A High Data Rate Extension to Bluetooth

Andrew Lillie, Andrew Nix & Joe McGeehan

University of Bristol, UK

TOSHIBA

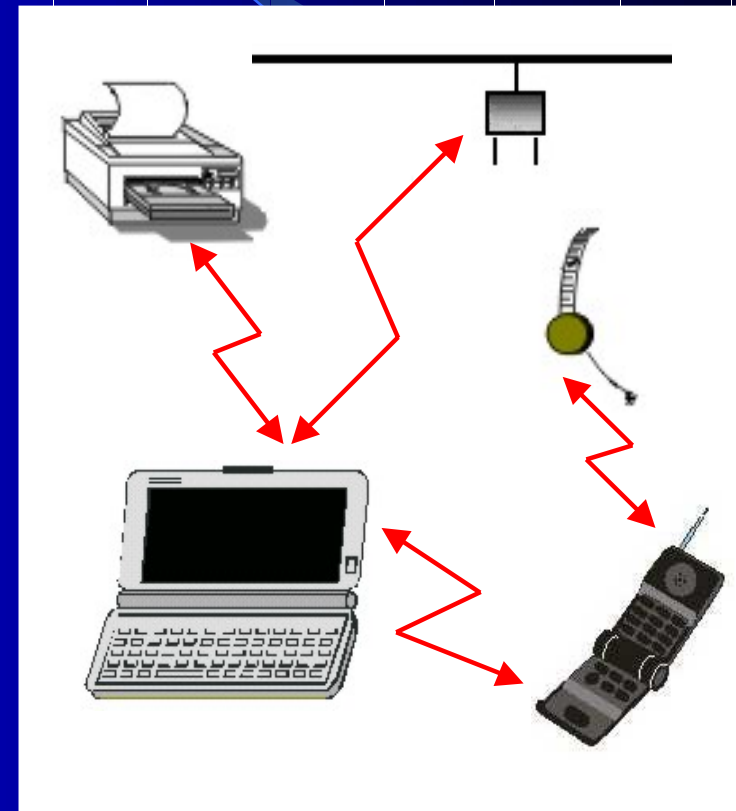# Contents

- Personal Area Networks (PAN)
- Bluetooth and its applications
- High data rate extension (HDR)
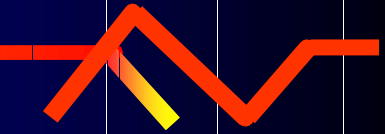- Result of simulations
- Conclusions and future work
- Questions

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Wireless PAN

- Short range wireless communications
- 3 application areas
  - mobile
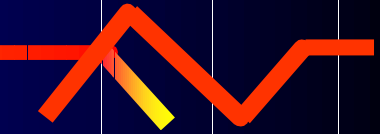 - stationary
  - consumer electronics
- Different roles

Bluetooth Summary

- Short range, low cost Wireless PAN
  - 10m range, cost $5, single chip implementation
- ISM band @ 2.4GHz
  - global
- Low energy consumption
  - portable
- Flexible
  - many applications

HDR Extension Justification

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- Bluetooth has a maximum data rate of 725Kbits/s
  - Suitable for many non-time bounded low data rate applications
  - Unsuitable for time bounded high data rate applications such as:
    - MPEG-2 transmission
      - digital broadcasting, video on demand
      - requires 2 - 20Mb/s depending on QoS
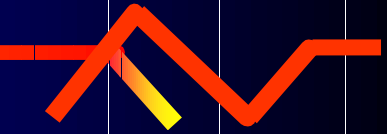- Requirement for a 10Mb/s short range link

HDR Requirements

- Interoperability with BT 1
  - capable of operating as BT 1 slave/master
  - HDR mode, optional point-to-point
- Data Rate
  - >7 Mbits/s maximum user data rate
- Range
  - similar to BT 1
  - error rate $< 10^{-3}$ BER@70dB PL
- Low Cost
  - $10 (not more than 2*BT 1)
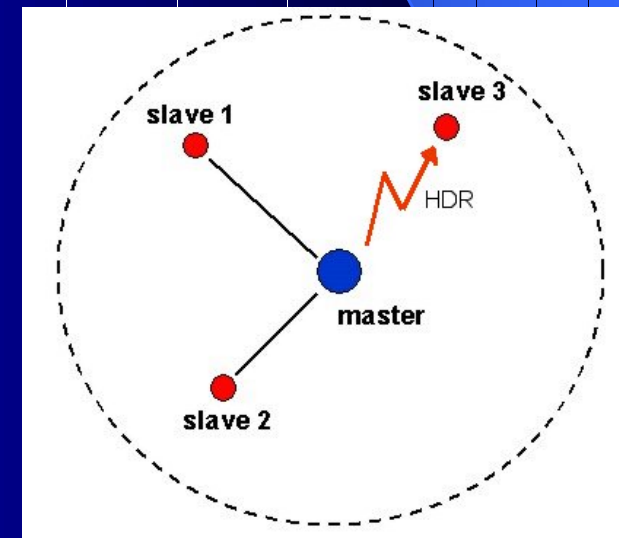
Solution

- Build on top of the existing standard

- Adaptive modulation scheme
  - Phase Shift Keying (PSK) family
  - Choice of three modulation levels (M=2,4&8)
  - Differential Detection

- Increase bandwidth to 5MHz
  - Achieves 10Mb/s using D-QPSK
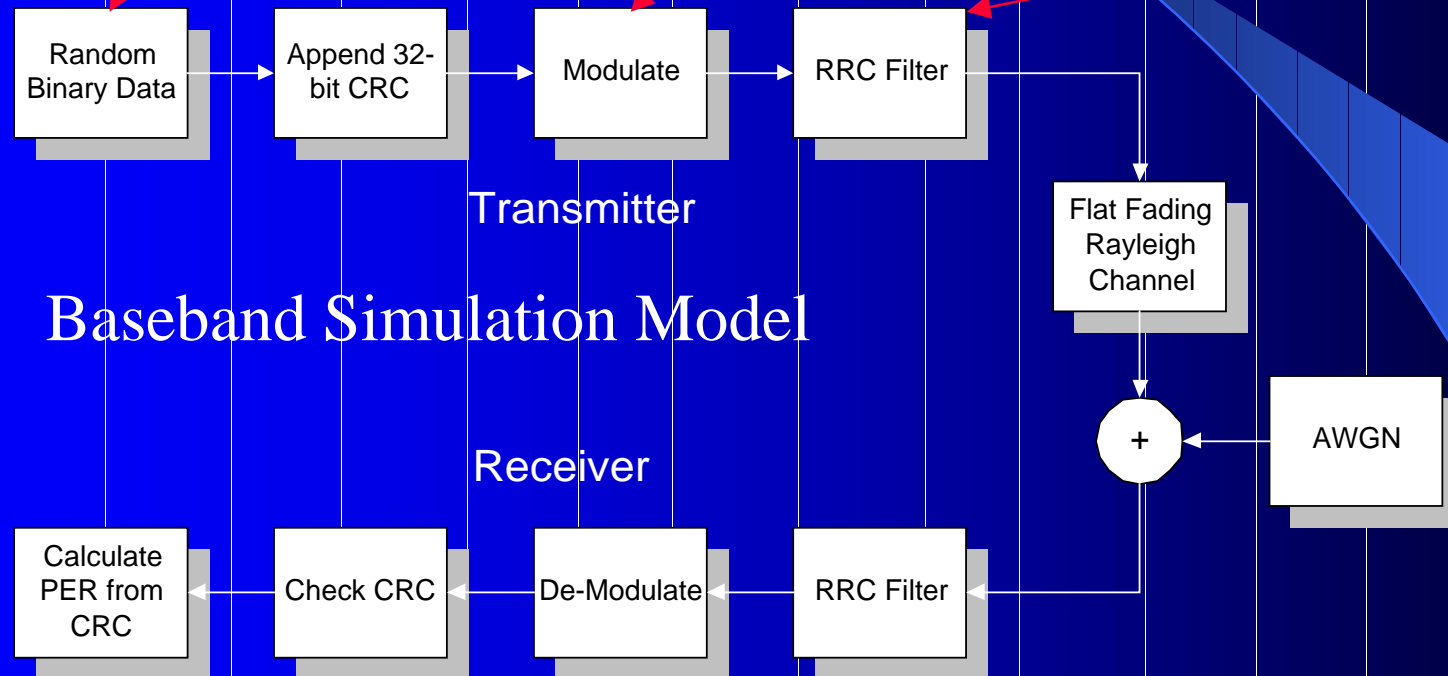 - Max raw data rate 15Mbits/s with D-8PSK

Packet Error Rate Simulation
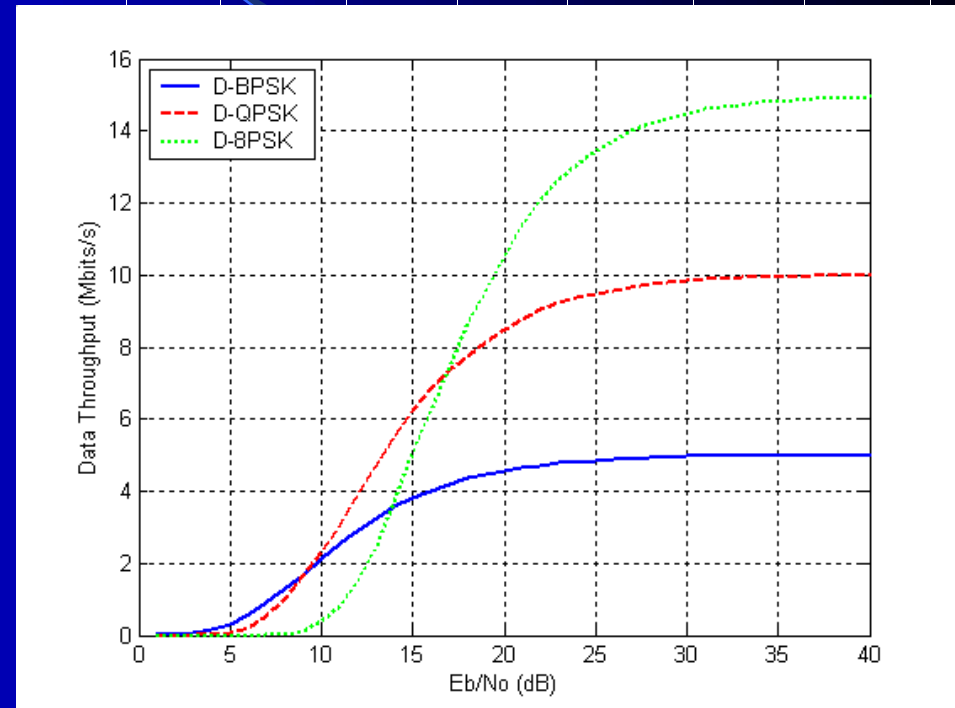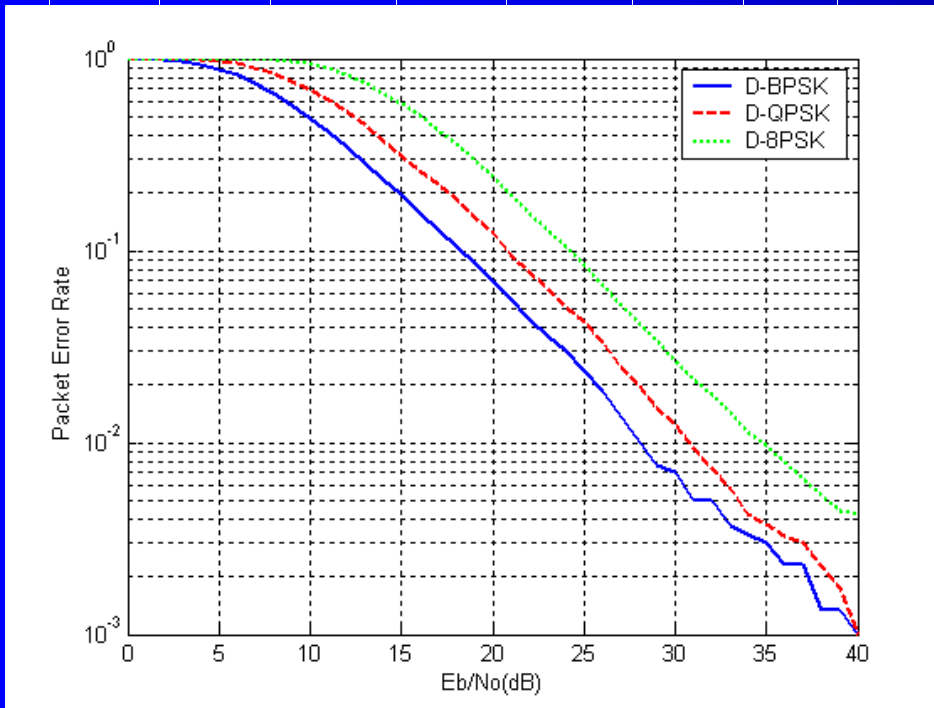
1000 bits per packet   D-BPSK, D-QPSK, D-8PSK

Roll off = 0.4

Random Binary Data → Append 32-bit CRC → Modulate → RRC Filter

Transmitter

Baseband Simulation Model

Flat Fading Rayleigh Channel

+ ← AWGN

Receiver

Calculate PER from CRC ← Check CRC ← De-Modulate ← RRC Filter

Packet Error & Data Rate

- Packet error defined as any packet failing CRC check

- $R = (1-PER)*BW*K$

Indoor Ray Launching Model

3.0m

3.0m

16.0m

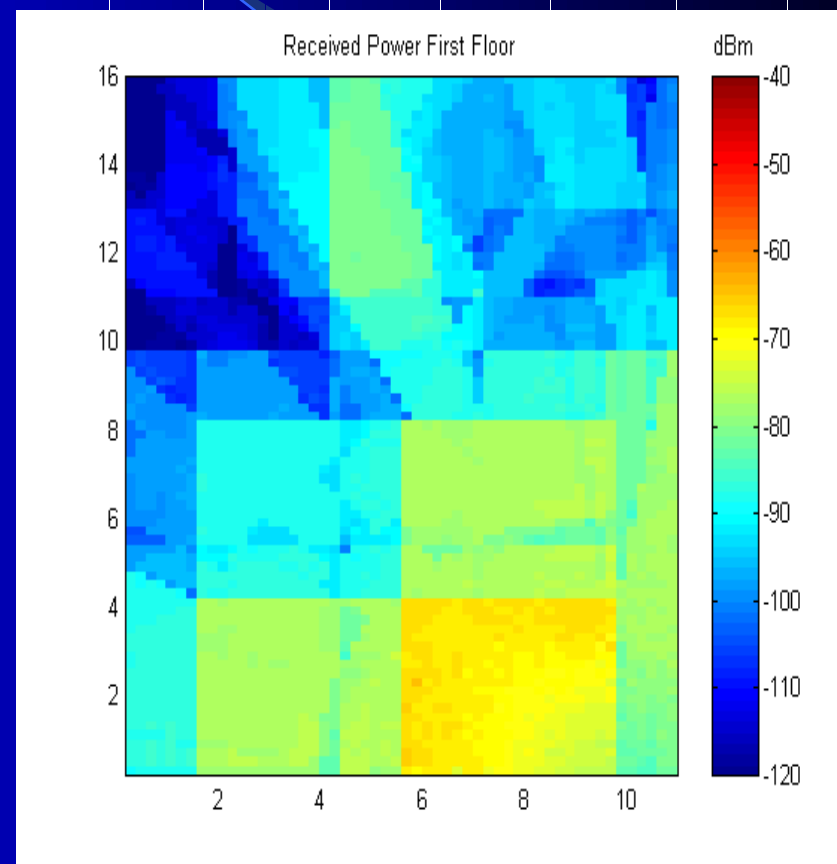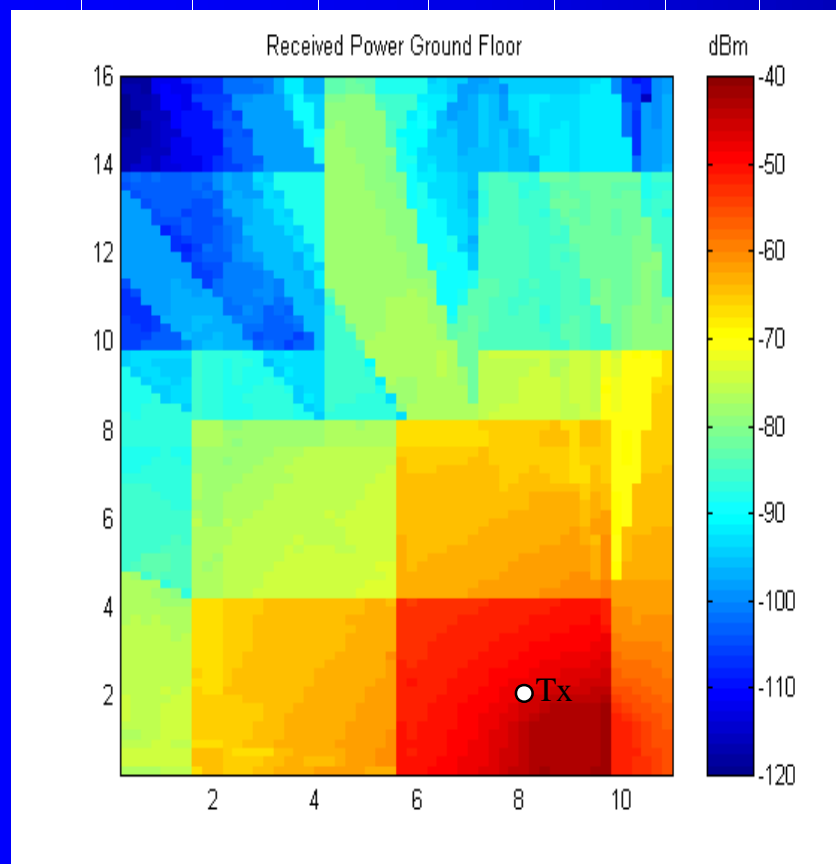11.0m
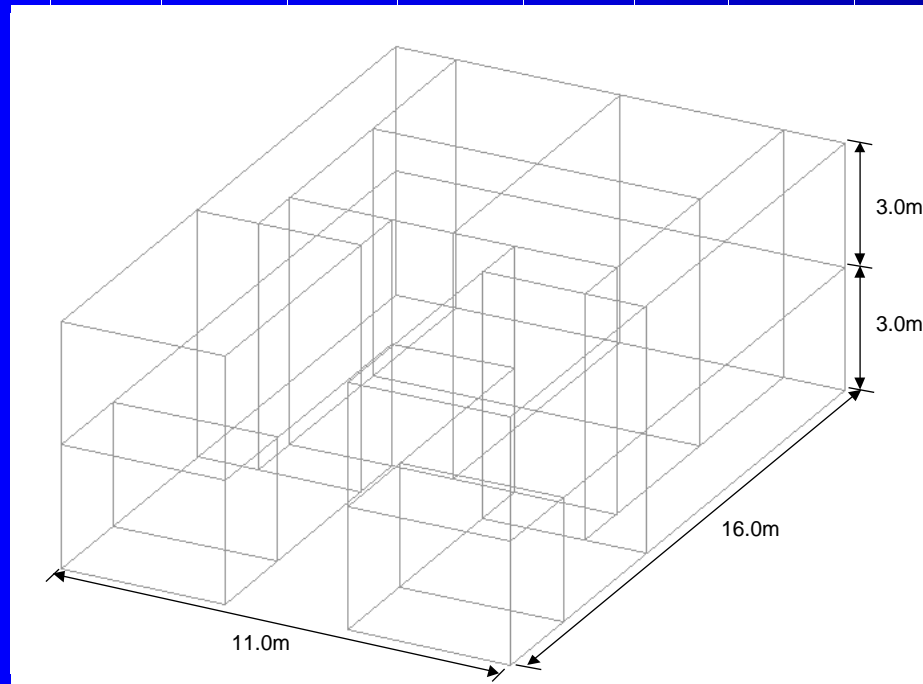
- 2 storey example house environment
- State of the art Ray Launching propagation model
- Maximum 6 orders of reflection & transmission, 1 order reflection
- Tx Power = 1mW (0dBm) (mean)
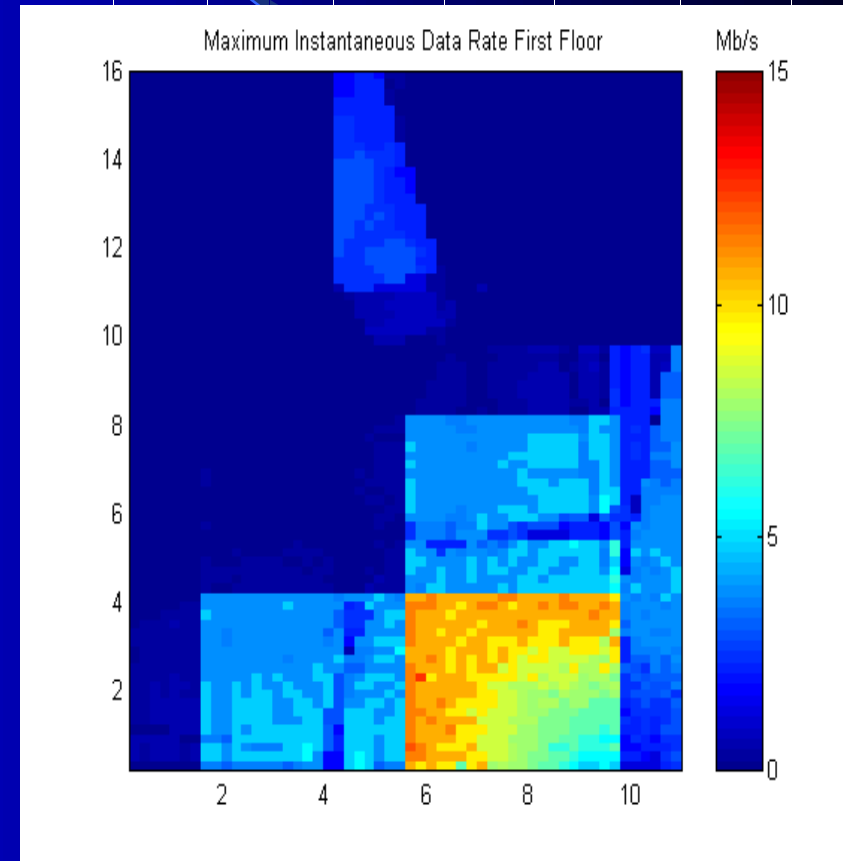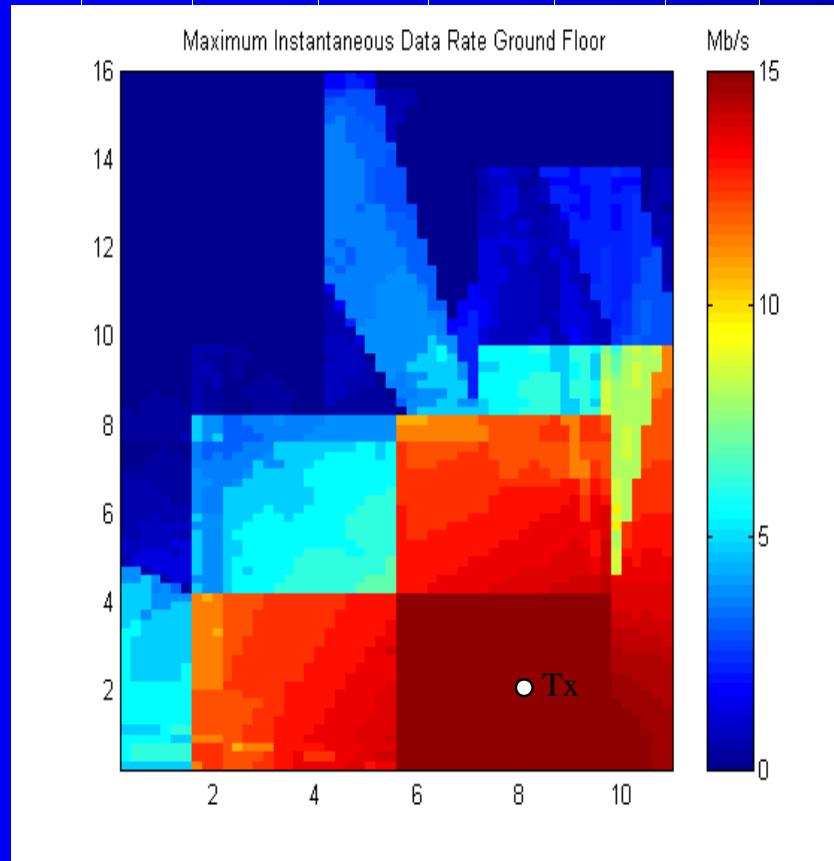- Dipole antenna, 0.8m above floor
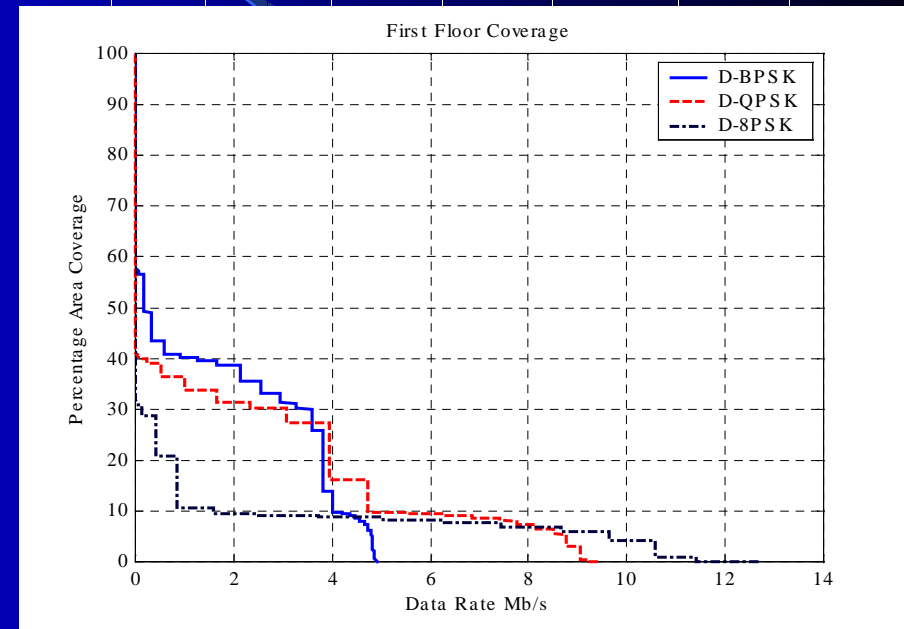
Received Power

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Received Power Ground Floor — dBm

Received Power First Floor — dBm

Tx

Maximum Instantaneous Rate

Maximum Instantaneous Data Rate Ground Floor — Mb/s

Maximum Instantaneous Data Rate First Floor — Mb/s

- $E_b/N_0 = P_R - N_0 + 10\log_{10}(1-\alpha/K) - \langle peak/mean \rangle$

Coverage Estimates

Ground Floor Coverage

First Floor Coverage
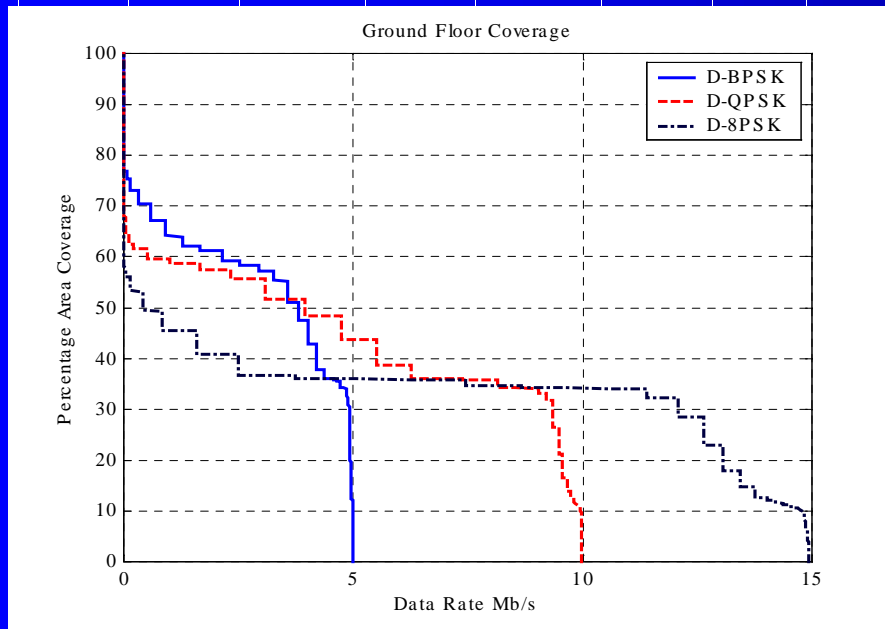
Target rate 7Mb/s, we get:
- Ground Floor ~ 35% coverage
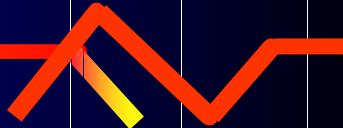- 1st Floor ~ 8% coverage

Optimum Modulation Mode

49.1%

72.3%
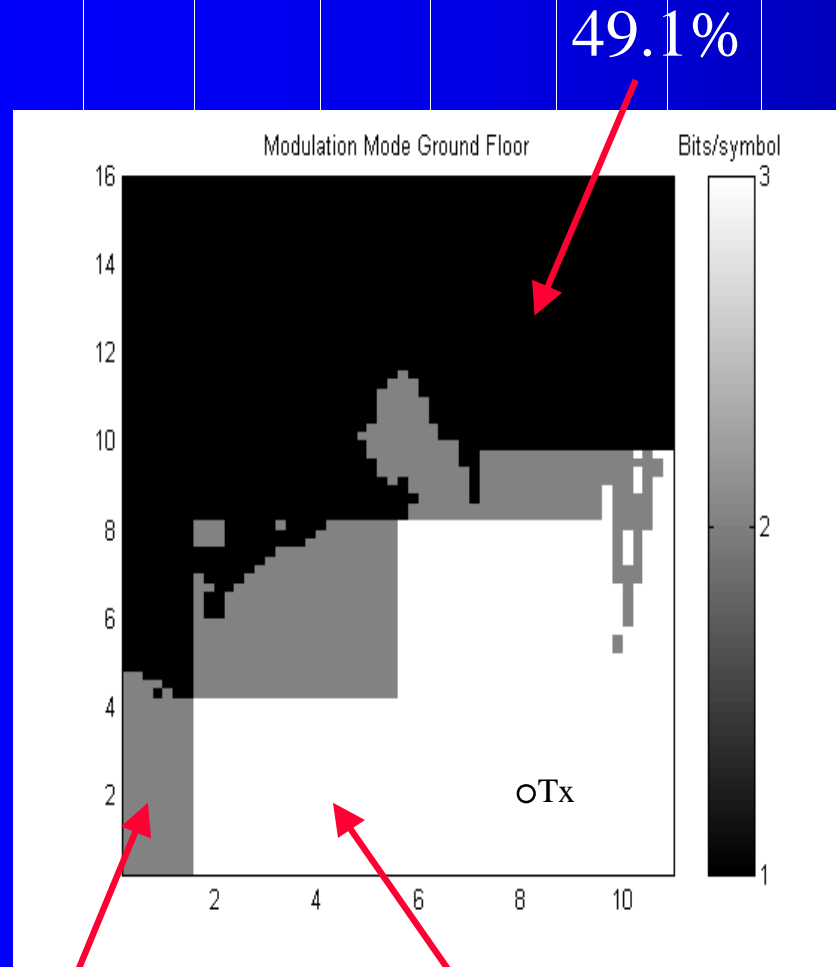
18.2%

32.7%

20.2%

7.5%
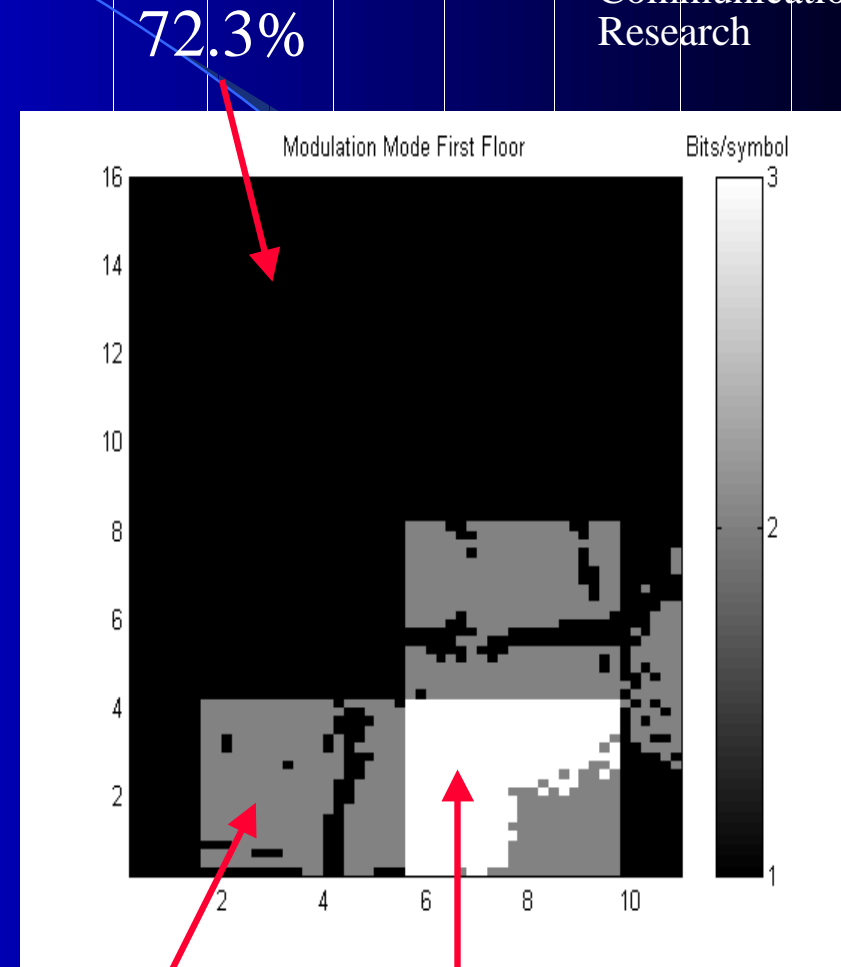
Conclusions and Future work

- There is a need for a High Data Rate extension
- Simulations show that the target rate of 7Mbits/s can be exceeded at short ranges
- Future work will focus on
    - suitable packet structure
    - techniques for improving the error rate
        - coding strategies
        - diversity/space time techniques
    - interference rejection
    - video profile

Acknowledgements & Questions

- Engineering & Physical Sciences Research Council (EPSRC)
- Toshiba Research Europe Limited (TREL)
- Beng Sin Lee (UofB) Ray Launching Model

Any Questions???