Mobility Service REvolution
(3G Telephony Services – Not !)

Mobility
Solutions

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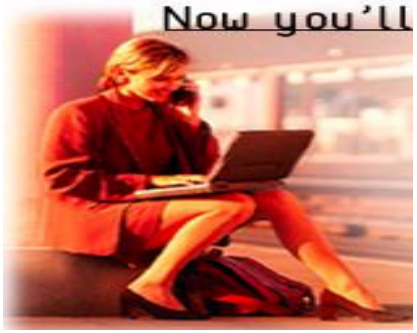
Current HSD Offers from Sprint and Verizon

Sprint PCS:

- US$ 80/month Unlimited
- Bundle Card+Service Package for enterprises

Verizon Wireless:



- US$ 79.99/month Unlimited
- Bundle Card+Service Package for enterprises

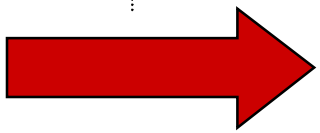
Lucent's Phased 3G Strategy

Phase 1	Phase 2
High-Speed Data for Enterprises (HSDe)	3G for Mass Market
Enterprise SME/SOHO	Early Adopting Consumers Mass Market

- Clear and simple needs
  - ü Access to Enterprise LAN
  - ü High access speeds
  - ü Laptop and PDA access
- Data centric
- High willingness to pay

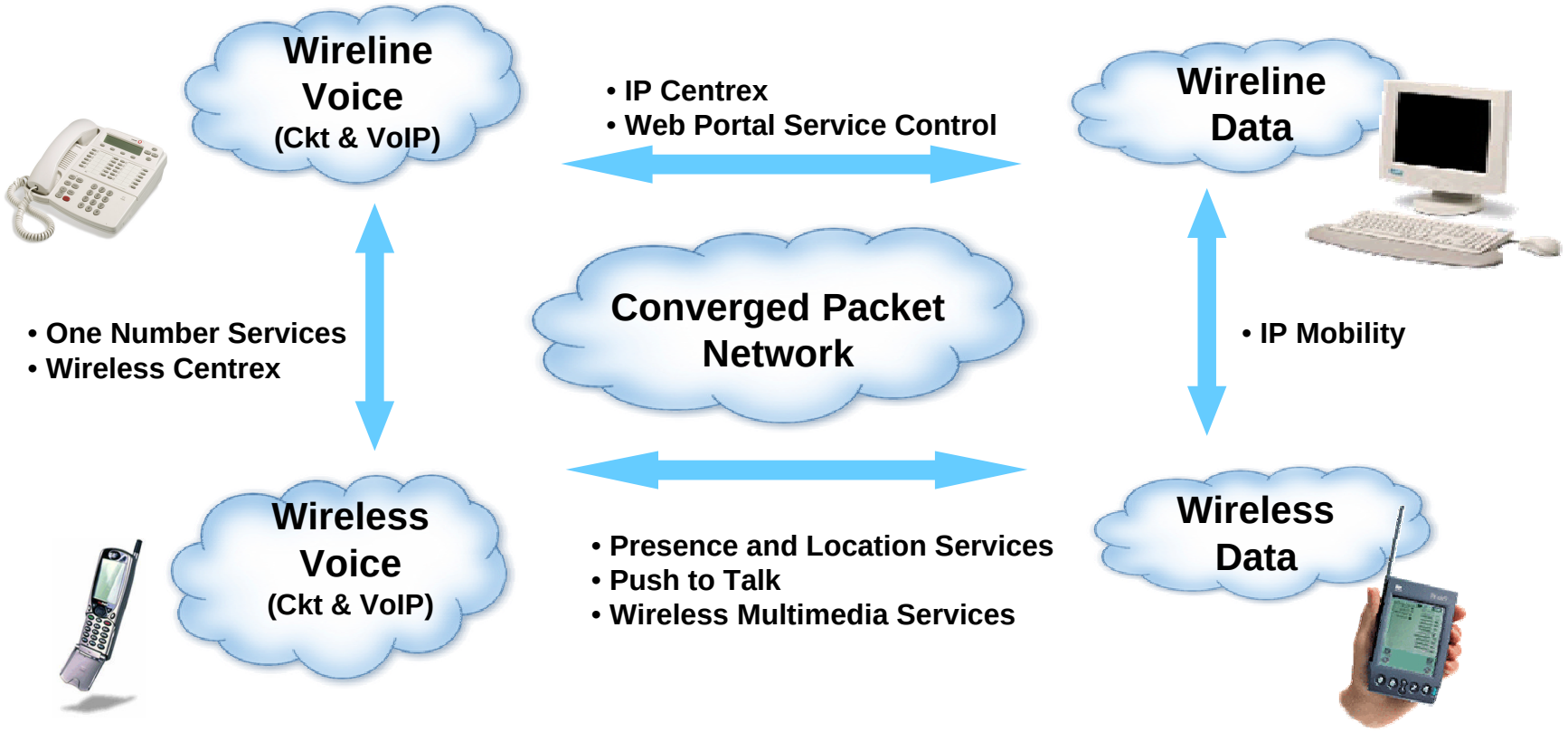
- Complex and variable needs
  - ü Lifestyle enhancements
  - ü High ease of use
  - ü Different modes of access
- Voice centric
- Largest number of subscribers

HSDe is right strategy for operators to succeed in early stages of 3G market



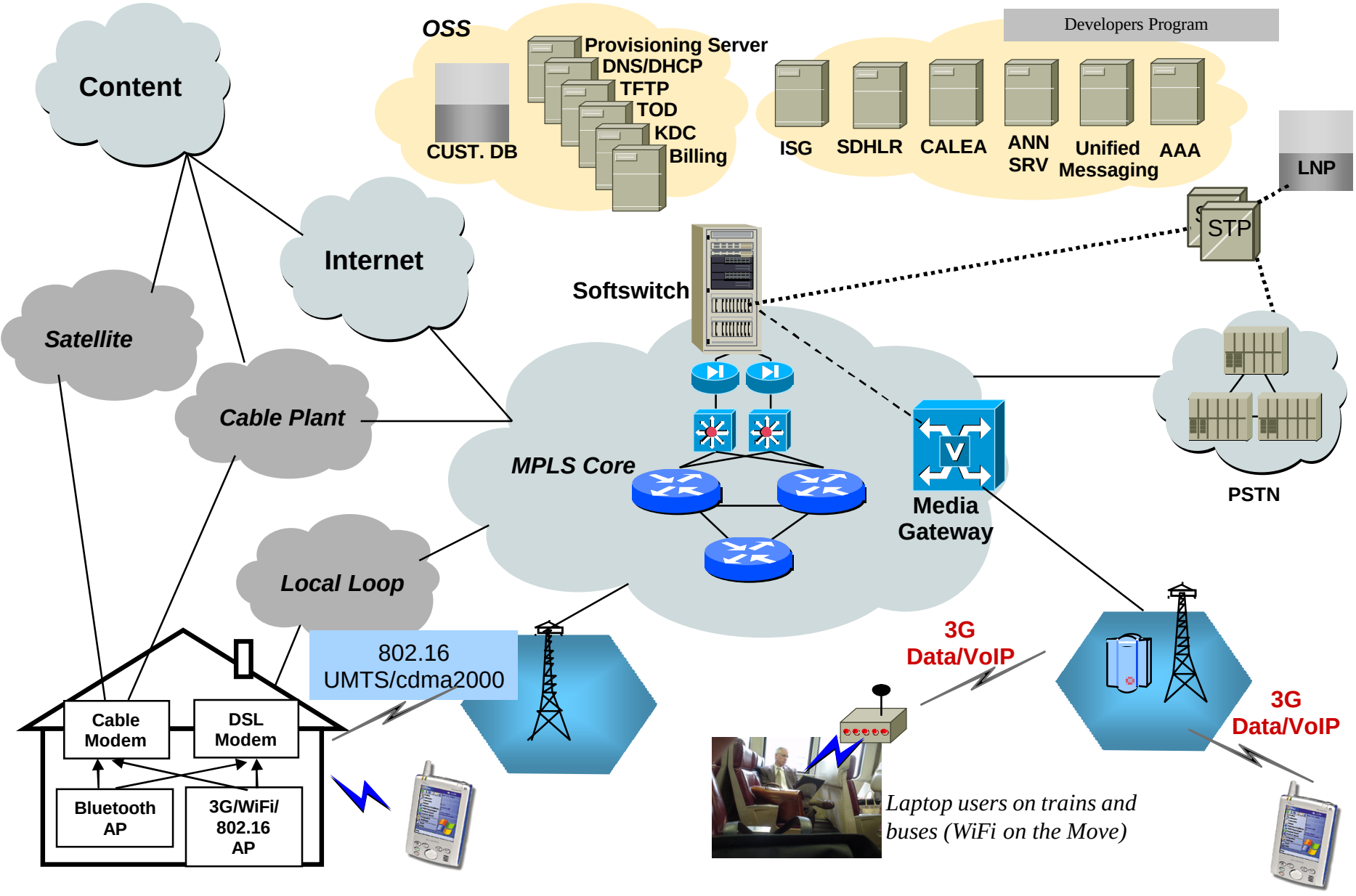
3G Mass Market is a natural evolution of the HSDe market entry strategy

Network Convergence



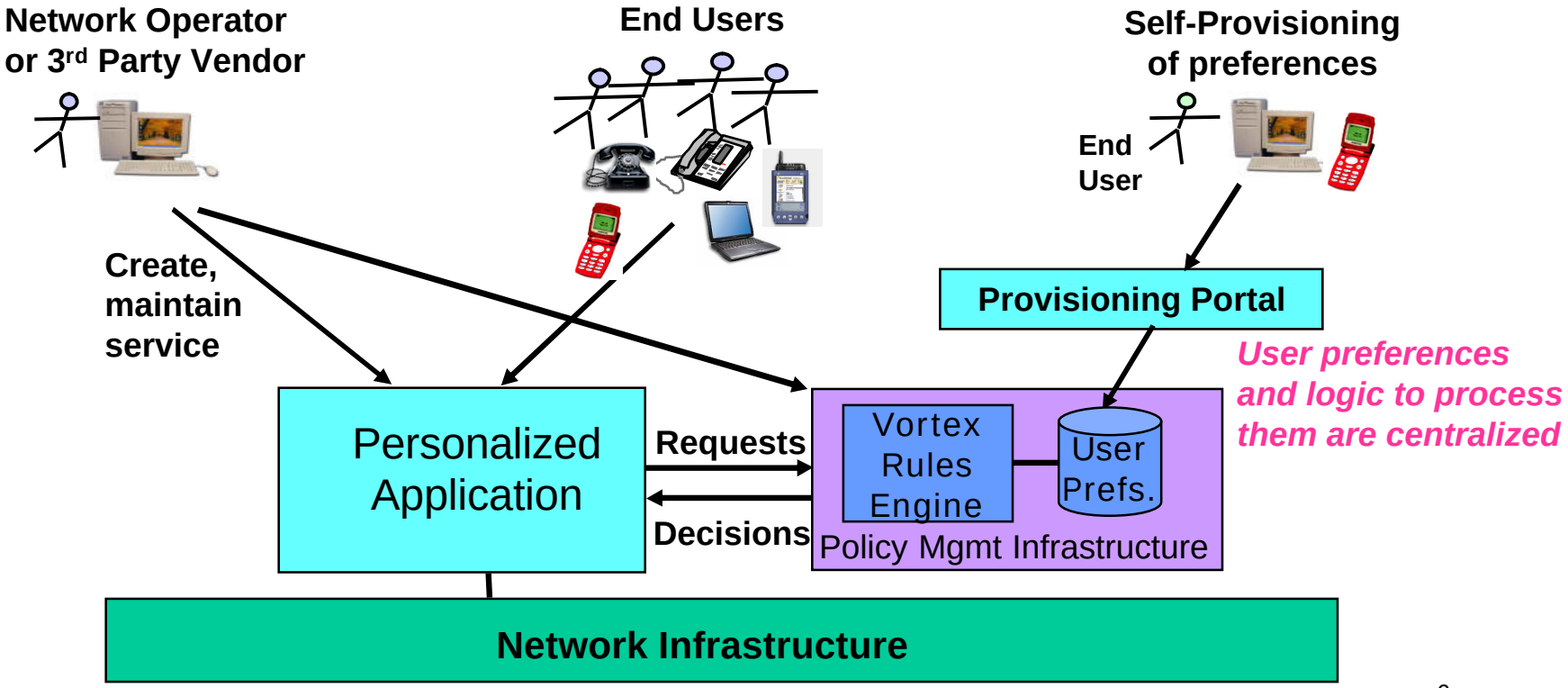
Convergence enables new Access Independent services Bringing the Network's Intelligence to the End-User

Reaching the End-User : Network of Networks



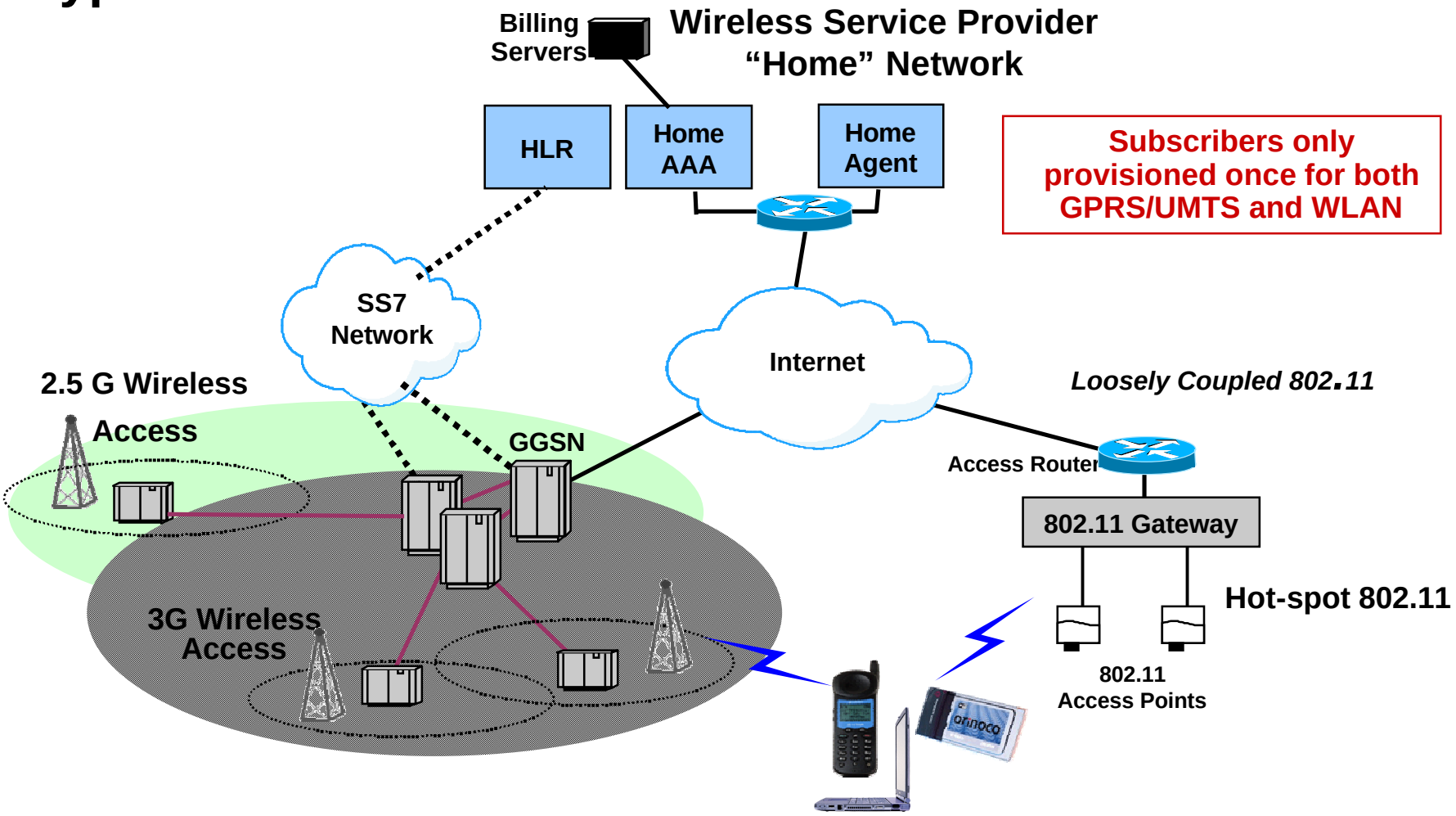
Policy Management

- High-performance rules engine
  - In the Internet Services Gateway, will be part of Application Hosting Environment
- Can support Personalization and Ease-of-Use
  - E.g., for call-forwarding, privacy of location info, anti-spam
- Can help Network Operator be more nimble
  - E.g., quickly install promotions into billing system



Integrating 3G and WLAN

Typical Solution



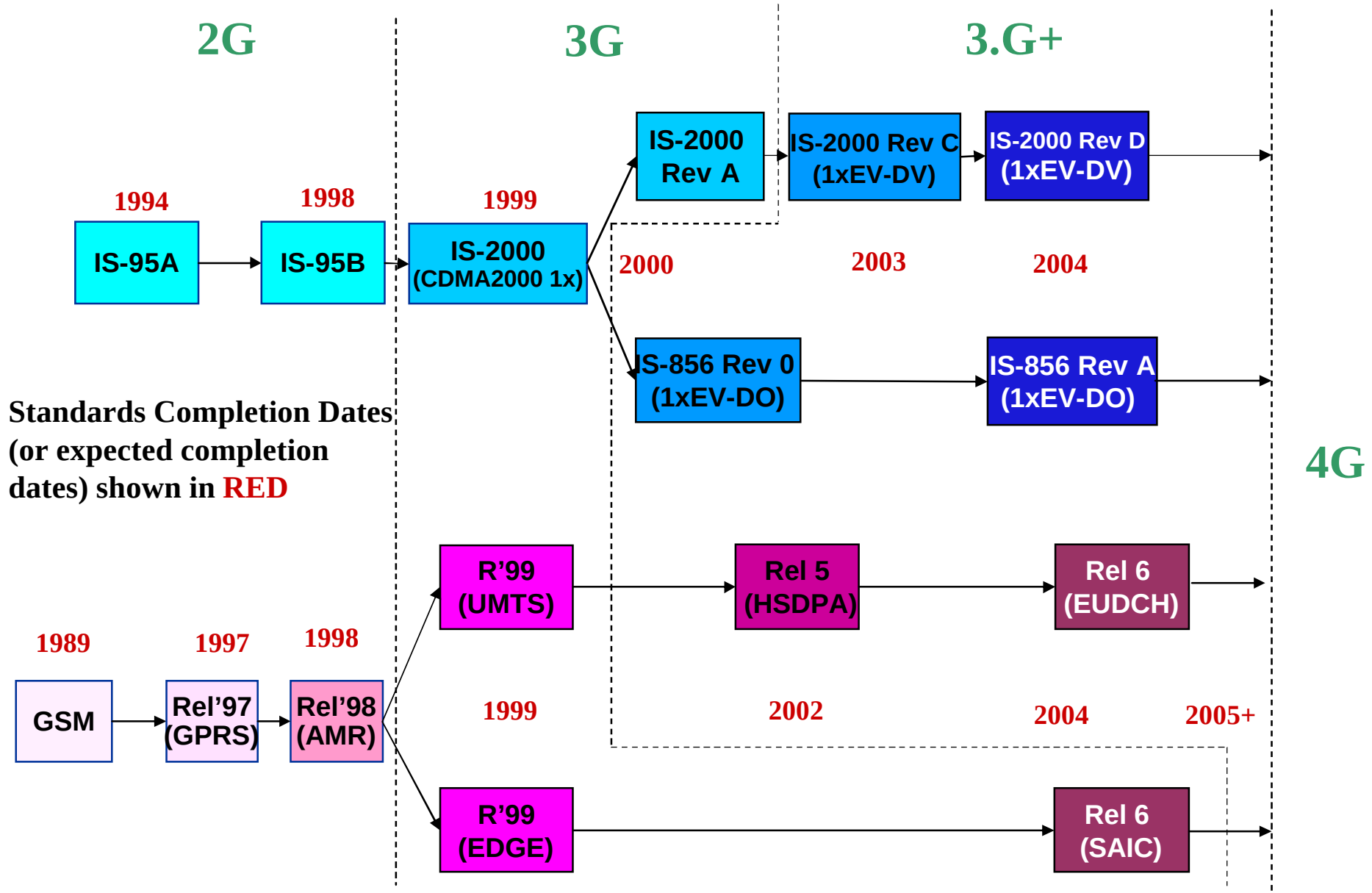
This solution integrates in-building solutions (WLAN) with macro mobility solutions (3G)
Lucent has executed many variations of this solution including Bluetoth

802.xx Standards

Standard	ANSI Approved	Comment
IEEE 802.11	**June '97**	Wireless LAN MAC and PHY 2.4 GHz Band
IEEE 802.11a	**Sep '99**	OFDM 5 GHz Band
IEEE 802.11b	**Sep '99**	DSSS 2.4 GHz Band
IEEE 802.11d	**June '01**	Reqs. for New Regulatory Domains
IEEE 802.11e	**N/A**	QoS
IEEE 802.11f	**June '03**	Multi-vendor Interoperability
IEEE 802.11g	**June '03**	Higher Speed for 802.11b
IEEE 802.11h	**Sep '03**	Spectrum and TX power Management
IEEE 802.11i	**N/A**	Security & Authentication
IEEE 802.11j	**N/A**	Japan 5 GHz
IEEE 802.11k	**N/A**	RRM Enhancements

Standard	ANSI Approved	Comment
IEEE 802.16	**Dec '01**	Fixed Broadband Wireless MAN 10-66 GHz Bands
IEEE 802.16a	**Jan '03**	2-11 GHz Bands
IEEE 802.16c	**Dec '02**	System Profiles for 10-66 GHz
IEEE 802.16d	**N/A**	System Profiles for 2-11 GHz
IEEE 802.16e	**N/A**	"Mobility"
IEEE 802.20	**N/A**	Mobile Broadband Wireless MAN < 3.5 GHz Bands

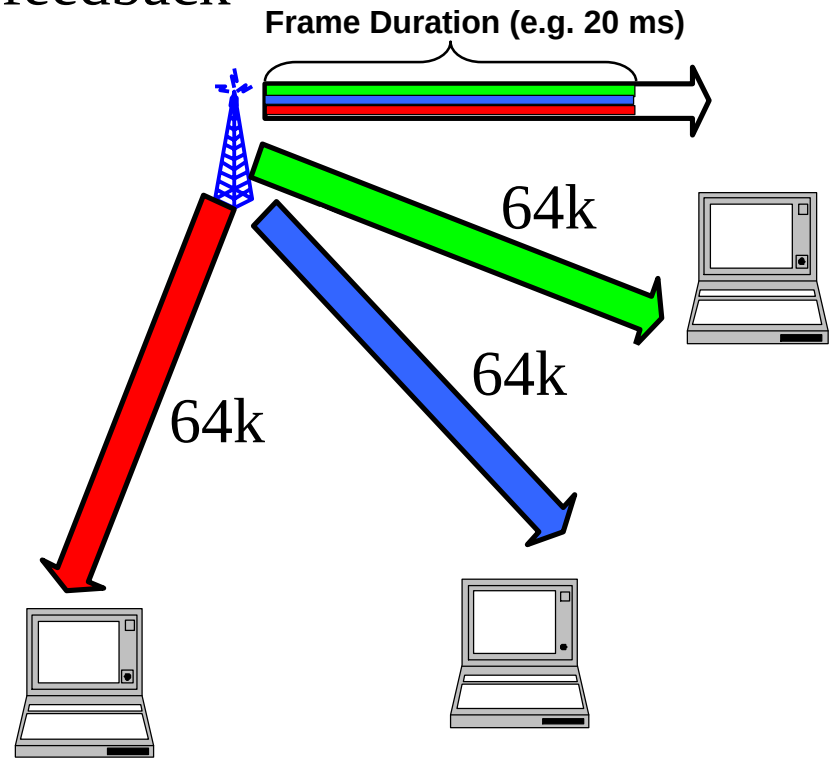
Standards Technology Evolutions



Initial 3G Data (1x example)

Power Control (PC) & Slow Rate Control

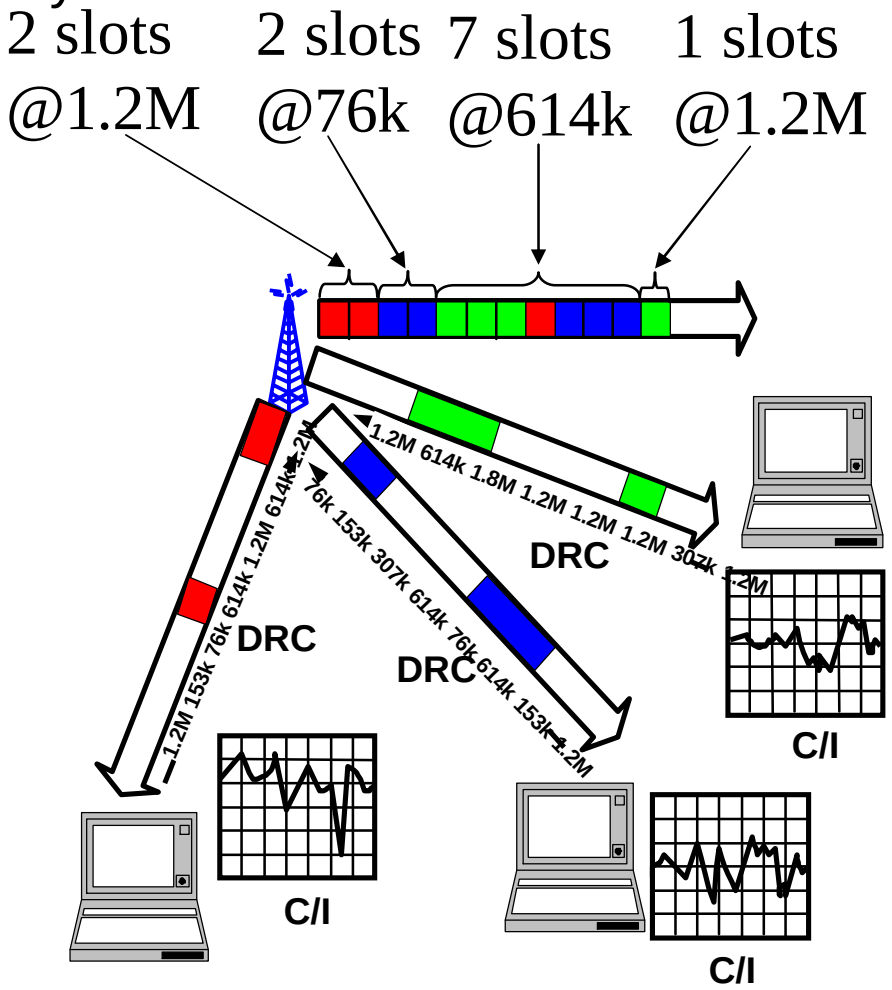
Note: No fast channel quality feedback



Ave. Aggregate Tput = 192 kbps

3G+ Data (EV-DO example)

Dynamic Rate Control & No PC



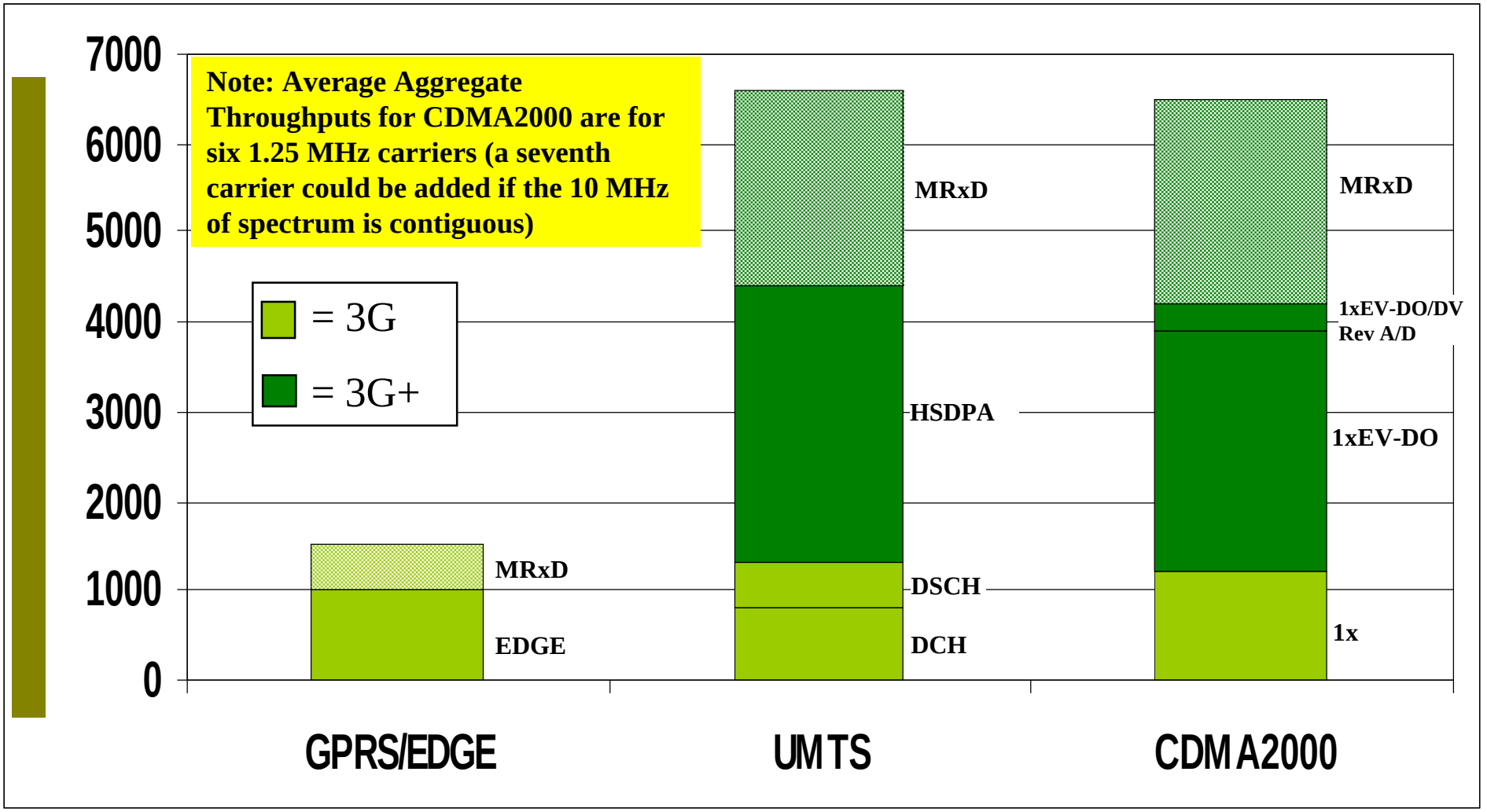
Ave. Aggregate Tput = 670 kbps

Standards Evolutions

- **1xEV-DO**
  - **Rev. 0**
    - FL Peak data rate 2.4 Mbps
    - RL Peak data rate 157 Kbps
    - VoIP capacity < 20 Erlangs
  - **Rev. A**
    - Shorter frames and HARQ in RL, DSC, More PHY layer packet sizes and multi-user frames in FL
    - FL Peak data rate 3.1 Mbps
    - RL Peak data rate 1.8 Mbps
    - ~35 Erl VoIP Capacity per carrier
  - ***Rev. B***
    - *TDM mode RL*
      - *e.g. Lucent's BURST Proposal*
      - *Peak data rate • 3 Mbps*
      - *At present, Rev. A 1.8 Mbps*
      - *à Symmetry between links*
    - *Improved Forward Link to support Higher Capacity*
    - *Increase in VoIP capacity*
    - *Higher data rates for Broadcast/Multicast*
    - *Evaluate OFDM (broadcast), Multi-carrier, and MIMO*
- **1xEV-DV**
  - **Rev. C**
    - FL Peak data rate 2.4 Mbps
    - RL Peak data rate 307 Kbps
  - **Rev. D**
    - FL Peak data rate 3.1 Mbps (Rev. 0 2.4 Mbps)
    - RL Peak data rate 1.8 Mbps (Rev. 0 157 Kbps)
    - For VoIP 10 msec with 40 msec delay for HARQ is too long
  - ***Rev. E***
    - *Improved Forward Link to support Higher Capacity*
    - *Increase in voice capacity (standards body request, no solution yet)*
    - *Increase VoIP capacity by reduction of frame length*
    - *Evaluate OFDM (broadcast), Multi-carrier, & MIMO*
- **3GPP HSDPA**
  - **Rel'5**
    - FLPeak data rate 14 Mbps
    - Rl Peak data rate 384 kbps
  - ***Rel'6***
    - *Enhanced Uplink DCH (E-DCH)*
    - *RL Peak data rate 2 Mbps*
    - *Efficient VoIP on HSDPA/EUDCH*
    - *Fast Cell Selection?*

Average Aggregate Data Throughput in 10 MHz (3G vs. 3G+)

Note: Capacities shown represent improvements as each feature is added to the features below it.



3G+ technologies provide significant data capacity/throughput improvements over initial 3G systems

3G Status

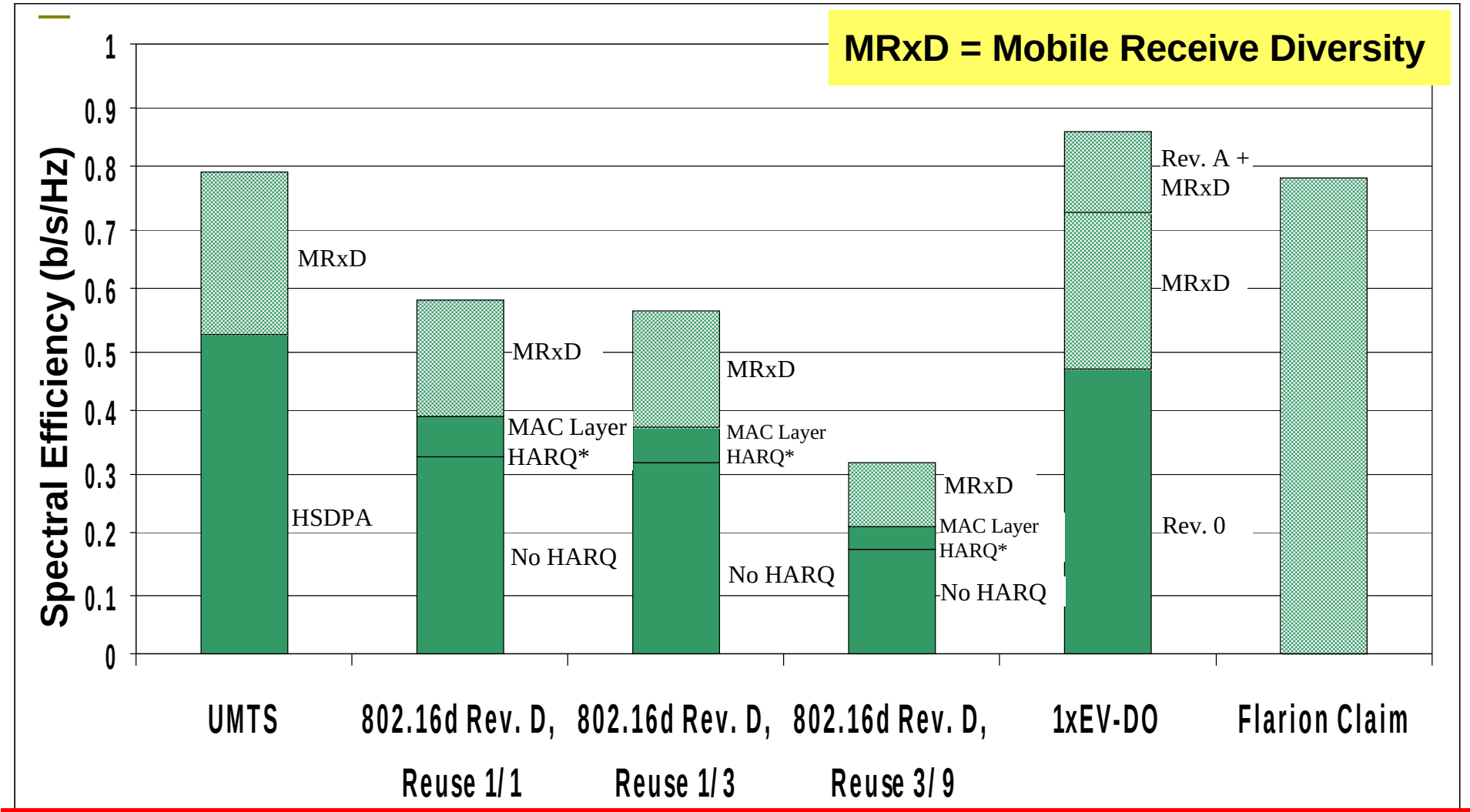
- Korea
- Japan
- North America
- India
- New Zealand/Australia
- Europe

Broadband Wireless Access – WiMAX 802.16

- The “triple play” is the delivering of the offer of integrated voice, data, and video. This may be delivered through the any combination of DSL, cable, satellite, 3G, 802.11, 802.16, etc.
- The “grand slam” is the addition of mobility to that offer (most specifically – wireless technology).
- WiMAX – 802.16 is a broadband wireless standard based on OFDM to deliver broadband data rates with limited mobility. With the appropriate technology advances, such as MIMO, it may be able to support broadcast video.
- Although 802.16 is not any more spectrally efficient than 3G+ technology, it does offer scalability over wide bandwidths. Wide-bandwidth systems are a perfect application of OFDM to deal with frequency selective fading.

Downlink Spectral Efficiency (SE)

Fixed Wireless Channel (results in higher values than mobile !)



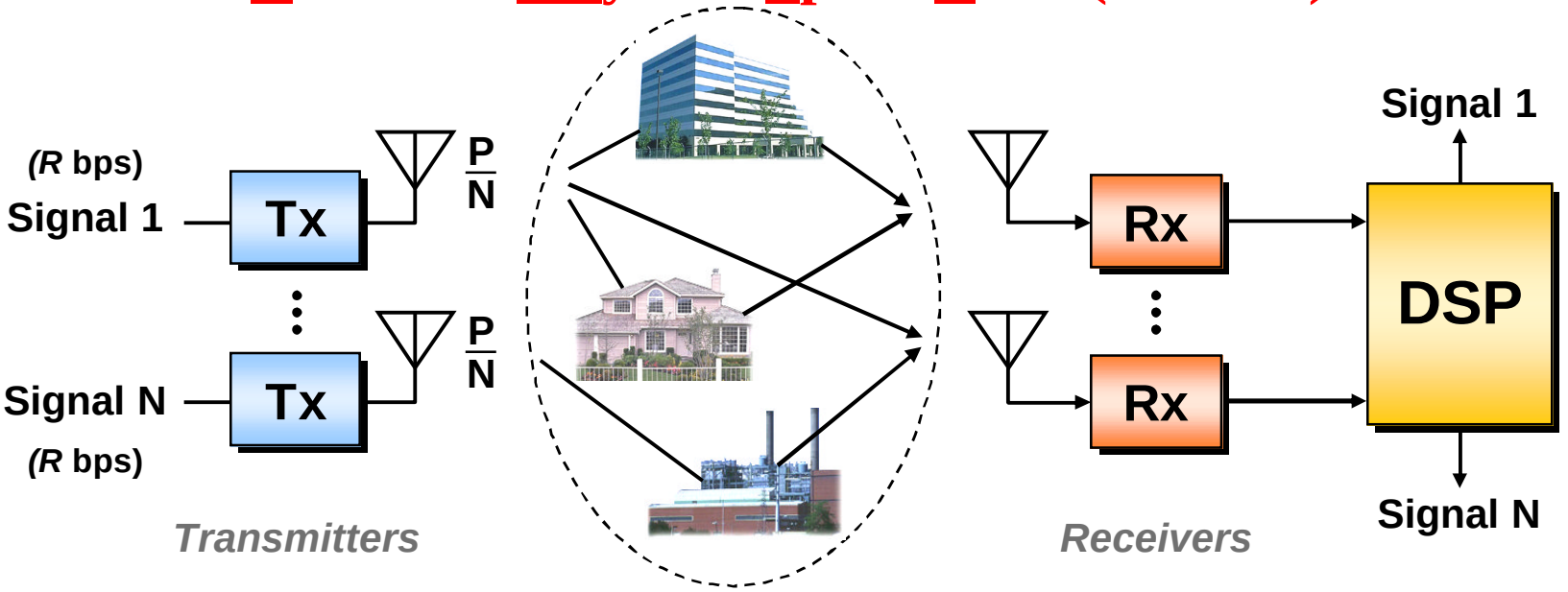
- **Differences in downlink SE are due to:**
  - 802.16d Ver. 5 defines HARQ at the MAC layer (HARQ in HSDPA and DO is defined at the physical layer)
  - Rel'5 UMTS/HSDPA and 1xEV-DO Rev. A have faster rate control than 802.16d Ver. 5
- **802.16e in reuse 1/1 will likely close the gap with HSDPA and 1xEV-DO Rev. A**

Intelligent Antennas

- The analysis thus far has assumed a “basic” antenna configuration
  - 1 Tx, 2 Rx at the BTS
  - 1 Tx, 1 or 2 Rx at the terminal
- The benefits of adding more antennas can be large, for example:
  - Estimated 2-3 dB coverage gain with 4-branch uplink receive possible
  - Estimated 80-100% with 4-element downlink IA solution
- MIMO/BLAST can provide even further capacity benefits
- The benefits of IA and MIMO/BLAST can be applied to any technology

MIMO Increase wireless capacity

Bell-Labs LAyered Space Time (BLAST)



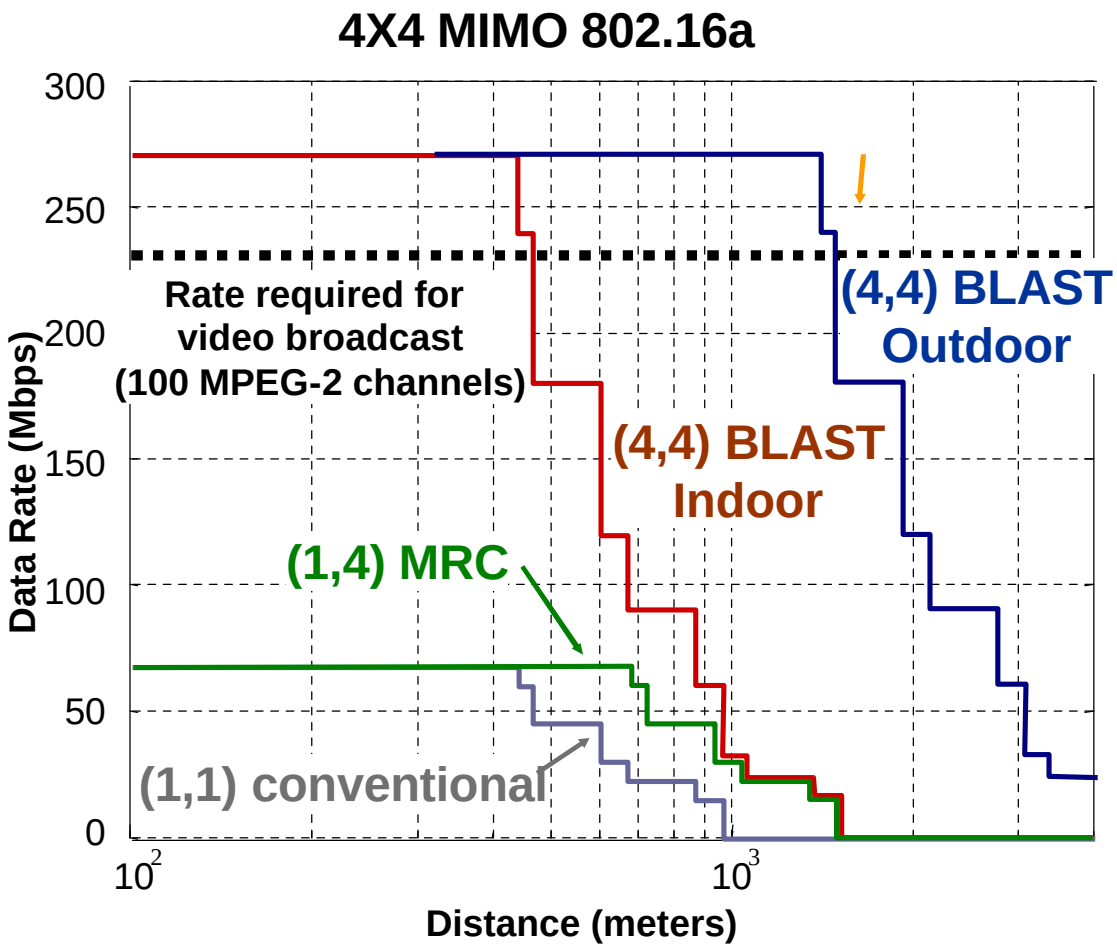
- Scattering scrambles the signals -- Each receiver has a different combination of signals
- DSP algorithm de-scrambles the received signal to reproduce original signals
- Capacity increases linearly with number of antennas with no increase in total power
- Useful in urban areas and in-building wireless

Lets wireless users access

- Full motion video
- Interactive applications
- Rich Internet content with fast response

BLAST Enhancement to 802.16 Will Enable Triple-Play

- Conventional 802.16 has limited range and peak rate
- MRC (or beamsteering) increases range but not peak rate
- BLAST increases peak rate for terminals near base
- BLAST uses MRC to increase range
- Broadcast now possible: 100 MPEG-2 video channels in 20 MHz.



BLAST enabled technologies make broadcast video possible

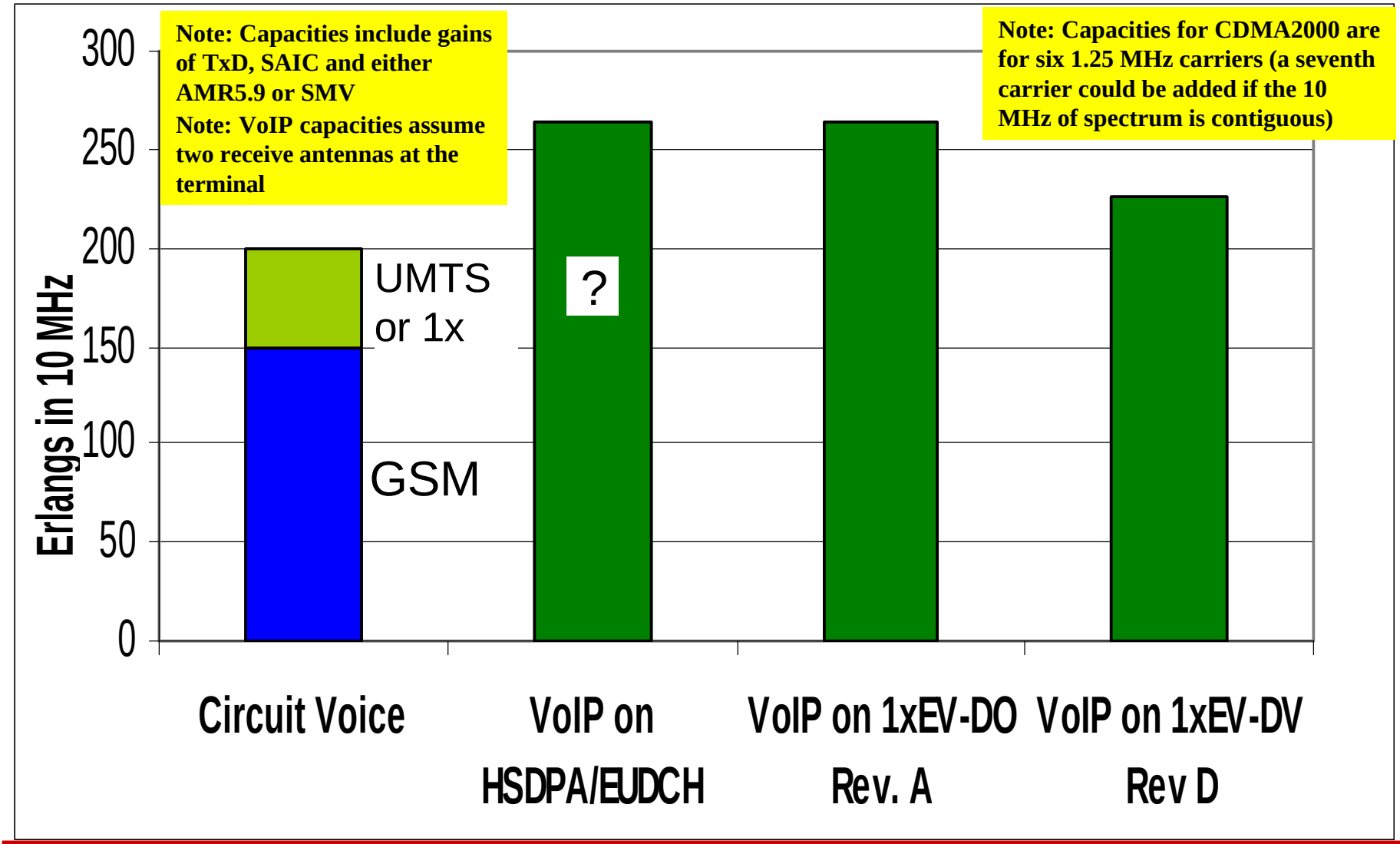
VoIP Performance Objectives

- **Basically be as good as circuit switched voice:**
  - Little or no degradation in voice quality (MOS performance)
    - comparison points are EVRC, AMR, EFR, SMV, etc
    - error tolerant, toll quality, low delay
  - End-to-end delay on the same order as circuit switched voice
    - For Mobile to PSTN and PSTN to Mobile scenarios, 3G1x CS Voice delay is currently ~135 msec
    - For Mobile to Mobile scenario, 3G1x CS Voice delay is currently ~270 msec
  - Radio interface efficiency and network capacity comparable to circuit switched voices
    - current 3G1x CS voice is ~ 26 Erlangs/sector-carrier, UMTS is ~ 3 times that number
  - Coverage, handoffs - equivalent to CS voice

VoIP Solution Space

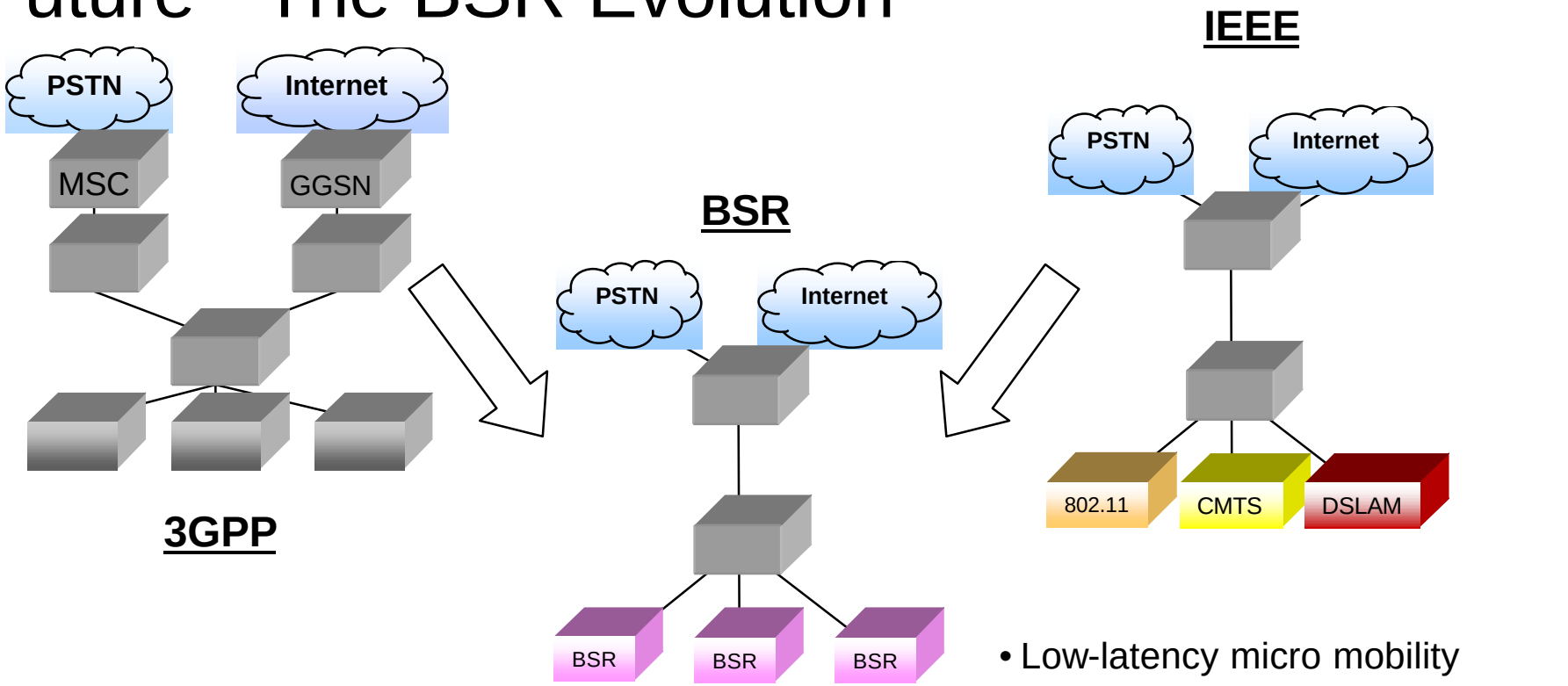
- **At the application**
  - header compression/stripping (ROHC, LLAROHC)
  - Frame aggregation
  - making the vocoders more VoIP friendly
    - Adaptive Jitter Buffering to Control Delay
    - Speech Coder Resynchronization to Improve Speech Quality and Reduce Delay
- **Forward link**
  - support for low bit rate users
  - support for QoS
- **Reverse link**
  - reduced latency and increased capacity
  - QoS
- **Radio Access Network**
  - New signaling mechanism to distinguish VoIP packets from regular data packets
- **Handoff**
  - New signaling and state migration techniques to support “make before break”
- **Core Network**
  - MPLS with DiffServ Traffic Engineering

Potential Performance of VoIP



VoIP on 1xEV-DO/DV and HSDPA/EUDCH may be as good or better than CS voice

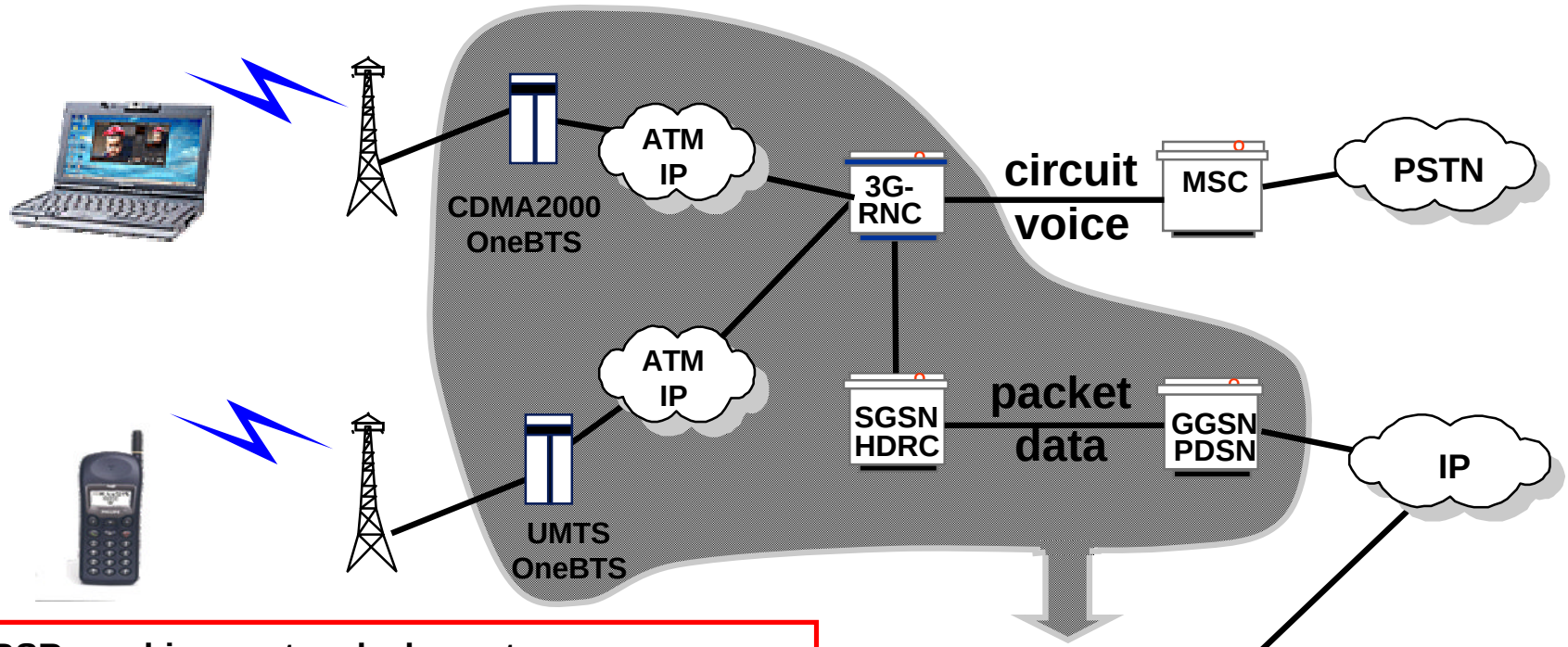
Future - The BSR Evolution



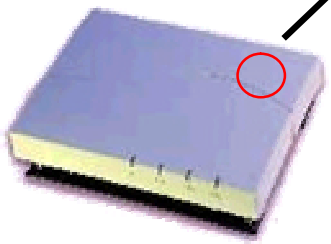
- Low-latency micro mobility
- pico through macro deployments
- High-speed data

- Distributed Basestation: Control placement for high capacity, high mobility systems
- Wireless mesh: Low-cost backhaul for HSD and pico-cells
- Wireless broadband: Universal control layer
- Plug in Air interfaces: Higher data rates

Vision - Basestation Router



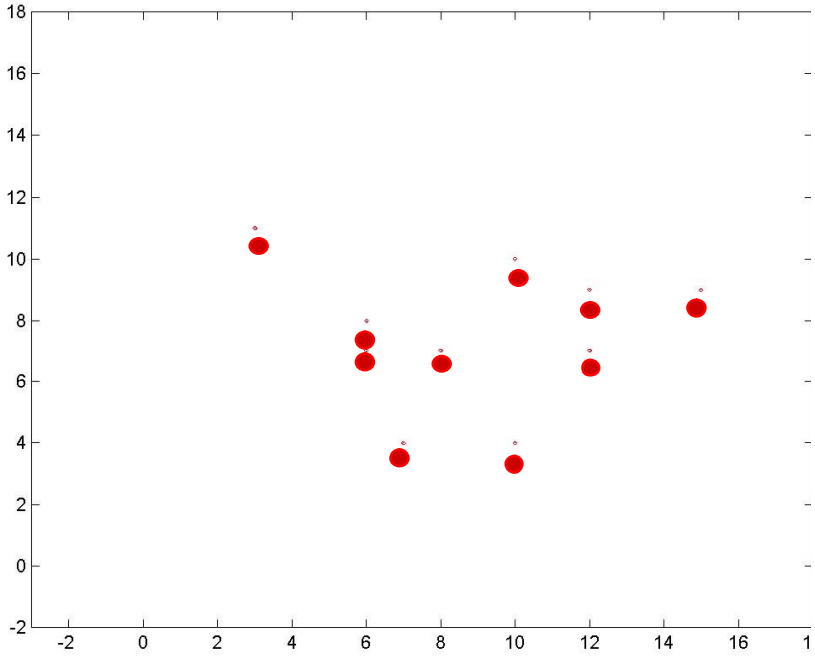
- BSR combines network elements
- End-to-End QoS support
- Enhanced VoIP support (header compression, etc.)
- Reduced latency
- Improved mobility management for data applications (shared packet data channels)
- Prototyped on GPRS and UMTS, EV-DO underway (air interface independent)
- Interworking at IP level, simple

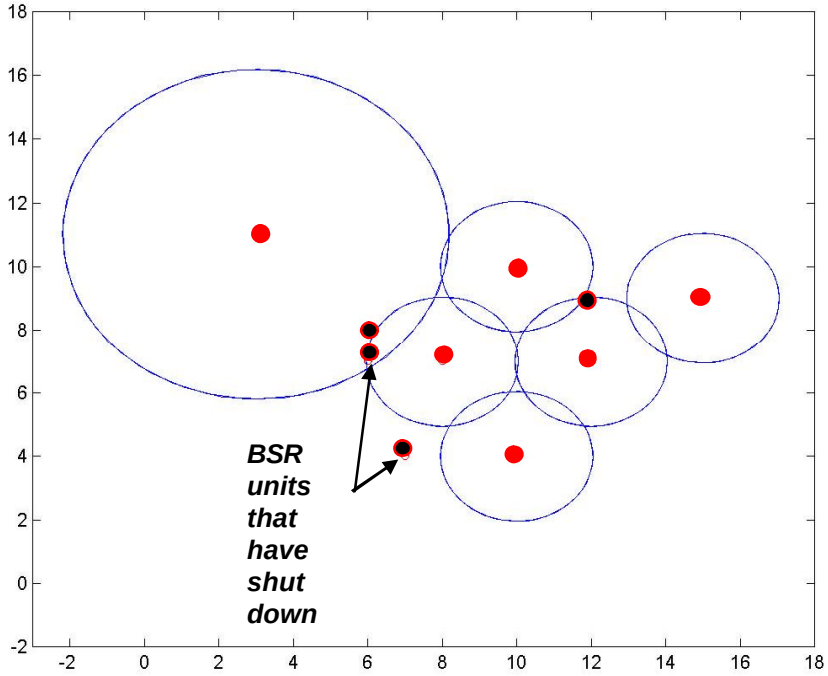


Will support : EV-DO/UMTS/HSDPA/ GSM/GPRS and 802.11/802.16

BSR

Vision - Dynamic network configuration





- Basestations are randomly placed in an area.
- Network viewed as cellular automata and configured based on local rules with nearest neighbors.
- Configuration is handled through direct basestation-basestation communication through wireless router.
- As a result in this example some basestations shutdown but retain network connection. May remain as possible router elements.

The Next Horizon: Cognitive Radio

- The FCC has several proceedings advancing the regulatory concept of “cognitive radios” or “smart Radios.” These radios sense either their location or radio environment before selecting and utilizing some fraction of the local spectral resources in a way that is to minimize interference to incumbent license holders and other “smart radios.”
- These radios may be either licensed or unlicensed and might share spectrum with, for example, the television broadcasters or with cellular operators.
- As either an overlay (such as Ultra-Wide Band) or as part-15 (unlicensed) devices, on either an exclusive, negotiated or shared common basis.
- Cognitive radios might offer either cellular-type services, wireless internet, telemetry or even broadcast television services.
- This poses both a competitive threat to existing wireless service providers as well as an opportunity for “subleasing” spectral resources or as an alternative spectral resource for expanded service.

Picocell Network Vision Summary

- Frequency and protocol agile radio
  - Radio is capable of operating in any frequency and any physical layer protocol
- FTTH backhaul
  - Each home has high bandwidth Internet access via optical fiber
  - The FTTH connectivity also provides backhaul for a picocell AP in each home (or high bandwidth cable)
  - Network is made up of an ad-hoc configuration of picocells, each picocell has ~50 meter range and a data rate of a few hundred MB/sec
- Handset
  - Very powerful handset (computationally) with significant computational and storage ability