Outline

- Definition of baseband
- System timing
- ACL and SCO links
- Packet structure
- Channel coding
**Baseband Defined**

**Baseband** Part of a device which controls the radio (see Figure 2-1). It is responsible for low level timing, error control, and management of link within the domain of a single data packet transfer.

**Figure 2-1** Link control and the baseband
System Timing

**CLKN** Real time clock. Implemented by 28 bit count which is reset to 0 at power up. Incremented every half slot, or 312.5 \( \mu s \)

All Bluetooth devices use CLNK to:

- synchronize Tx-Rx data exchanges between devices
- differentiate between lost and re-sent packets
- generate predictable and reproducible sequence of hop channel numbers

Piconet Clock

Each Slave in a piconet adds an offset value onto its CLNK (see Figure 2-2). New value—denoted CLK and called **piconet clock**—is an estimate of Master’s CLNK

Master adds another offset to its CLNK to obtain an estimate, CLKE, of the CLK in a Slave device. CLKE is used to connect to Slave before Slave is synchronized to Master
**Figure 2-2** Conceptual Bluetooth CLK offset application

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**ACL Links**

ACL (Asynchronous Connectionless) links provide packet-switched connections:

- A Master may have a number of ACL links to different Slaves
- Only one ACL link can exist between a Master and a Slave
- A Master need not transmit to a Slave in regular fashion
- Master determines which Slave to transmit to and receive from on a slot by slot basis
More on ACL Links

- Most ACL packets facilitate error checking and re-transmission
- ACL links carry data to and from L2CAP and Link Manager (LM) layers
- Data carried in DH (Data High rate) packets and DM (Data Medium rate) packets. DM packets carry less data, but provide extra error protection
- Broadcast packets are ACL packets that are not addressed to a specific Slave

SCO Links

SCO (Synchronous Connection Oriented) links provide circuit-switched connections:

- Symmetric link between Master and Slave with reserved bandwidth in the form of reserved slots
- Intended for use with time-bounded information such as audio
- Master can support up to three SCO links to the same Slave or to different Slaves
More on SCO Links

- SCO packets are not retransmitted

- A SCO link is set up by a LM command from the Master to the Slave. Message contains timing parameters to specify the reserved slots

Packet Structure

Every packet consists of (see Figure 2-3):

**Access code** Used to detect the presence of a packet. Identifies the packet as being from or to a specific Master

**Header** Contains all control information associated with the packet and link, such as address to intended Slave

**Payload** User data and control information from higher layers
| 68 or 72 bits access code | 54 bits header | 0-2745 bits payload |

**Figure 2-3** Bluetooth packet structure

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**Access Code**

Access code consists of (see Figure 2-4):

- 4 bits preamble used to detect edges of received data
- 64 bits synchronization word
- 4 bits trailer
**Figure 2-4** Access code structure

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**Synchronization Word Algorithm**

1. Determine 24-bit Lower Address Part (LAP) of Bluetooth device address (48 bit IEEE MAC address)

2. Append 6-bit Barker sequence to LAP to improve auto-correlation properties

3. XOR new sequence with bits 34 to 63 of full length, 64-bit Pseudorandom Noise (PN) sequence

4. Encode resulting 30-bit sequence with (64,30) BCH (Bose-Chaudhuri-Hocquenghem) block code to obtain 34 parity bits
Algorithm Continued

5. 34-bit parity word XOR’d with the remaining bits, 0 to 33 of PN sequence to remove cyclic properties of block code

Remark: 34 bits BCH parity word exhibits very high auto-correlation and very low co-correlation properties. Thus, a correlator can be used to obtain a match between the received and expected (reference) synch world

Packet Header

- 54 bits packet header (see Figure 2-5) contains 18 bits of information encoded with a rate 1/3 repetition code, i.e., each information bit is transmitted 3 times

- The large amount of overhead is included because each header field is crucial to the correct operation of the link
Figure 2-5 Packet header structure

**Header Fields**

**AM_ADDR** Master assigns Active Member ADDRes (AM_ADDR) to Slave. 3-bit field sufficient for 7 Slaves. Broadcast packet has address zero

**Flow** Flag asserted when device is unable to receive any more data due to full receiver buffer

**ARQN and SEQN** SEQN toggled each time new packet with CRC is transmitted, ACK represented by ARQN=1 and NAK by ARQN=0

**Header Error Check (HEC)** 8-bit CRC
More Header Fields

Packet type  Defines which type of traffic is carried by packet:

- SCO, ACL
- ID packet consists of access code, used during “pre-connection”
- NULL packet consists of access code and header, used for flow control or to pass ARQ
- POLL packet same structure as NULL packet, must be acknowledged
- FHS (Frequency Hop Synchronization)

ACL Payload

The ACL payload is divided into three fields (see Figure 2-6):

- payload header with fields:
  - L.CH (Logical CHannel) Field indicates whether payload is start or continuation of message

  Flow  Controls data transfer at L2CAP level

  Length  Number of data bytes in payload

- payload data

- CRC, calculated over both payload header and payload
**Figure 2-6** ACL payload and payload header structure

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**SCO Packet Structure**

- Same access code and header as ACL packets

- ARQ and SEQ fields in header redundant since flow control and retransmission are not used

- CRC field in header not used

- Payload size fixed at 30 bytes (240 bits), error control code with rate 1/3, 2/3, or 1 (no code) used for source data size of 10, 20, or 30 bytes
More on SCO Packet Structure

Research Opportunity: Maximum overhead for SCO packet is equal to the maximum number of control bits divided by the total number of bits in packet:

\[
\frac{72 + 54 + 160}{72 + 54 + 240} = \frac{286}{366} \approx 0.78
\]

Is this really necessary?

Error Control Coding and Encryption

CRC Performed on all packet headers and ACL payload data

FEC (Forward Error Correction) Non, rate 1/3 repetition code, and rate 2/3 shortened (15,10) Hamming code

Encryption Chiper stream produced by encryption engine XOR’d into bitstream data path
Bitstream Processing

**Whitening or bit randomization** Pseudo random bit sequence mixed with data bitstream. Reduces DC bias, thus avoiding channel drift

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**Summary**

- Baseband responsible for coding, timing, and link management within the domain of a single data packet transfer

- Devices exist in two modes of operation, namely Slave and Master

- SCO data links for time bounded data and ACL links for packet based data