Interference Evaluation of Bluetooth and IEEE 802.11b Systems

By N.Golmie…
Presented by:
Sushanth Divvela
Agenda

- Introduction
- WPAN
- WLAN
- Simulation Models
- Simulation results
- Concluding remarks
Introduction

- Coexistence of WPAN and WLAN
- Performance evaluation WLAN and Bluetooth when operating in close proximity.
- Results are based on MAC, PHY and Wireless channel
- Results are done using analysis, simulation and experiment results.
Bluetooth

- Short Range (0-10m) wireless technology
- Operates in the ISM frequency (2.402 GHz-2.483GHz)
- 79 RF channels of 1 MHz
- Antenna power is 1 mW
- Binary Gaussian Frequency Shift Keying (GFSK)
- Data rate 1 Mbps
- TDM is used to divide the channels into 625 micro sec slots
- Piconet
- Master and Slave
- The Slave always follows the Master packet transmission
- Slaves in the piconet synchronize their timing and frequency once the connection is established
The two types of link connections:

- **Synchronous Connection-Oriented (SCO)**
  - Symmetric Point–Point connection between a master and slave where master sends an SCO packet in one TX slot at regular time intervals, defined by Tsco time slots.

- **Asynchronous Connection-Less (ACL)**
  - Asymmetric Point–Point connection between a master and slave in the piconet which uses ARQ for lost packets.
Both ACL and SCO have the same frame format

- It consists of a 72-bit access code used for message identification and synchronization, a 54-bit header and a variable length payload that contains either a voice or a data packet.
- A repetition code is applied to the header, and a block code is applied to the access code so that up to 13 errors can be detected and 6 can be corrected.
- Uncorrected errors in the header and access code lead to packet drop.
- HV packets do not have CRC in the payload.
IEEE 802.11b

- The IEEE 802.11 standard defines both the physical (PHY) and medium access control (MAC) layer protocols for WLANs.
- The three different PHY specifications: frequency hopping (FH) spread spectrum, direct sequence (DS) spread spectrum, and IR.
- The transmit power for DS and FH devices is defined at a maximum of 1 W and the receiver sensitivity is set to $-80$ dBmW. Antenna gain is limited to 6 dB maximum.
• The basic data rate for the DS system is 1 Mbit/s encoded with differential binary phase shift keying (DBPSK).

• Higher rates of 5.5 and 11 Mbit/s are also available using techniques combining quadrature phase shift keying and complementary code keying (CCK).

• All the systems use 22 MHz channels.
MAC layer

- Coordinate the communication between stations and control the behavior of users who want to access the network.
- The Distributed Coordination Function (DCF), which describes the default MAC protocol operation, is based on a scheme known as carrier-sense, multiple access, collision avoidance (CSMA/CA).
- Both the MAC and PHY layers co-operate in order to implement collision avoidance procedures.
• Carrier sense is used to determine if the channel is busy.
• A virtual carrier sense mechanism is also provided at the MAC layer. It uses the request-to-send (RTS) and clear-to-send (CTS) message exchange to make predictions of future traffic
- The PHY, and MAC layers developed in C and OPNET.
- For interference to occur, the packets must overlap in both time and frequency.
- The bit errors in the packet depends on:
  1. the signal-to-interference ratio (SIR) and the signal-to-noise ratio at the receiver
  2. the type of modulation used by the transmitter and the interferer
  3. the channel model
• MAC model:
  • Bluetooth hopping pattern algorithm is implemented using OPNET.
  • The MAC/PHY interface module is used for 802.11b in the OPNET library.
• PHY model:
  • The receiver at the Bluetooth is noncoherent limiter-discriminator receiver.
  • The 802.11b uses CCK receiver.
• Channel model:
  • Line of Sight propagation for first 8m and a propagation exponent of 3.3 for distances over 8m.
  • AWGN is used to model noise at receivers
Simulation Results

- Factors effecting interference
  - WLAN transmission power
  - Offered load
  - Bluetooth traffic type
  - Bluetooth transmission power

- Realistic interference topologies
  - WLAN device in the midst of Bluetooth Piconets
  - WLAN access point acting as a source
• Scenario 1: The WLAN mobile is the generator of data and WLAN AP is the sink.
• Scenario 2: The traffic is generated at the AP and received at the WLAN mobile.
• For Bluetooth voice and data applications are considered
• Voice – 64kbps using HV1 packet encapsulation
• The packet interarrival time is \( T_b \) is exponentially distributed.
• For WLAN 11 Mbps is used. The packet payload is fixed to 12000 bits and vary the offered load.
• **WLAN transmitted power:**
  - Saturation around 10 mW
  - Between 1 mW and 5 mW a small change in WLAN power triples the Bluetooth packet loss.
  - As offered load increases the packet loss increases
  - Voice has the lowest packet loss
  - The packet loss decreases as the WLAN transmitted power increases.
  - Between 1 and 5 mW there is a bump due to closed-loop interference.
Probability of packet loss for Bluetooth slave
Scenario 1

![Graph for Scenario 1]

Scenario 2

![Graph for Scenario 2]
• Probability of packet loss for WLAN mobile device
  • The packet loss decreases as the WLAN transmitted power increases.
  • Between 1 and 5 mW there is a bump this is due to closed loop interference.

• Probability of packet loss for WLAN source
  • The packet loss for WLAN does not change.
  • Increase in power does not necessarily improve the performance.
Offered Load:

- In scenario 1: Bluetooth is interferer and WLAN transmission power is fixed at 25 mW.
- The WLAN packet loss is proportional to the Bluetooth offered load.
- It also depends on the packet sizes of both systems.
- The short Bluetooth voice packets lead to less packet loss for Bluetooth but cause more interference for WLAN.
Realistic interference topologies

- **Topology 1:**
  - When WLAN system is not operating the Bluetooth packet loss is negligible.
  - As the Bluetooth offered load is increased, WLAN packet loss increased.
  - Bluetooth Voice is worst case interference for the WLAN.
Topology 2:

- The effect of Bluetooth piconets on four WLAN sinks
- The WLAN packet loss depends on the Bluetooth traffic conditions and is insensitive to WLAN traffic activity.
Concluding remarks

- Performance of Bluetooth and WLAN and analyzed.
- The power control may have limited benefits.
- Limiting the WLAN power may help avoid interference with Bluetooth devices.
- Bluetooth voice represents the worst type of interference for WLAN.
- WLAN performance seems to degrade as the Bluetooth offered load is increased.
- ECC on Bluetooth is of little use.
• Achieving acceptable performance for a particular system comes at the expense of the other system’s throughput.
Thank You

Questions ..