3G/4G research topics for WINLAB focus projects

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Disclaimer

All 3G information and data found in this talk is publicly available from the corresponding standardization bodies

URL: ftp://ftp.3gpp2.org

- **Username: anonymous**
- **Password: your_email_address**

URL: http://www.3gpp.org

CDMA2000 1x-EV-DV Numerology

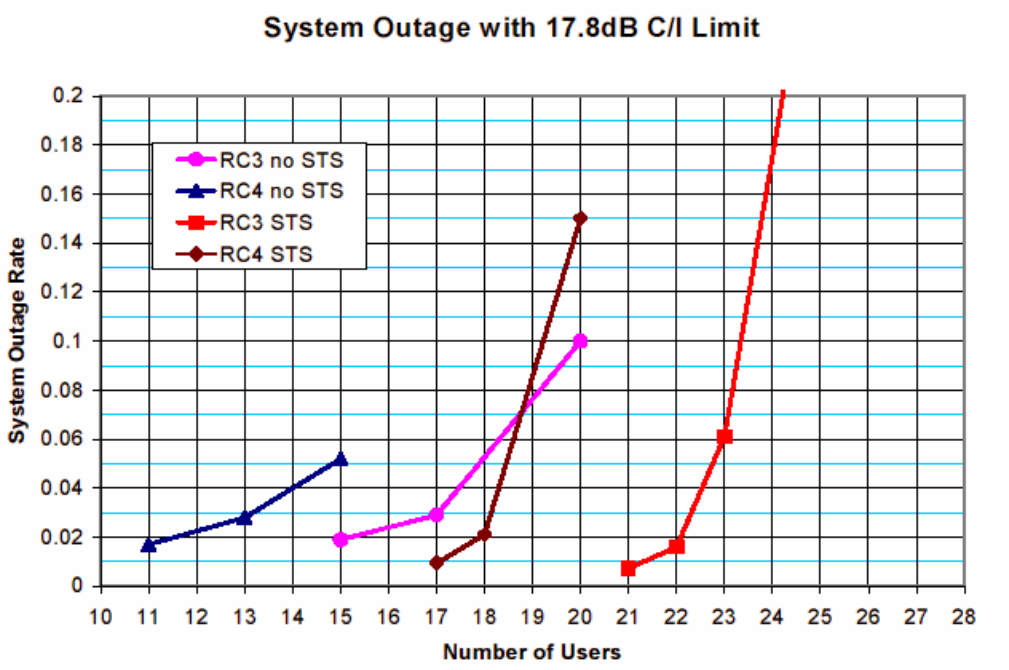
- Chip Rate 128*9600 = 1228800 chips/sec
- Number of Carriers = 1
- Power Control rate = 800Hz
- Walsh length from 32 up to 256 depending on the channel
- Max. BTS transmit Power = 20 W
- Maximum achievable geometry ~ 18dB (no equalization)

Channel model mix

Channel Model	Multi-path Model	# of Fingers	Speed (kmph)	Fading	Assignment Probability
Model A	Pedestrian A	1	3	Jakes	0.30
Model B	Pedestrian B	3	10	Jakes	0.30
Model C	Vehicular A	2	30	Jakes	0.20
Model D	Pedestrian A	1	120	Jakes	0.10
Model E	Single path	1	0, f_D=1.5 Hz	Rician Factor K = 10 dB	0.10

Model	Finger1 (dB)	Delay	Finger2 (dB)	Delay (Tc)	Finger3 (dB)	Delay (Tc)	FURP (dB)
Ped-A	-0.06	0.0					-18.8606
Ped-B	-1.64	0.0	-7.8	1.23	-11.7	2.83	-10.9151
Veh-A	-0.9	0.0	-10.3	1.23			-10.2759

Voice Capacity for channel mix (STS)



Voice Capacity Max C/I 17.8 dB Capacity		
	RC3	RC4
With STS	22	18

Most of channels here are single path fading

Data Throughput

Shannon gain 29%

Sector Throughput (kbps)			
	C/I Limit 13 dB	C/I Limit 17.8 dB	Percent Gain
10 users, 3 kmph	1678	1856	10.6%
20 users, 3 kmph	1763	1949	10.6%
10 users, 30 kmph	856	952	11.2%
20 users, 30 kmph	926	981	5.9%
10 users, 100 kmph	774	844	9.0%
20 users, 100 kmph	785	854	8.8%

	System Throughput (HTTP Test Case, C/I Limit of 13 dB)	
	Average Network Throughput	Average Offered Load
44 users, HTTP	724	730

UMTS and CDMA-2000-3x

- **UMTS High Speed Dowlink Packet Access (HSDPA)**
- **Multi-carrier CDMA-2000-3x (Spreading Rate 3)**
- **Roughly 3 times 1x-EV-DV capacity**

3G positives

- **True ubiquity:**
  - **Global Coverage area. Ad-Hoc local networks (IEEE-802.11) will have hard time to match**
  - **Support for true mobility (works even at high mobile speeds)**
  - **Indoor/outdoor**
- **High availability due to centralized (and expensive) network management**

3G negatives

- **Relatively low data rates for today's bandwidth hungry broadband applications like streaming video, video conferencing, DB updates, etc.**
- **Difficulties supporting large numbers of low rate messaging users (MMS)**
- **Support for circuit switched voice and packet switched data complicates network management**

Need for 3.5G and 4G

- **Need for a true mobile ubiquitous broadband solution**
  - **Rates up to 20Mbps/sector**
  - **Support for mobile speeds up to 200km/hour (Japan, EU).**
- **All packet switched network to simplify network management**
- **Support for QoS management**

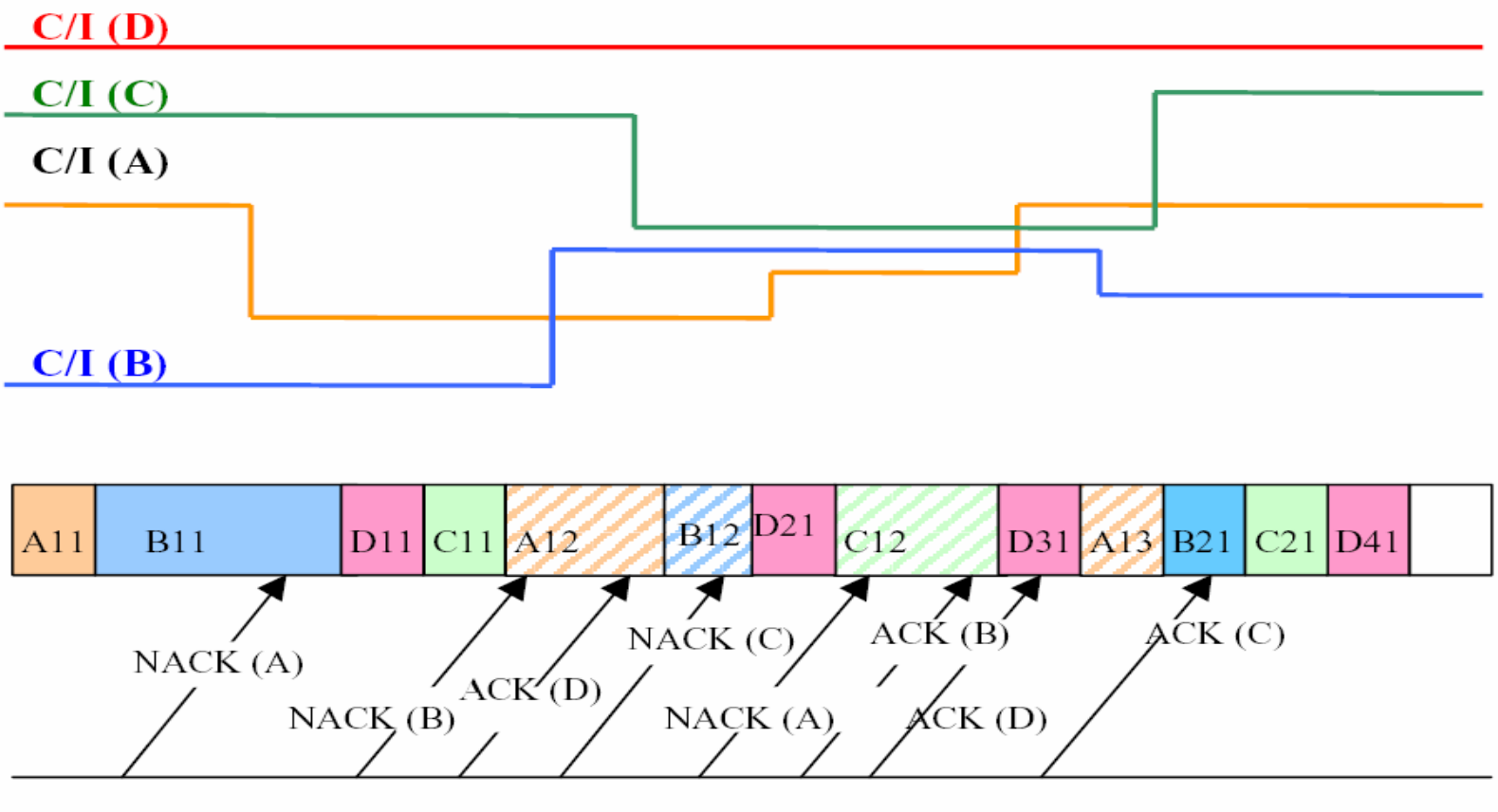
Probable 3.5/4G features

- larger bandwidth than 3G (20-50MHz ??)
- Multipath/Doppler resistance modulation scheme
- Voice over IP
- Mobile IP
- Smart channel sensitive scheduling to enable QoS management and utilize multi-user diversity
- Adaptive Coding/Modulation: asynchronous H-ARQ with Incremental Redundancy and TCM or BICM CMS.
- RF enhancements in form of Adaptive Antennas; MIMO
- Multi-level user admission (active, hot stand-by, cold-stand-by, dormant, etc) to facilitate large number of MMS users

Possible WINLAB focus projects

- **Combined Multi-Path Doppler resistant signaling:**
  E.g.: IOTA-OFDM [2] with and without spreading
- **2D Time-Frequency double dispersive channel estimation and equalization**
- **Adaptive modulation and asynchronous H-ARQ:**
  - **Optimal/sub-optimal QAM demodulation in the presence of channel interleaver**
  - **Soft combining across QAM constellations**
  - **Switching hand-off and H-ARQ interactions (OPnet/NS2 simulations)**
- **Advanced channel sensitive QoS scheduling algorithms**
- **Resource management for various traffic scenarios (large number MMS, few high rate users, etc)**

Example of AA H-ARQ operation



References

- **3GPP2 TSG-C WG5 documents:**
  - **3GPP2-C00-HARM_20011105004__1xEVDV_ForwardLink_Overview.pdf**
  - **C50-20010820-012 L3NQS System Simulation Results.pdf**
- **3GPP2 TSG-C WG3 documents:**
  - **C30-20020311-005R2_C.S0002-C v0.060.pdf**

1. **M.Medard, R.G.Gallager, *Bandwidth Scaling for Fading Multipath Channels,* IEEE Trans. Info.Theor. 48(4) 2002, 840-852**
2. **B.Floch, M.Alard, C.Berrou, *Coded Orthogonal Freq. Division Multiplex, IEEE Proc. 83, 1995, 982-996***