Operator Service Requirements

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Purpose:

FYI

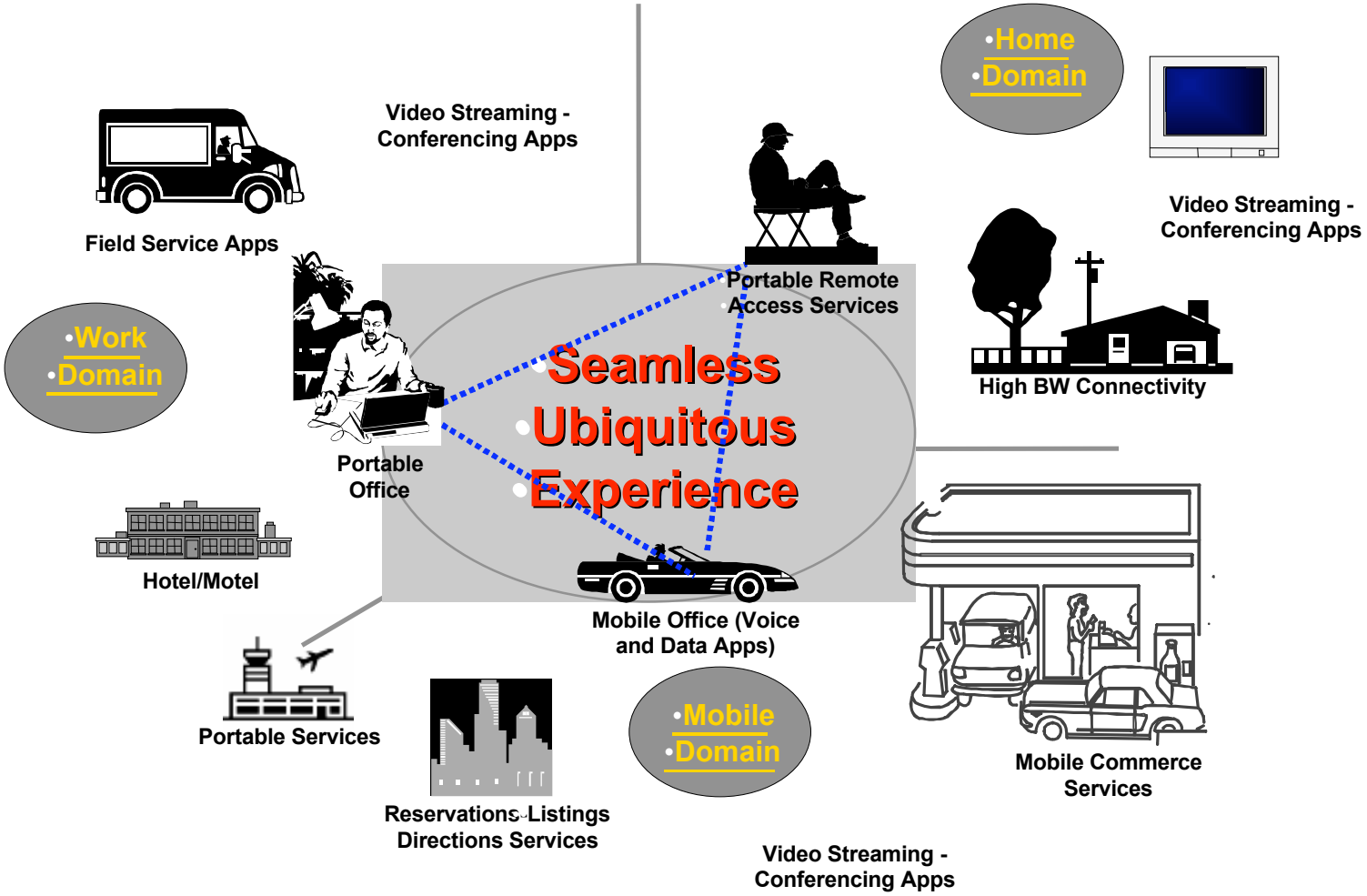
Joint Contribution on Operators Vision for Service & Technical Requirements

Contents

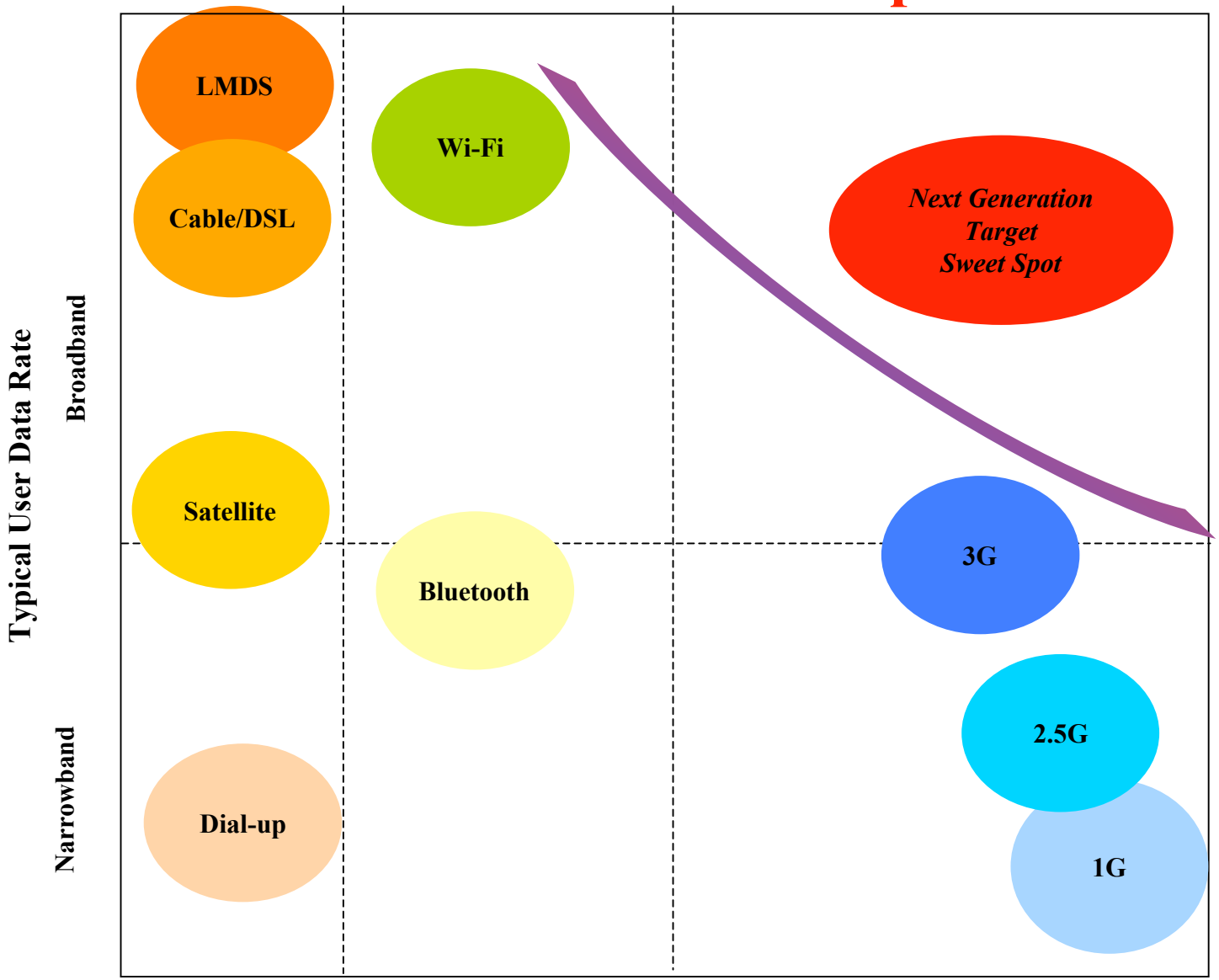
Operators Vision for Wireless Broadband Data

- End-to-End Wireless IP Data Services Design
- Better than 1+ Mbps Performance User Experience
- Mobility for Data with IP QoS suppport
  - Day 1 - Non real time
  - Future - Real time
- Integrated wireless backhaul capability
- True International Standard and Devices
  - Requires flexibility for bandwidth and bandplans
  - Need to support both TDD and FDD based on spectrum allocations
- Devices examples: Desktop modem, PCMCIA card, Handset, Compact Flash
  - Embedded into all broadband capable consumer devices
- *10x+* competitive advantage to current 3G systems

Broadband Wireless Access



Service Requirements – Market Drivers
Next Generation Wireless – "Sweet Spot"



Source: FCC, 2002, with modifications by author

Technical Requirements

Topic	Requirement	Considerations
Average User Data Rate Performance	1 Mbps DL, 384 kbps UL – with overhead (without channel coding, just PHY data rate).	User Data Rate performance defined as average data rate at peak load for 90% of cell 90% reference = 90% of the cell area
Bursting Capabilities	>3 Mbps DL, >1 Mbps UL	Bursting capability is defined as maximum rate achievable within the cell (at highest modulation order)
Mobility & Handover	The system shall support mobile performance at a minimum of 60 km/hr with an option to support higher speeds (upto 120 km/hr) with a graceful degradation of data rate. (Day one) The system shall support handover to existing networks (i.e. seamless handover from BWA to existing mobile networks).	▪802 Based Systems – Layer 2 & above handover (open for discussion) ▪3G Based Networks – Open, to be decided later Make before Break (MBB) supported in logical channel & Break Before Make (BBM) in physical channel is one option, open to others
Mobility Management	MobileIP+ implementation	▪Latency budget for Mobile IP based handover ▪Mobile IPv4 vs. v6: Triangular Routing, Addressing etc ▪Micro-Mobility & Macro-Mobility ▪Leverage mobility management of IMS system ▪L2 handover to .11 and other 802 interfaces (option) ▪Handover to 3G systems ▪3G-Based Protocols

Technical Requirements

Topic	Requirement	Considerations
Radio Network Architectures	Macro-Cellular	▪Large cell sizes (>3 km) in suburban environment ▪ Coverage limited ▪ Utilizing existing cellular cell sites & antennas ▪ Economical Backhaul
	Micro-Cellular	~1 km cell sizes Capacity limited Low-power base stations with self-healing, self-routing properties Utilizing low-height (<20 m) sites like utility poles and repeaters
		Option to look at Micro- Cellular with repeaters and Mesh Networking **Utilizing low-height (<20 m) sites like utility poles and repeaters**

Technical Requirements

Topic	Requirement	Considerations
Roundtrip Latency	<50 msec (user experience latency over the air link)	Assumptions Session is "Active" or "On" (I.e. resources are allocated) No queuing delay
Data Session Set-up time	<120 msec	Time taken from idle to active
Deep Indoor Penetration – Improved Link Budget Performance	Deep Indoor Penetration is required to provide ubiquitous service	160 dB is the target "System Gain"- combination of deterministic (like EIRP) and statistical (like Diversity, MIMO Smart Antenna) gains of the system ▪Initial motivation for large cell sizes, deep indoor penetration and large capacity gains to reduce capital expenditure and cost/MB ▪Initial target for desktop like devices (30 dBm EIRP), can be relaxed for PC card devices
IP QoS	Support for Real-Time based applications using IP QoS protocols and Priority Based Queuing Examples : Gaming, Video telephony and Conferencing	Future Requirement Real time applications with seamless handoff

Technical Requirements

Topic	Requirement	Considerations
Embedded Devices	Low- Power RFIC & SoC technology development to enable low-cost embedded chips for laptops, handhelds and other consumer broadband appliances (Built-in .11 hub with home device)	
Channel Bandwidths	Multi-Channel bandwidth ranges are possible. Chip sets should support 5 & 10 MHz with option of supporting others with similar tone structure. Devices should support multiple channel bandwidth including 5 and 10 MHz with option of supporting 20 MHz or other multiple channel bandwidth as necessary.	▪Uplink Channel bandwidths – link budget concerns, device processing capabilities ▪ Lower cost/MB with wider bandwidths ▪Spectral Mask issues ▪Multiplexing Gain
Maximum Delay Spread	Up to 10 usec	▪Multipath fading channel assumed Rayleigh with K=0 ▪ Channel model for MIMO smart antenna application ▪Symbol duration and cyclic prefix ratio

Technical Requirements

<table>
<tr><th>Topic</th><th>Requirement</th><th>Considerations</th></tr>
<tr><td>Sustained Spectral Efficiency & System Throughput</td><td>
<table>
<tr><th rowspan="2">Re-use Factor</th><th colspan="2">Spectral Efficiency</th><th colspan="2">Examples (5MHz for 1x1 and 15MHz fo 1x3)</th></tr>
<tr><th>Downlink</th><th>Uplink</th><th>Downlink</th><th>Uplink</th></tr>
<tr><td>1x1</td><td>2 b/s/Hz/sector
6 b/s/Hz/cell</td><td>1 b/s/Hz/sector
3 b/s/Hz/cell</td><td>10 Mbps/sector
30 Mbps/cell</td><td>5 Mbps/sector
15 Mbps/sector</td></tr>
<tr><td>1x3</td><td>4 b/s/Hz/sector
4 b/s/Hz/cell</td><td>2 b/s/Hz/sector
2 b/s/Hz/cell</td><td>20 Mbps/sector
60 Mbps/cell</td><td>10 Mbps/sector
30 Mbps/cell</td></tr>
</table>
</td><td>Uniform distribution of users Mixed mobility environment (open to different proportion)
1/3 stationary users, 1/3 low speed users, 1/3 high speed users. Fully loaded system
Note: Uplink is assumed to be 50% of downlink. Also, ideal sectorization gain of 3 is assumed.</td></tr>
<tr><td>Duplexing</td><td>International Standard would have both TDD or FDD options with common radio technology.</td><td></td></tr>
<tr><td>Frequency Re-Use</td><td>1x1, 1x3 (Cell Re-Use x Sector Re-Use).</td><td>▪High Capital Efficiency – High Mbps/Sector for Low Cost/MB
▪ Handover Mechanism and Radio Design
▪Interference management for re-use of 1</td></tr>
</table>

Technical Requirements

Topic	Requirement	Considerations
Link Budget – System Performance	160 dB is the target "System Gain"- combination of deterministic (like EIRP) and statistical (like Diversity, MIMO, Smart Antenna) gains of the system	▪Initial motivation for large cell sizes and large capacity gains to reduce capital expenditure and cost/MB ▪Initial target for desktop like devices (30 dBm EIRP), can be relaxed for PC card devices
Multiple Access	OFDMA	
MAC Efficiency	> 80%	
Packet Error Rate	To minimize TCP/IP application errors because of radio system fluctuations Error rate for 512 byte packet <=1% pre-ARQ Implement an (H)ARQ algorithm to correct errors at L2 and allow lower C/I at physical layer (higher error rate)	▪Lower C/I to get more robust radio performance ▪Short packets (64 bytes or less)
Space-Time Processing or Smart Antennas	Support hooks for space-time processing technologies like x-order diversity, NxM MIMO or smart antenna technology in the air interface design	▪X+ Capacity & Coverage Performance ▪Tradeoffs between device complexity, cost and performance for multiple antenna elements and tx/rx chains ▪Array-based technologies for BS and associated cabling/loading issues

Technical Requirements

Topic	Requirement	Considerations
IETF based L3+	Use IETF based IP protocols for L3+ for addressing, application support, routing , security, authentication	▪AES, EAP ▪ IMS systems ▪ Interworking with 3G systems ▪ Gateway designs
# of Active Sessions	Contention-less Active Sessions 100 per carrier per sector Contention Based Active Sessions 1000 per carrier per sector	

Operators Feedback

Topic	Requirement	Meets Req?
Throughput	1Mbps (DL), 384kbps (UL) per user 3Mbps (DL), 1Mbps (UL) Bursting 2 b/s/Hz/sector (1x1 reuse)	**Unknown** **Unknown** **Unknown**
Mobility Support & Management	Support 60km/hr and up to 120km/hr with graceful degradation	**Unknown**
Network Architecture	Macro-cell Micro-cell Micro-cell with repeaters and mesh	**Yes** **Yes** **Unknown**
Roundtrip Latency	50 msec	**Unknown**
Link Budget	160dB	**Unknown**
International Interoperability	5 & 10MHz channel bandwidths at the minimum	**Yes**
IP QoS	IP QoS support for Real-time Apps	**Unknown**

Operators Feedback

Topic	Requirement	Meets Req?
Delay Spread & Multiple Access	Up to 10 usec based on OFDMA	**Yes**
Packet Error Rate	< 1%; pre-ARQ	**Unknown**
MAC Efficiency	> 80%	**Unknown**
Advanced Antenna System Support	Space-Time coding, Beam forming, or others	**Unknown**
IETF based L3	List the dependencies of IETF L3 to 802.16e	**Unknown**
Multi-carrier management	Seamlessly scale individual sectors to meet localized demand with efficient load-balancing mechanisms between carriers	**Unknown**
Robust inter-frequency handoff	Needed to support micro-to-macro handoffs (indoor to outdoor systems), transitions between license blocks, interference mitigation, and frequency reuse plans for both active and idle modes.	**Unknown**
Capability Negotiation	Negotiation of preferred PHY modes needed to support roaming of devices onto different operator networks. Device needs to be “Plug and Play” onto network.	**Unknown**

Definitions

Definitions

- Bursting Capabilities - maximum data rate achievable within the cell (at highest modulation order)
- Channel Bandwidth – regulatory licensed channel block
- Duplexing – the simultaneous operation of a transmitter and a receiver, most commonly used in FDD systems with a fixed transmit to receive frequency offset
- Delay Spread – The scattering of signals due to multipath effects, causing multiple copies of the original signal to arrive at the receiver with variable time offsets.
  - Maximum Tolerable Delay Spread - 10 μsec
- Embedded Device – Here, this refers to communications devices that will be incorporated into the designs of numerous other consumer products.
- Data Session Set-Up Time – The time for creating a new MAC layer services entity for the application session, including the margin for random access delay variation

Definitions - continued

- Frequency Re-use – is described as (the number of times a specific channel usage pattern is used in a network) x (the number of unique channels in the pattern)
  - A 1 x 1 pattern means all sectors at all base stations use the same channel
  - A 1 x 3 pattern means that for a network of 3 sectored base stations, each sector of an individual base station uses a different channel, and this pattern is repeated at every base station.
- IETF based L3+: This refers to the Internet Engineering Task Force published documents describing standardized methods of handling IP based addressing, applications support, routing, security and authentication.
- Link Budget – The Link Budget, or System Gain, is a measure of the capacity of the physical layer to overcome all losses in its environment.
- MAC Efficiency – This is defined as the ratio of the data transmission active period to the total transmit active time.

Definitions - continued

- Mobility – Any non-fixed use of a mobile data terminal
  - Pedestrian – speeds to 3 km/hr
  - Vehicular – initially support speeds of 60 km/hr, with an evolutionary path to 120 km/hr
- Mobility Management – is defined as any one of several of the various solutions for seamlessly supporting a mobile client operating in a wireless network and traveling between base stations, or possibly between diverse networks.
- OFDM – Orthogonal Frequency Division Multiplex is a modulation technique that divides a transmitted data signal into a large number of narrowband data transmissions all sent simultaneously.
- OFDMA – Orthogonal Frequency Division Multiple Access is a variant of OFDM that allows multiple subscribers to all transmit simultaneously and not interfere with each other.

Definitions - continued

- Packet Error Rate – Is the percentage of invalid to valid packets delivered by the Subscriber Station (SS.)
- QoS – This is short for Quality of Service and refers to various techniques use to differentiate and expedite IP traffic flows.
- Round-Trip Latency - The round-trip latency is defined here to be the duration from when a data frame is received by the physical layer of the transmitter to the time when an acknowledgment for that frame is received by the transmitting station.

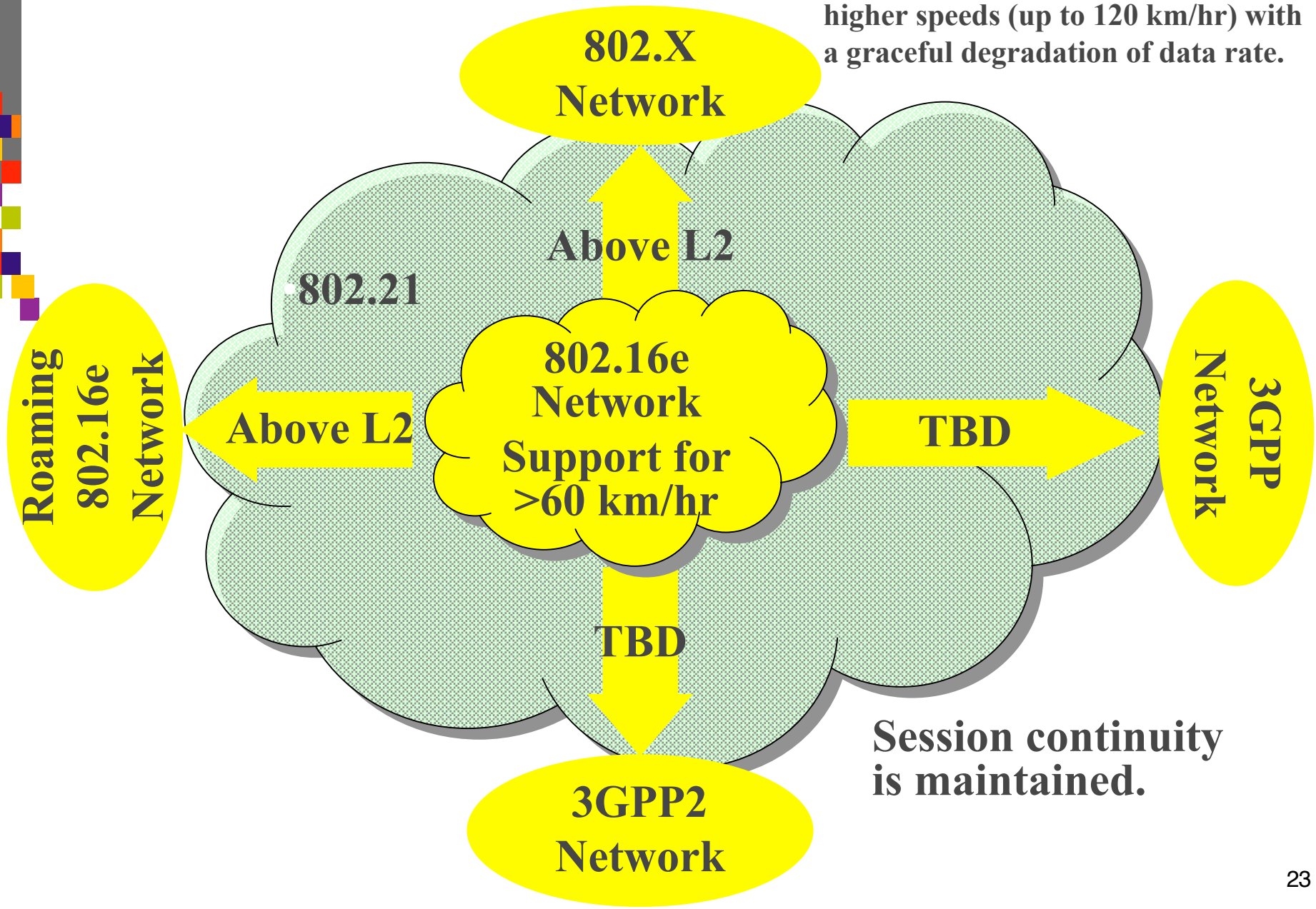
Definitions - continued

- Spectral Efficiency - Sustained spectral efficiency is computed in a loaded multi-cellular network setting. It is defined as the ratio of the expected aggregate throughput (taking out all PHY/MAC overhead) to all users in an interior cell divided by the system bandwidth. The sustained spectral efficiency calculation shall assume that users are distributed uniformly throughout the network and shall include a specification of the minimum expected data rate/user.
- Space-Time Processing – This is a general term covering a variety of technologies that leverage the multiple propagation paths a signal may take to improve airlink robustness.
- VoIP – This stands for Voice over Internet Protocol and refers in general to voice services that are delivered via packet protocol.

Appendix

Mobility & Handover

➢The system shall support mobile performance at a minimum of 60 km/hr with an option to support higher speeds (up to 120 km/hr) with a graceful degradation of data rate.



Session continuity is maintained.