Bluetooth: An Overview

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Bluetooth: What Is It?

- Cable replacement technology
- Specification for wireless communication between small, mobile devices
- De-facto standard and a specification by industry group
Bluetooth Architecture

[Diagram of Bluetooth Architecture]

- vCard/vCal
- OBEX
- WAE
- WAP
- UDP
- TCP
- IP
- PPP
- RFCOMM
- L2CAP
- Host Controller Interface
- LMP
- Baseband
- Bluetooth Radio
- AT-Commands
- TCS BIN
- SDP
- Audio

Blue to Core Protocols
Bluetooth Architecture

Four major components in any Bluetooth system:

- **Radio unit**: the actual radio transceiver which enables the wireless link between Bluetooth devices
- **Baseband unit**: provides all required functionality to establish and maintain a Bluetooth wireless connection between devices
- **Software stack**: driver software or firmware which enables the application level software to interface with the baseband unit
- **Application software**: implements the user interface and overall functionality of the Bluetooth device
Bluetooth Network Topology

- Piconet: Ad-hoc connection between two or more Bluetooth units. One Master and up to 7 slaves in a Piconet.
Bluetooth Network Topology

- **Scatternet**: A collection of interlinked Piconets
- If multiple piconets cover the same area, a unit can participate in two or more overlaying Piconets
Bluetooth Radio

- Physical radio link between Bluetooth devices
- Operates at 2.4 GHz Industry, Scientific and Medicine band
- Uses Frequency Hop Spread Spectrum to avoid interference
- Has the advantage of high hop rate (1600 hops/s), small packet lengths and low power consumption
- Hop rate divides channel into slots of 625µs and hops are made in pseudo-random order.
- When units communicate, master determines hop channel, which is determined by the hop sequence and by the phase in the sequence
- Full duplex transmission through Time Division Duplexing
Bluetooth Baseband and Link Manager

- Physical layer of Bluetooth
- Performs the following functions:
  - Manages physical channels and links (SCO or ACL)
  - Connection Establishment (Page/Inquiry Scan)
  - Error detection and correction (CRC, FEC and ARQ)
  - Hop selection
  - Security (Authentication and Encryption)
  - Flow Control (Through receiver feedback)
  - Synchronization between communicating units
Bluetooth Host Controller Interface

- Provides a command interface to Baseband controller and Link Manager.
- Provides a uniform method of accessing the Bluetooth Baseband capabilities.
- Consists of the following:
  - HCI Firmware, which resides on the host controller (i.e. the actual Bluetooth hardware device)
  - HCI Driver, which resides on the host (i.e. can be a software entity)
  - Host Controller Transport Layer, which can be several layers between the HCI Firmware and the HCI Driver. This performs data transfer between the firmware and the driver.
Bluetooth L2CAP

- Data Link Layer
- Provides the following functions
  - Connection-less and Connection-oriented data services to higher layer protocols.
  - Protocol Multiplexing. Baseband does not support identification of higher layer protocol.
  - Segmentation and Reassembly. Maximum Baseband payload size is 341 bytes. L2CAP permits higher-layer protocols to use packet sizes of up to 64 Kilobytes
  - Quality of Service. Negotiated at connection establishment time.
  - Group Abstractions that map higher layer protocol groups to Piconets.
- The following are out of scope of L2CAP:
  - Transport of Audio designated for SCO links
  - Channel Reliability
  - Data integrity
  - Reliable Multicast channel
Bluetooth RFCOMM and SDP

- **RFCOMM**
  - Provides emulation of serial ports over L2CAP
  - Is the main cable replacement protocol specified by SIG
  - Supports up to 60 simultaneous connections between two Bluetooth devices

- **Service Discovery Protocol (SDP)**
  - SIG defines Service Classes with unique IDs
  - Service class definitions provide attributes of the service
  - SDP allows Bluetooth devices to discover what other Bluetooth devices can offer.
  - SDP performs Search or Browse for Services from other Bluetooth devices
  - SDP lets Bluetooth devices determine Service Characteristics
Higher Layer Protocols

- Based on usage models defined by SIG. Usage Models are usage scenarios defined by the SIG.
- Each usage model has an associated Profile.
- A Profile is a vertical slice through the protocol stack.
- Profiles are used to decrease the risk of inter-operability problems between different manufacturer’s products.
- Four general profiles defined:
  - Generic Access Profile (GAP)
  - Serial Port Profile
  - Service Discovery Application Profile (SDAP)
  - Generic Object Exchange Profile (GOEP)
Higher Layer Protocols (Cont.)

- Several existing protocols (PPP, UDP, TCP/IP, OBEX, WAP etc.) adopted by SIG to expand application base.
- Sample usage models: file transfer, internet bridge, LAN access, synchronization etc.
- Profile for file transfer usage model (Baseband and other lower layers not shown):
Complementary/Competing Technologies

- **Infrared Data Association (IrDA):**
  - Infrared interface between devices.
  - Maximum payload exceed Bluetooth
  - Only supports limited point-to-point connections (two parties)
  - Line of sight restriction

- **IEEE 802.11 (Wireless LAN):**
  - Aimed at enabling LAN based applications with wider radio coverage
  - Has higher transmission capacity and simultaneous users than Bluetooth
  - Bluetooth hardware is expected to be smaller and cheaper than 802.11

- **Home RF**
  - Aimed at home network of devices
  - Very similar to Bluetooth
  - Can handle up to 127 units per net
  - Uses only 50 frequency hops per second