Multiband OFDM for UWB Communication: Analysis and Extensions

Chris Snow, Lutz Lampe, and Robert Schober

{csnow, lampe, rschober}@ece.ubc.ca

Communication Theory Group

Department of Electrical and Computer Engineering

University of British Columbia

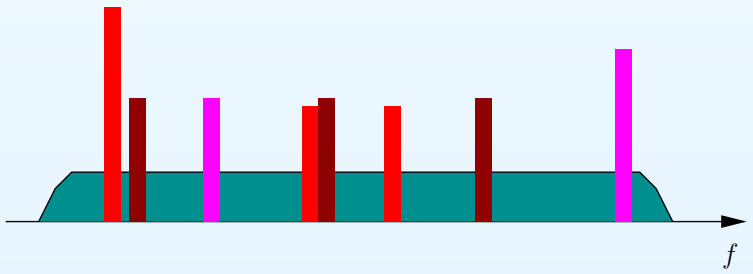
Vancouver, Canada

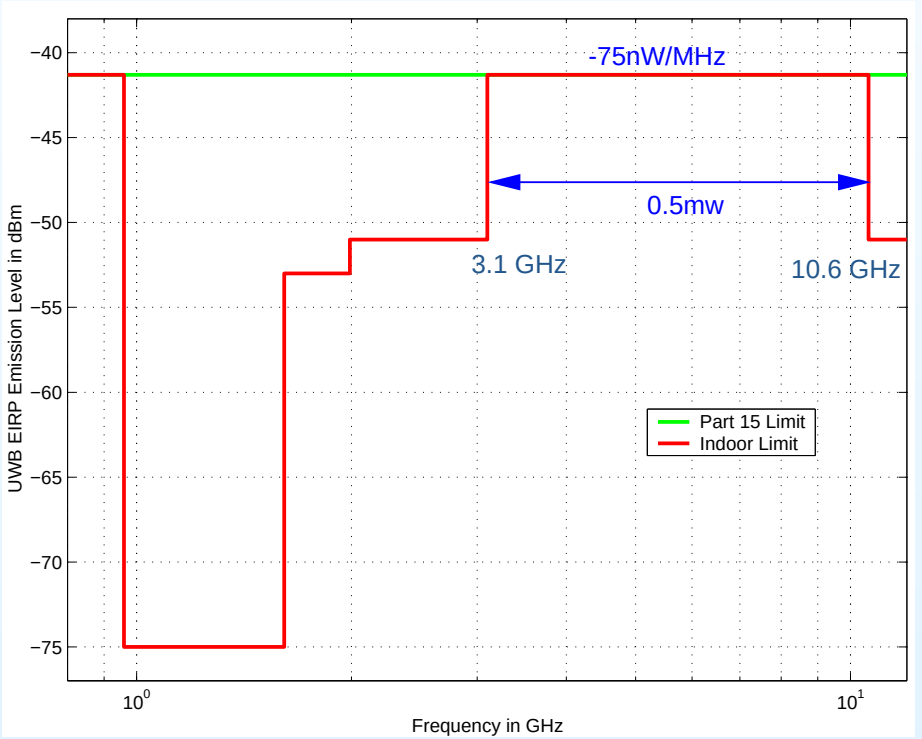
Agenda

- What is UWB?
- Multiband OFDM proposal for high data-rate UWB
- Our research in Multiband OFDM at UBC
  - How good is the standard?
  - How can we improve it?
  - Impact of interference?
  - Tools for analysis and design
- Future research directions

Ultra-Wideband (UWB) Wireless Transmission

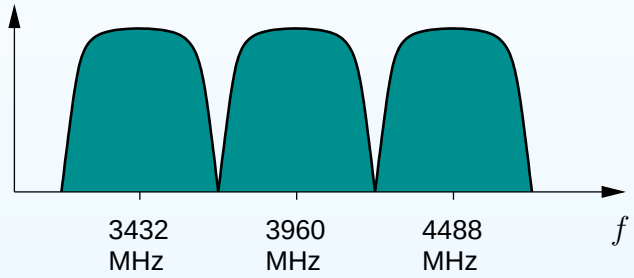
- UWB is a wireless technology that uses an ultra-wide bandwidth ($>$ 500 MHz) and operates at very low power
- Underlay (reuse spectrum, potential for interference)
- FCC: license-exempt operation in 3.1–10.6 GHz band



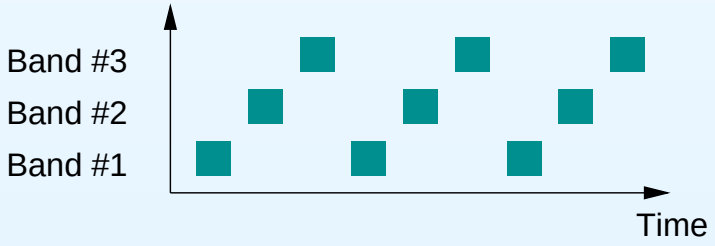


UWB — Multiband OFDM

- Multiband OFDM: leading proposal for high-rate UWB
- First-gen: use three 528 MHz bands in 3.1–4.8 GHz

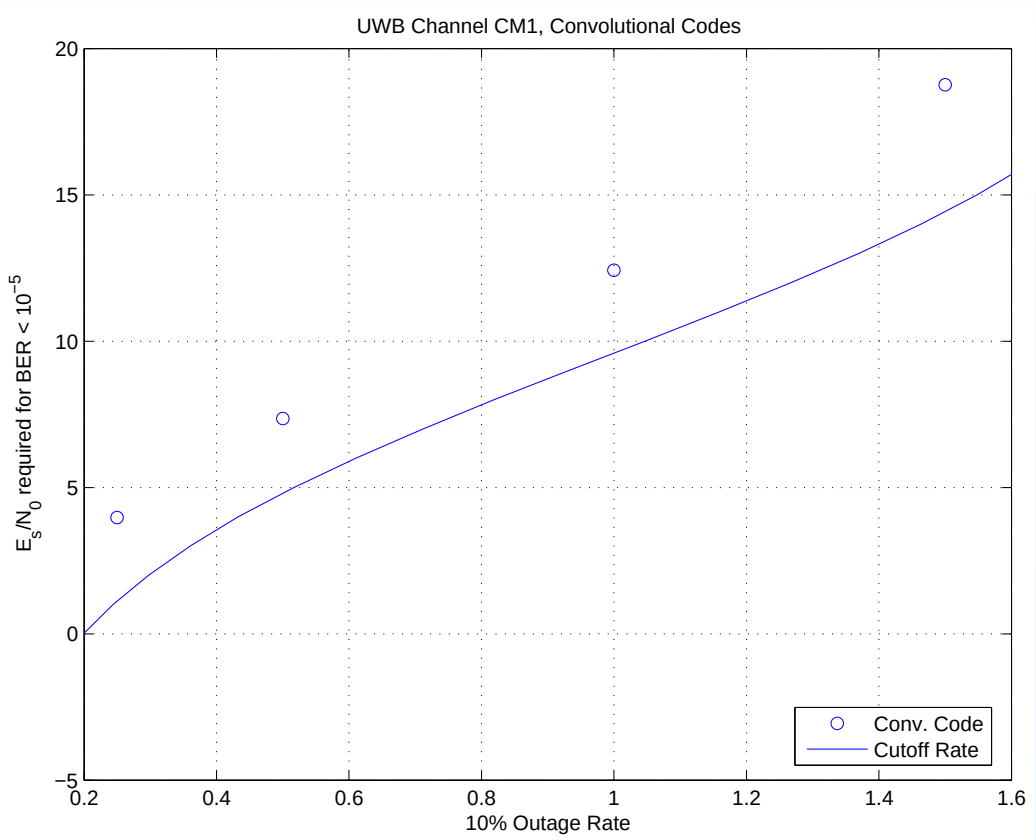


- Data rates between 55 and 480 Mbps
- Frequency hopping (simultaneously operating piconets)



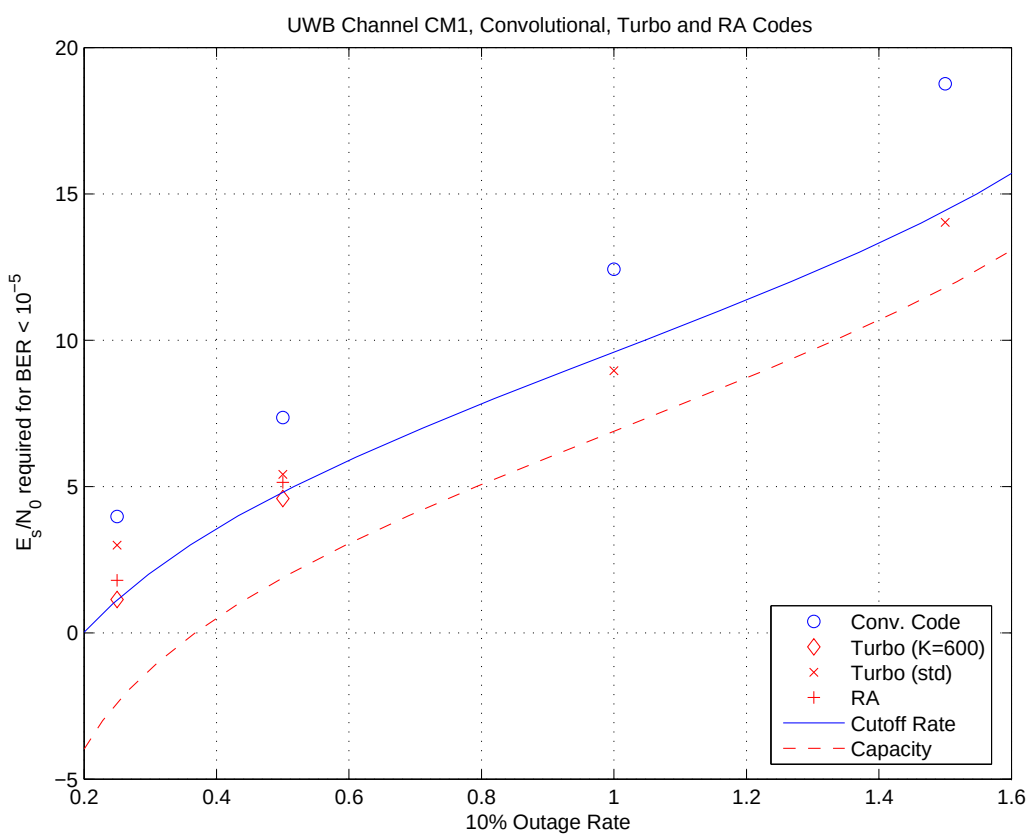
- Will be used in Wireless USB, Wireless 1394 (Firewire)

Contributions: How good is the PHY Layer?



- Standard proposal close to corresponding theoretical limit...

Contributions: PHY Layer Improvements



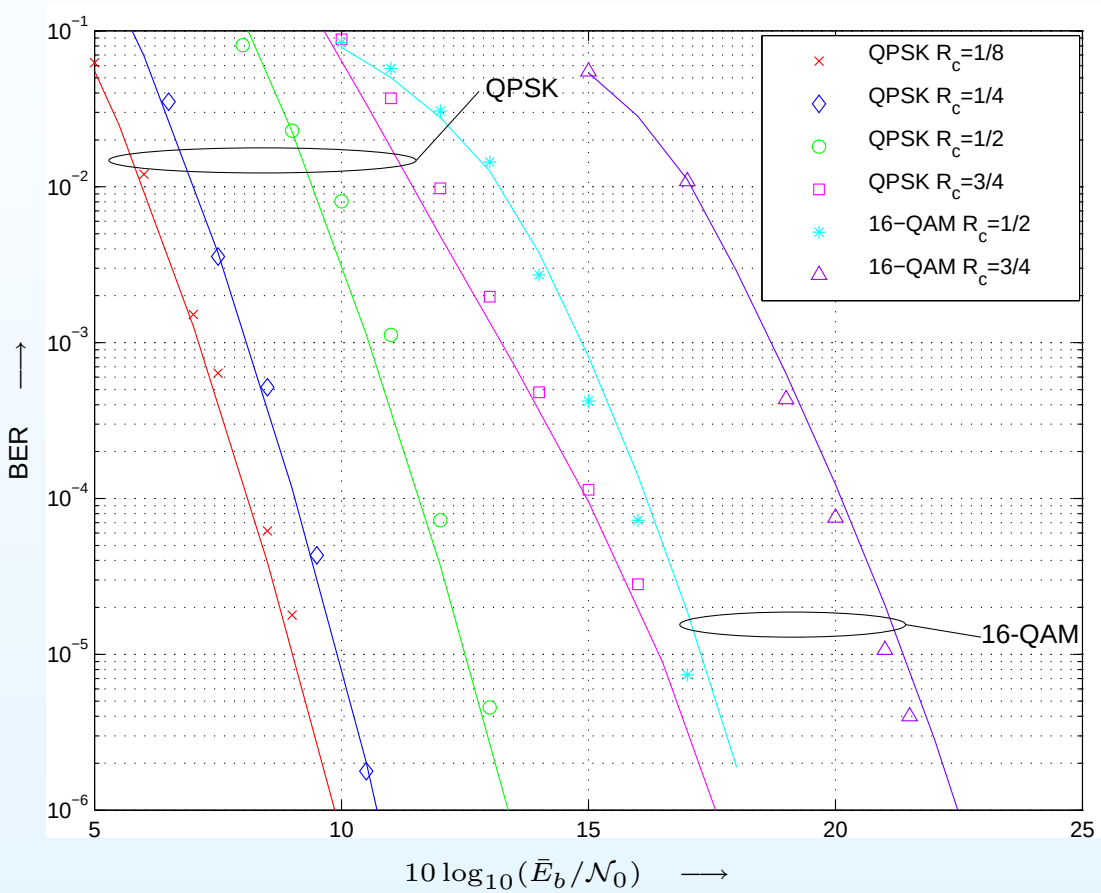
- Our extensions: improvement by up to 5 dB!

Contributions: PHY Layer Improvements

System	$10\log_{10}(\bar{E}_s/\mathcal{N}_0)$	Gain (dB)	% range increase
CC, no loading (Standard Proposal)	18.76	–	–
CC, CCB loading	15.38	3.38	**47 %**
CC, $D = 2$ clustered loading	15.47	3.29	**46 %**
TC, no loading	14.09	4.67	**71 %**
TC, CCB loading	12.48	6.28	**106 %**
TC, $D = 2$ clustered loading	12.58	6.18	**103 %**

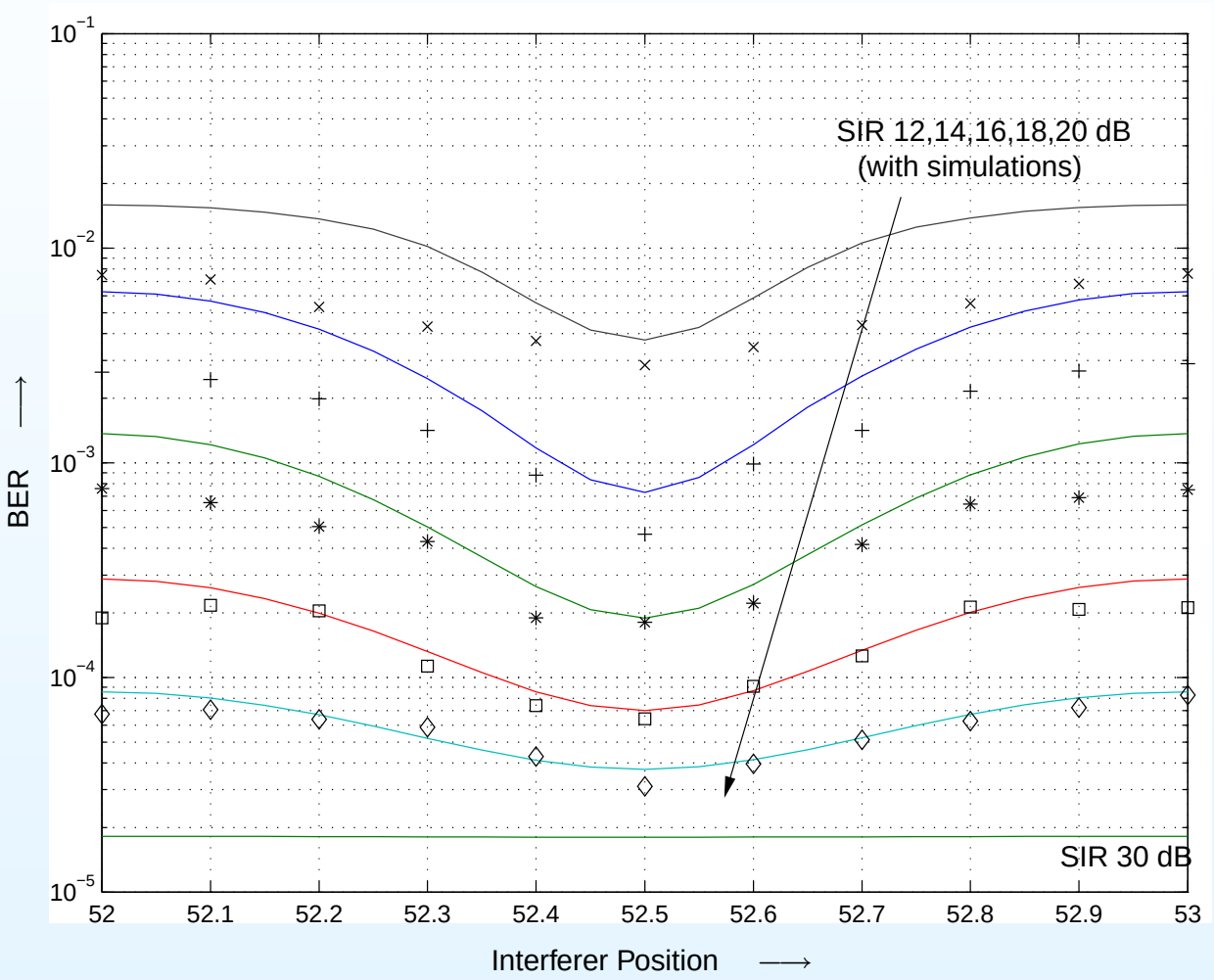
(Assumptions: UWB Channel CM1, 480 Mbps, free space path loss exponent, $\mathrm{BER} \leq 10^{-5}$ for the 90% best channel realizations)

Contributions: Error Bounds



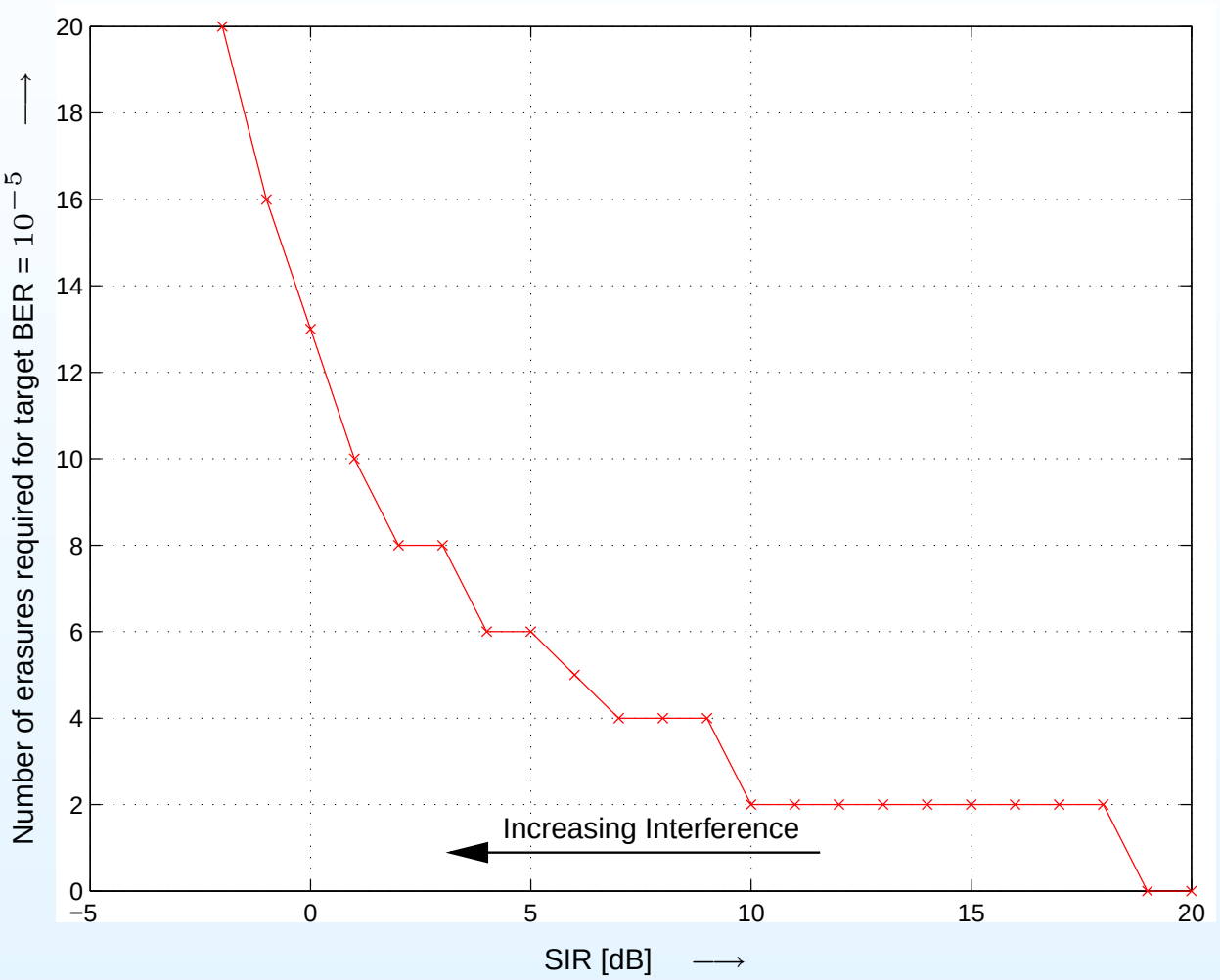
- We have a method to accurately predict the error rates of coded Multiband OFDM systems.
- Much faster than simulation.

Contributions: Narrowband Interference (1)



- Narrowband interference may have a large effect on Multiband OFDM...

Contributions: Narrowband Interference (2)



- We can compensate with erasure decoding.

Future Work

- More complex interference models
- Cognitive Radio
  - Smart spectrum usage
  - Detect and avoid narrowband systems — will be required in Japan (and Europe ?)
  - Intelligent radios $\longrightarrow$ better performance!
- New schemes to enhance Multiband OFDM system

Conclusions

- Multiband OFDM: an excellent technology for Wireless PANs
- We have made contributions in
  - Performance analysis (limits, actual performance)
  - System enhancements
  - Effect of interference
- More to come!

csnow@ece.ubc.ca
Papers from www.ece.ubc.ca/∼csnow/