Next Generation BLE Beacons

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What Is a Beacon? – A Brief Review

- Simplest of Bluetooth Low Energy devices
- Periodic broadcast of a pre-defined advertising packet
- One-way transmitter
- Enabler for “proximity aware” smartphone apps
- Small and typically battery powered
- Sometimes integrated with other services
  - e.g. temperature, open/close sensors, etc.
- Not defined by the Bluetooth SIG
  - All beacon formats are *pseudo*-standards
  - e.g. iBeacon and Eddystone
Proximity Aware Applications

- Retail marketing push notifications
  - Personalized greetings
  - Loyalty programs – coupons, points

- Point-of-sale
  - Fast food pick up
  - Vending machine secure payments

- Indoor navigation and information
  - Hospitals, museums, airports, shopping centers
  - Could be integrated with Bluetooth mesh nodes e.g. commercial lighting

- Asset tracking
  - Location awareness of goods/containers within supply chain
  - Geo-fencing for inventory control and management
BLE 4.x Advertising Packet

- Up to 47 byte packet
  - Variable data payload up to 31 bytes
  - Organized as tuplets – length, type, data
- 376 µs for a full packet
- 3 packets per advertising event
  - One packet on each of three advertising channels

*Preamble* | *Access Address* | *Protocol Data Unit (protected by CRC)*
---|---|---
(1) | (4) | (2) PDU Header | (6) Adv Addr | (0 to 31) Data Payload | (3) CRC

376 µs

Adv

Adv

Adv

... 

Adv

Adv

Adv

... 

Adv

Adv

Adv

... 

~ 1 ms

min: 100 ms
Challenges

- Limited 31-byte payload
  - iBeacon – UUID, major, minor
  - Eddystone – Four different beacon formats
- Interleaving multiple beacon formats
  - e.g. iBeacon @ 100 ms + Eddystone @ 1000 ms
- Crowded advertising channels
  - Especially with arrival of Bluetooth mesh
- Range
New in Bluetooth 5

Bluetooth 5
Go Faster. Go Further.

- Two new PHYs
  - LE 2M PHY - 2Mbps
  - LE Coded PHY (500kbps, 125kbps)
- New channel selection algorithm
  - Enables +20dBm in EU
- Advertising Extensions
  - Secondary advertising channels
  - Advertising Packet Chaining
  - Advertising Sets
  - Periodic Advertising
  - High Duty Cycle Advertising
# Advertising PDU Types

<table>
<thead>
<tr>
<th>Description</th>
<th>PDU Type</th>
<th>ADV PDU</th>
<th>4.x</th>
<th>5.0</th>
<th>Allowed LE PHY</th>
<th>Advertising channel</th>
</tr>
</thead>
<tbody>
<tr>
<td>Connectable and scannable undirected advertising</td>
<td>ADV_IND</td>
<td>•</td>
<td>•</td>
<td>•</td>
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<td>Primary</td>
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<tr>
<td>Connectable directed advertising</td>
<td>ADV_DIRECT_IND</td>
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<td>•</td>
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<td>Primary</td>
</tr>
<tr>
<td>Non-connectable and non-scannable undirected advertising</td>
<td>ADV_NONCONN_IND</td>
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<td>•</td>
<td>•</td>
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<td>Primary</td>
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<tr>
<td>discoverable undirected advertising event replaced by ADV_SCAN_IND</td>
<td>ADV_DISCOVER_IND</td>
<td>•</td>
<td>•</td>
<td>•</td>
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<td>Primary</td>
</tr>
<tr>
<td>replaced by CONNECT_IND</td>
<td>CONNECT_REQ</td>
<td>•</td>
<td>•</td>
<td>•</td>
<td></td>
<td>Primary</td>
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<tr>
<td>Scan request</td>
<td>SCAN_REQ</td>
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<td>•</td>
<td>•</td>
<td></td>
<td>Primary</td>
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<tr>
<td>Scan request</td>
<td>AUX_SCAN_REQ</td>
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<td>•</td>
<td>Secondary</td>
</tr>
<tr>
<td>Scan response</td>
<td>SCAN_RSP</td>
<td>•</td>
<td>•</td>
<td>•</td>
<td></td>
<td>Primary</td>
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<tr>
<td>Connection request</td>
<td>CONNECT_IND</td>
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<td>•</td>
<td>•</td>
<td></td>
<td>Primary</td>
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<tr>
<td>Connection request</td>
<td>AUX_CONNECT_REQ</td>
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<td>•</td>
<td>•</td>
<td>•</td>
<td>Secondary</td>
</tr>
<tr>
<td>Scannable undirected advertising</td>
<td>ADV_SCAN_IND</td>
<td>•</td>
<td>•</td>
<td>•</td>
<td></td>
<td>Primary</td>
</tr>
<tr>
<td>All advertising events (except connectable and scannable undirected)</td>
<td>ADV_EXT_IND</td>
<td>•</td>
<td>•</td>
<td>•</td>
<td>•</td>
<td>Primary</td>
</tr>
<tr>
<td>All advertising events (except connectable and scannable undirected)</td>
<td>AUX_ADV_IND</td>
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<td>•</td>
<td>•</td>
<td>•</td>
<td>Secondary</td>
</tr>
<tr>
<td>AUX scan response</td>
<td>AUX_SCAN_RSP</td>
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<td>•</td>
<td>•</td>
<td>•</td>
<td>Secondary</td>
</tr>
<tr>
<td>Periodic advertising</td>
<td>AUX_SYNC_IND</td>
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<td>•</td>
<td>•</td>
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<td>Secondary</td>
</tr>
<tr>
<td>Additional advertising data</td>
<td>AUX_CHAIN_IND</td>
<td>•</td>
<td>•</td>
<td>•</td>
<td>•</td>
<td>Secondary</td>
</tr>
<tr>
<td>Connection response</td>
<td>AUX_CONNECT_RSP</td>
<td>•</td>
<td>•</td>
<td>•</td>
<td>•</td>
<td>Secondary</td>
</tr>
</tbody>
</table>
Secondary Advertising Channels

- Channels 37, 38, 39: **primary advertising channels**
- Channels 0 – 36: data and **secondary advertising channels**
- New packet type for Primary Channels ADV_EXT_IND
  - Only contains header with Aux pointer to secondary advertising channel
Can use any PHY: 1M, 2M or LE Coded PHY

- Up to 254 byte payload

- Can include Aux pointer to another packet - Advertising Packet Chaining
  - Multiple packets can be chained for payloads larger than 254 bytes

- Offloads traffic from primary advertising channels
  - Especially important with Bluetooth mesh
Advertising Data Sets and Scan Event Reporting

- **Advertising Data Sets**
  - One device acts as a multiple beacons
  - Separate instances of the advertising state
  - Each uses different advertising parameters
    - PHY, power level, interval, packet format, etc.
  - Interleaving is managed by link layer
    - No host CPU involvement necessary
    - More power efficient

- **Scan Event Reporting**
  - Scan requests notified to the host processor
  - Positive indication that advertisement was successfully heard
  - Host can take action e.g. stop successive advertisements
Other Advertising Enhancements

- **Periodic Advertising**
  - Deterministic timing between advertising events
  - Used to stream data over secondary channels
  - Multiple receivers sync to advertising stream

- **High Duty Cycle Non-Connectable Advertising**
  - Minimum interval reduced from 100 ms to 20 ms
  - Better location accuracy for moving objects
Advanced Beacons

- Virtually limitless content (large packets or chained packets)
  - All-inclusive beacons
    - e.g. Eddystone UID + URL + TLM
  - No more compressed URLs
    - Better network security
- Polymorphic beacon formats (advertising data sets)
  - e.g. iBeacon + Eddystone-UID + proprietary
- Long-range beacons (+20 dBm, Coded PHY, CSA#2)
- Offloaded traffic from Primary Advertising Channels
- Enabled with firmware update (AE)
- Backward compatible
- The future: Precision location with Angle-of-Arrival
  - Check schedule for the next presentation
## Silicon Labs Devices for Bluetooth 5 Beacons

### SoC

<table>
<thead>
<tr>
<th>SoC</th>
<th>EFR32BG12</th>
<th>EFR32BG13</th>
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</thead>
<tbody>
<tr>
<td>Bluetooth version</td>
<td>5.0 and mesh (2M and Bluetooth 5 AE)</td>
<td>5.1 and mesh (2M, LE LR and Bluetooth 5 AE)</td>
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<tr>
<td>Proprietary</td>
<td>2.4G and sub-GHz</td>
<td>2.4G and sub-GHz</td>
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<tr>
<td>Max TX power</td>
<td>+19 dBm</td>
<td>+19 dBm</td>
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<tr>
<td>CPU (Clock Speed)</td>
<td>Cortex M4 (38.4 MHz)</td>
<td>Cortex M4 (38.4 MHz)</td>
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<tr>
<td>Flash size (kB)</td>
<td>1024</td>
<td>512</td>
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<tr>
<td>RAM (kB)</td>
<td>256</td>
<td>64</td>
</tr>
<tr>
<td>Sleep Current (EM2)</td>
<td>1.5µA (16kB RAM, LFXO)</td>
<td>1.3µA (16kB RAM, LFXO)</td>
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<tr>
<td>Active Current (EM0)</td>
<td>70 µA/MHz</td>
<td>70µA/MHz</td>
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<tr>
<td>Max GPIO</td>
<td>65</td>
<td>31</td>
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<tr>
<td>Crypto Acceleration</td>
<td>2x AES-128/256, ECC, SHA-1/224/256, TRNG</td>
<td>2x AES-128/256, ECC, SHA-1/224/256, TRNG</td>
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<tr>
<td>Operating Voltage</td>
<td>1.8V – 3.6V</td>
<td>1.8V – 3.6V</td>
</tr>
<tr>
<td>Max Operating Temp (Ta / Ti)</td>
<td>-40 - +85C / -40 - +125C</td>
<td>-40 - +85C / -40 - +125C</td>
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<tr>
<td>Packages (mm)</td>
<td>7x7 QFN48, 7x7 BGA125</td>
<td>5x5 QFN32, 7x7 QFN48</td>
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### Modules

<table>
<thead>
<tr>
<th>Modules</th>
<th>BGM13P</th>
<th>BGM13S</th>
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<tbody>
<tr>
<td>Bluetooth version</td>
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<td>5.1 and mesh (2M, LE LR and Bluetooth 5 AE)</td>
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<tr>
<td>SoC</td>
<td>EFR32BG13</td>
<td>EFR32BG13</td>
</tr>
<tr>
<td>Antenna</td>
<td>Chip or U.FL</td>
<td>Chip or RF pin</td>
</tr>
<tr>
<td>Max TX power</td>
<td>+8 / +19 dBm</td>
<td>+8 / +18 dBm</td>
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<tr>
<td>Flash size (kB)</td>
<td>512</td>
<td>512</td>
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<tr>
<td>RAM (kB)</td>
<td>64</td>
<td>64</td>
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<tr>
<td>Max GPIO</td>
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<td>30</td>
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<tr>
<td>Operating Voltage</td>
<td>1.8V – 3.6V</td>
<td>1.8V – 3.6V</td>
</tr>
<tr>
<td>Max Operating Temp</td>
<td>-40 to +85C</td>
<td>-40 to +85C</td>
</tr>
<tr>
<td>Package dimensions (WxLxH) (mm)</td>
<td>13.0 x 15.0 x 2.2 LGA</td>
<td>6.5 x 6.5 x 1.4 LGA</td>
</tr>
<tr>
<td>Certifications</td>
<td>BT, CE, FCC, ISED, Japan, S-Korea and Taiwan</td>
<td>BT, CE, FCC, ISED, Japan &amp; S-Korea</td>
</tr>
</tbody>
</table>
Thank You