Meeting Enterprise Requirements with Broadband Wireless Access

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Agenda

- The problem
- The technical challenge
- Wireless challenges and solutions
- Packet challenges and solutions
- Shared access media challenges and solutions
- Network challenges and solutions
- Summary

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The problem:

- Delivering a broadband connectivity solution to an enterprise where:
  - Geographic location makes broadband wireline connectivity cost prohibitive, or
  - Broadband services provided by incumbent providers is inadequate, not cost-effective, or not available

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The technical challenge:

- Providing suitable data networking services
  - Broadband speeds (2 - 20 Mbps)
  - SLA's, guaranteed services, differentiated services
- Supporting appropriate levels of quality
  - Interactive multimedia (video, telephony, etc.)
    - Low jitter, latency
    - Adequate bandwidth
  - High speed Internet access
    - Support data burstiness
- Enabling cost-effective installation, support and services
- All in a wireless "shared access media" environment

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The historical broadband access conundrum:

- Broadband access at the edge is expensive and difficult to provide cost-effectively
  - Legacy (telco) access approaches utilize circuit-switching-like access network architectures
  - Circuit - switching can provide service guarantees, but at excessive cost
  - Shared media access architectures (cable modems, passive optical networking, etc.) are cost effective, but traditionally couldn't provide service guarantees
- Wireless access must utilize shared media access
  - Therefore, must solve the service guarantee problem
  - Must "make shared act like switched" in terms of quality

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The challenge for fixed wireless broadband

- Wireless
  - Delivering reliability of the wired world
  - But wireless is unreliable given the noisy and interference-prone nature of radio transmissions
- Shared
  - Ensuring efficient and fair sharing of the broadband bandwidth
  - But a shared medium is contention-based and non-deterministic
- Packets
  - Delivering differentiated services of the circuit-switched world without its inherent bandwidth inefficiencies
  - But IP packets are unpredictable given their bursty nature

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The challenge deploying fixed wireless broadband

- Low cost with broadband bandwidth
  - Installed CPE costs
  - Infrastructure capital costs
  - Operational costs
- Mass deployability
  - Point-to-multipoint topology
  - Easy install, use existing cellular sites
  - Fast large-scale rollouts
  - Non-line-of-sight (NLOS) coverage
  - Easy management and provisioning
  - Support of enterprise connectivity and networking requirements

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Wireless challenges

- The challenge of the RF environment:
  - Non-line-of-sight with obstacles such as trees and buildings
    - Multipath
    - External interference
  - Delivering reliable broadband access in a changing RF environment
    - Bit error rate as high as 10^{-3} resulting in high probability of packet errors
- Solution: OFDM
  - **O**rthogonal **F**requency **D**ivision **M**ulitplexing
  - Complex RF modulation technique (many DSP's and MIPS)
  - Solves multipath and line-of-sight restrictions
  - Greatly enhances noise immunity

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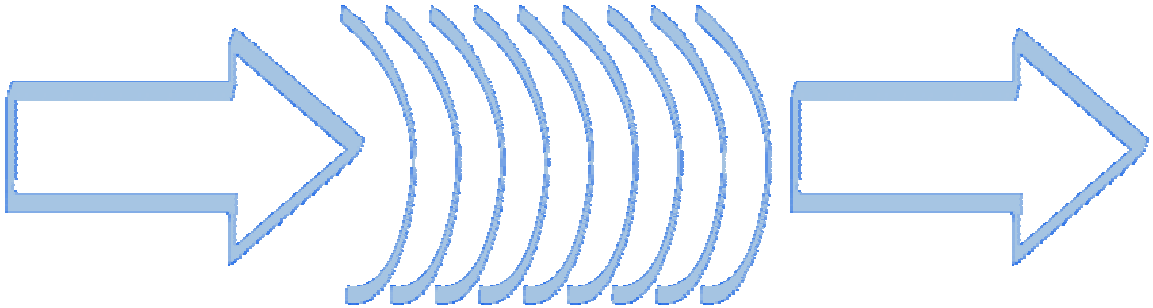
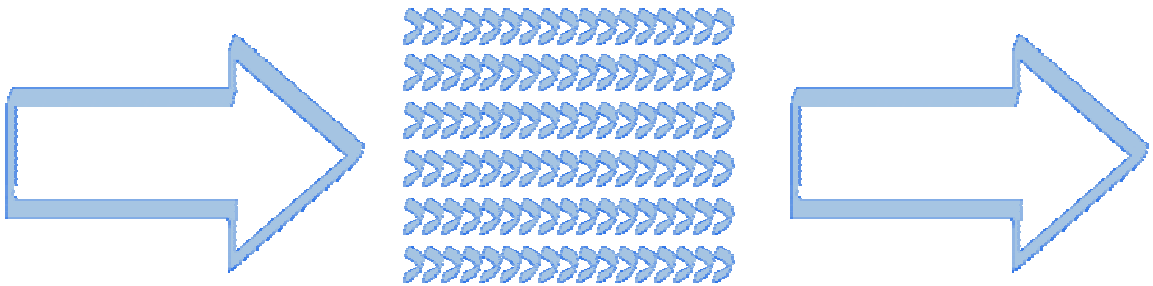
Obstacles to receiving the signal at the subscriber

Obstacles can reflect or block the transmitted signal



- Single carrier uses one large carrier
- Interference and multipath can block the entire signal
- Errors often require retransmission



- OFDM uses many small carriers
- Interference and multipath affect only a small portion of the signal
- Most errors can be completely recovered with forward error correction

OFDM delivers resiliency and non-line-of-sight operation

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TCP/IP and packet loss don’t mix

- Lower Bit error rate with dynamic FEC, but there is still packet loss
- Problem: TCP does not distinguish between congestion and noise for packet loss
- Implication: TCP assumes the network is congested and slows down and then restarts creating congestion (global synchronization) and additional traffic load
- Result: subscribers’ service quality declines
- Solution 1: automatic repeat request (ARQ)
  - Lost parts of packet are retransmitted locally between the BTS and CPE, without TCP involvement
- Solution 2: TCP rate management without packet discard
- Benefit: maintain consistent subscriber experience

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Challenges of a wireless shared medium

- Delivering bandwidth efficiency
  - High link utilization
  - Eliminating contention for the medium
  - Reducing control overhead
  - Retransmissions only when necessary
- Providing efficient and load-independent support for real time multimedia traffic such as telephony, video conferencing & gaming
  - Delivering bounded delay and jitter
  - Maximizing throughput while minimizing delay
  - Enabling the delivery of differentiated services
- Supporting levels of over-subscription while maintaining guarantees and acceptable service levels
  - Too many users means lower throughput, high delays & no fairness

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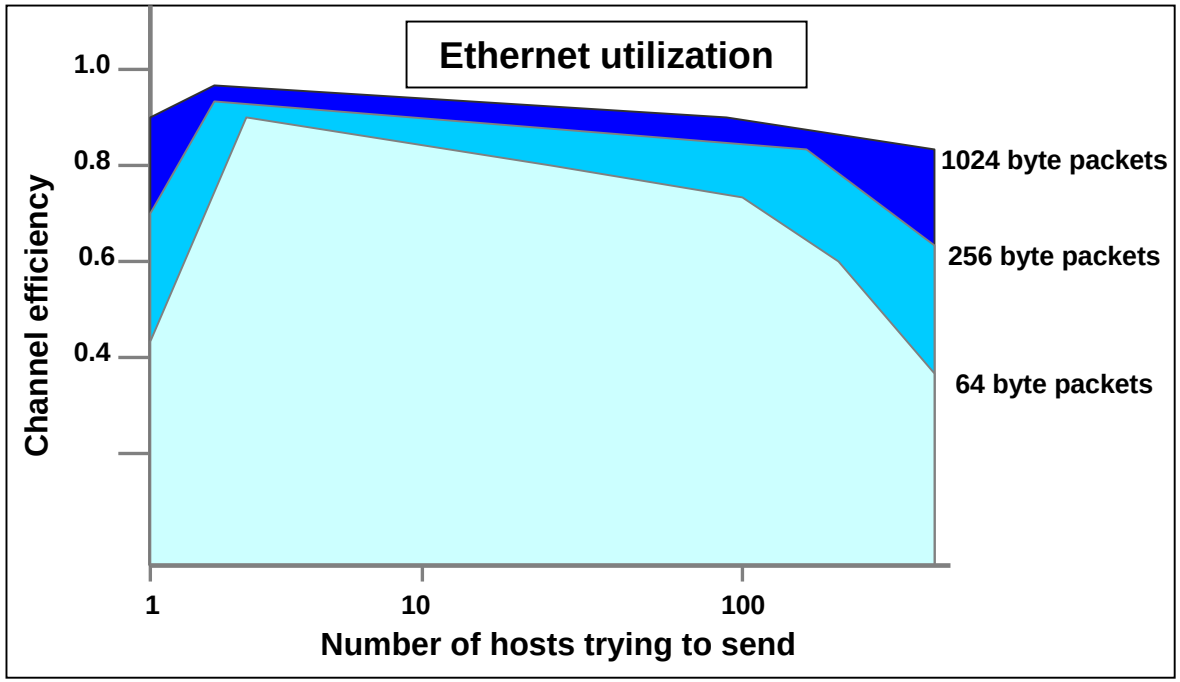
Too many users: lower utilization, high delays & no fairness

Why?

- Random-access MAC protocols (Aloha, CSMA/CA protocols) are not well-suited for wireless broadband
- Collisions waste bandwidth, generate more collisions & create the capture effect
- Retransmissions due to collisions can be high as 10-15 times
- % of dropped frames (16 consecutive collisions) can be as high as 60-80%



Source: Molle Technical Report CSRI-298

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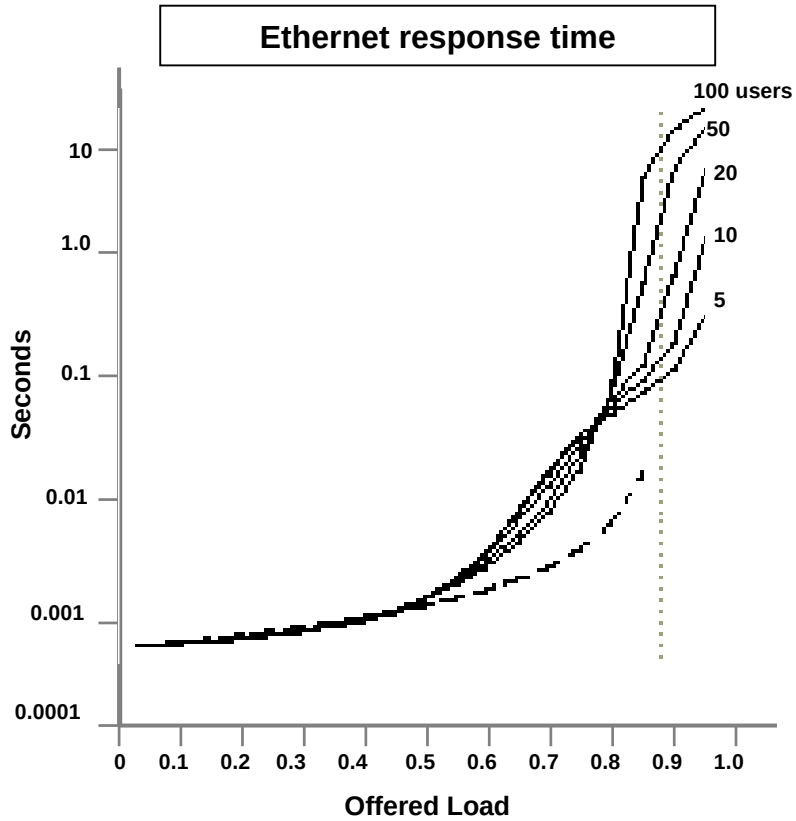
Response time rapidly increases

Result

- No fairness
- Unpredictable response times as high as 8 secs in 90% offered load with 50 hosts
- Worst case bandwidth utilization degrades by 50%



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Networking challenges

- Must have a MAC (media access control) layer that is optimized for RF PHY characteristics while providing support for SLA's and guaranteed services
- System must be dynamically responsive to changing RF PHY and TCP/IP flow characteristics
- System must be aware of individual TCP/IP packet flow requirements
- Must have an intelligent Scheduler that manages system resources appropriately to individual flow requirements and is responsive to RF PHY conditions
- Must have policy-based QoS control to implement and enforce system resource allocations

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More networking challenges:

- Enterprises require differentiated services:
  - Guaranteed
  - Best Efforts
  - Service Level Agreements
- Will need policy-based QoS
- Will need end-to-end QoS
  - DiffServ, RSVP, MPLS mediated
- Shared media access nature of RF connectivity at the edge makes end-to-end QoS very difficult
- RF characteristics add to the difficulty

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Solution:

- A wireless system that is architected to integrate requirements of broadband TCP/IP traffic with special challenges of RF:
  - Provides enterprise-based SLA's & differentiated services
  - Compensates for shared media access characteristics at the network edge
  - Manages TCP/IP congestion detection mechanisms
  - Utilizes RF bandwidth efficiently while providing high QoS
- RF System based on OFDM
- TCP/IP packet classification and processing
- Optimized Scheduler and MAC
- Policy-based QoS capability tied to end-to-end QoS
- Bounded jitter and delay

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Summary:

- System can overcome line-of-sight obstacles
- RF noise and interference can be compensated for
- SLA's and guaranteed services can be cost-effectively supported without expensive circuit switching
- Bounded jitter and delay for interactive multimedia support
- True end-to-end policy-based QoS capability
- Wireless broadband access will become an important connectivity solution for enterprises, even where wireline is available

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