial Diversity Advantage



BWIF PHY Standard: Block Diagram



- Diversity
- Interference cancellation
- Soft decoding

- Time synchronization
- Frequency locking
- Adaptive level control

BWIF MAC Capabilities

Proven, widely deployed MAC

Best effort data

VoIP

IP multicast support

Enhanced security and privacy

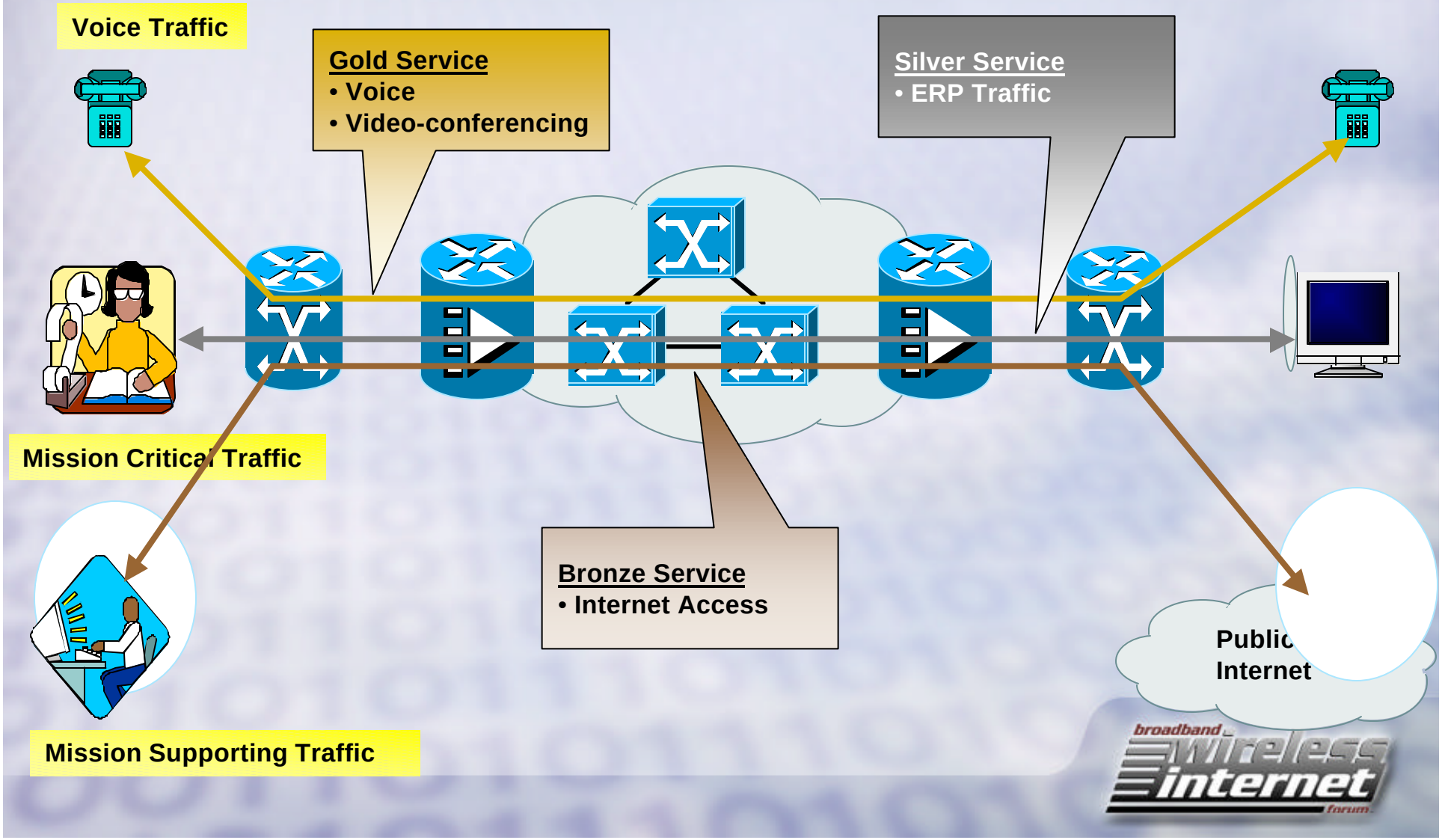
QoS guarantees

Virtual Private Networks

DOCSIC 1.1 MAC:

- **Fragmentation**
- **Concatenation**
- **Payload header suppression**

Service Level Agreements (SLAs): Network and Service Quality Guarantees



Alternative OFDM Technologies

LAN OFDM	BWIF OFDM	WDSL OFDM
802.11 & WiLAN	Standards based products available today	Very similar to BWIF OFDM
Simple forms of OFDM	Open standard	Differences are expensive with marginal benefit
Lacks coherent detection	Service being rolled out	Will be in development for > 2 more years
Lacks MIMO operation and interference cancelation	Silicon devices available Jan '01	MIMO OFDM intellectual property problems
Spectral efficiency is low (PHY & MAC)	Low cost CPE available early '01	
Limited MAC & QoS		

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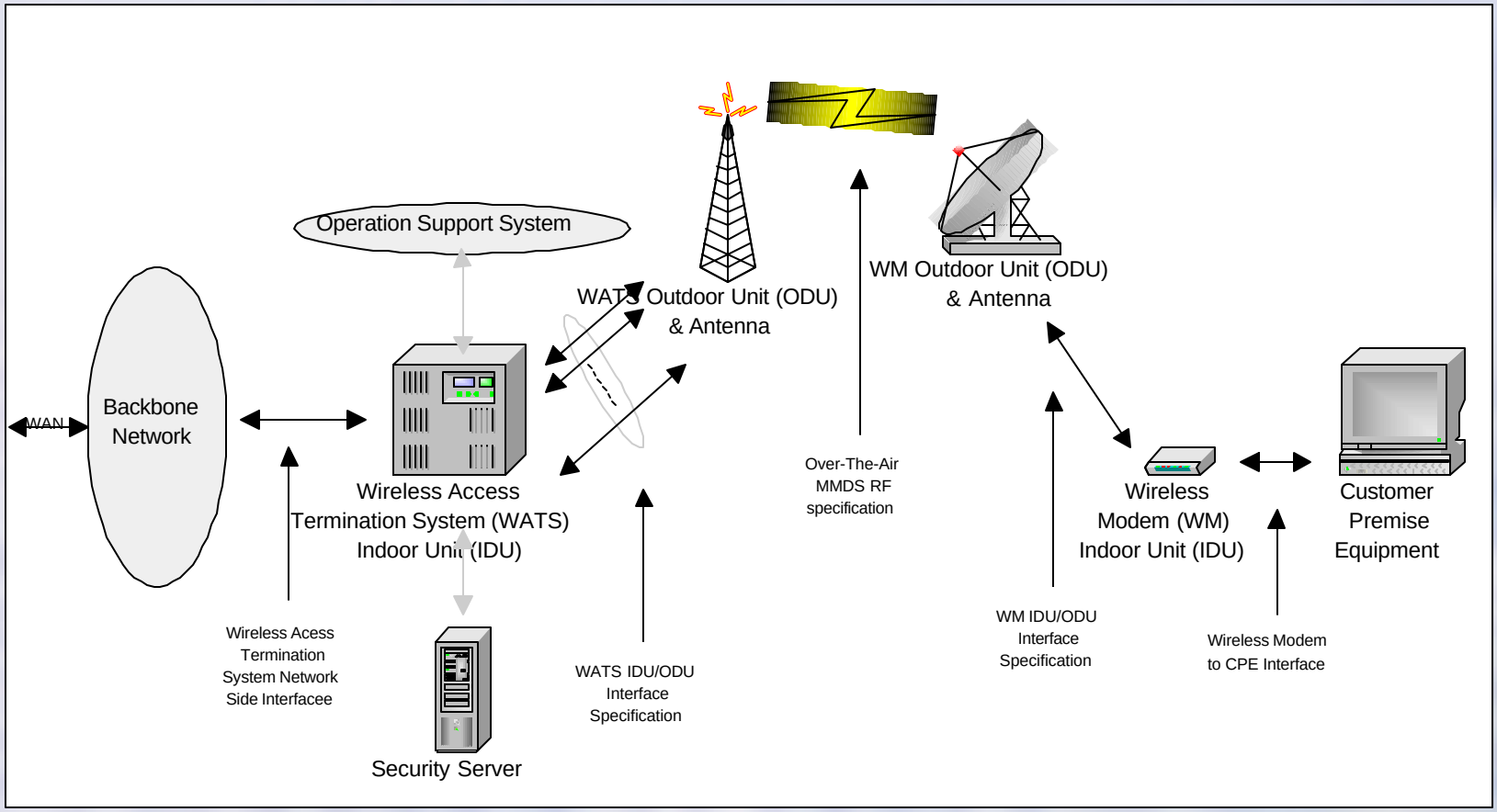
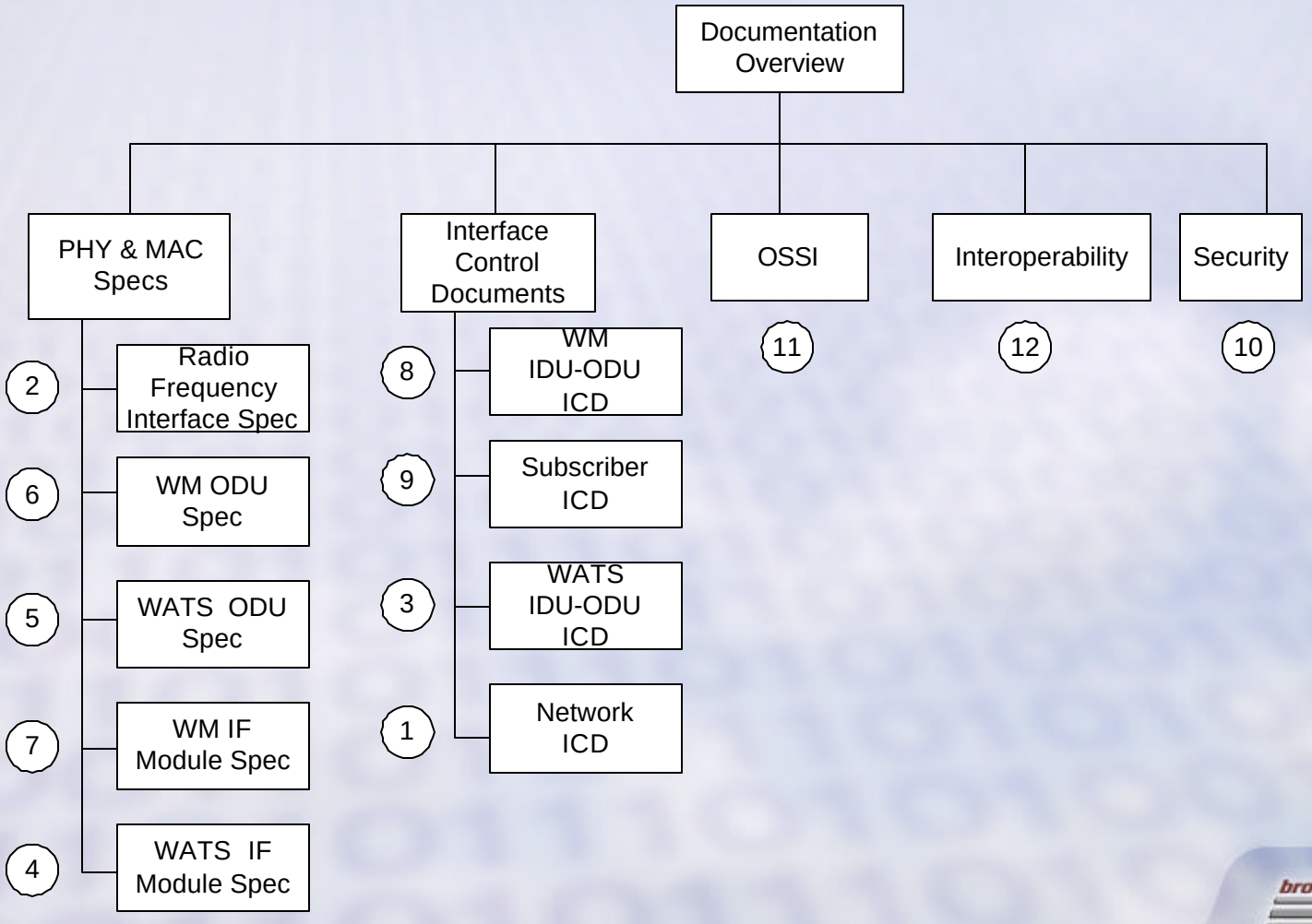
BWIF Members
(as of 9/8/2000)

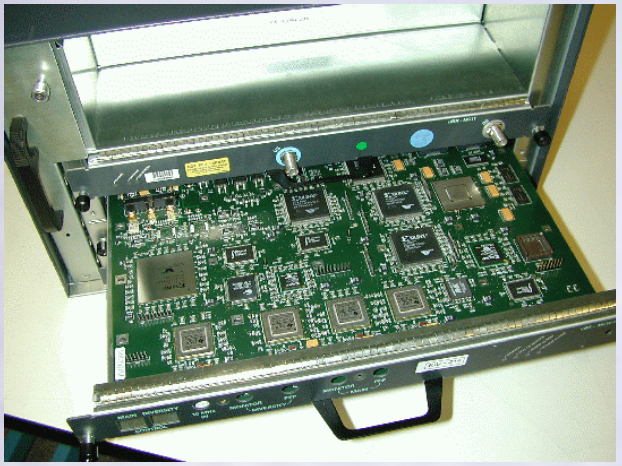
Wireless Reference Architecture

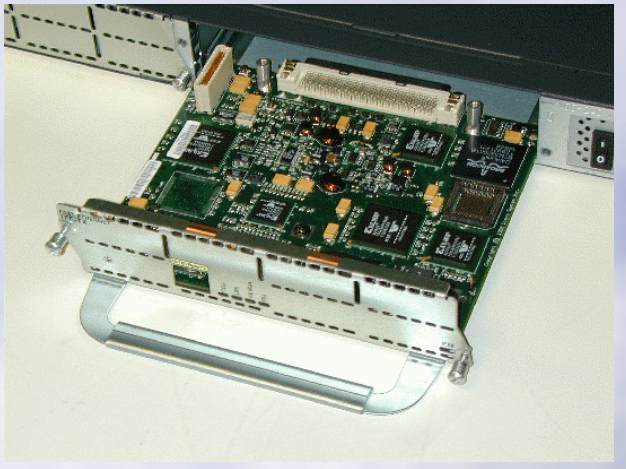


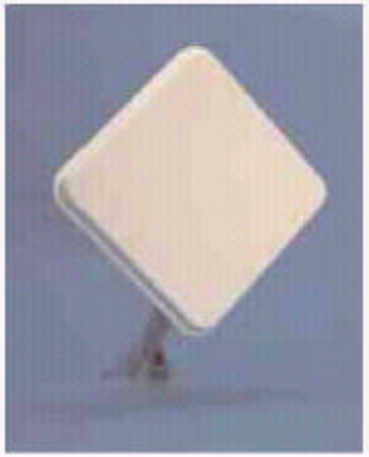
BWIF Specifications



BWIF Standards Compliant Base Station and CPE Product Status







6. SX1123A mounted at 30°– J

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Future BWIF Standards Enhancement Possibilities

- More bandwidth (75 Mb/s)
- More spectral efficiency modes
- Microcell base stations and ultra low cost portable laptop/PDA implementations
- More MIMO transmit and receive diversity options
- Narrowband upstream options
- Multi-channel MIMO modulation
- Layer 1 ARQ
- Real-time adaptive modulation and coding
- All future enhancements will be customer-driven and backwards compatible with Revision 1.0 and subsequent specs