TCP performance over links with adaptive modulation and fast link retransmissions

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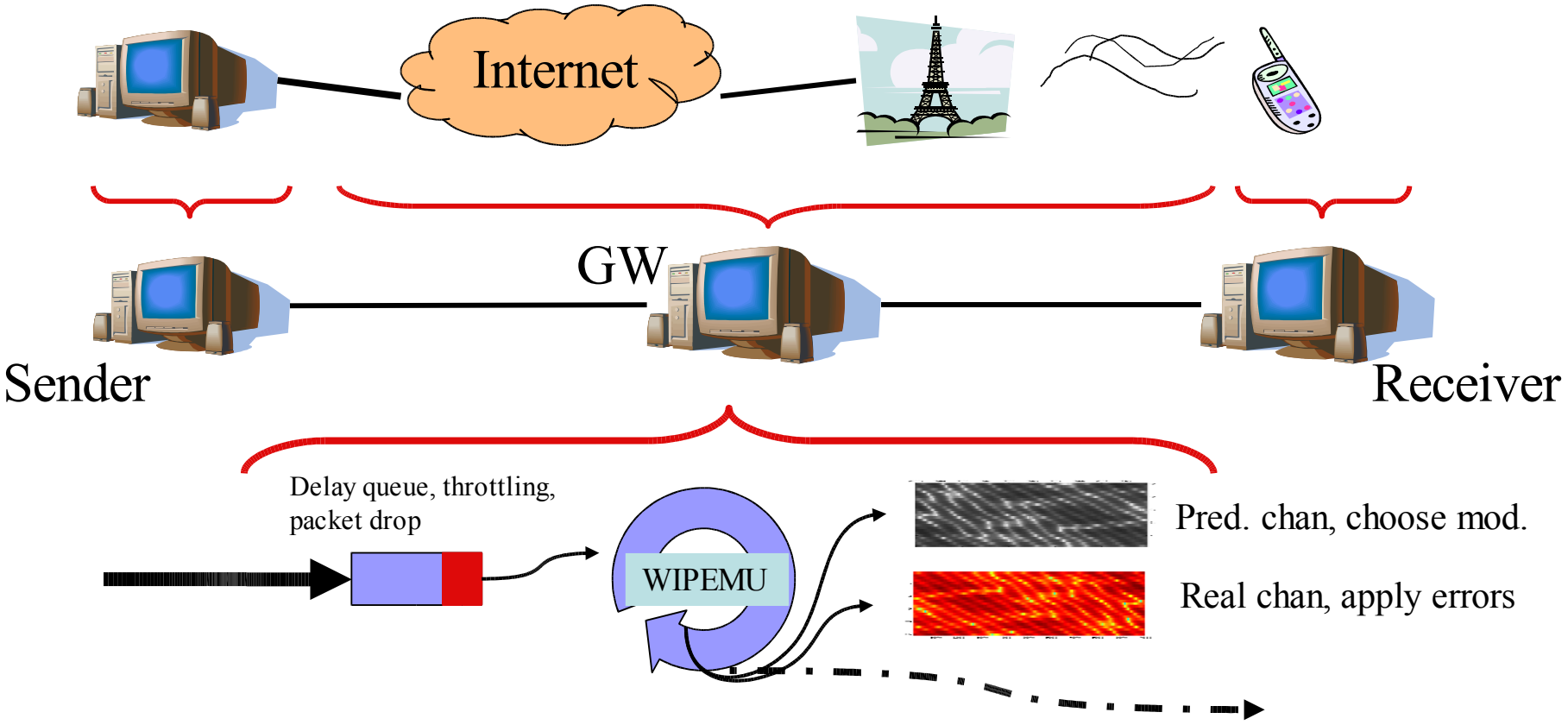
Background and purpose

- The Wireless IP project is putting forward a 4G system proposal...
- ... but how will it interact with the existing infrastructure (TCP/IP)?
- Purpose of studies: examine the effect of different phys/link layer design decisions on upper layers, give performance expectations

Agenda

- Emulation overview and setup
- Emulator validation
- Experiments with TCP over fix + adaptive modulation, with varying link ARQ and AM switching levels
- Looking forward

Emulation overview



WIPEMU - Validation

Bits/sym * 108 symbols/frame / 8

Bytes/frame * 1500 frames/s

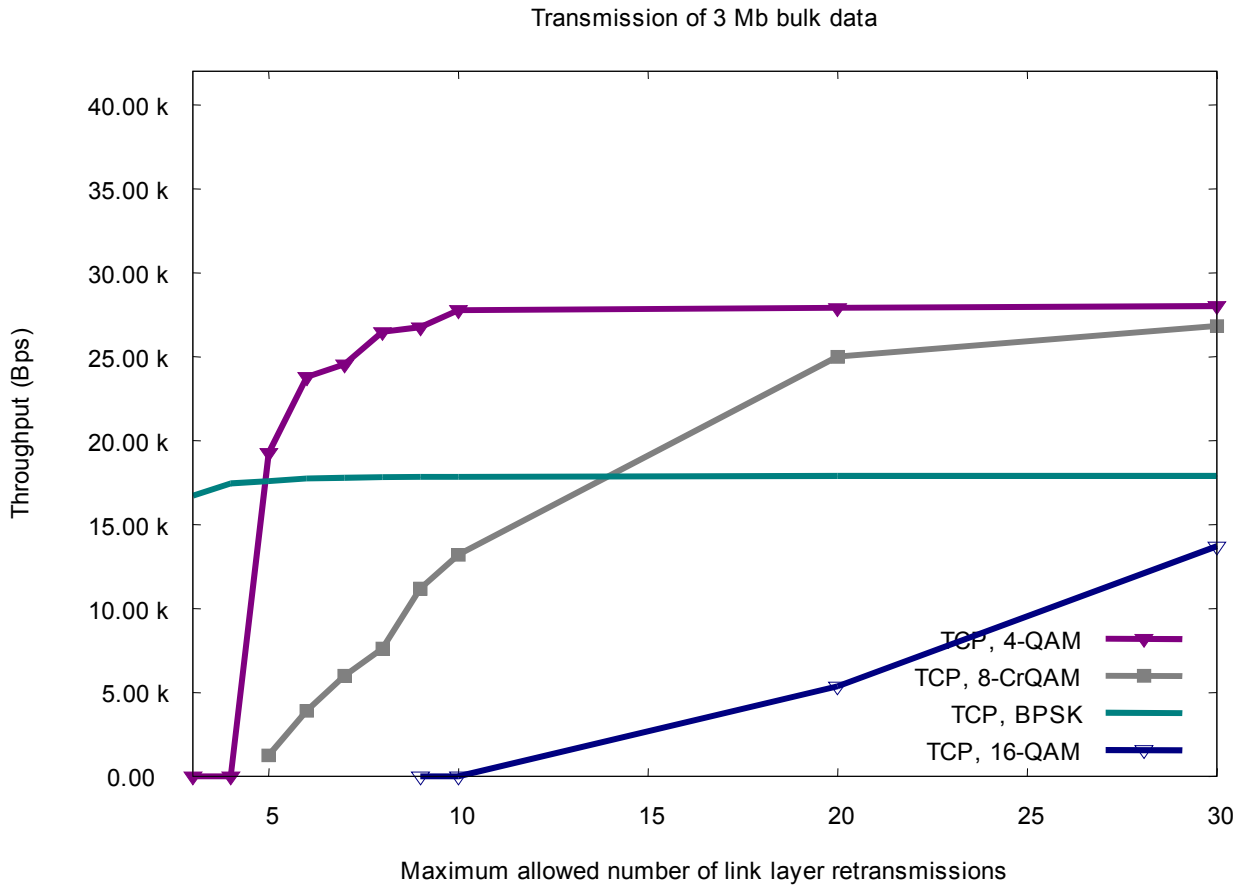
Modulation	Bits/ symbol	Bytes/ frame	Application throughput	Ideal throughput	App/ideal	TCP/IP header	App+header/ideal
BPSK	1	13,5	19516	20250 4050	0,964	0,027	0,991
4-QAM	2	27	38952	0	0,962	0,027	0,989
8-QAM	3	40,5	57268	60000	0,954	0,027 0	0,981
16-QAM	4	54	77552	81000	0,957	,027	0,984
32-QAM	5	67,5	95109	100500	0,946	,027	,973
4-QAM		1	115090	121500	0,947	0,027	0,974
128-QAM	7	94,5	136605	141000	0,969	0,027	0,996
256-QAM	8	108	156347	162000	0,965	0,027	0,992

Emulation parameters

- Channel parameters
  - 75 km/h, prediction horizon = 2 ms, pred. error NMSE 0.1 @ 16 dB mean SNR
  - 12 tap Jakes fading model + AR(1) shadow fading with 4 dB var.
  - Original WIP system; 108 data symbols per frame, 1500x25 frames per second (time x freq) (5 Mhz -> 25 x 200 kHz OFDM)
  - Most parameters can be changed easily (channel, time x freq, modulation + switching levels, queue size, …, !num_users, ! scheduling)

- Single user, one channel
  - C = 1500 x 1 frame/s * 108 * log2(modulation_order) / 8 byte/s

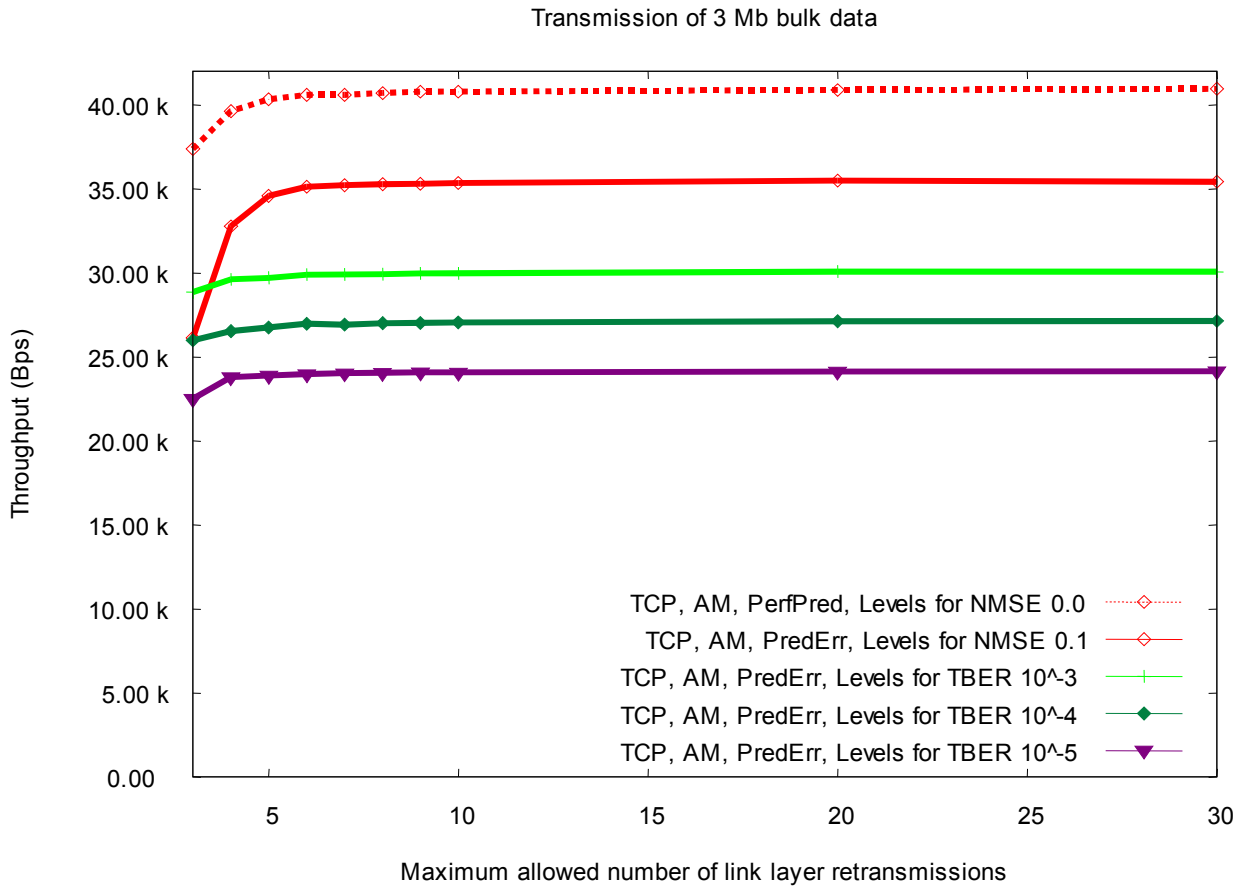
Fix modulation (at ~ 16 dB)



Obtaining better performance

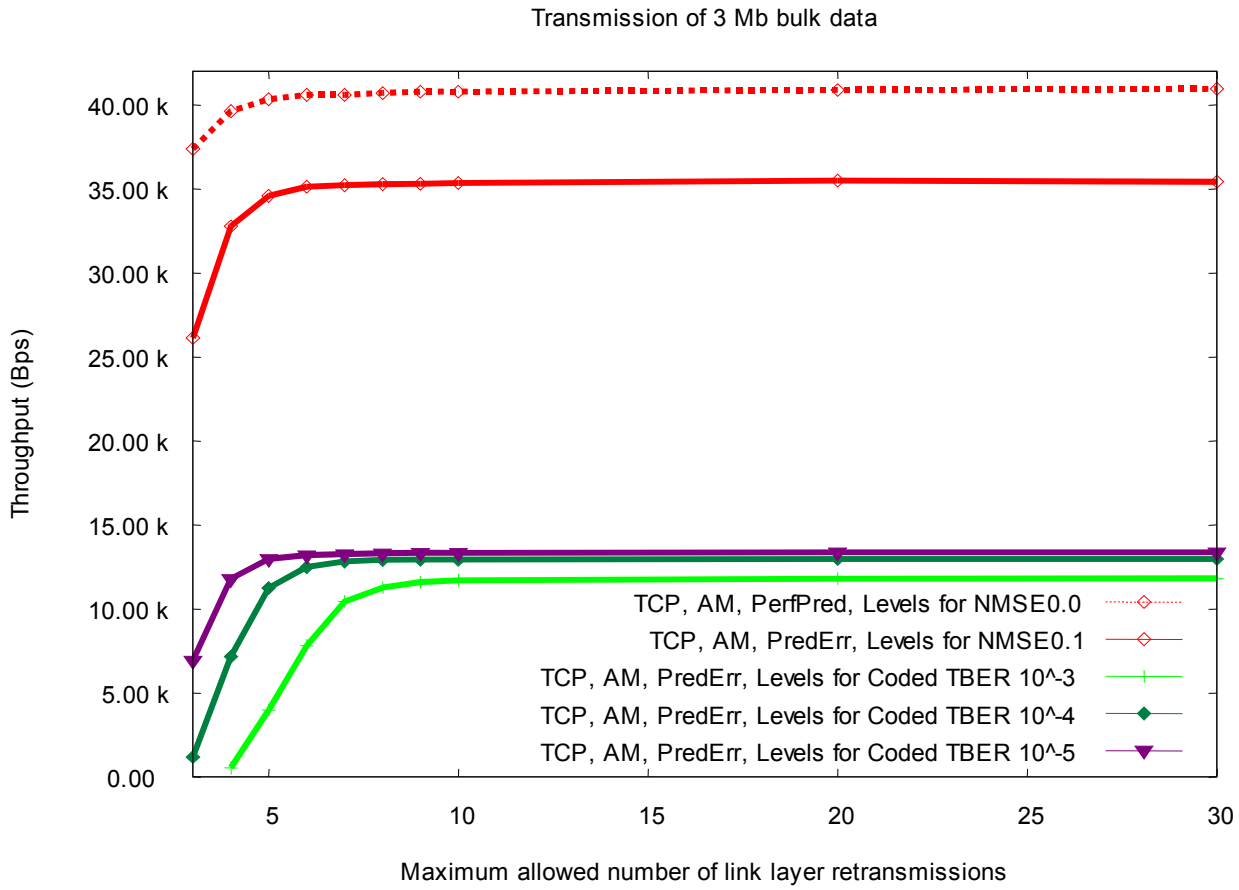
- Use adaptive modulation
  - Optimize for max throughput
  - Optimize for target BER
  - Uncoded / coded system

Adaptive modulation, non-coded

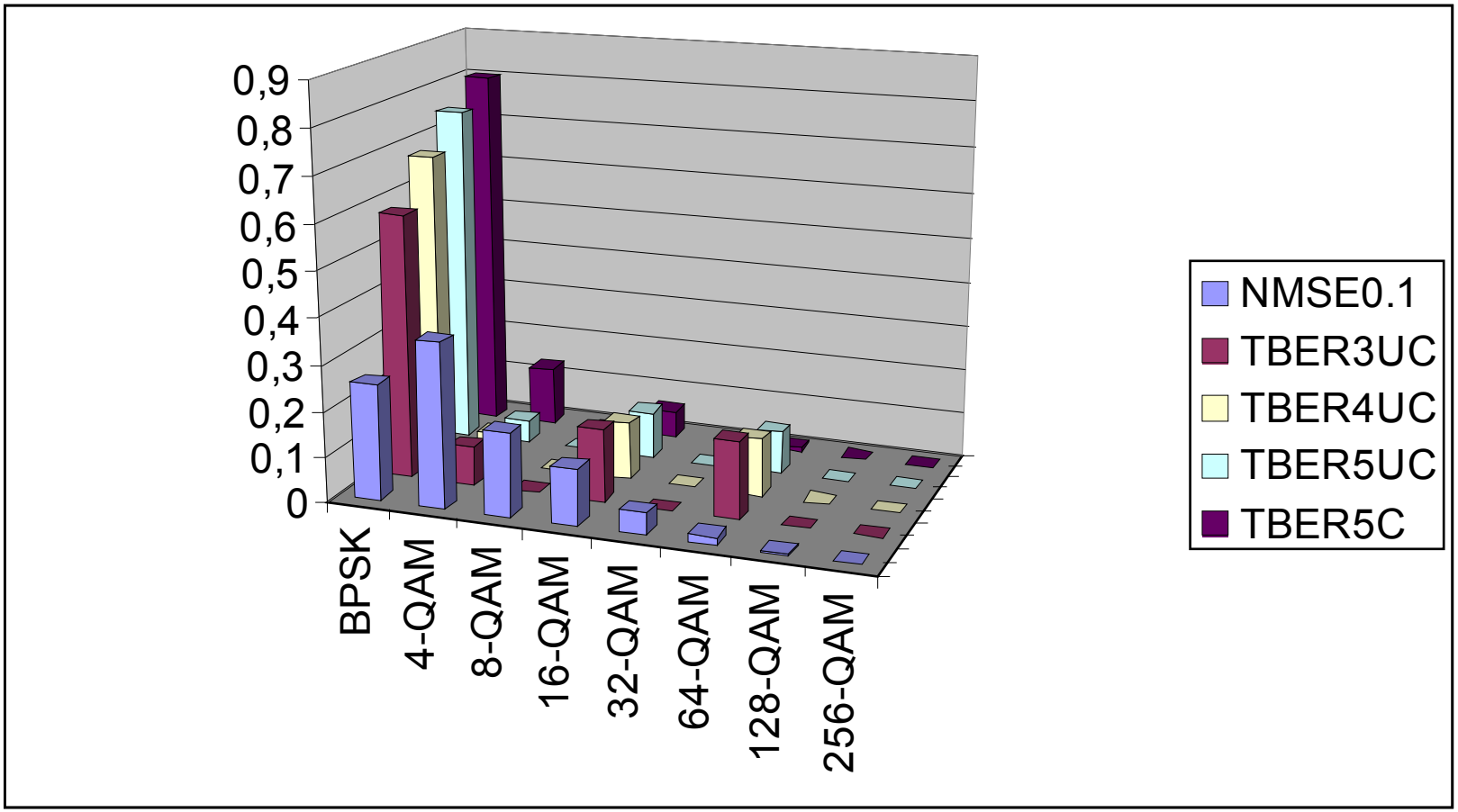


Adaptive modulation, coded

(not reliable results!)



Modulation level distribution



Analysis / Discussion

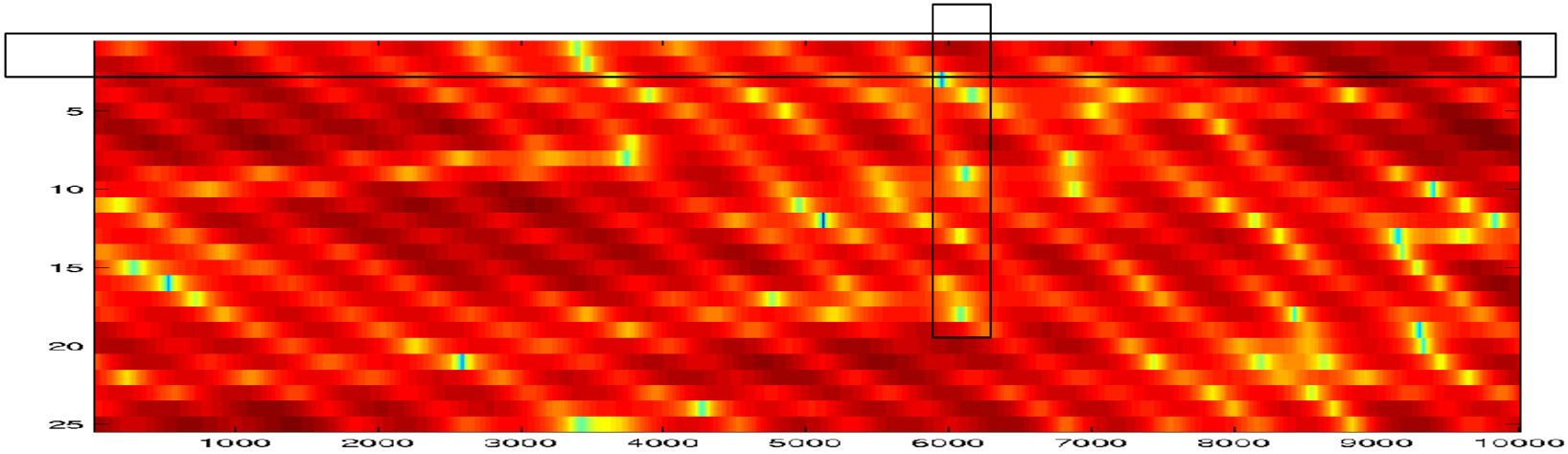
- Target BER assumes cut-off level, or use modulation+coding that preserves BER constraint below BPSK limit (< about 11-14 dB in this case)
- When below cut-off, another user will instead be scheduled for that time-frequency bin
- No suitable user -> transmit anyway?
- Is end-user throughput a good metric? (may be unfair comparison as seen earlier; a cut-off would produce even lower throughput!)

Looking forward

- WIPEMU – Work In Progress Emulator
  - Adjusting BER calculation to account for coding gains
  - Channel scheduling
    - For single and multi-user
  - Going multi-user to really see effects of Target BER constraints

Thanks for your attention

Questions, comments?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