How can we enable ~~ubiquitous~~ any mobile video services?

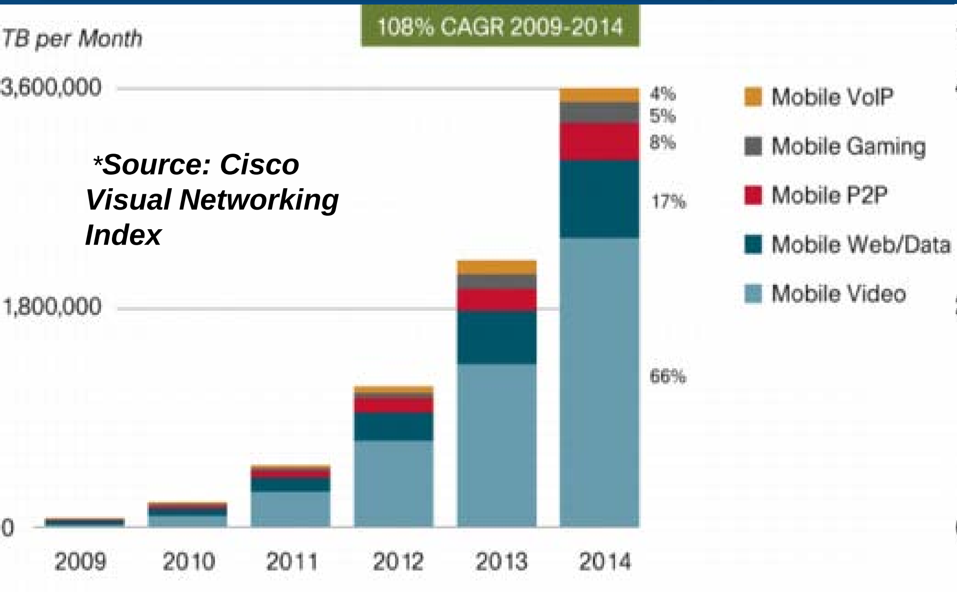
Communication Theory Workshop, May 2010

Jeff Foerster, Intel Labs
Ozgur Oyman, Intel Labs
Srinivasa Somayazulu, Intel Labs

The Trend

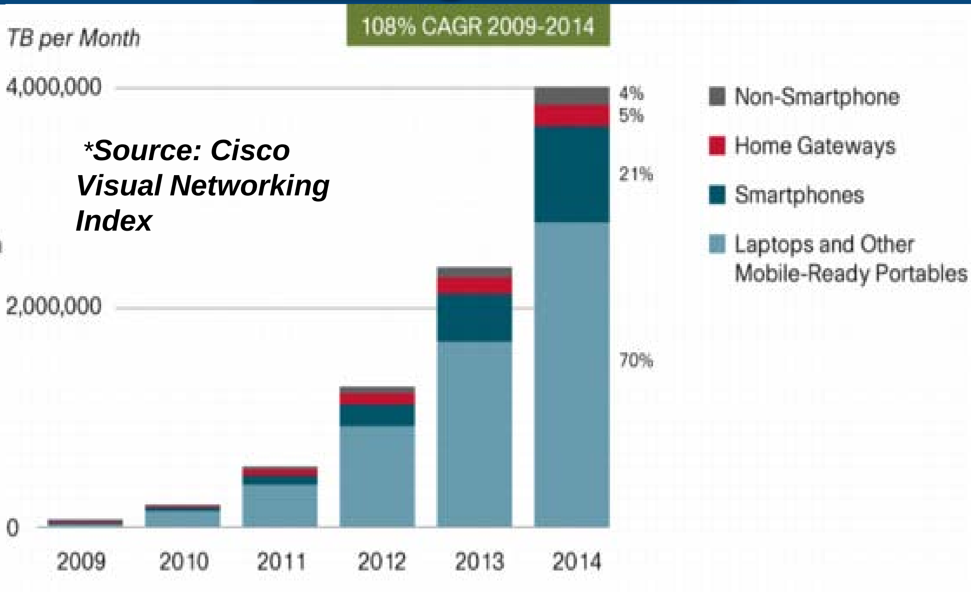
- Mobile traffic is growing, mostly video
- Continuum of screen sizes exist
- Not just linear TV: social, interactive TV
- BUT, Wireless capacity still limited

Video Will be 66% of Global Mobile Data Traffic by 2014



Source: Cisco VNI Mobile, 2010

Laptops and Smartphones Driving Growth



Source: Cisco VNI Mobile, 2010

Multiple Video Content Delivery Methods

Multiple Content Sources	**Home (Slingbox)**	**Internet (Hulu, Joost, Netflix, Blockbuster)**	**Broadcast Networks**	**IPTV, cable, telecom carrier**
Multiple Networks	**Kiosk**	**WiFi Hotspot**	**Broadband wireless (3G, LTE, WiMax)**	**Broadcast (Terrestrial, Sat.)**
Multiple Devices	**Car**			

- Mobile content delivery methods:
  - Streaming: unicast, broadcast
  - Download: kiosk, STB, over-the-air
- New usage models
  - Video conferencing, video share
  - Video twitter, video blogging
  - Live video broadcasting, video upload

Key criteria:
Quality
Latency
Throughput
Capacity
Scalability
Cost

The Challenge

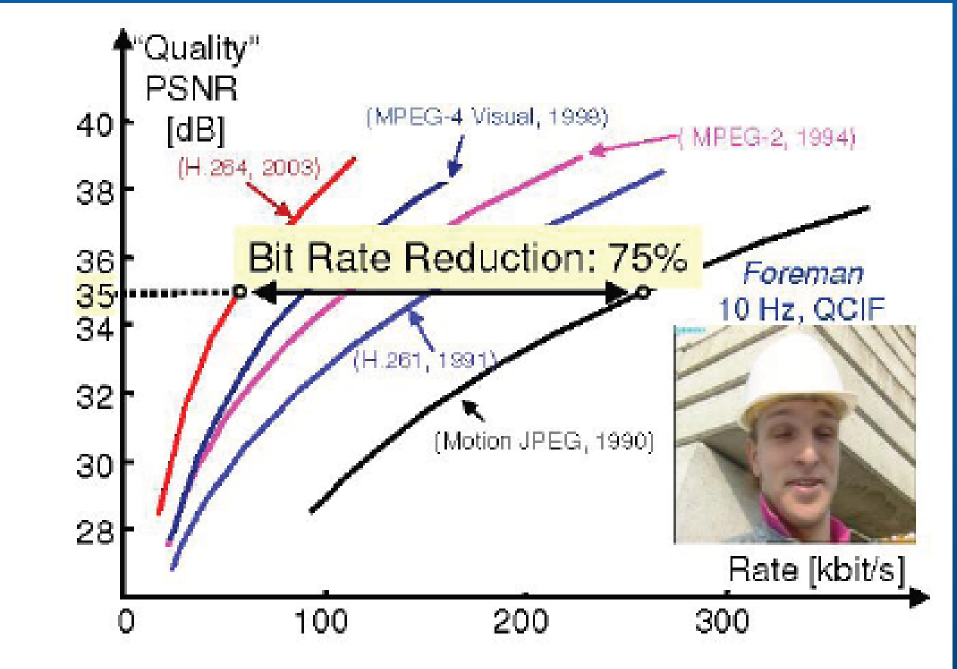
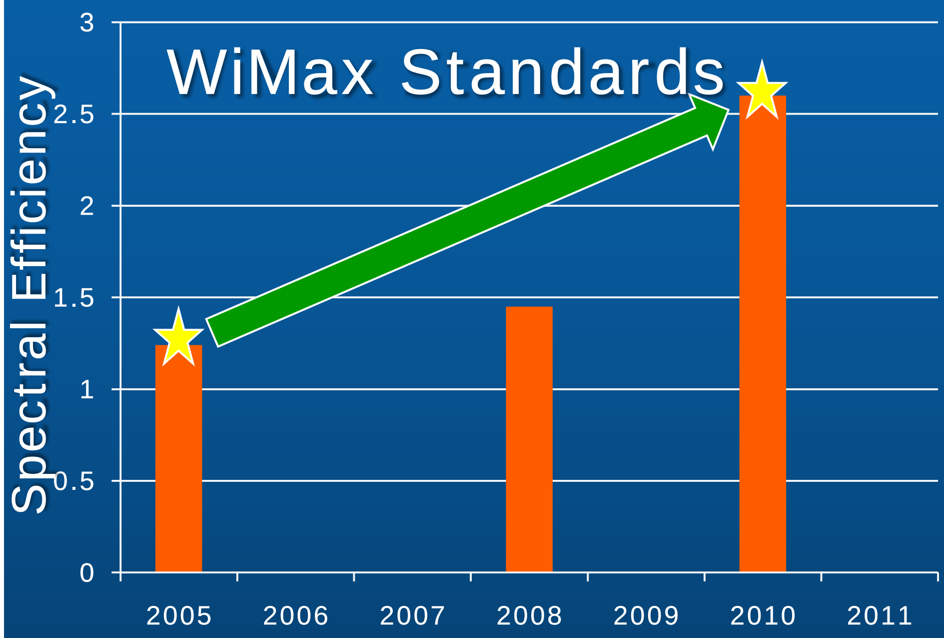


Fig. 2. Progress in video compression efficiency.



* Isnardi, M.A.; Histrorical Overview of Video Compression in Consumer Electronics Devices; ICCE, 2007.

Compression efficiency has improved ~2-3x every 10 years

Spectral Efficiency has improved by ~2x every 5 years

Video characteristics not yet exploited in wireless networks

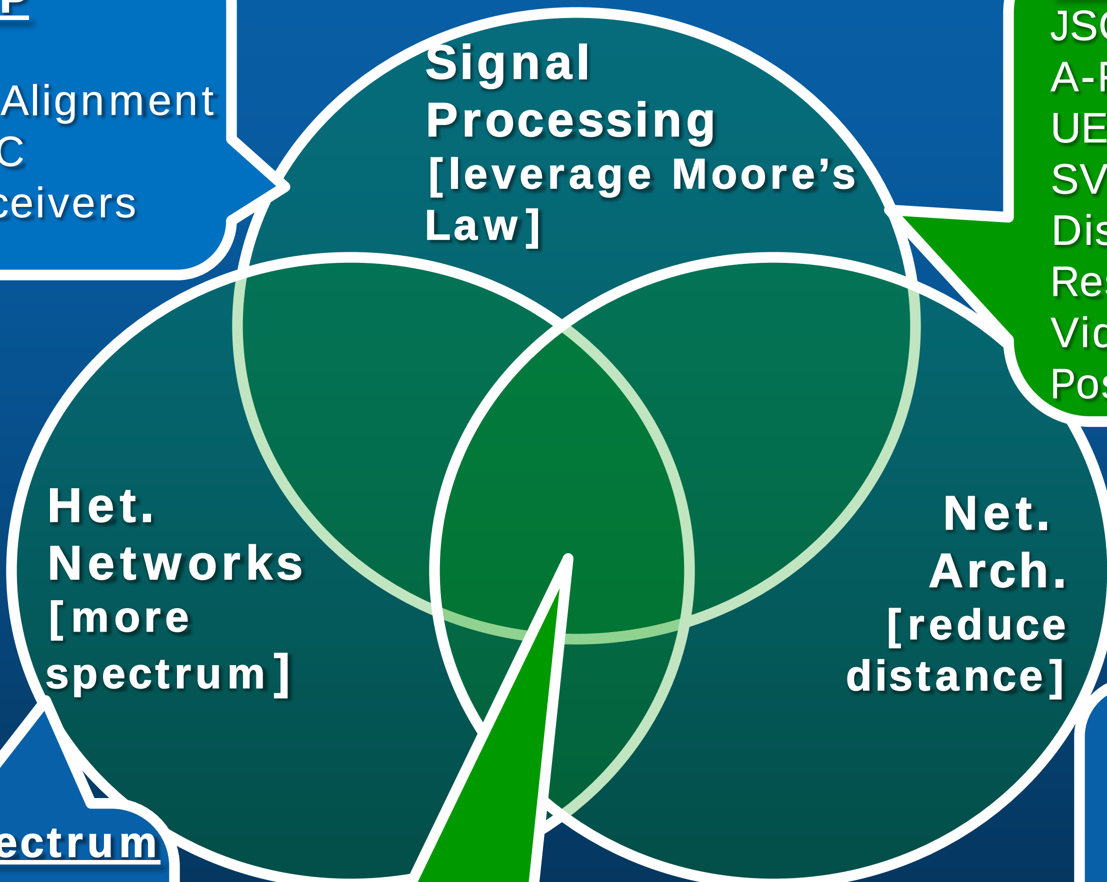
Capacity Analysis

	WiMAX	3GPP LTE
Duplexing mode	TDD, DL:UL=1:1	FDD
OFDMA symbol bandwidths	20 MHz (TDD), 80 MHz (TDD)	2x10 MHz (FDD), 2x40 MHz (FDD)
Subcarrier spacing	10.9375 kHz	15 kHz (unicast) 7.5 kHz (MBSFN)
OFDMA usable data subcarriers per 10 MHz bandwidth	768 (DL/UL 802.16m) 720 (DL 802.16e) 560 (UL 802.16e)	600 (unicast) 1200 (MBSFN)
OFDMA useful symbol duration	91.43 usec	66.7 usec (unicast) 133.3 usec (MBSFN)
Cyclic prefix (CP) length	1/16 of a symbol	4.6 usec (unicast) 33.3 usec (MBSFN)
OFDMA symbol duration w/ CP	97.1 usec	71.6 usec (unicast) 166.7 usec (MBSFN)
Frame duration	5 msec	10 msec (Sub-frame duration is 1 msec.)
Number of OFDMA symbols in frame	51	14 per sub-frame (unicast) 6 per sub-frame (MBSFN)
Number of usable OFDMA symbols in a sub-frame for data	50 (if DL:UL=1:1, 25 DL, 25 UL symbols)	12 (unicast) 6 (MBSFN)
MBS/MBMS control overhead	10%	10%
DL unicast control overhead	11.2% (802.16m) 24.1% (802.16e)	17%
UL unicast control overhead	9.23% (802.16m) 16.7% (802.16e)	9%

The Limits - Unicast

Technology	Unicast Video Users/Sector for R = 384 kbps	Unicast Video Users/Sector for R = 768 kbps	Unicast Video Users/Sector for R=1.536 Mbps
3GPP Rel. 10 (LTE Adv.) 4x2 MU-MIMO 2x10 MHz FDD	10	6	3
WiMAX Rel. 2.0 (802.16m) 4x2 MU-MIMO 20 MHz TDD 1:1	11	6	3
3GPP Rel. 10 (LTE Adv.) 4x2 MU-MIMO 2x40 MHz FDD	42	21	10
WiMAX Rel. 2.0 (802.16m) 4x2 MU-MIMO 80 MHz TDD 1:1	44	22	11

Potential research vectors



PHY / MAC SP
MU-MIMO
Interference Alignment
Advanced FEC
Advanced receivers

Video Aware SP
JSCC
A-FEC
UEP
SVC
Distortion Aware Resource Allocation
Video pre- and Post- processing

Existing Spectrum
Broadcast
Cellular
WiFi & WPAN
New Spectrum
TVWS
Cog. Radios

System Opt.
Network coding
Coop. error recovery
Peer-to-peer
Distortion aware routing

Macro
Micro
Femto
Cooperative
Multi-hop
Mesh

Wireless Network Components

Content Cloud

Hulu
Netflix
SlingMedia
CBS
CNN
ESPN

- Compress
- ‘Snack-size’
- Side-info.

Portal, Proxy Server

Move Networks
Ortiva Wireless

- Transcoding
- Adaptive streaming
- Opt. transport
- Ad insertion
- Fast channel switch

Routers, Network servers

Cisco (Medianet)

- Prioritized routing
- Admission control
- VQE measure, management

Base-Station, AP

Ericsson, Huawei

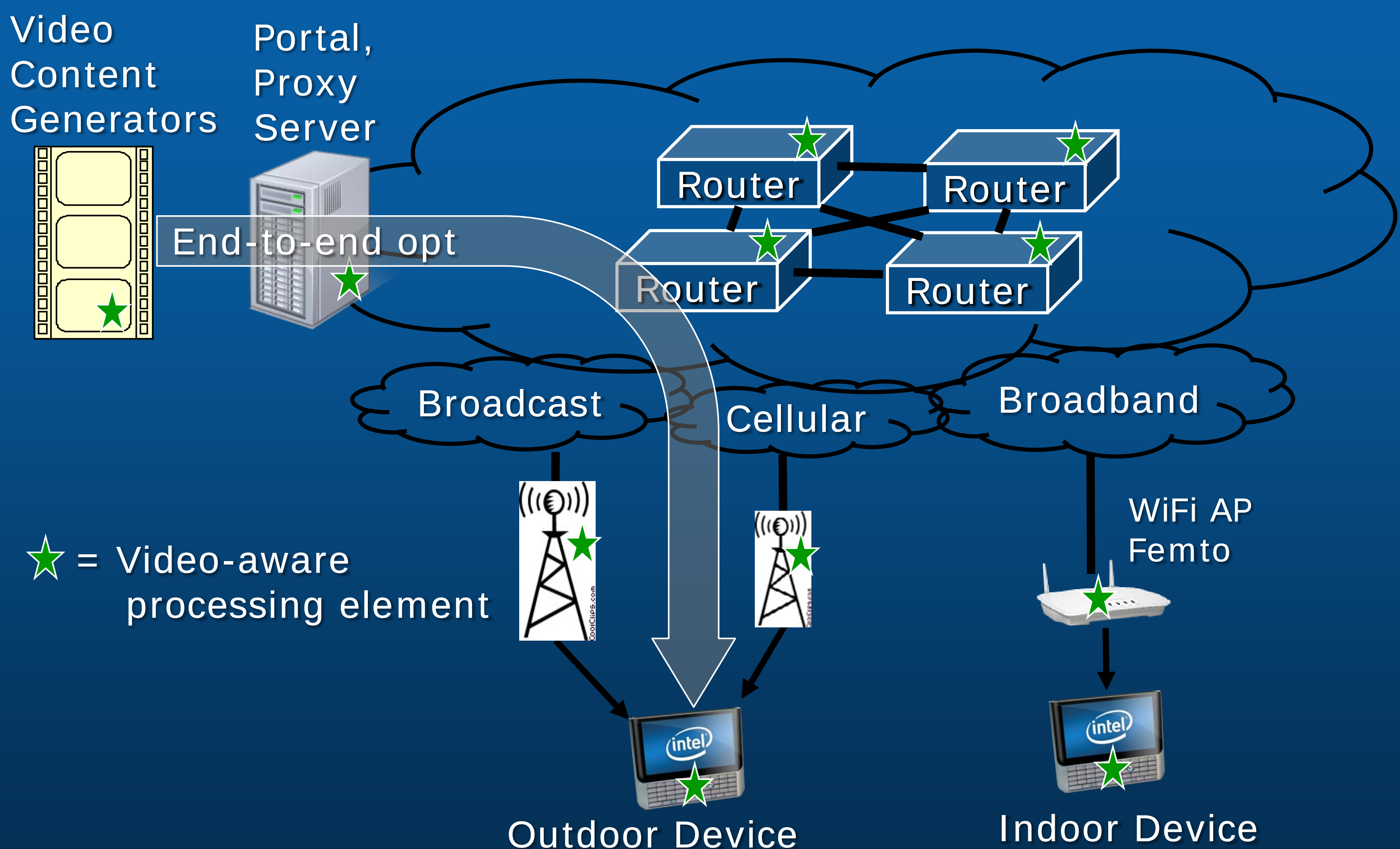
- Enhanced capacity (LTE/WiMax)
- Unicast
- MBS/MBMS
- Ex: LTE+SVC testbed

Client

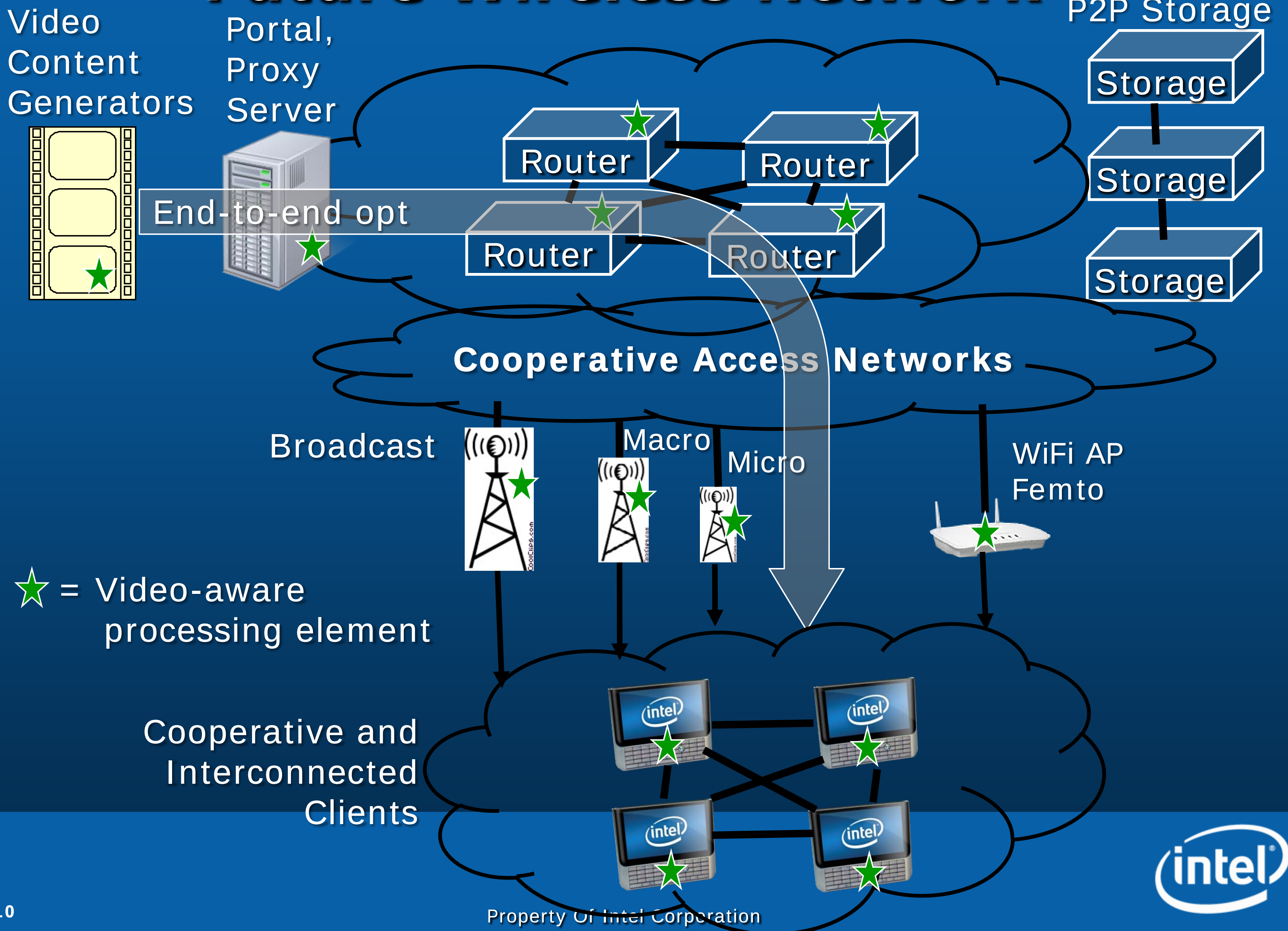
Apple, RIM

- Encode
- Decode
- Broadcast
- HD capable
- HDMI
- SW/Apps

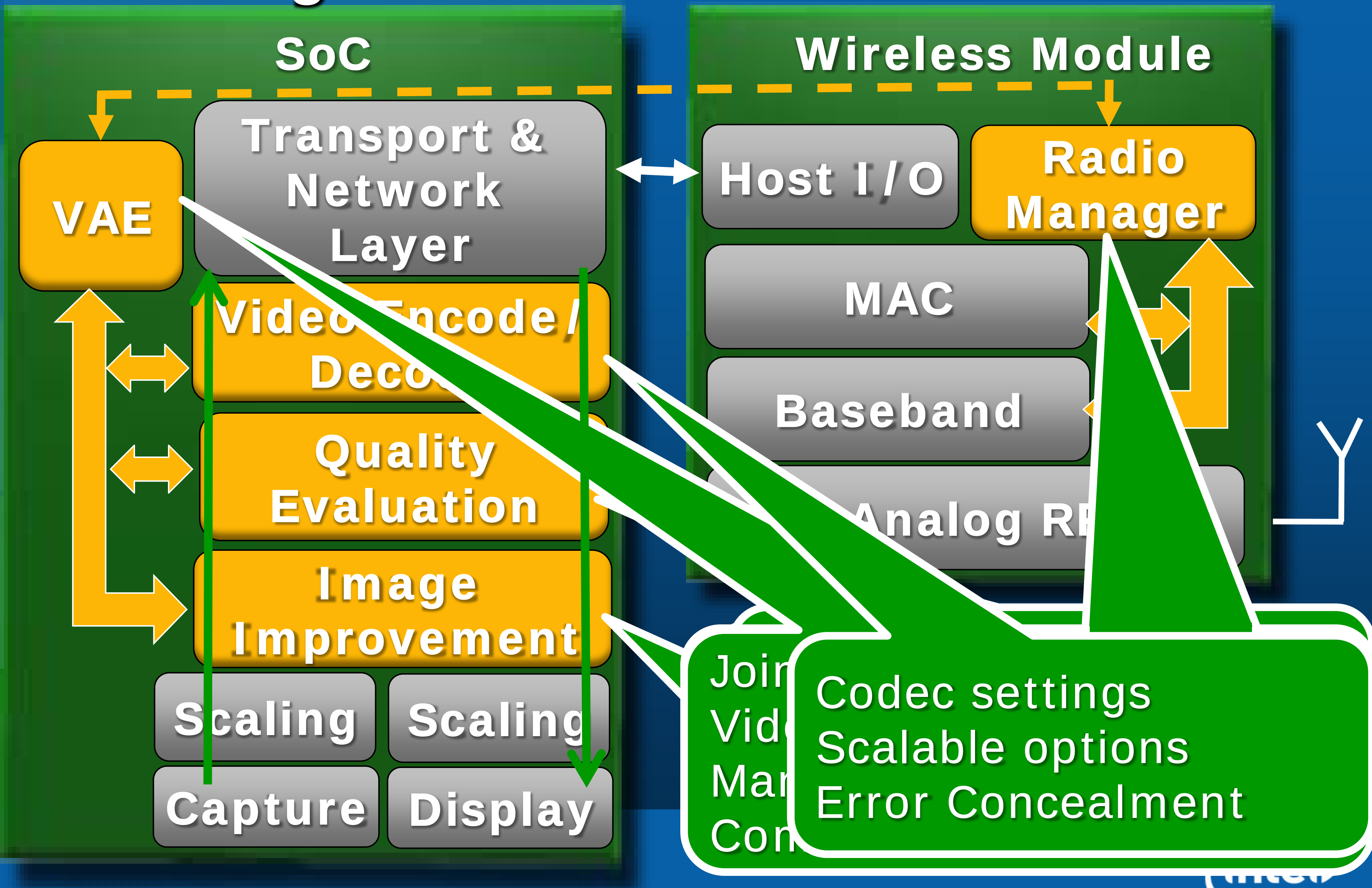
Wireless Network Components



Future Wireless Network

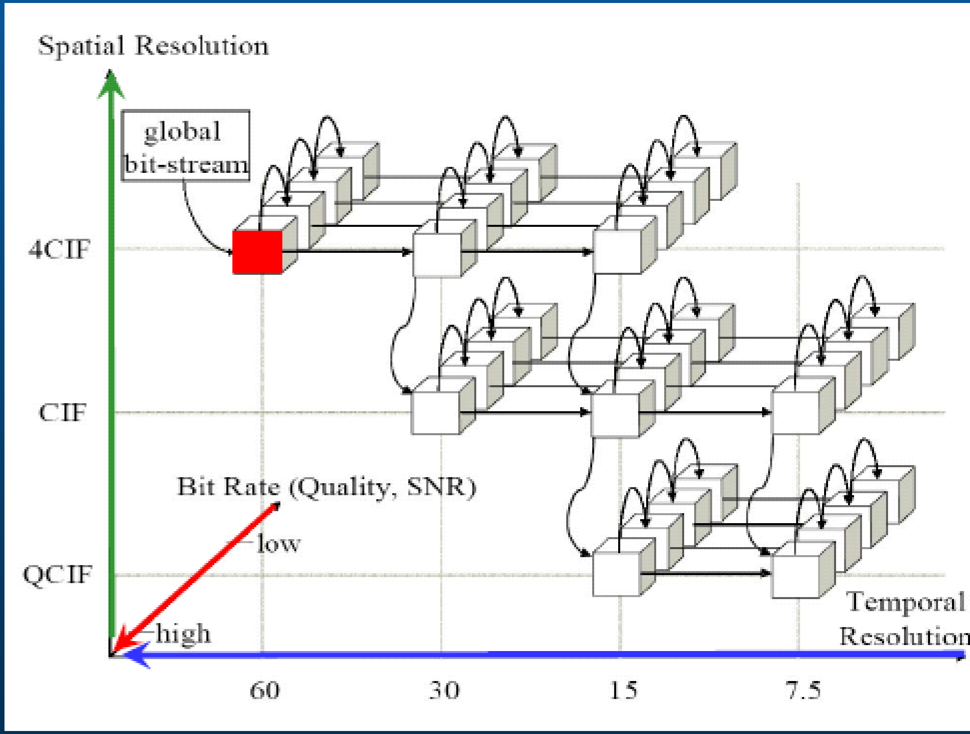


Adding Video Awareness to Clients



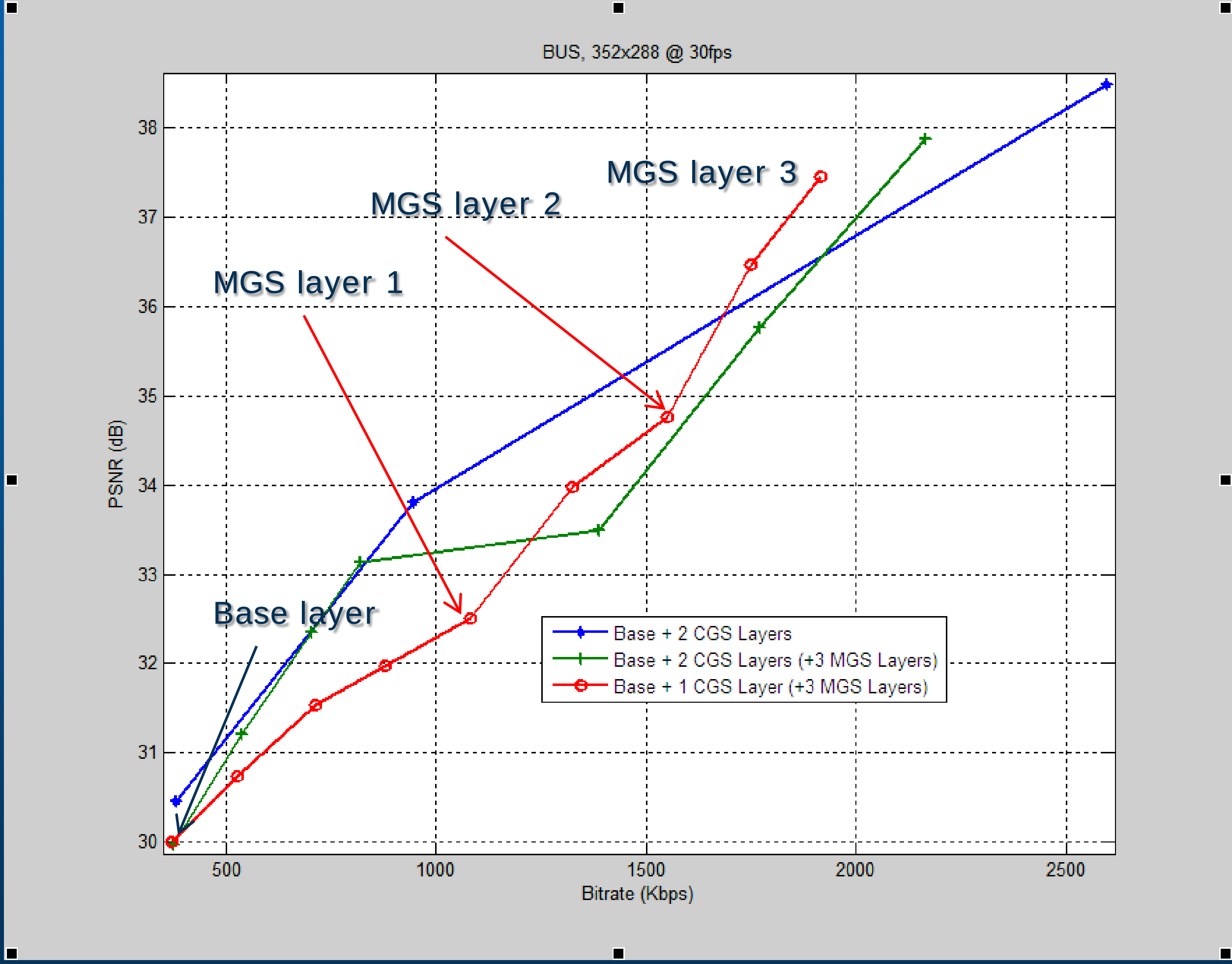
High-level Overview of H.264 SVC

- 3 dimensions of scalability (all or a subset may be present in a bitstream)
- Temporal Scalability
- Spatial Scalability
- Quality Scalability
  - Coarse Grained (CGS)
  - Medium Grained (MGS)

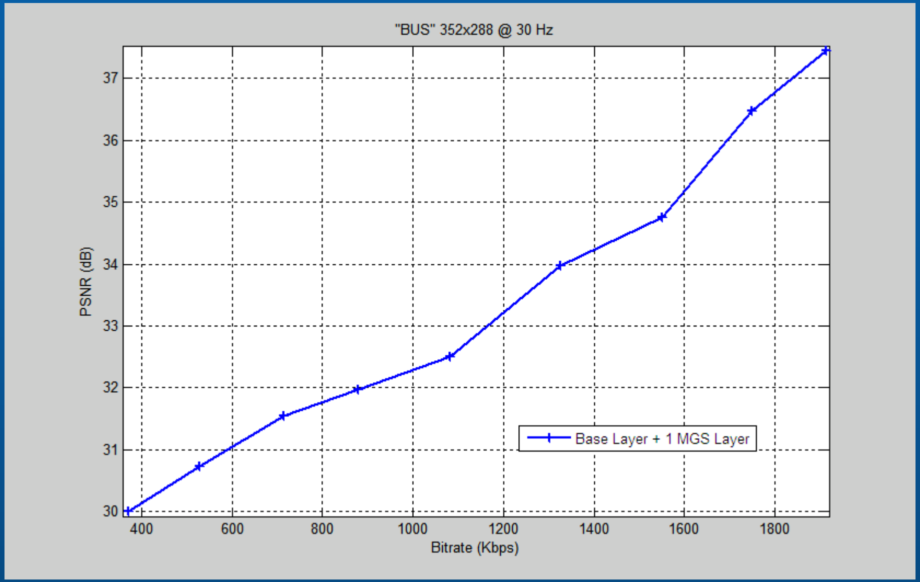


H.264 SVC SNR Scalability Example

- Medium Grain Scalability (MGS) enables extraction of multiple bit rates
- Bitstreams with multiple quality layers enable fast rate adaptation, cross-layer optimization opportunities



Video Aware Engine Example



Example R-D Curve

Given **SNR** and **H** [MIMO Alamouti STC]

$$PER \propto f\left(\frac{SNR}{2}\|H\|_F^2, R\right)$$

$$D\max \propto f\left(D(R), \mathrm{EC}\right)$$

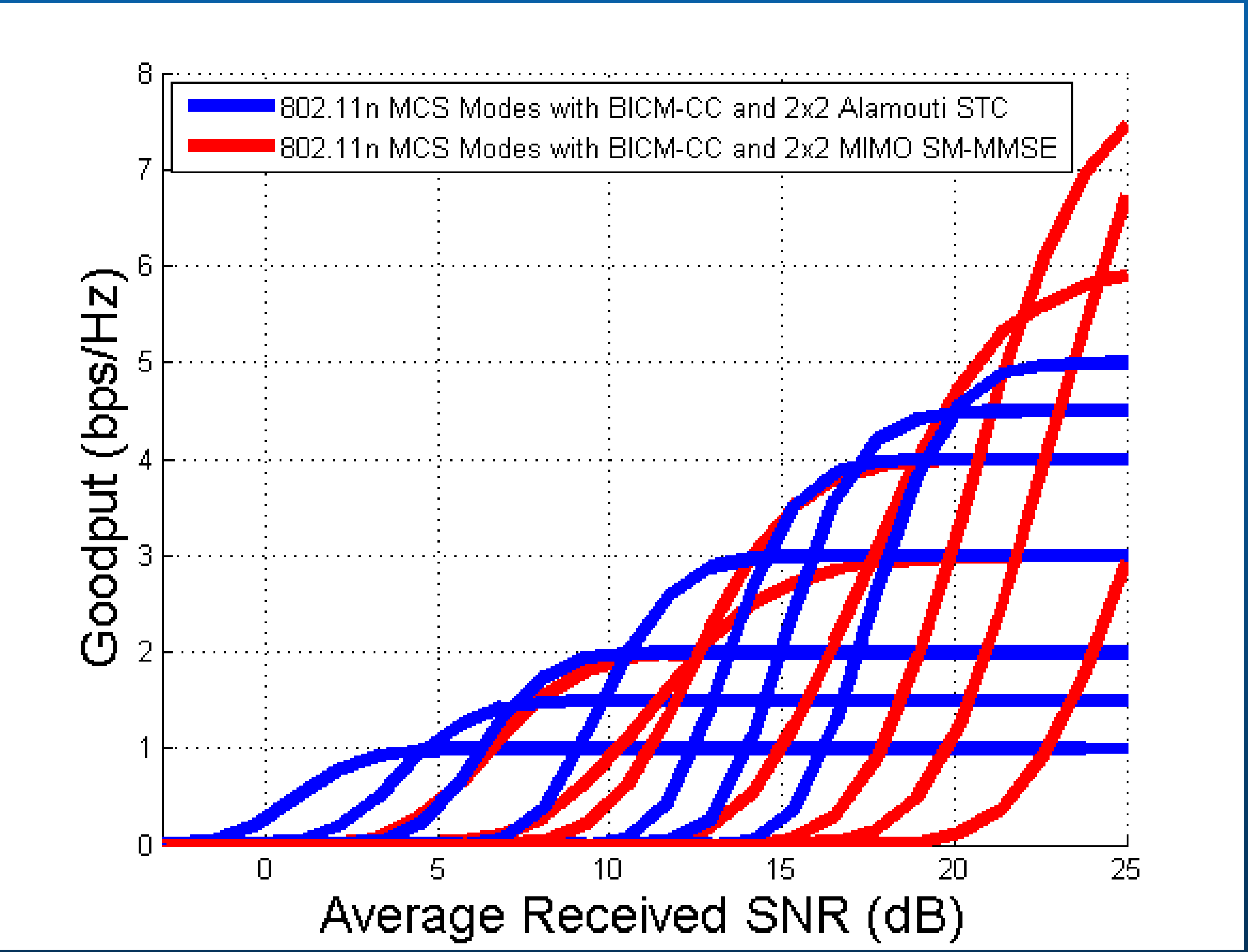
[*measured or tables*]

Client Optimization

$$MCS_{SELECTED} = \arg\min_{MCS} D(R) * \left(1 - PER\right) + D_{\max} * PER$$

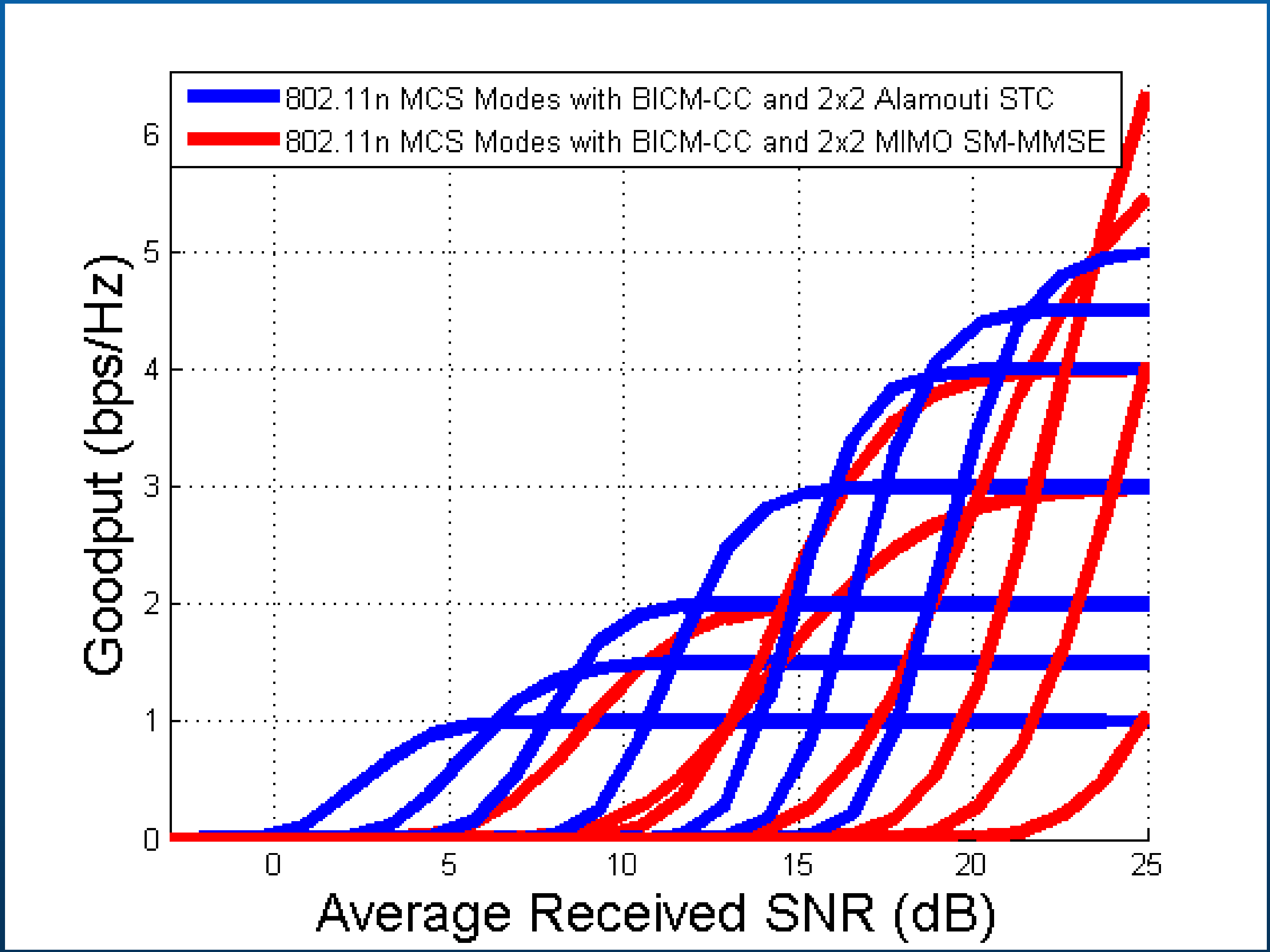
Client Recommended MCS and Codec Rate

WiFi LLS Performance



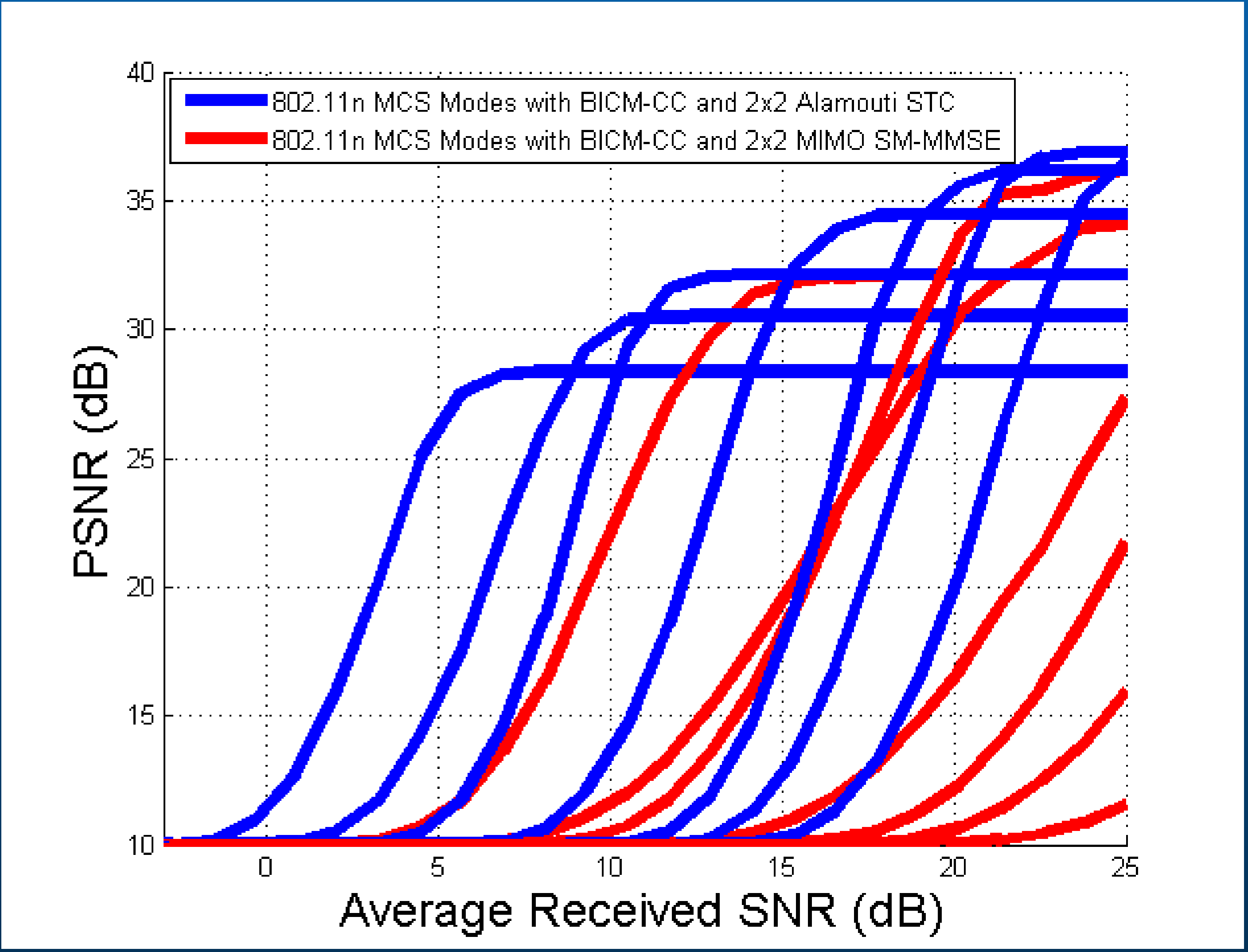
Goodput-maximizing link adaptation (variable PER)

WiFi LLS Performance



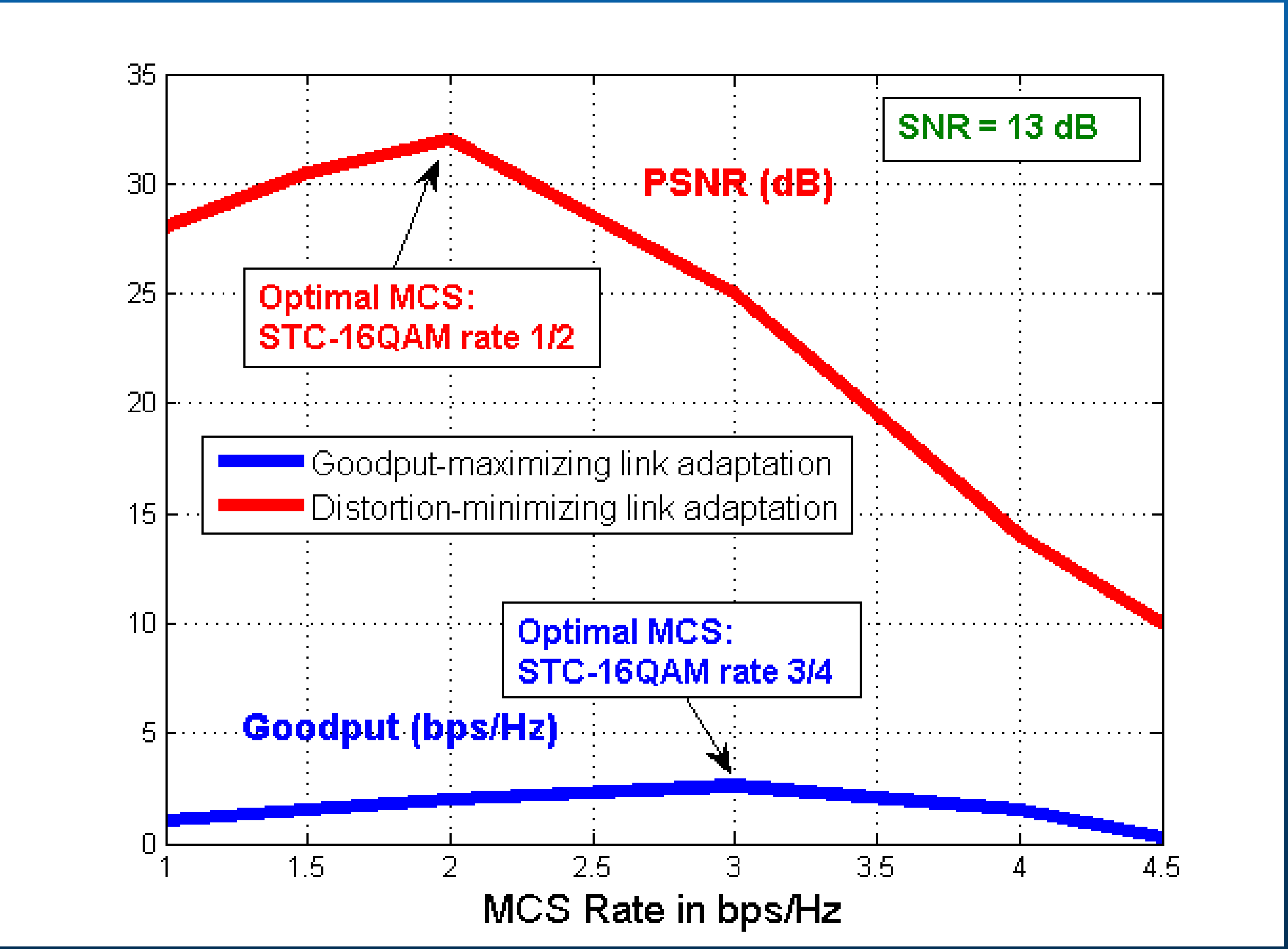
Goodput-maximizing link adaptation (target PER=1%)

WiFi LLS Performance

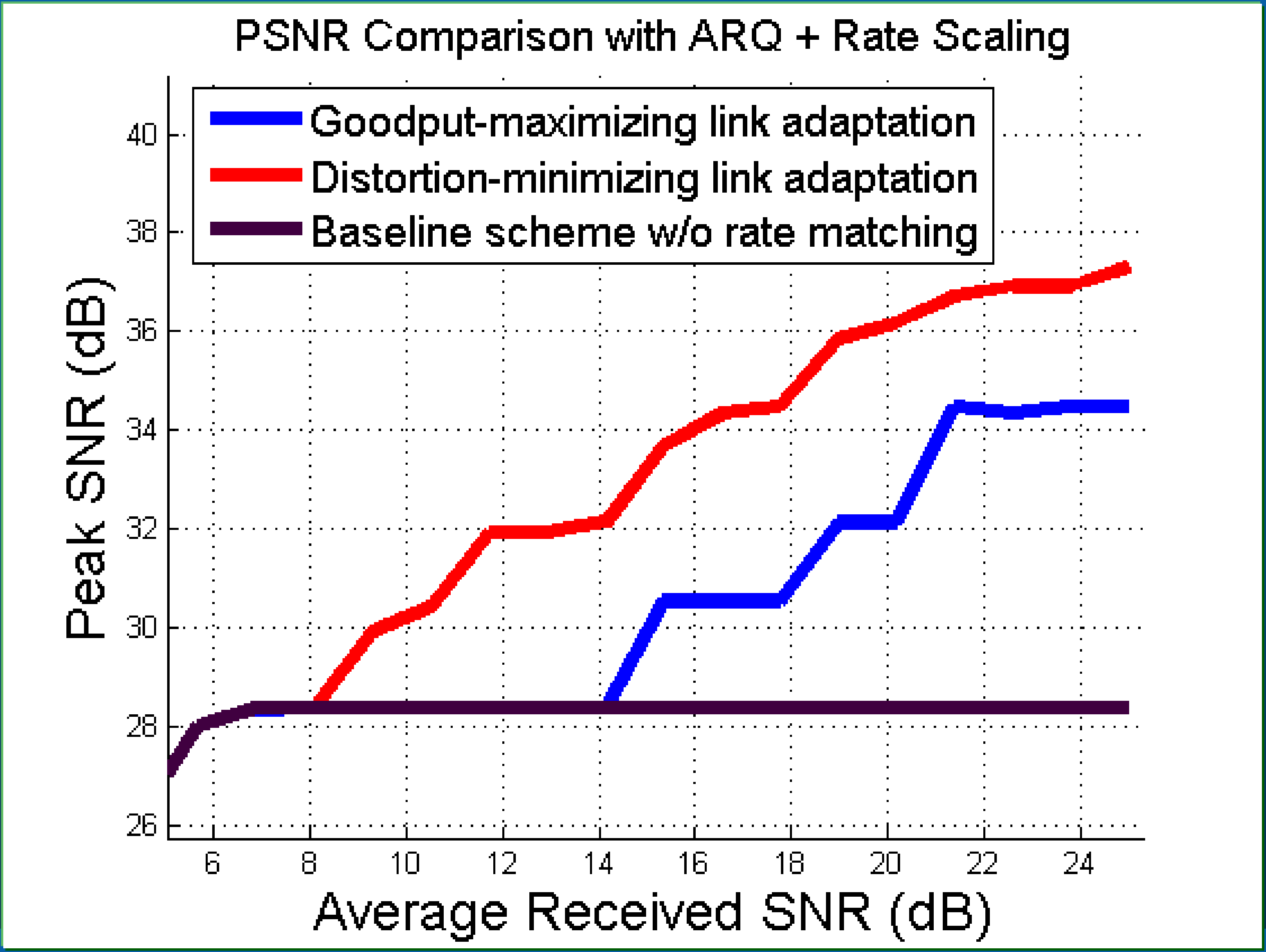


Distortion-minimizing link adaptation

WiFi LLS Performance



WiFi: Impact of ARQ & Rate Scaling



What's New w/ 'JSCC'? Why Now?

Ecosystem ('Perfect storm?')

- Powerful devices, larger screens, good graphics
- Higher capacity wireless networks [good enough]
- IPTV and accepted social video usage models

Technology

- Running into limits in wireless network improvements
- Good scalable video compression (H.264 SVC)
  - Enables distributed management of video transport
- Improved video quality understanding (visual perception quality metrics)
- Greater meta-data creation for video content (linking linear TV w/ internet)...can help improve transport?
- Improved video processing, more memory in mobile devices
- 3D, stereoscopic video

Conclusions

- Video content could dominate future traffic
  - Demand could be there if network capacity allows it
- Video characteristics not yet fully exploited
  - What information is useful / needed?
  - How to make information broadly accessible (in real-time)?
  - How to best use this information in a wireless network?
  - What is the benefit / gain?
- Cooperation at many levels needed
  - Content, transport, access, cellular, broadcast, etc.
- Intel issuing RFP for 'Video Aware Wireless Networks'
  - Device Optimizations for Video Communications
  - End-to-End Video Transmission Optimizations
  - Novel System and Network Architectures for Video Delivery

Thanks!

Questions?

intel®

Leap ahead™