



CDMA IS-2000 EVDO Interoperability for Data Optimization

Mobile Broadband Americas

**Krishna Ramadas
Fellow, Product Technology**

Agenda

- **1xRTT Vs EVDO**
 - Speed
 - Link resource allocation strategy
 - Hybrid geographical coverage
- **Data optimization**
 - Speeding up transactions
 - Enabling higher subscriber density
 - Improving Service consistency
- **1xRTT and 1xEVDO interoperability**
 - Hand Off optimization
 - Interoperability Specifications
 - Potential for service degradation
- **Measuring optimization efficiency**
 - Test bed and tools
 - Application suite
 - Lab and field testing

Technology Overview

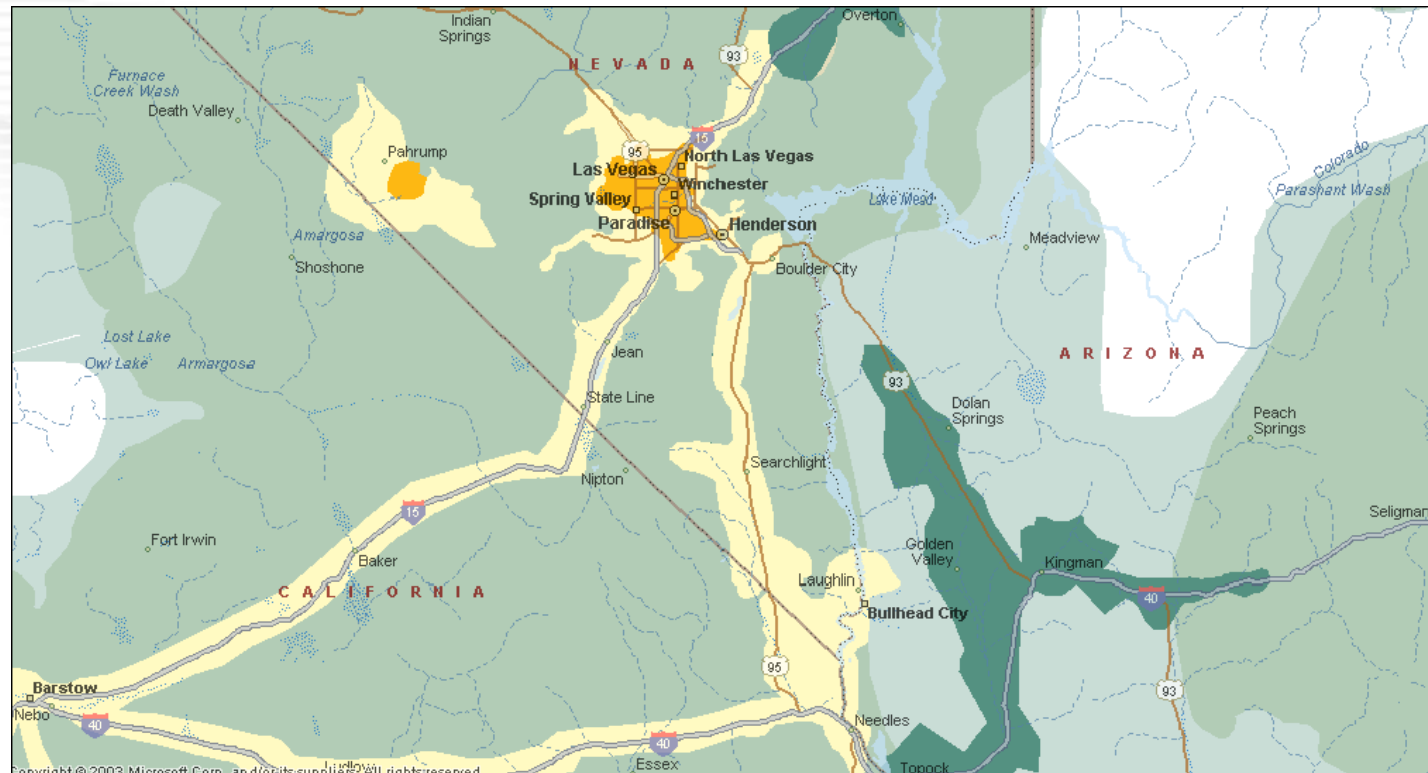
1xRTT

- Lower downlink speed (153Kpbs)
- Link resources shared between data and voice
- SCH (Supplemental Channels) for data burst
- Tighter BER budget
- Basic rate modulation and coding
- Limited number of data subscribers; SCH channel assigned for 160 milliseconds
- ARQ (Automatic Receive Request) based link recovery

EV-DO

- Higher downlink speed (2.4Mbps)
- Link resources dedicated for data only
- TDD (Time Division Duplex) Frame structure
- Flexible BER budget
- Advanced Modulation and coding (higher efficiency)
- Larger number of subscribers & always-on experience; TDD slots 1.67 milliseconds
- Faster NAK feedback improves AQK link recovery

Hybrid Deployments



- Are enabled by common characteristics
 - RF, bandwidth
- Introduce broadband access with lower costs
 - shared cell sites, antenna and equipment
 - Integrated chipsets : affordable hybrid handsets

Data Wireless challenges

- **Interference**
 - Caused by Cell load variations and increased load causes problem at the receiver
 - is compensated by changing link layer coding
 - Rate variation is frequent
- **Fading**
 - Caused by mobility both by subscriber and objects in multi-path situations
 - Leads to error bursts that are compensated by link layer retransmission algorithms
 - Leads to delay variation
- **Signal Strength**
 - Is a primary factor in reception quality
 - Degrades away from the tower and inside buildings
- **Bandwidth sharing**
 - Spectrum Allocation adjustment causes rate and delay variation along the packet path

Cross-Layer Optimization - Solution

Smart Content Compression

- Content and application specific
- High performance algorithms (Wavelet, PPM) for better image fidelity
- Lossy & Lossless algorithms
- Benefits
 - Reduces data on the Radio Access Network (RAN)

Adaptive Airlink Optimization™

- Venturi Transport Protocol (VTP)
 - Optimized Wireless Transport
- Payload Optimization
- Benefits
 - Faster network
 - Greater coverage
 - Improved network efficiency

Caching

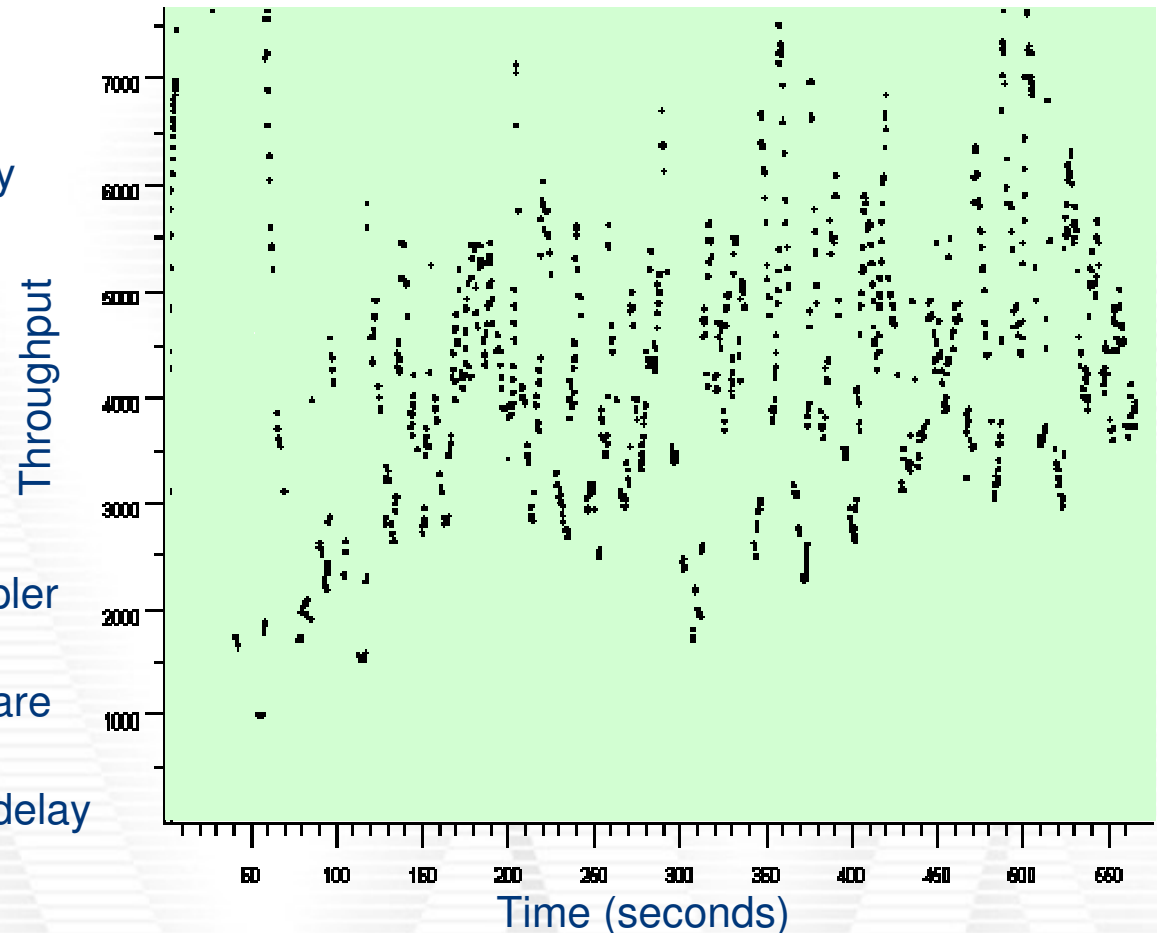
- Pre-fetches content
 - Client-Server
- Caches pre-compressed objects
- Benefits
 - Reduced impact of Internet latencies
 - Backbone savings

Compression based Optimization

- DCT, Wavelet, LZ/PM based techniques
- Enhanced performance through dictionaries
- Intelligent application of compression engine
- Symmetric code between Client and server
- Designs that offload to alternate processor
- Compression takes bits off the air and increases more subscriber transactions over limited spectrum resources
- Compression Management
 - Provides Service levels
 - Define “loss” and type
 - Provide service distinction
 - Enables Client Control
 - Select service level
 - Enabled by Server
 - Based on network speed
 - Based on utility value w.r.t file size & resulting compression
 - Smart Cache-interaction

TCP efficiency

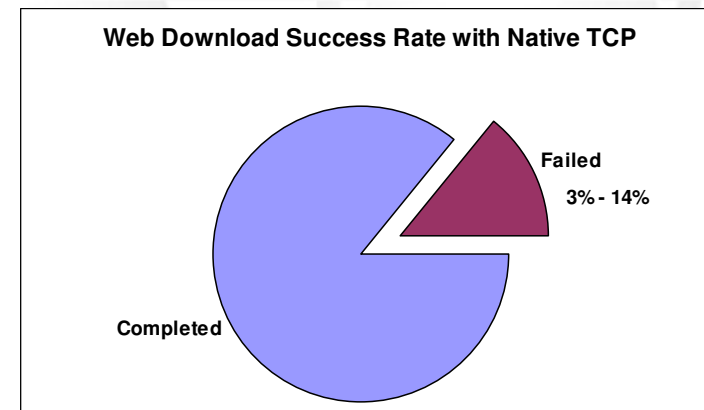
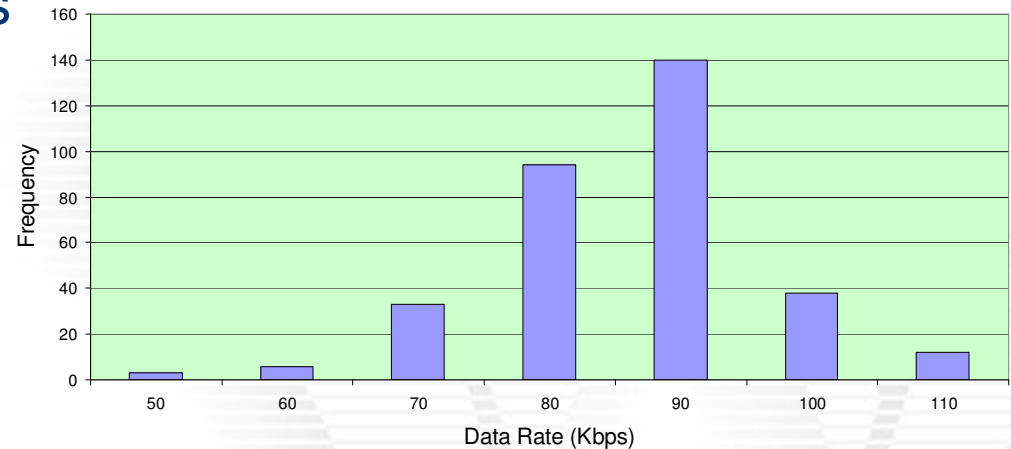
- Sliding Window suffers on wireless links
 - Link bandwidth is changing rapidly
 - Radio links is susceptible to error bursts
- Congestion and Flow Control implementations are linked
 - Causes inefficient use of link bandwidth
 - Congestion control needs be simpler on capacity engineered links
 - Round Trip Time Measurements are not reliable as Time Out metrics
 - Wireless link exhibits wild delay variations
- Three way connection hand shake
 - Results in longer delays in using the link resources



Service Consistency

- Coverage area often includes poor response spots
 - Modem remains connected
 - Transaction progress painfully slow
- Large variance in download speed leads to poor service perception
- Unsuccessful terminations block uptake of wireless for business applications
- Application efficiency is low despite good spectrum efficiency
 - e.g HTTP utilizes only fraction of the available link bandwidth

Distribution of Throughput Rates



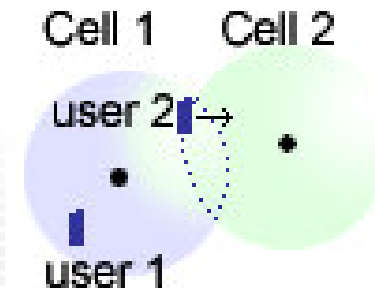
Transport for efficiency and consistency



- **Flow Control**
 - Most Important factor determining link utilization
 - Rate based transmission control
 - Avoids problems of sliding window problems for wireless
 - Enforces rate with minimum protocol overhead
- **Congestion Control**
 - Retains internet congestion control with a split-TCP-path deployment
 - Supplies Cross layer hooks for handling hybrid switching cases
- **Robust delivery**
 - Achieves link efficiency by using UDP protocol
 - Implements a NACK based retransmission scheme
- **Transport optimization increases service consistency, increases download speed and moves users towards wire line like experience**

CMDA Hand-off overview

- Soft hand off minimizes traffic disruption
- MS maintains pilot sets
 - Neighbor Set, Candidate set, Active set
- Configurable thresholds for smoother HO
 - TADD, TDROP, Active Set ADD and Drop threshold
- MS monitors BSs even during sleep mode
 - To minimize interference to neighbors when exiting into traffic mode
 - Monitoring must satisfy sleep mode objective : saving battery
- Buffering techniques are used to at the BS to gracefully switch packet stream during HO
- Inter-Frequency HO procedures
 - Minimize disruption while monitoring across frequency channels
- Hybrid HO specification
 - HDR -> 1XRTT transition
 - 1xRTT->HDR transition (only through dormant state)



Hybrid HO Transition

- Dormant cross-system HO incurs minimum disruption to the end user traffic stream
- Active cross-system HO
 - EVDO->1XRTT
 - Down transition; Supported by most MS
 - Potential impact on application stream
 - Delayed arrival
 - Loss of packets
 - 1xRTT->EVDO
 - Up transition only through dormant state
 - Potential for longer disruption
 - MS may delay transition to interim dormancy
 - Based upon transmit buffer queues
 - Transition depends on application flows
- Cross layer optimization can be applied to minimize HO impacts to application throughput

Benchmarking in the field

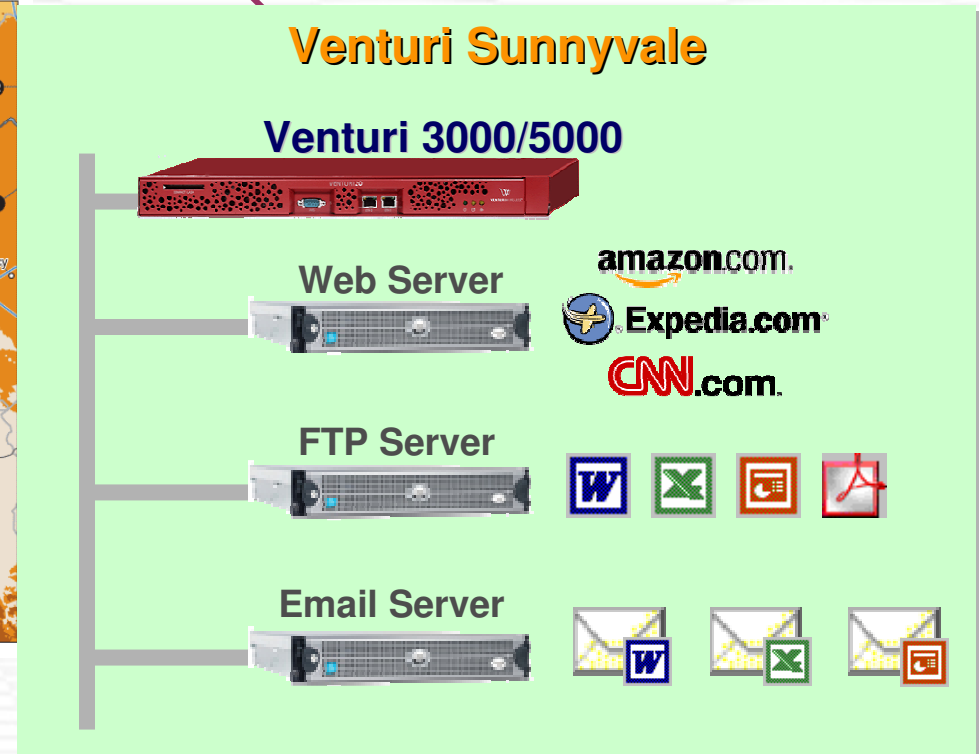
Test Scenarios



- BroadbandAccess and V CAST Rate and Coverage Area
- Future BroadbandAccess and V CAST Rate and Coverage Area
- NationalAccess Rate and Coverage Area
- NationalAccess Service Not Available

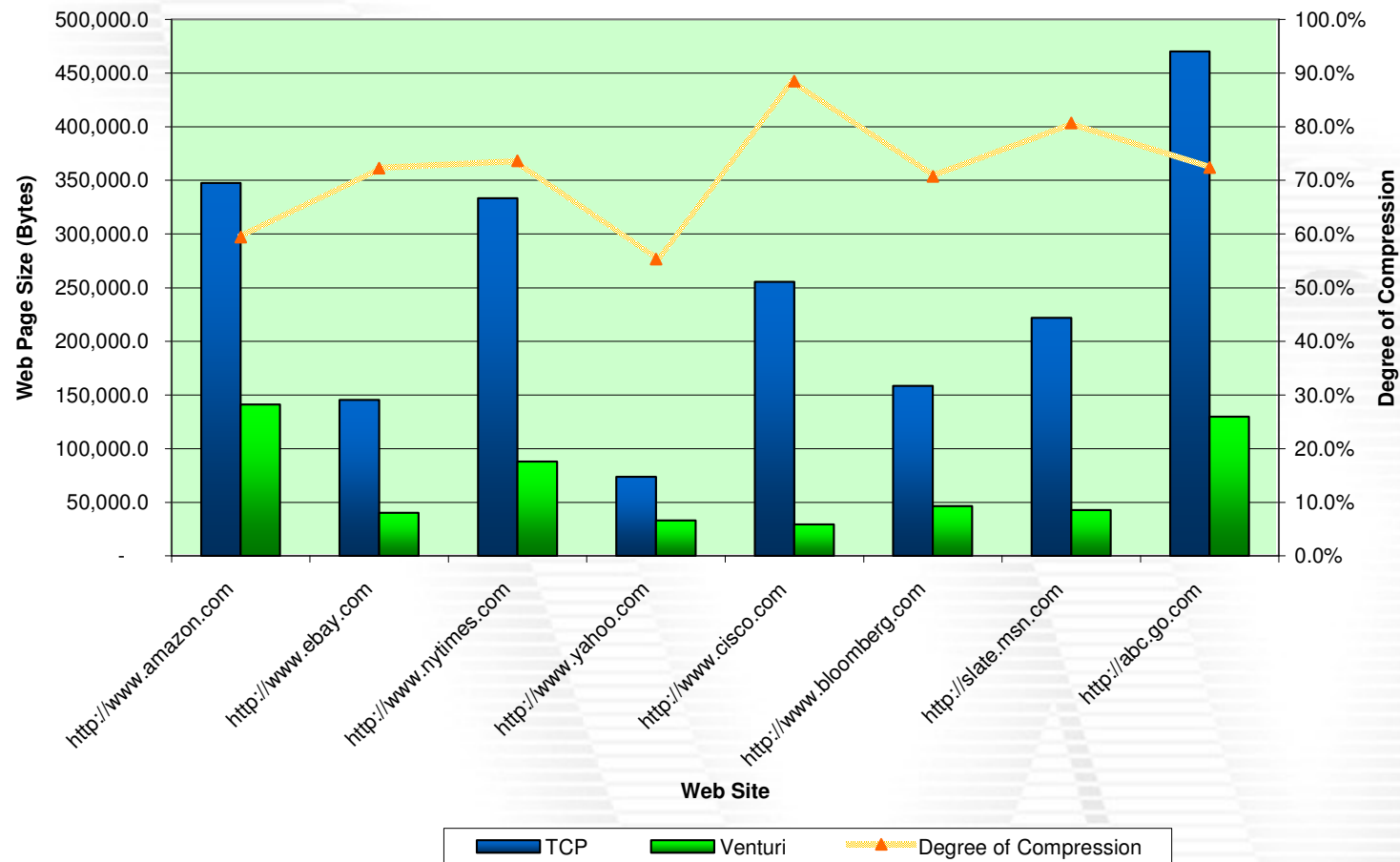


- IBM ThinkPad
- Windows XP Professional SP-2
- Automatic Scripts
- 100 iterations per test



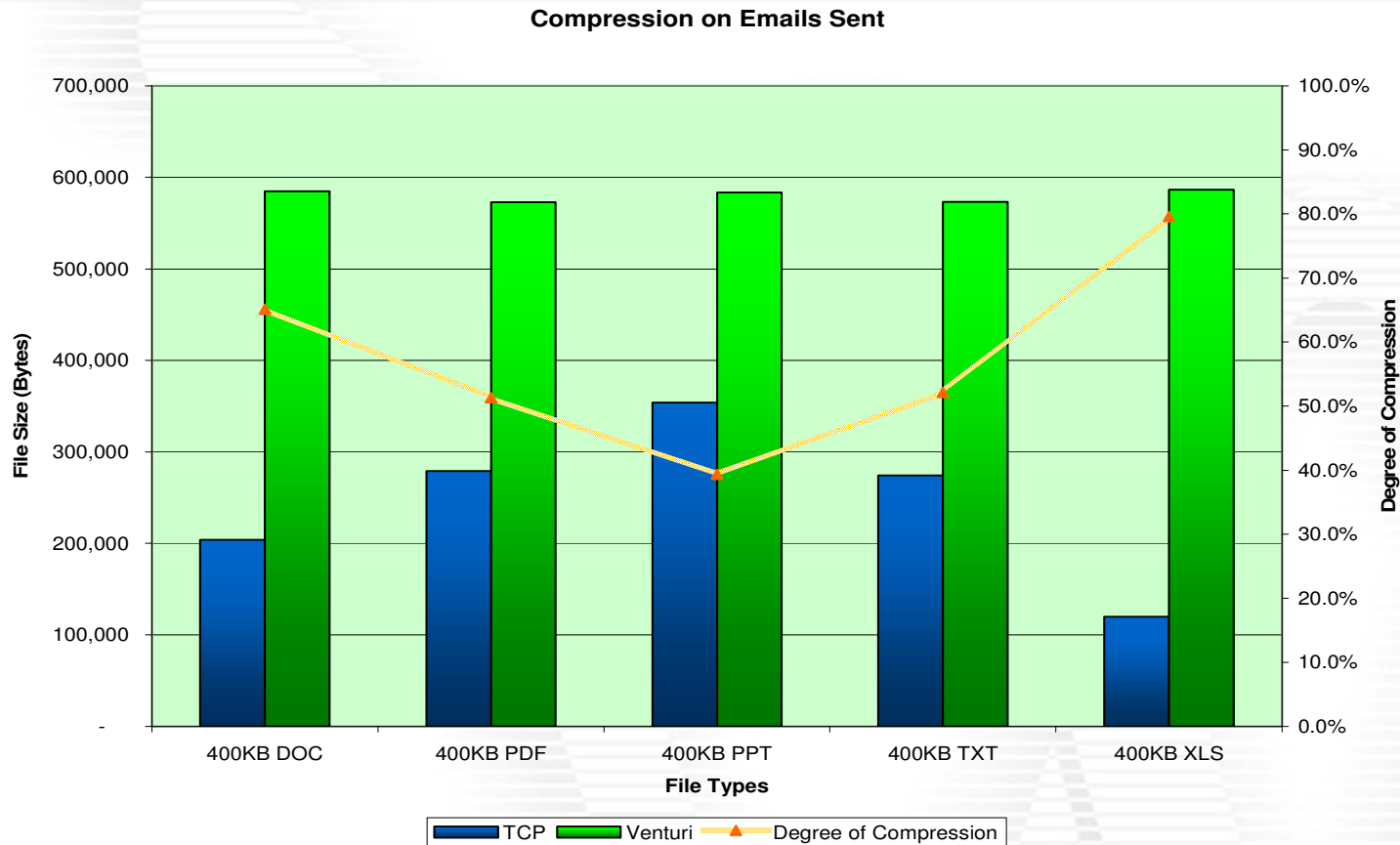
Compression benefits (web pages)

Degree of Compression



- Web style and content dictate the level of compression benefit
- Compression benefits from image objects (lossy) and text (lossless) add up

Compression benefits (email)

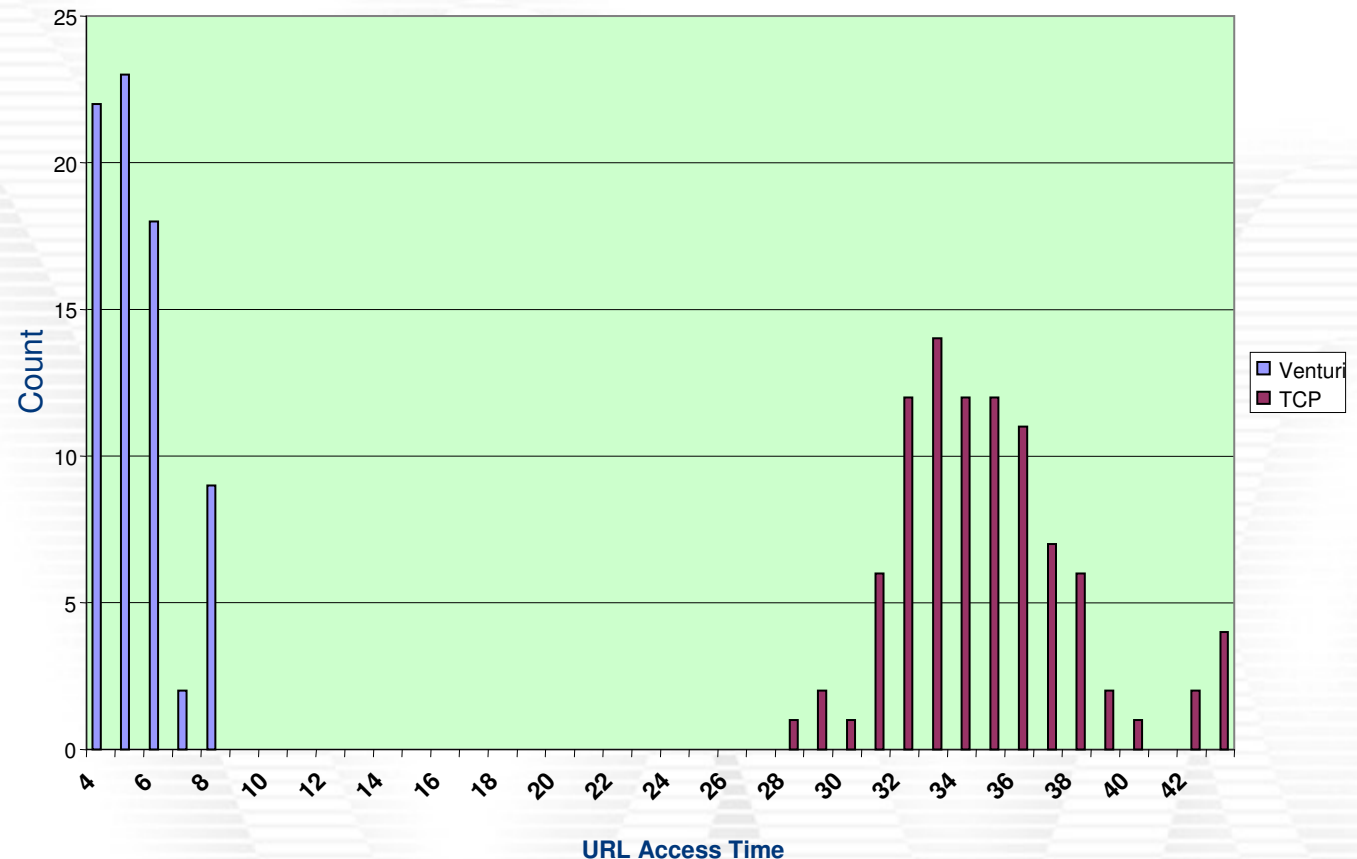


- Different mail attachment invoke different compression engines
- Compression benefits can symmetrical

Extending Reach

Frequency Distribution Chart

- Average response time is better with transport optimization
- Narrower distribution of response times indicates improved consistency
- RSSI : -94 dbm,
- EC/Lo : -9 to -13 EC/Lo

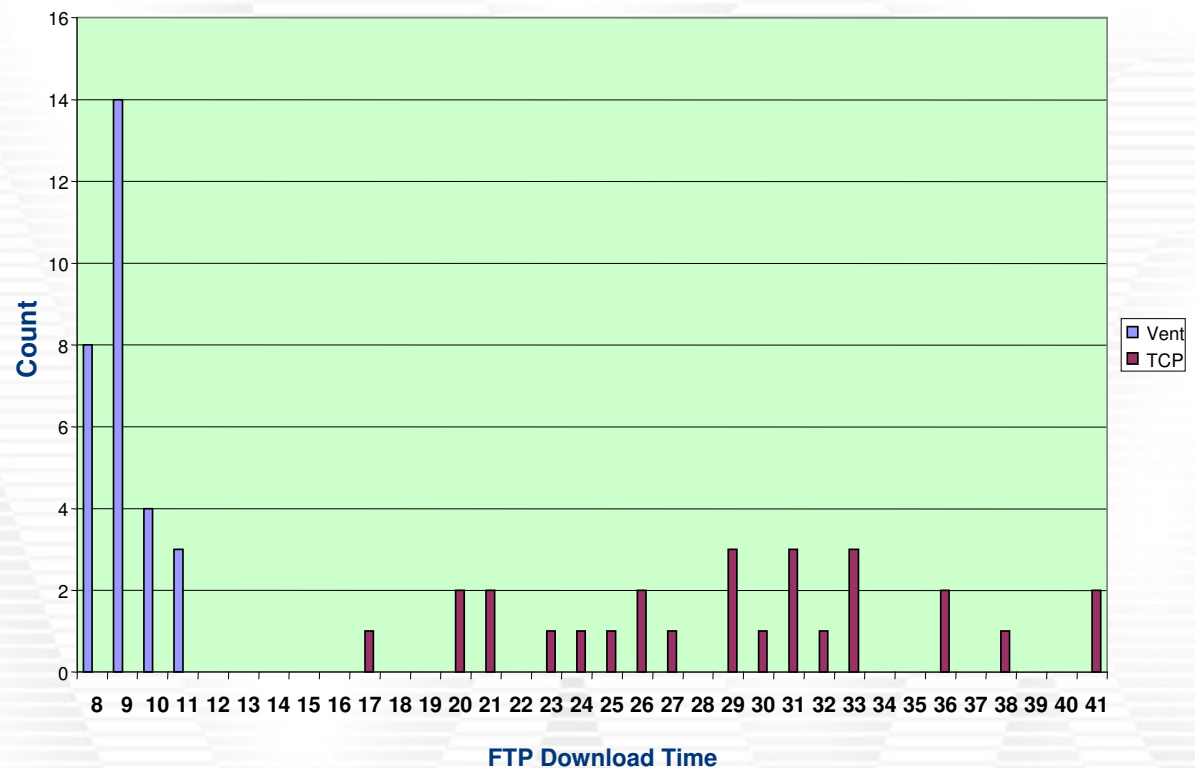


- Transport optimization betters performance under poor coverage

Increasing Robustness

- Rate based transmission improves subscriber experience
- Example measurement for FTP
 - Email applications (POP3, SMTP)
 - Video/Audio download
- Consistency increases also in good signal conditions

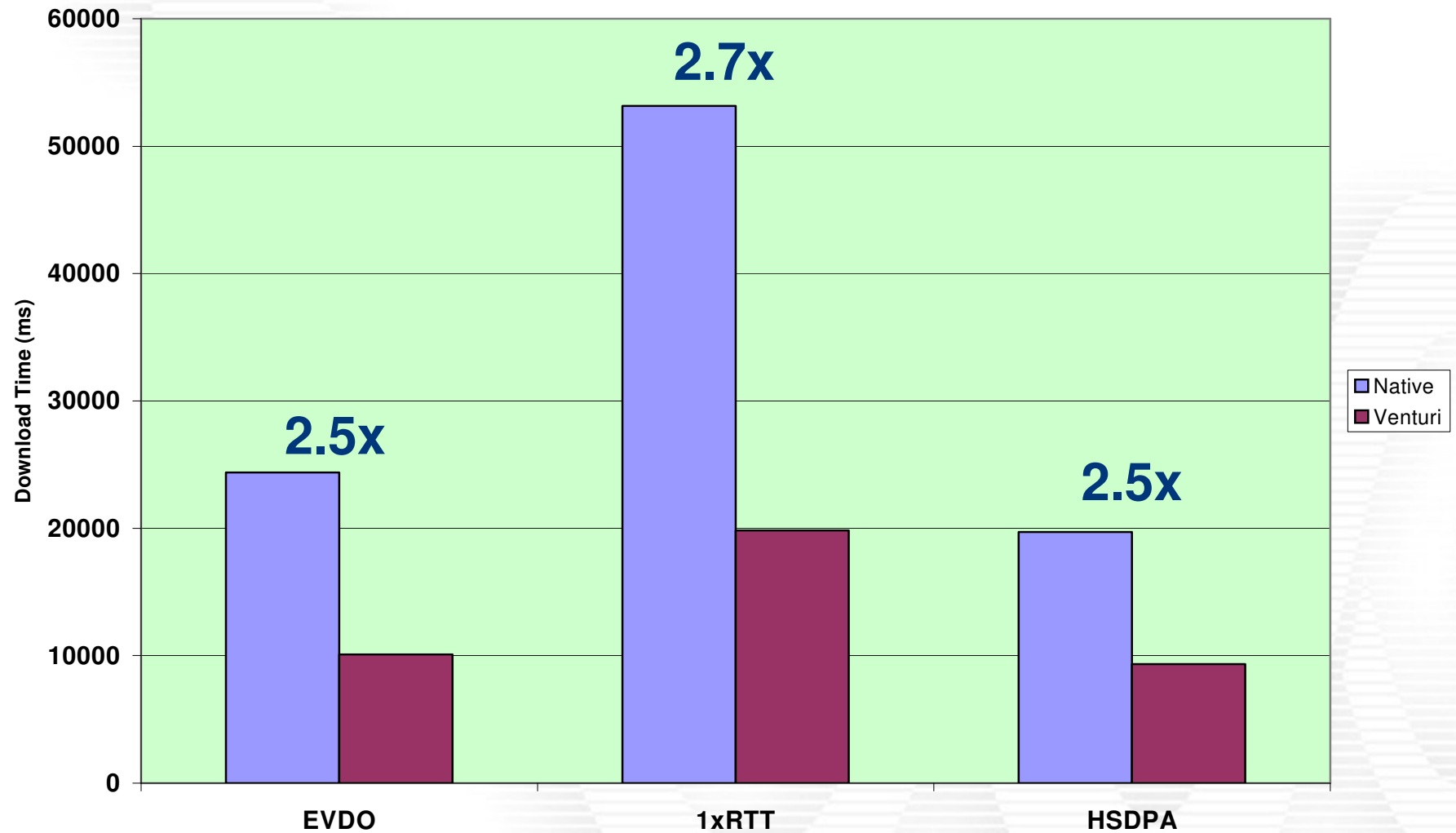
Frequency Distribution Chart



- Transport optimization reduces download time variability

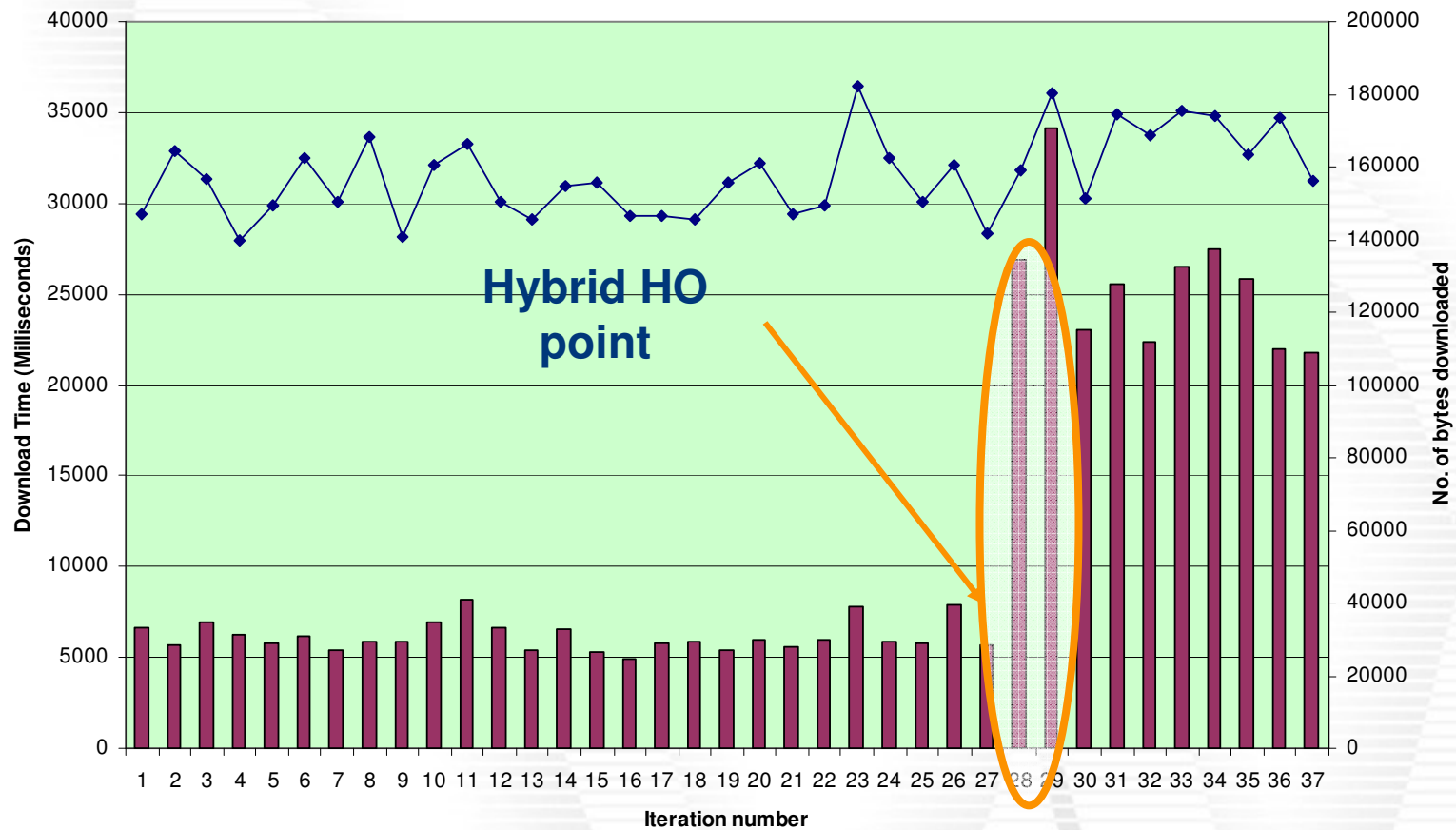
Performance Comparison (HTTP)

Web Performance



Hybrid HO results

Hybrid HO Performance



- MS should see transactions succeed during HO
- Retransmitted byte overhead should be minimal
- Download time around HO should settle close to 1xRTT target

Summary

- Partial migration to EVDO is possible with interoperability between 1xRTT and EVDO
- Data Optimization equipment can improve end user experience in both 1xRTT and EVDO
- Standards have developed different procedures to achieve efficient HOs
- Benchmark tests can be easily extended to measure optimization benefits and variability



Questions?