



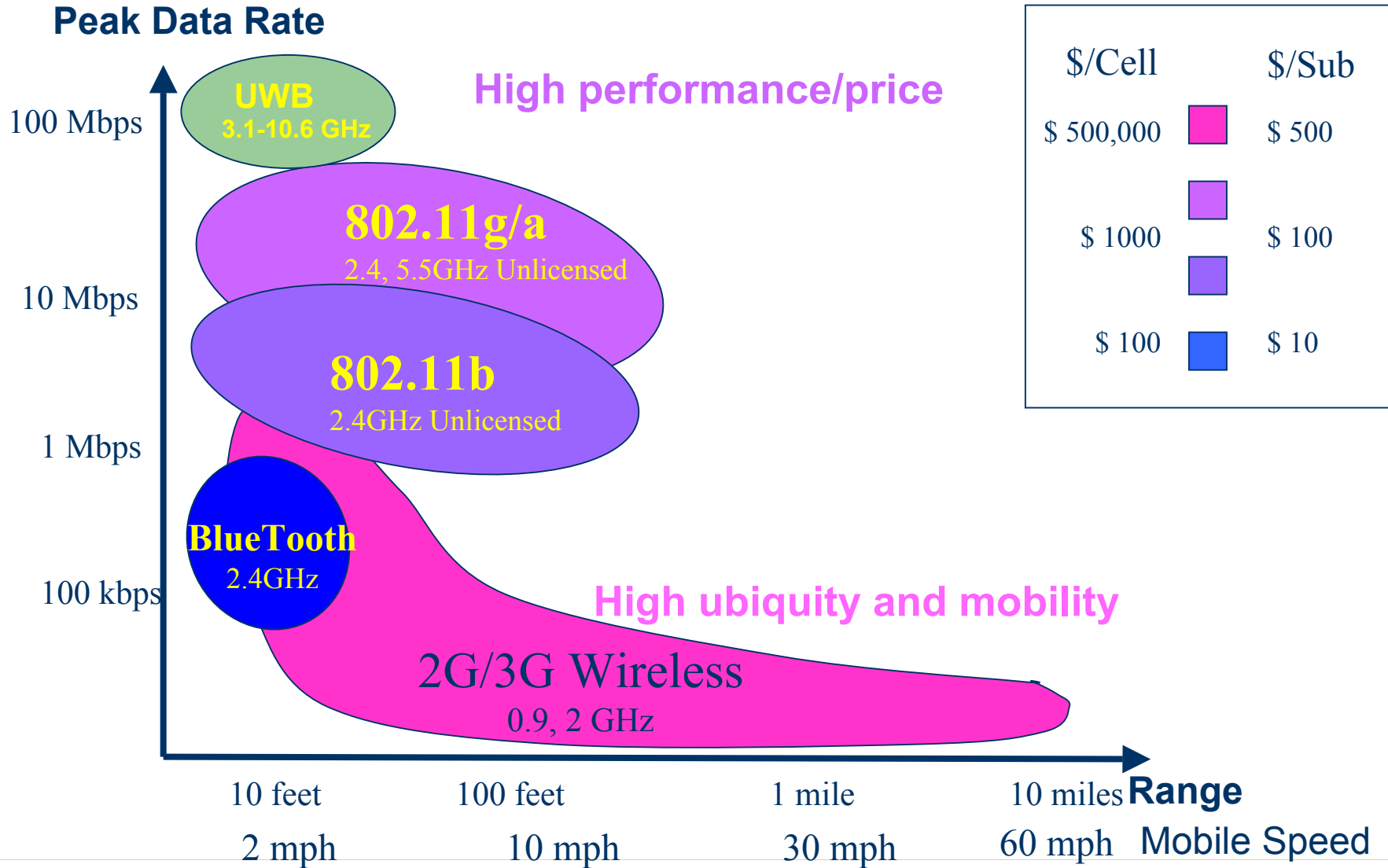
Integration of Cellular Systems with WLAN and Internet

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OUTLINE

- Current Systems
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Current Systems



Current Trends in WLANs

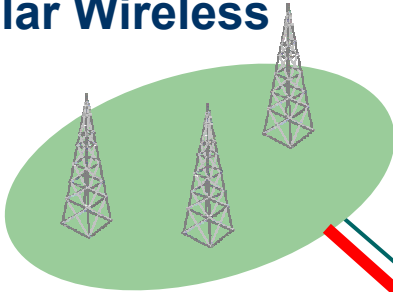


- Business WLANs dominate, but home usage growing faster (14 million WLANs sold last year)
- Spontaneous appearance of neighborhood/residential access sites via consumer broadband wire-line connections
- Public WLAN offerings for enterprise and home users when they are away from the office or home
 - Players:
 - Wayport
 - Cometa (AT&T, Intel, IBM)
 - Aggregators: Boingo Wireless
 - Cellular companies (Verizon, AWS)

Internet Roaming

- Seamless handoffs between WLAN and WAN
 - high-performance when possible
 - ubiquity with reduced throughput
- Management/brokering of consolidated WLAN and WAN access
- Adaptive or performance-aware applications
- Nokia GPRS/802.11b PCMCIA card
- NTT DoCoMo WLAN/WCDMA trial

Cellular Wireless

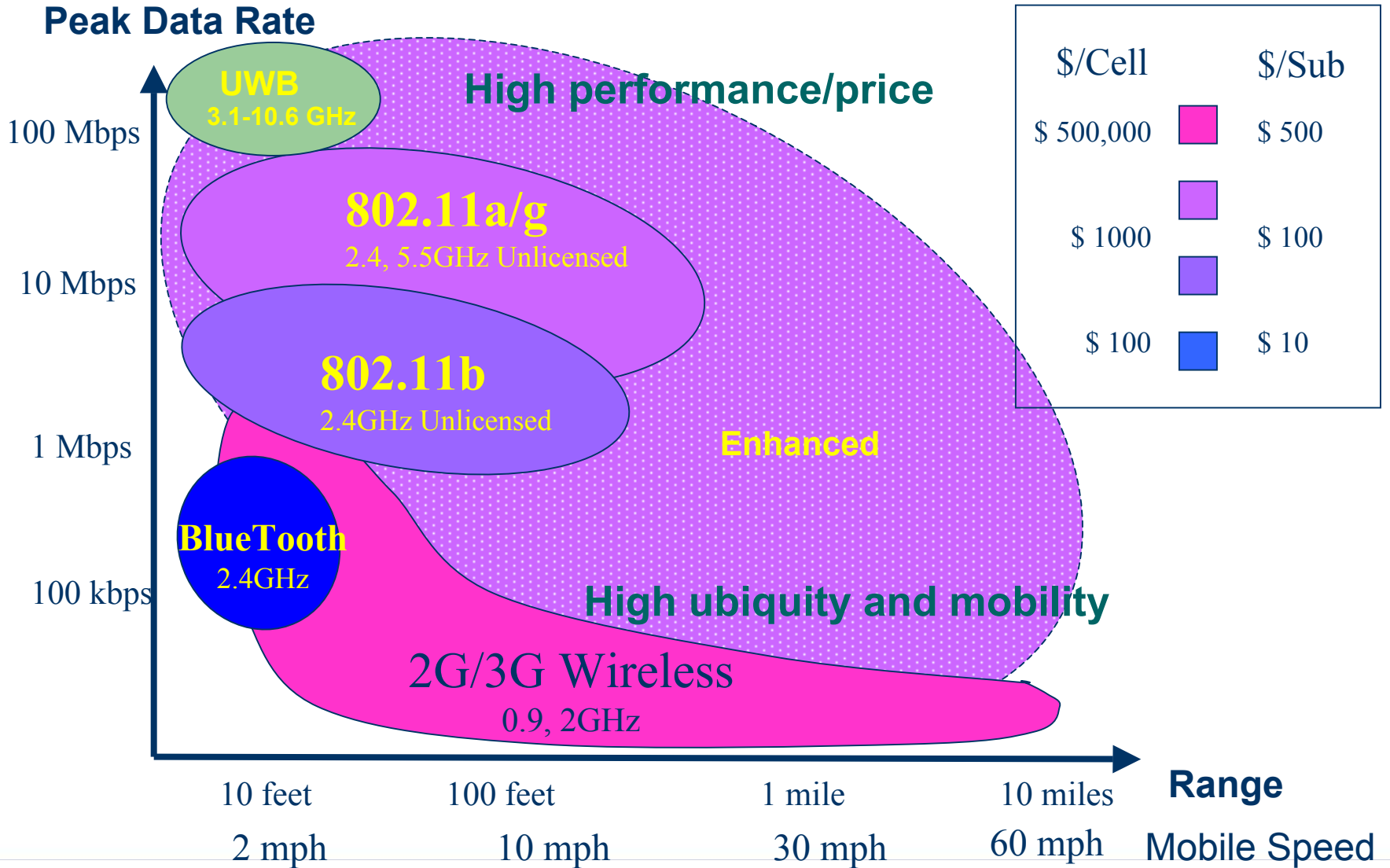


Wireless LAN's

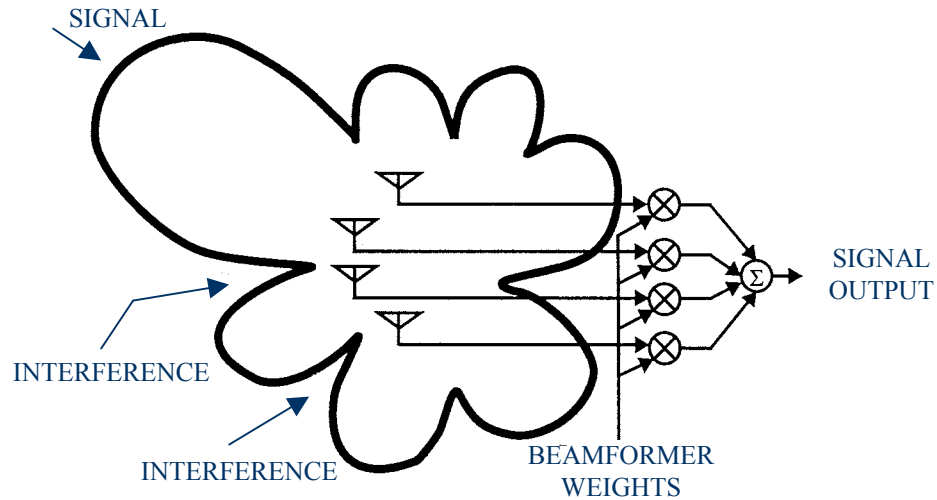


- Handoffs: Many architectures proposed (see, e.g., Session 11C), currently in standards committees
- Voice/Music streaming/Video streaming in WLANs (802.11e) (MERU)
- Range
- Higher data rates in both cellular and WLANs
- Capacity/Interference

- Key constraint: Stay within existing **standards**/standard evolution (enhance performance within **standards** and drive standards evolution)

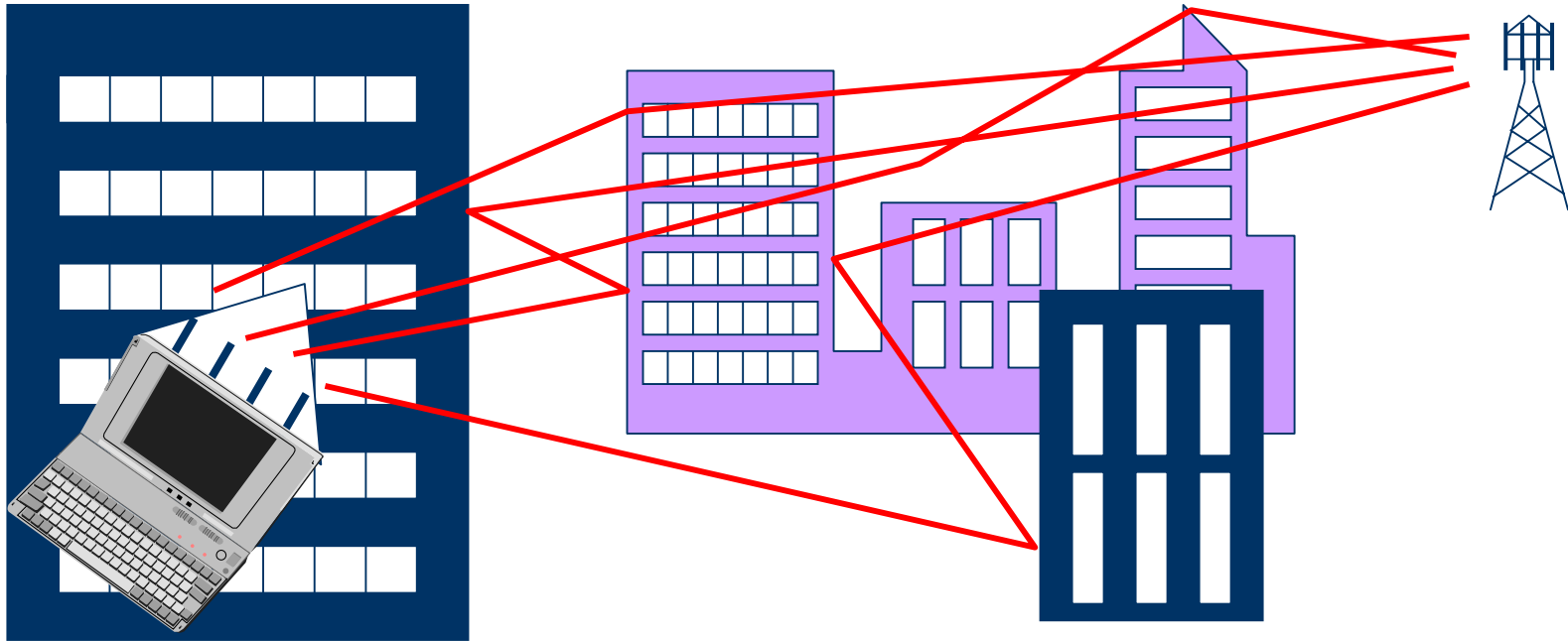


- Smart Antennas (keeping within standards):
 - Range increase
 - Interference suppression
 - Capacity increase
 - Data rate increase using multiple transmit/receive antennas (MIMO)
 - Can be combined with radio resource management techniques for even greater gains



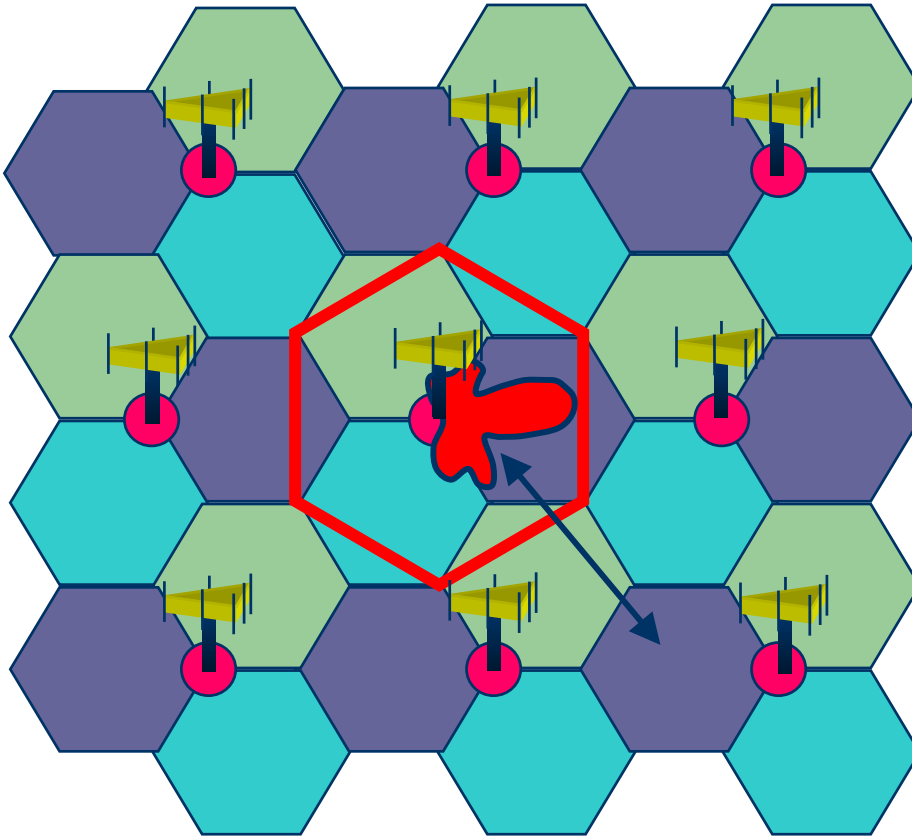
Smart Antennas significantly improve performance:

- Higher antenna gain with multipath mitigation (gain of M with M -fold diversity) \Rightarrow Range extension
- Interference suppression (suppress $M-1$ interferers) \Rightarrow Quality and capacity improvement
- With smart antennas at Tx/Rx \Rightarrow MIMO capacity increase(M -fold)

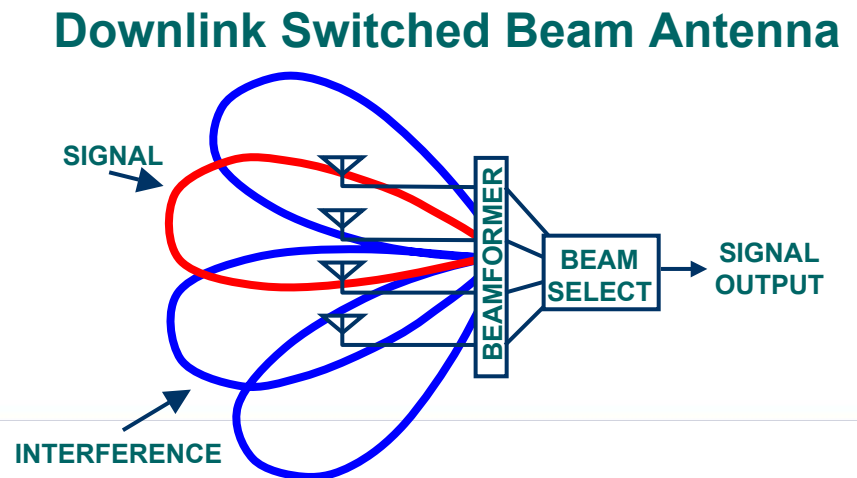
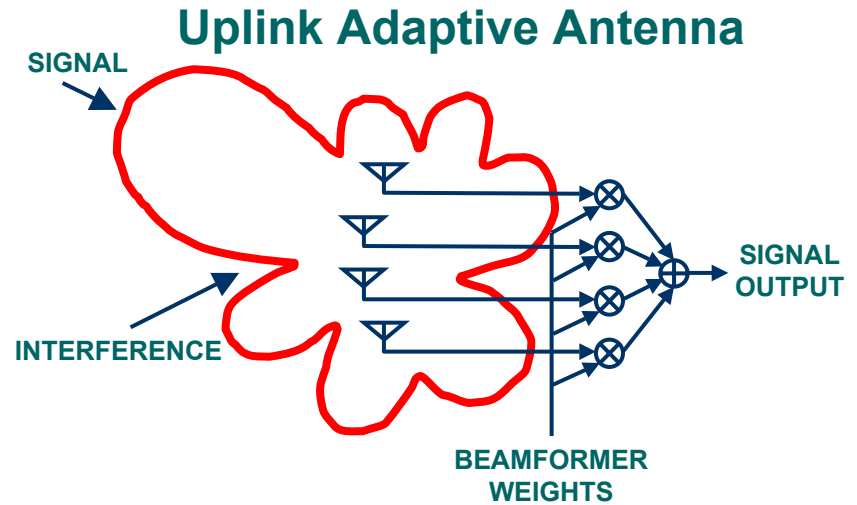


- With M transmit and M receive antennas, can provide M independent channels, to increase data rate M -fold with no increase in total transmit power (with sufficient multipath) – only an increase in DSP
 - Indoors – up to 150-fold increase in theory
 - Outdoors – 8-12-fold increase typical
- Measurements (e.g., AT&T) show 4x data rate & capacity increase in all mobile & indoor/outdoor environments (4 Tx and 4 Rx antennas)
 - 216 Mbps 802.11a (4X 54 Mbps)
 - 1.5 Mbps EDGE
 - 19 Mbps WCDMA

- Key enhancement technique to increase system capacity, extend coverage, and improve user experience in cellular (IS-136)

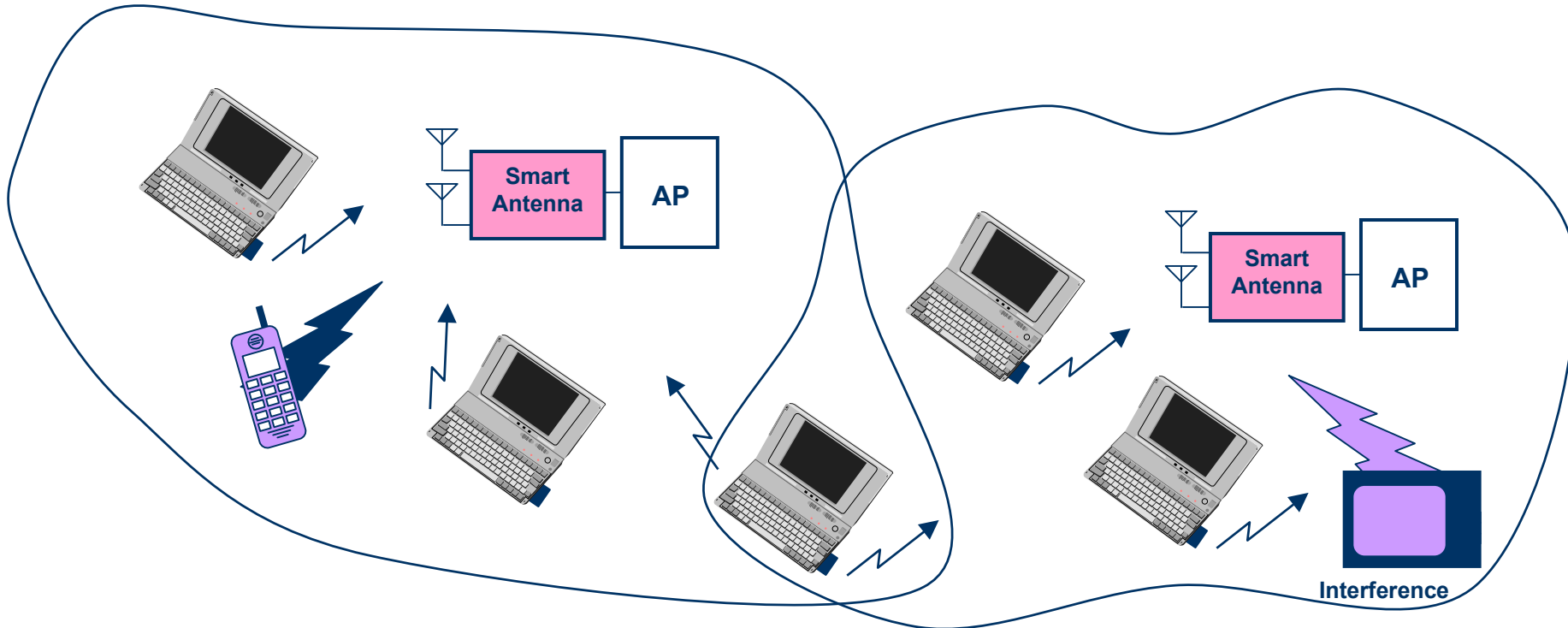


In 1999, combining at TDMA base stations changed from MRC to MMSE for capacity increase



Smart Antennas in Cellular Systems

- Smart antennas for WCDMA can provide significant gains (>7 dB at handset)
 - But not justified today (Innovics, Metawave)
- MIMO for WCDMA may be implemented in 2-5 years



Smart Antennas can significantly improve the performance of WLANs

- TDD operation (only need smart antenna at access point or terminal for performance improvement in both directions)
- Interference suppression \Rightarrow Improve system capacity and throughput
 - Supports aggressive frequency re-use for higher spectrum efficiency, robustness in the ISM band (microwave ovens, outdoor lights)
- Higher antenna gain \Rightarrow Extend range (outdoor coverage)
- Multipath diversity gain \Rightarrow Improve reliability
- MIMO (multiple antennas at AP and laptop) \Rightarrow Increase data rates

“We don’t believe in dumb access points,” says William Rossi, vice president and general manager for Cisco’s wireless business unit. “The access points will eventually become smart antennas.”

Network World 06/02/03

Communications Design Conference:

Craig Barratt (Atheros) - expects the technology (smart antennas) to first appear before the end of next year in silicon for access points supporting multiple antennas linking to single-antenna PC chip sets to provide greater range or capacity - followed by support for multiple antennas on both client and access-point chip sets. (Airgo - MIMO)

Craig Mathias (Farpoint Group) - expects to see cellphones with WiFi emerge at the Consumer Electronics Show in January and to be in production by June - we will see the logical convergence of cellular and WiFi networks next year

Christian Kermarrec (Analog Devices) - you need standardization for roaming to happen, and that won't come from the 3GPP until the end of this year - it will probably not be implemented for another two or three years

Andrew Seybold (Outlook 4Mobility) - seamless roaming between the two networks won't arrive for as many as three years

- Smart antennas for 802.11 APs/clients
- Cellphones, PDAs, laptops with integrated WLAN/cellular
- Smart antennas for both WLANs and cellular in these devices
- MIMO in WLANs (802.11n), with MIMO in cellular (base stations)
- Seamless roaming with WLANs/cellular