WiMAX System Modeling Methodology

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WiMAX Forum Internal Use Only

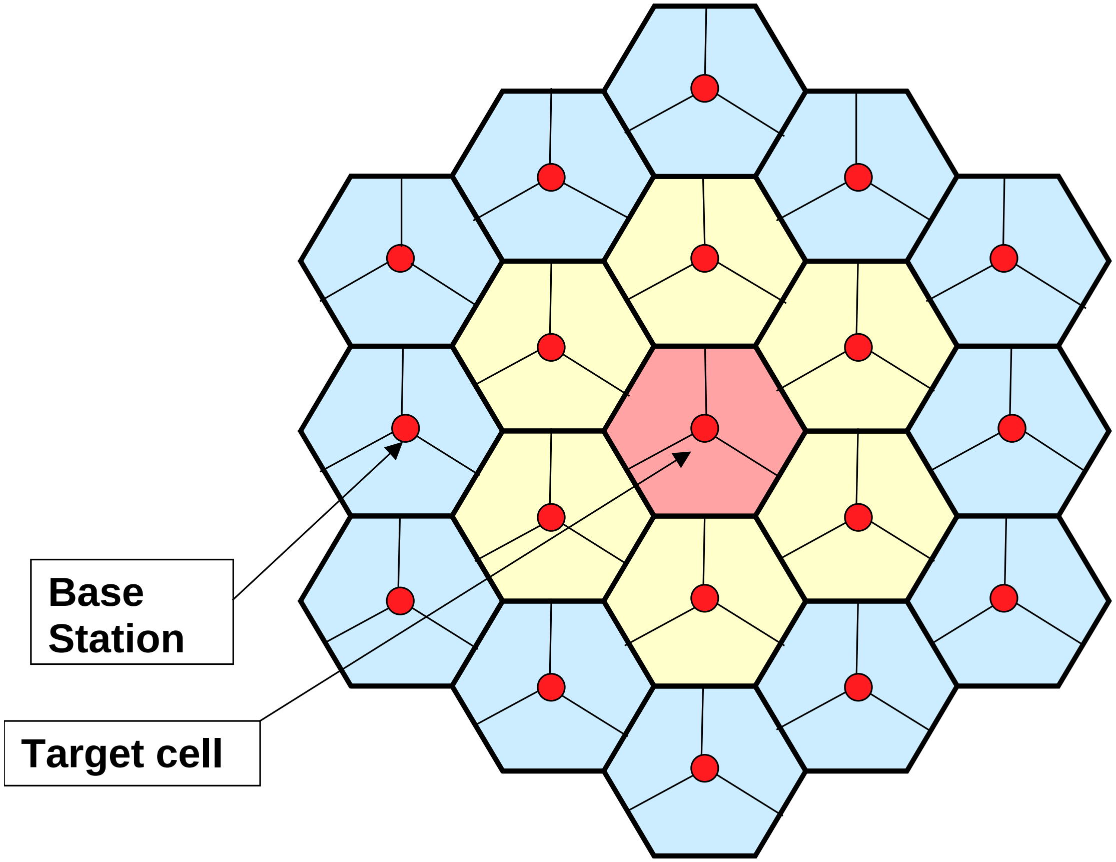
The current Plan

- Define a uniform methodology for WiMAX system level simulation
  - Adapt 3GPP and 3GPP2 documents
- Universities to create WiMAX simulations and produce data
  - Rensaler Polytechnic Institute (RPI): Simulating T1 replacement service over WiMAX links; estimate optimized parameter set
  - Information and Communication University (ICU) Korea : Compare WiBro, HSDPA vs WiMAX configurations for VoIP, Selected TCP applications
  - Beijing University of Posts and Telecommunications (BUPT): PHY abstractions, Link simulation outputs for system simulation
  - Washington University in Saint Louis (WUSTL): Methodology and Scheduler, HARQ, Power Control
- Publish results that can be used by MWG

Participating Forum members

- Service Providers
  - ATT, Bell Canada, Sprint, Verizon
- Equipment vendors
  - Lucent
  - Huawei
  - Alvarion
  - eAccess
  - ArrayComm
- Others
  - Intel
  - Venturi Wireless
- This is an evolving list with expression of interest from a number of other members

System Simulation Approach



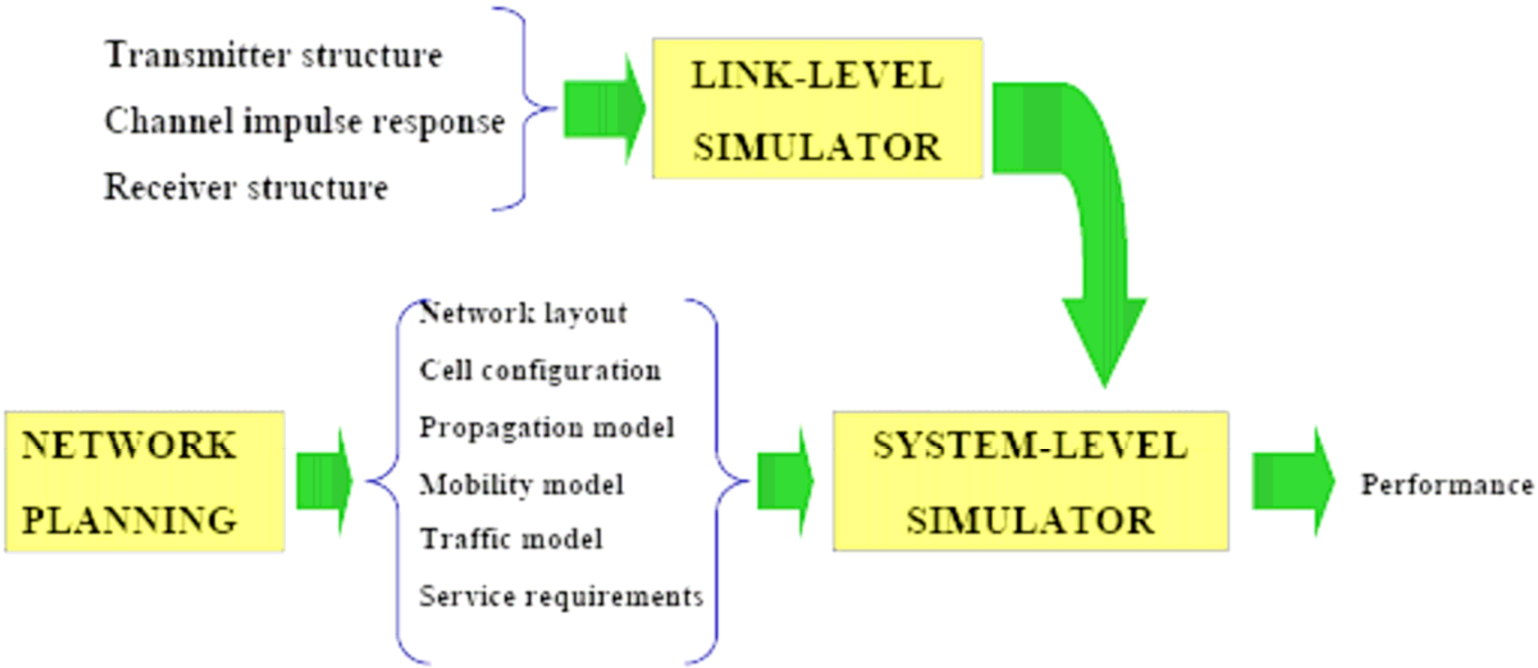
System Simulation Approach

- Simulate multiple WiMAX cells
- Model different applications with different levels of penetration
- Simulate application traffic streams;
  use realistic traffic models
- Distribute user session randomly among the cells
- Utilize neighboring cell traffic to create interference in the center cell
- Abstract PHY to a table/graph mapping physical condition to Block Error Rate (BLER)
- Apply generic MAC scheduler and MAC layer interfacing with PHY abstraction
- No link level simulation

System Simulation assumption

- Clarify the following items with help from MTG, vendor contributions
  - Antenna horizontal pattern:
    70 deg (-3 dB) with 20 dB front-to-back ratio
  - Site to site distance: 2800 m Or 1000 m
    (Need to do preliminary link budget analysis to set this distance – WiMAX performance Whitepaper Part I has this info)
  - Propagation model = 128.1 + 37.6 $Log_{10}(R)$
  - Power: -10 dB
  - Slow fading Model
  - Correlation between sectors:1.0
  - Correlation between sites: 0.5
  - Correlation distance of slow fading: 50 m
  - Carrier frequency: 3.5 GHz BS
  - antenna gain: 14 dB
  - BS total Tx power: Up to 44 dBm
  - Specific fast fading model
  - Channel width: 5/10 MHz
  - Frequency Re-use: 1

System Simulation Diagram



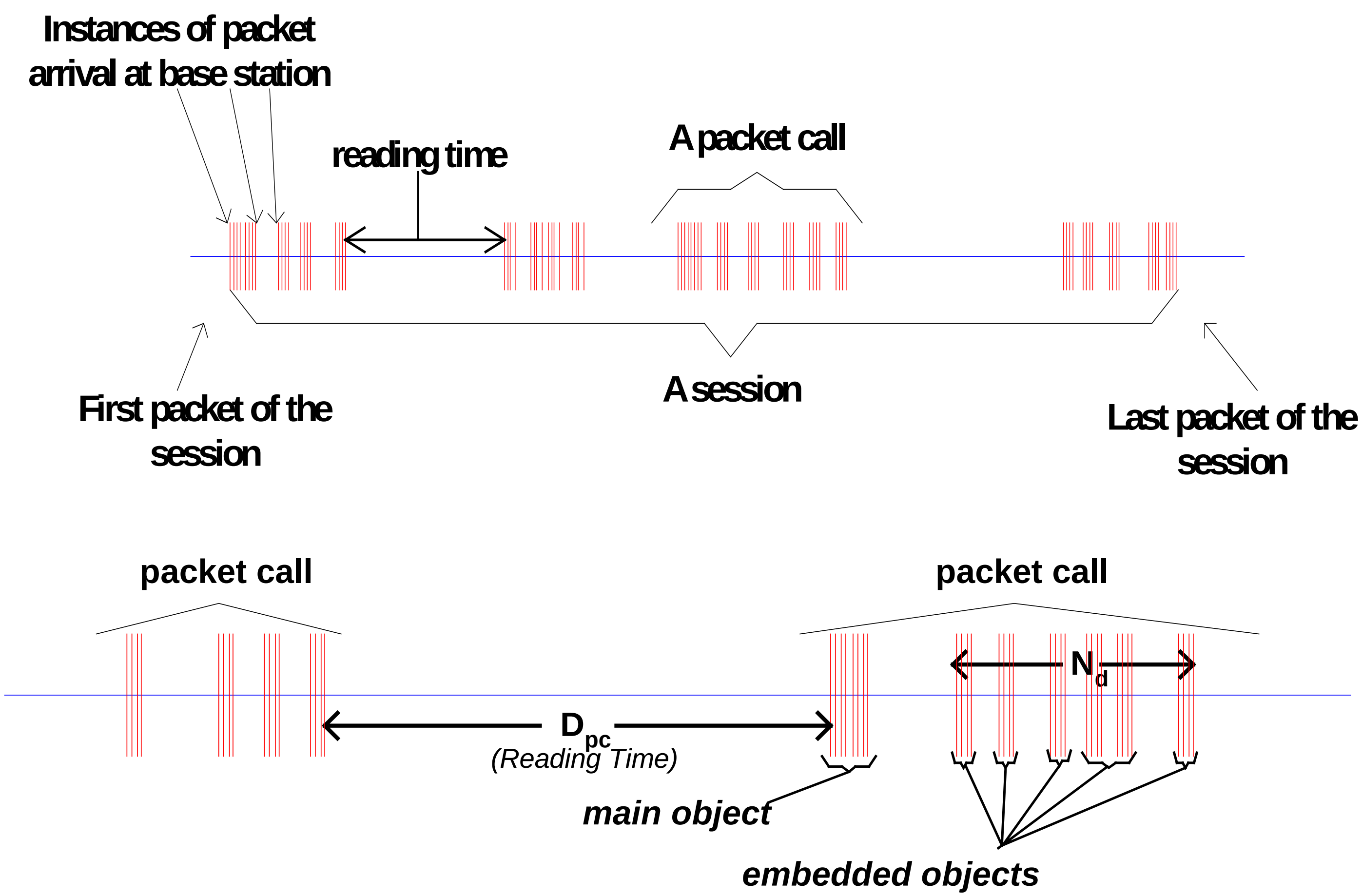
Interaction between radio network planning, link-level and system-level simulators

[Alvarion]

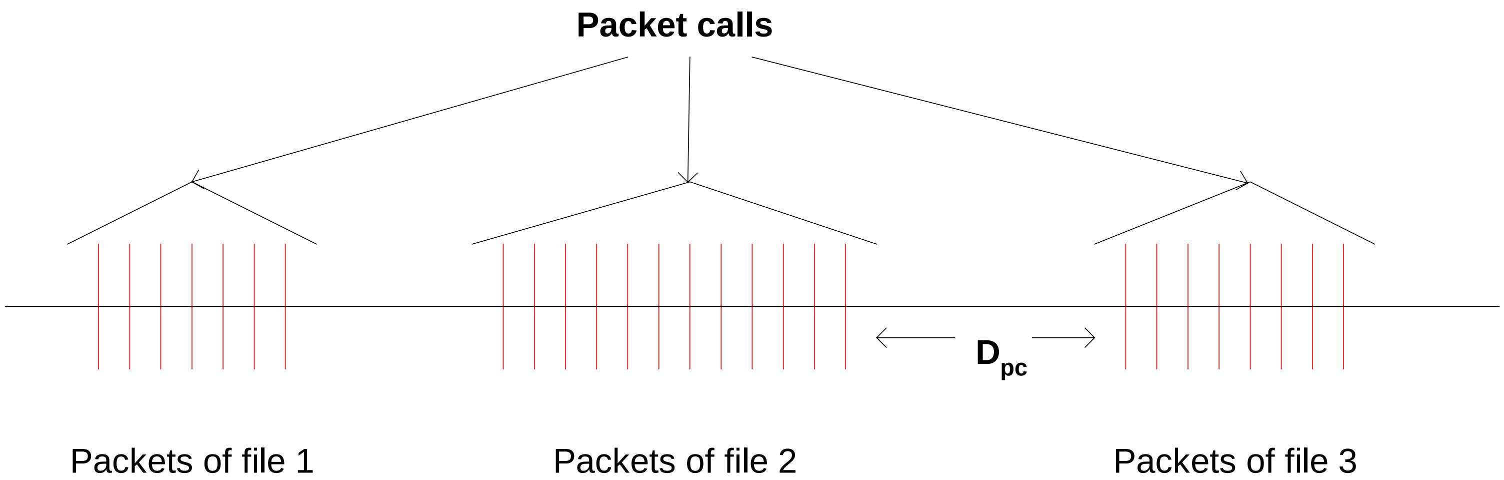
Traffic Models

- Full buffer
  - Advantages: Simple, Easily reproducible results, packets/sec
  - Disadvantages: Not representative of real applications, cannot estimate user capacity, delay characteristics
- Real queue models
  - HTTP
  - FTP
  - Non-Real-time TV

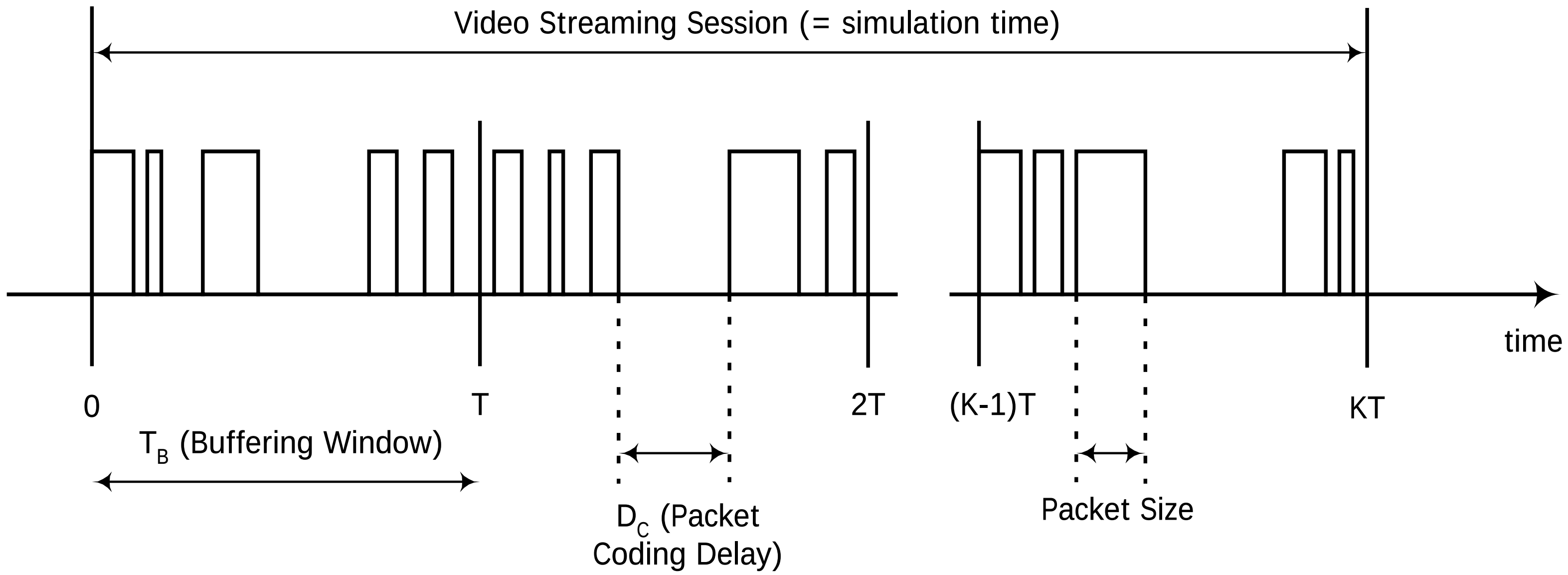
Traffic Models (HTTP)



Traffic Models (FTP)



Traffic Models (NRTV)



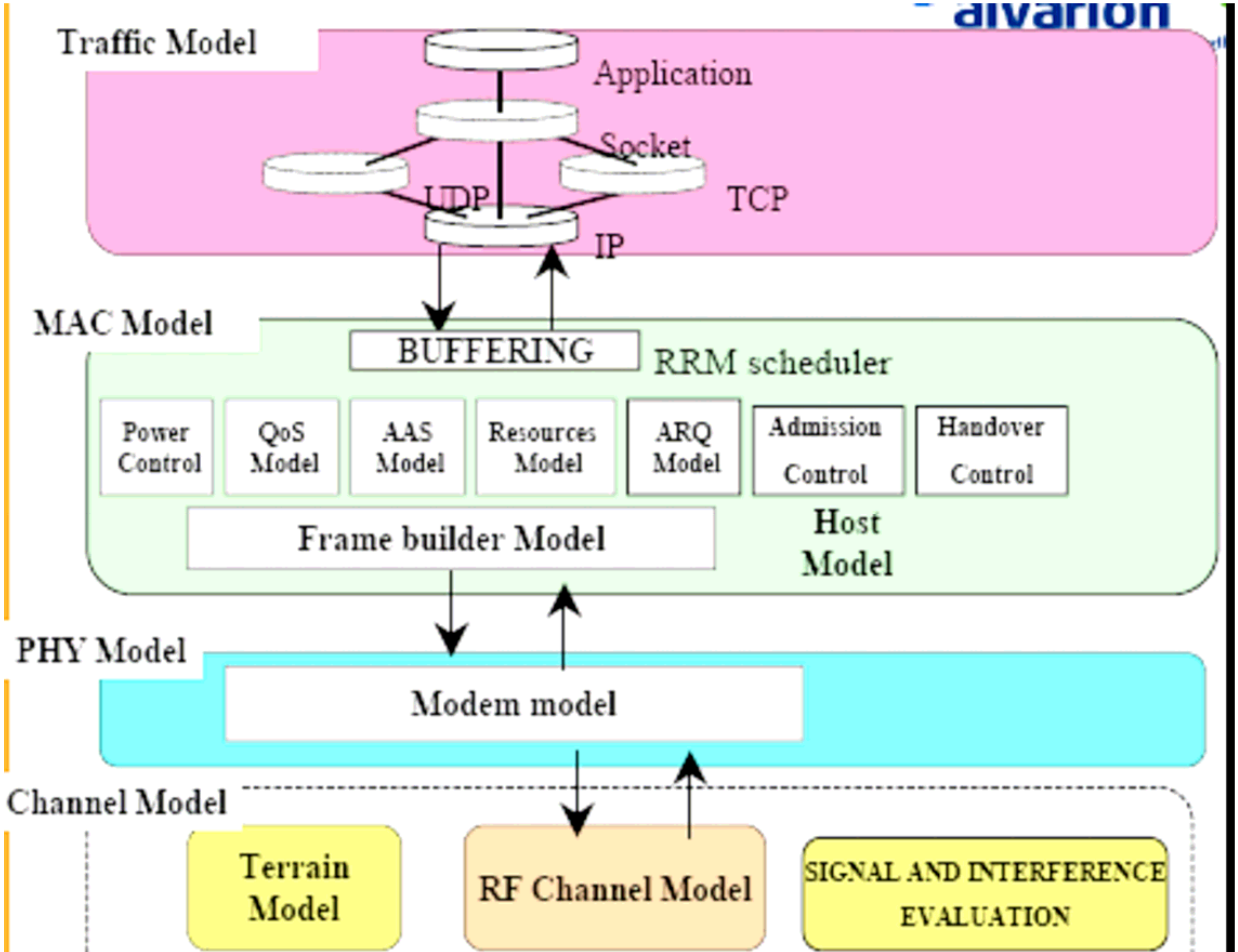
Protocol Layer modules

- TCP
- UDP
- RTCP
- …

NS2 Eco-system Code

- Existing system simulation modules for
  - 802.11
  - UMTS
  - GSM
  - LAN

System Simulation Modules



[Alvarion]

Results from example simulation run

- Comparing the results

technology	throughput per sector/per channel		
	downlink		uplink
	1 Rx	2 Rx	2 Rx
1XEVDO rev A 2.5 MHz	0.9 Mbps	1.3 Mbps	0.5 Mbps
HSPA 10 MHz	2.4 Mbps	3.6 Mbps	1.5 Mbps
Mobile WiMax 2:1 DL/UL 2x2 -10 MHz	NA	14 Mbps	5.3 Mbps

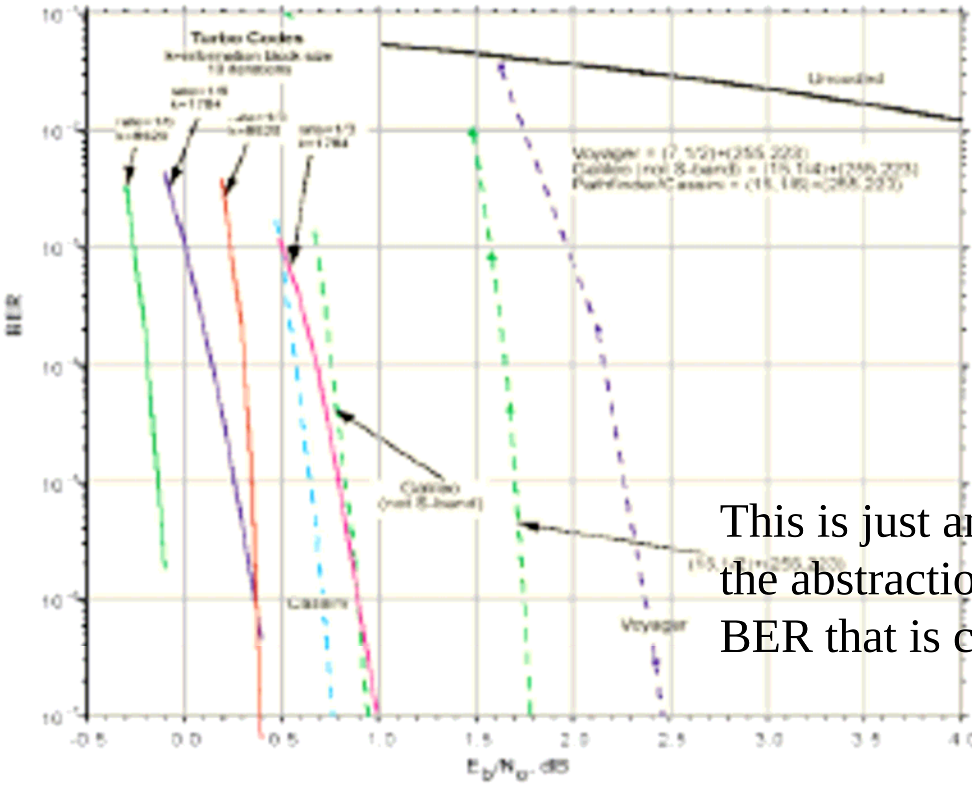
[Intel]

MAC layer model

MAC Layer Model Components:

- Scheduler
- HARQ
- Power Control
- Resource contention
- QoS
- Advanced topics
  - AAS
  - Admission control
  - Handover control
- frame builder interface
  - How packets are split into frames
  - Queuing of Frames
  - Receiving ACKs
  - Determining Frame drop event based on simulated BLER (from PHY abstraction)

Linking MODEM Performance (Example)



Modem Performance:
BER vs SNR

$$BER = f_4\left(\frac{E_b}{N_0}\right)$$

This is just an example. In general, the abstraction model would provide BER that is correlated in time.

MAC level simulation can simulate packet successful reception by a random draw that accounts for:

- -BER
- -Packet size

This is just an example. In general, the abstraction model would provide BER that is correlated in time.

[Alvarion]

Joint PHY-MAC Abstraction (Example)

- **Interaction of physical layer events with MAC layer events**
  - Event driven network simulation
- **Simplified model for general communication system:**

$$P_R = f_1(\text{Geography})$$

$$I = f_2(\text{Geography, traffic model})$$

$$\frac{E_b}{N_0} = f_3(P_R, I)$$

$$BER = f_4\left(\frac{E_b}{N_0}\right)$$

$$FrameLoss = f_5(BER)$$

P_R received power

I interference

BER bit error rate

[Alvarion]

Joint AWG & MTG Activity: PHY-MAC Abstraction for OFDMA

- Help on defining the right level of abstraction
- Help from MTG: Guidance and model reviews
- Utilize a Exponential Effective SIR Mapping (EESM) type of method to reduce complexity
- Meeting to collect ideas and come out with a common method

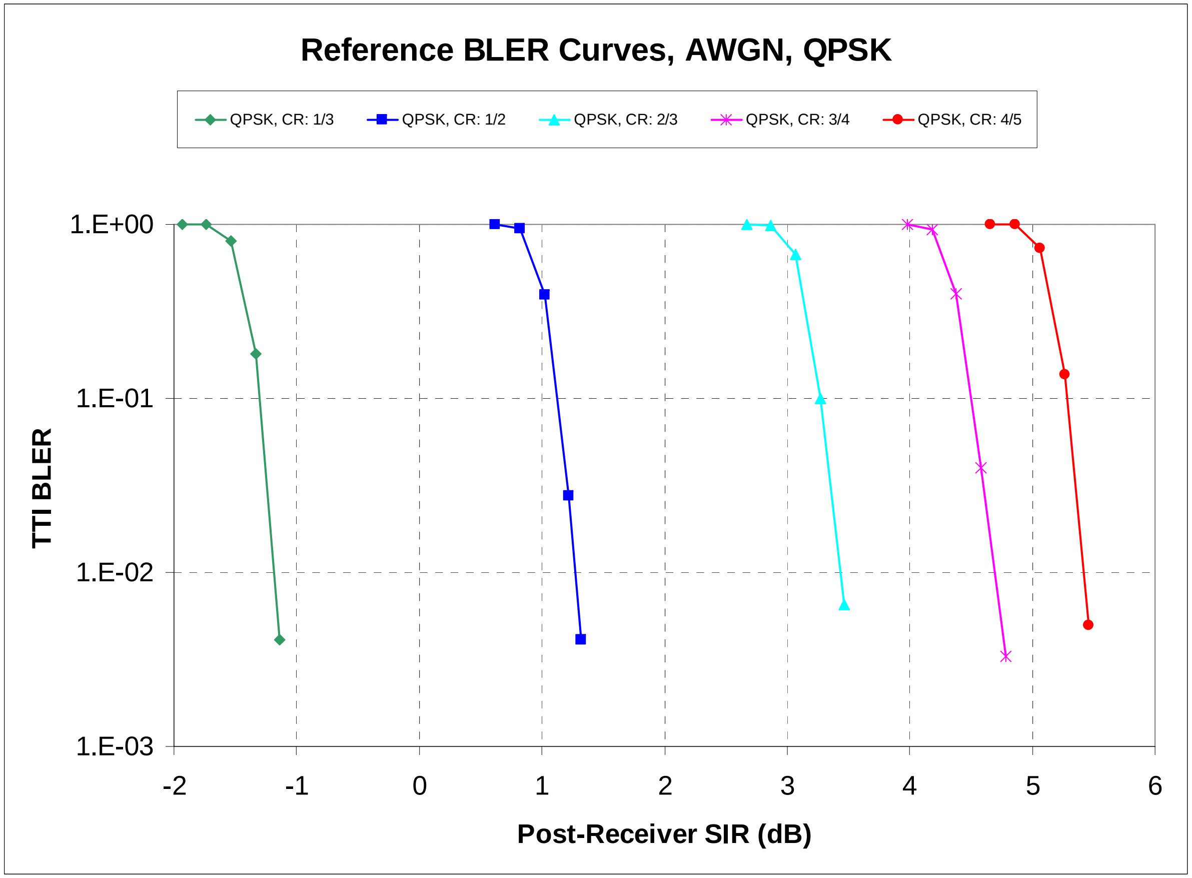
Channel Model

- Dropped user mobility characteristic is based on probability
- The fading characteristic of the user is then determined using channel model formulas
  - We are seeking contributions for broadband channel models

Channel Model	Multi-path Model	# of Paths	Speed (km/h)	Fading	Assignment Probability
Model 1	Ch-100	1	30	Jakes	0.1
Model 2	Ch-100	1	120	Jakes	0.1
Model 3	Ch-104	6	30	Jakes	0.1
Model 4	Ch-104	6	120	Jakes	0.1
Model 5	Ch-102	4	3	Jakes	0.3
Model 6	Ch-103	6	3	Jakes	0.3

Example BLER graph

- Representative graph for OFDM



Representative Beta table

- Beta are determined from pre-runs
- Seek contributions from vendors
- Also utilizing BUPT to supply results from link runs
- Include table from your main document

Example simulation run

- OFDMA assumptions

Number of Cells	19
Number of Sectors per Cells	3
Number of MSSs per sector	20 users in Active State
Minimum Distance Between BS & MSS	35 m
Distance between nearest BSs	3000 m
FFT/IFFT Size	1024
Permutation	PUSC
Antenna Structure	1x1
CIR Feedback Delay	5ms Frame
Entire Bandwidth	10 MHz
Centre Frequency	2.6 GHz
HARQ	Chase-Combining
Maximum Number of Retransmission	3

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[Intel]

Example simulation run

- DL/UL assumptions

Simulation assumption for downlink

Transmission Power	45.0 dBm
Tx Antenna Horizontal Pattern	70 degrees (-3dB) with 20dB front to back ratio
Transmit Antenna Gain	15 dBi
Thermal Noise	-174.0 dBm/Hz
Noise Figure	10.0 dB
Receive Antenna Gain	-1.0 dBi

Simulation assumption for uplink

Transmission Power	23.0 dBm
Rx Antenna Pattern	Omni-Direction
Transmit Antenna Gain	-1.0 dBi
Thermal Noise	-174.0 dBm/Hz
Noise Figure	5 dB
Receive Antenna Gain	15 dBi

[Intel]

WiMAX Profile elements

- List of relevant profile elements
- Open discussion
  - List profile elements with the values used by Intel (Alamouti slides)
  - We need vendor/operator participation to review and refine the numbers

CP ratio (G)	1/8	
Frame length (ms)	5	
DL/UL Ratio	2:1	
Bandwidth (MHz) (BW)	10	5
FFT Size (N_{FFT})	1024	512
Sampling frequency (MHz) (Fs = floor(n*BW*8000)/8000)	11.42	5.71
Subcarrier spacing (KHz) ($\Delta f = Fs/N_{FFT}$)	11.16	11.16
Useful symbol time (µs) ($T_b = 1/\Delta f$)	89.64	89.64
CP Time (µs) ($T_g = G*T_b$)	11.20	11.20
OFDMA symbol time (µs) ($T_s = T_b + T_g$)	100.84	100.84
Sampling time (µs) (T_b/N_{FFT})	87.54	175.07
Number of OFDMA symbol per frame	49	49
TTG	29.41	29.41
RTG	29.41	29.41
Number of OFDMA symbol per frame for data	48	48
Number of OFDMA symbol per frame for DL data	36	36
Number of OFDMA symbol per frame for UL data	12	12

[Intel]

References

- 3GPP, TS25-892, OFDM Modeling
- 3GPP, TS25-996,
- 3GPP2, C.R1002-0, CDMA2000 Evaluation Methodology, Rev. 0, December 10, 2004
- SCM-111, SCM Text V2.3, Spatial Channel Model AHG