Project: IEEE P802.15 Working Group for Wireless Personal Area Networks (WPANs)

Submission Title: [Samsung Pre-proposal to TG8 CFC: Overall PAC Procedures]
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Re: [.]

Abstract: [Presentation of PAC procedures to meet functional requirements including identified features from PFD]

Purpose: [Corresponding to Call for Contribution]

Samsung Pre-proposal to CFC: Overall PAC Procedures

March, 2014

Samsung

1. Overall

- High Competition for Next Big Trend
  - **Proximity-based Service**

Title	Company/ Organization	Note
iBeacon	Apple	Launched in December 2013
LTE Direct	3GPP	Specified until September 2014
NAN†	WiFi Alliance	Spec. 1.0
Gimbal	Qualcomm	Context-awareness Platform

†NAN(Neighbor Awareness Networking)

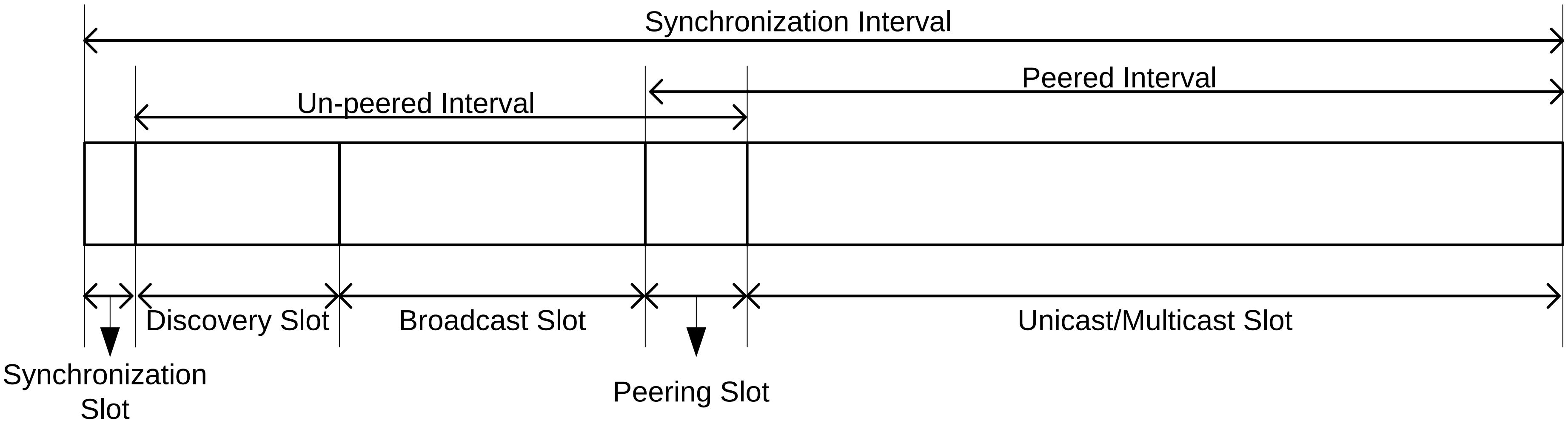
- PAC Competitive Features
  - Low power consumption for peer discovery
  - Large number of detected discovery information
  - Higher throughput for communication

1.1. PAC Procedures

- Synchronization
  – Based on Pulse-Coupled Oscillator (PCO) algorithm
- Peer Discovery
  – Broadcast Discovery Information via selected resource
- Broadcast
  – Broadcast data traffic without peering
- Peering
  – Link establishment for unicast and multicast links
- Unicast/Multicast
  – Request/Response-based resource assignment

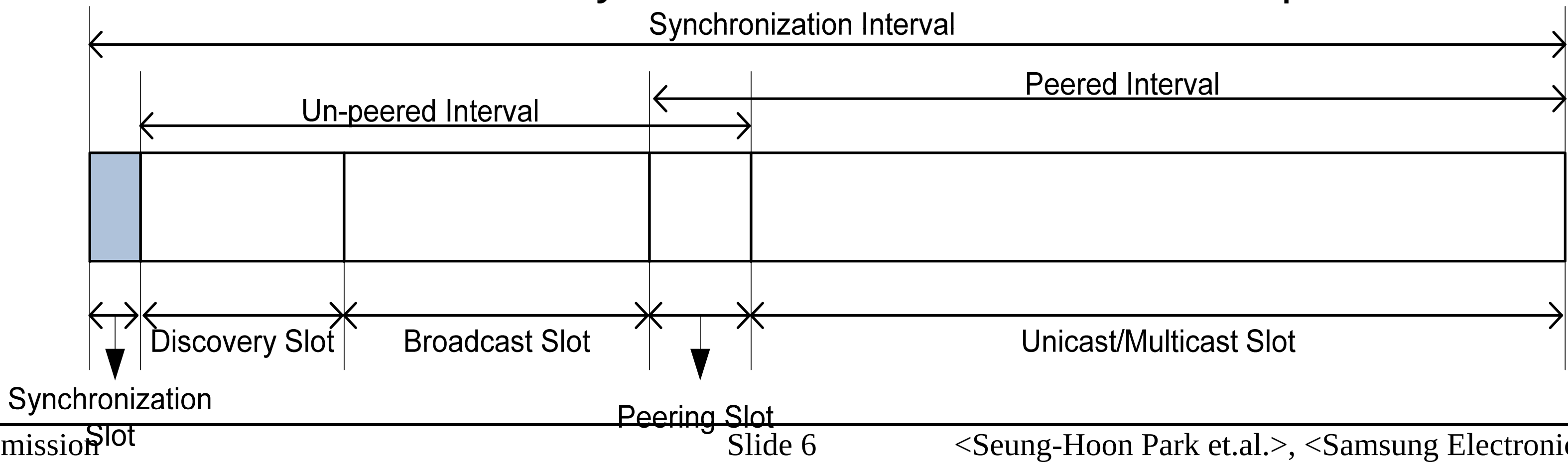
1.2 Frame Structure

- Un-peered Interval
  - Synchronization / Peer discovery / Broadcast / Peering
- Peered Interval
  - Peering / Unicast / Multicast



2. Synchronization

- Synchronization for Scalable Network
  - Distributed synchronization
    - Master-slave synchronization should be avoided
      - PDs between two different synchronized group happen
    - It is matched well to flat architecture (no hierarchy)
  - Synchronization should be done before peer discovery
    - Peer discovery prior to link connection (peering)
    - Broadcast-based synchronization mechanism is required



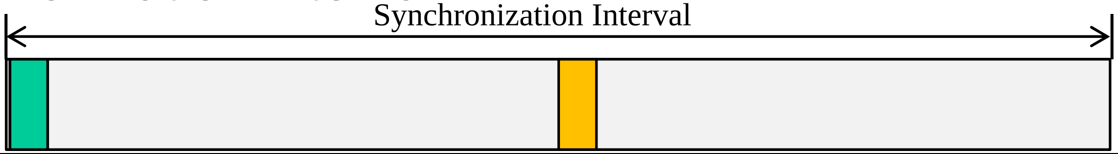
2. Synchronization

- Proposal
  - Physical layer signaling based synchronization
  - Details referred from 15-13-0376-01
- Synchronization Signal (SS)
  - ZC-sequence is suggested
    - Low PAPR with high detection probability
- Two Type of SS
  - Type-1 SS: for initial synchronization
    - PD performs just synchronization without frame structure
    - Short SS interval: e.g. 10 ms
  - Type-2 SS: for maintaining synchronization
    - PD follows operations defined in frame structure
    - Long SS interval: e.g. 1000ms SS

2. Synchronization

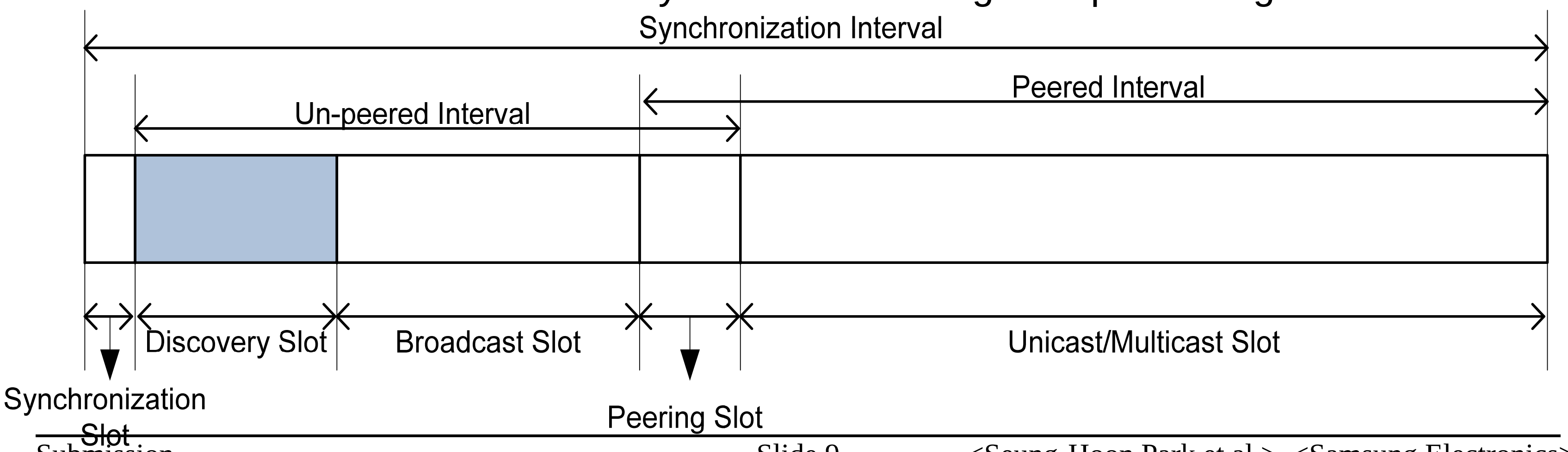
- Technical Issues
  - Low detection probability in a high dense environment

- Proposal 1
  - A PD has triggering condition to take a role of SS transmitter
  - e.g.
    - 1) When the PD is a discovery information transmitter
    - 2) Based on the detected number of SS transmitter
- Proposal 2
  - SS transmitter may transmit SS with different offset in the synchronization interval



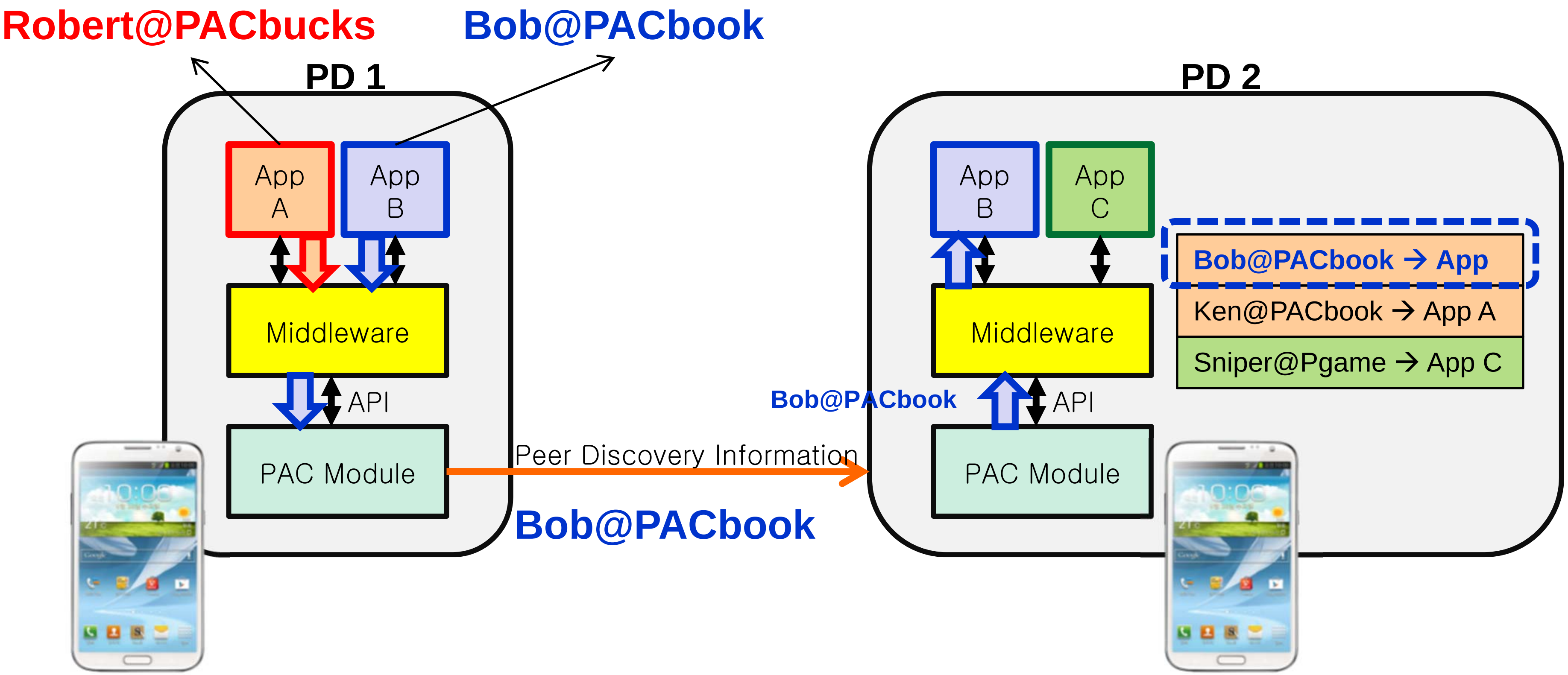
3. Peer Discovery

- Design Considerations
  - Discovery Information (DI)
    - Came from application or middleware
      - Plain DI: Application ID (PACbook), or User ID (Bob@PACbook), or etc
      - Coded DI: generated by middleware or retrieved from server
    - Discovery matching
      - PD A is matched by other PDs storing DI representing PD A

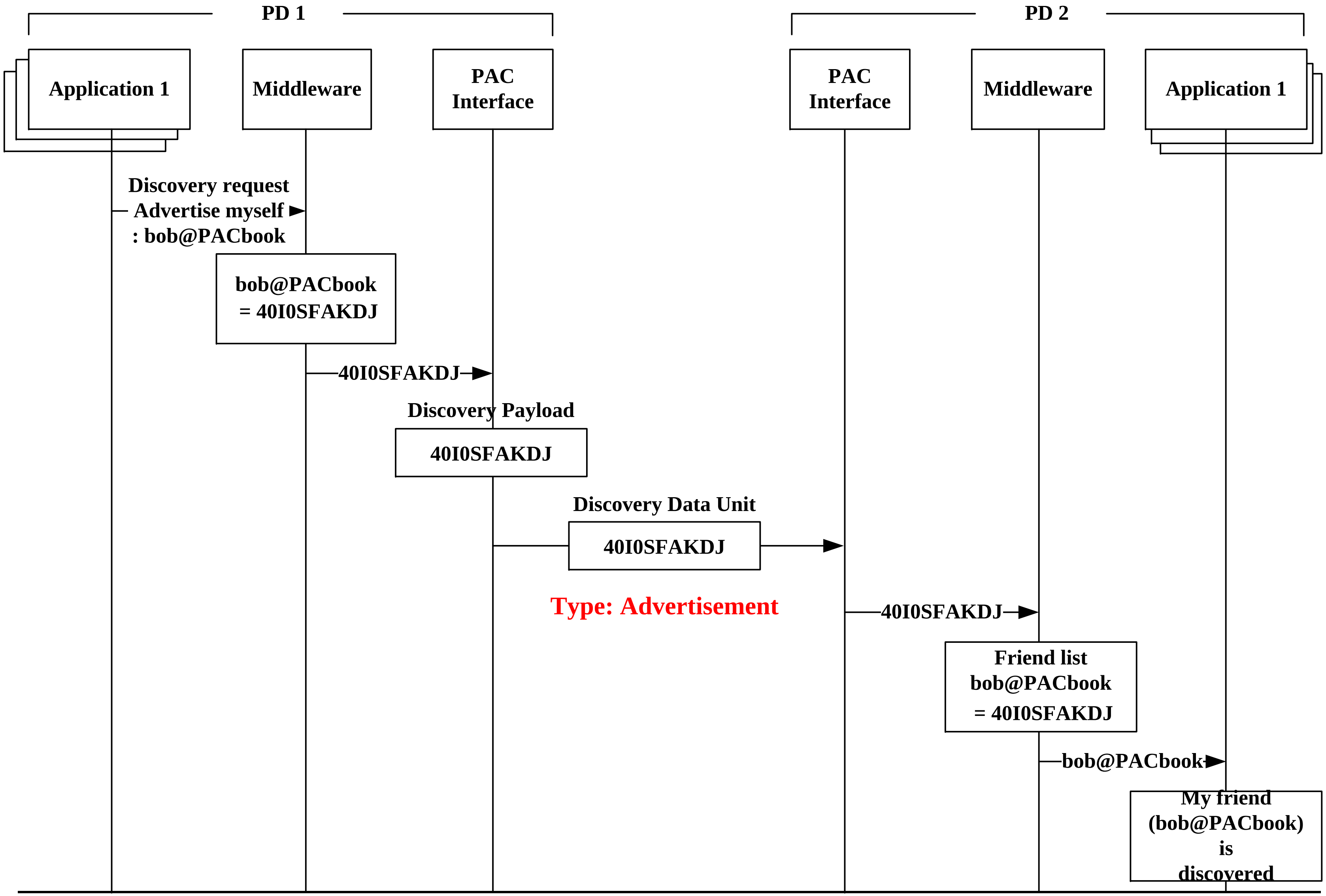


3. Peer Discovery

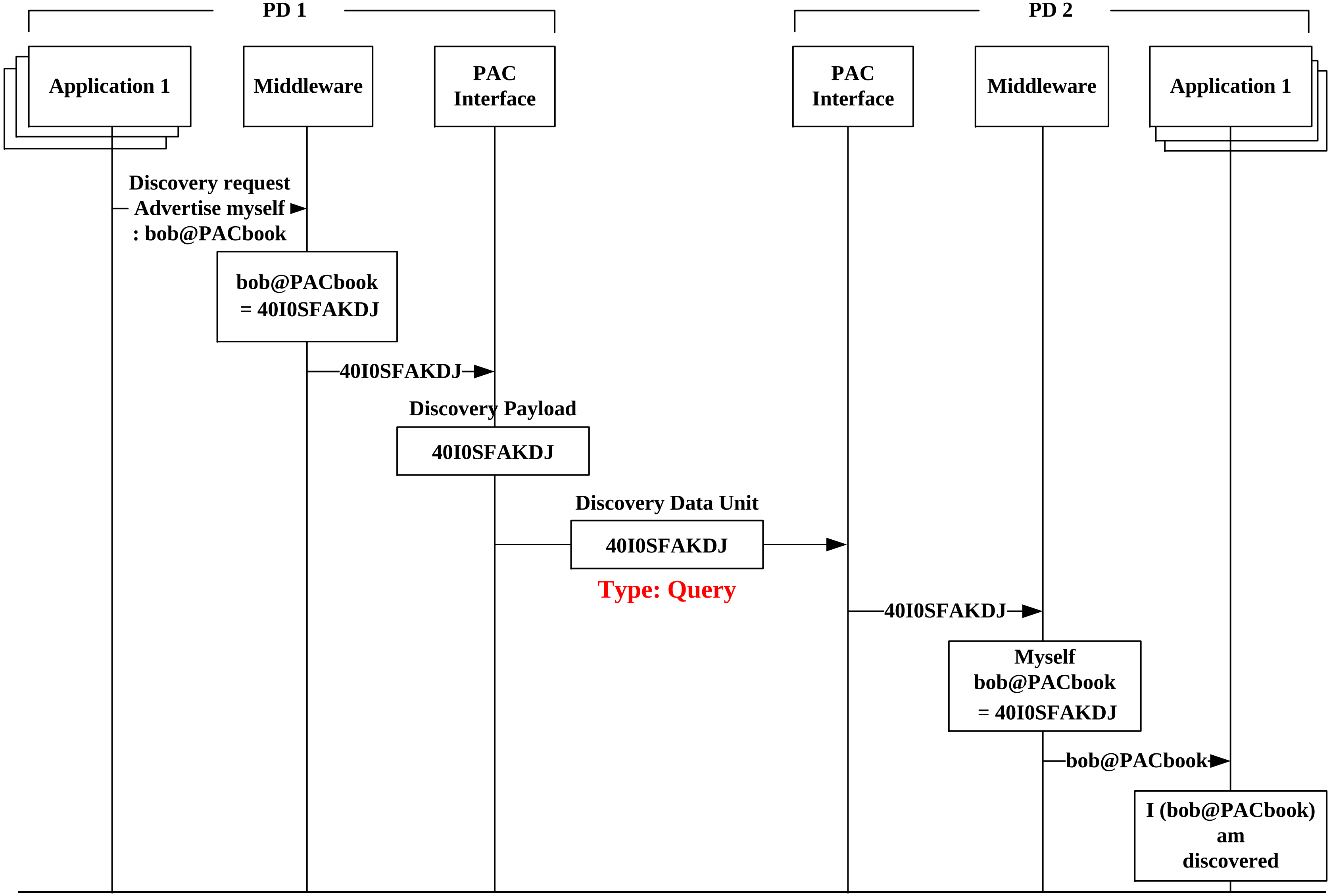
- What is Peer Discovery?
  - A peer represents an application-specific entity, not a device



Advertisement/Publish Scenario



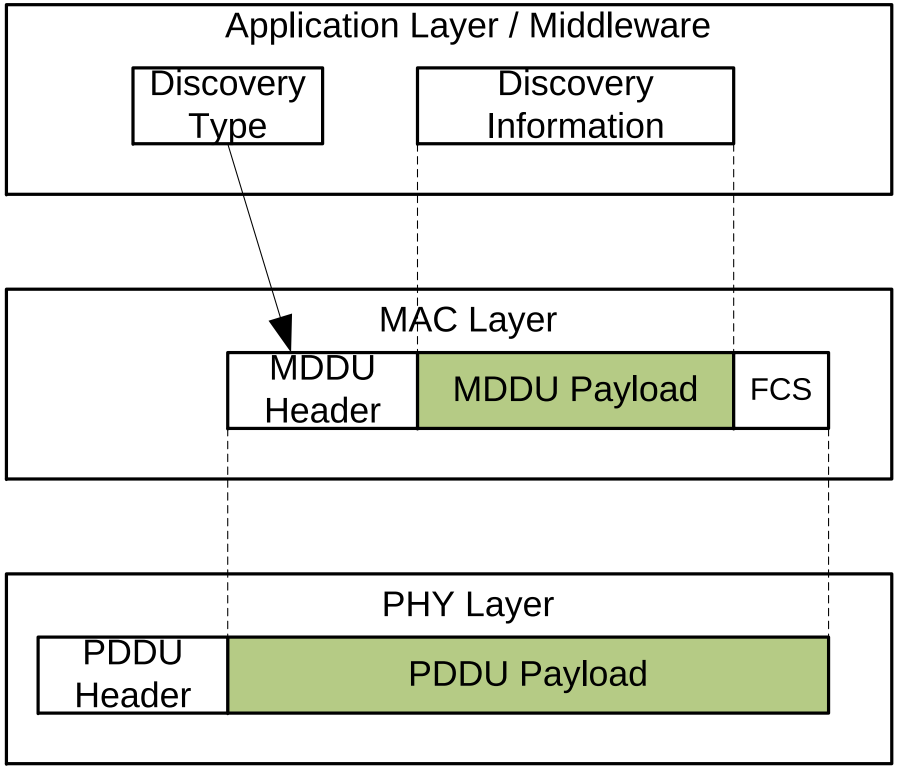
Query Scenario



3. Peer Discovery

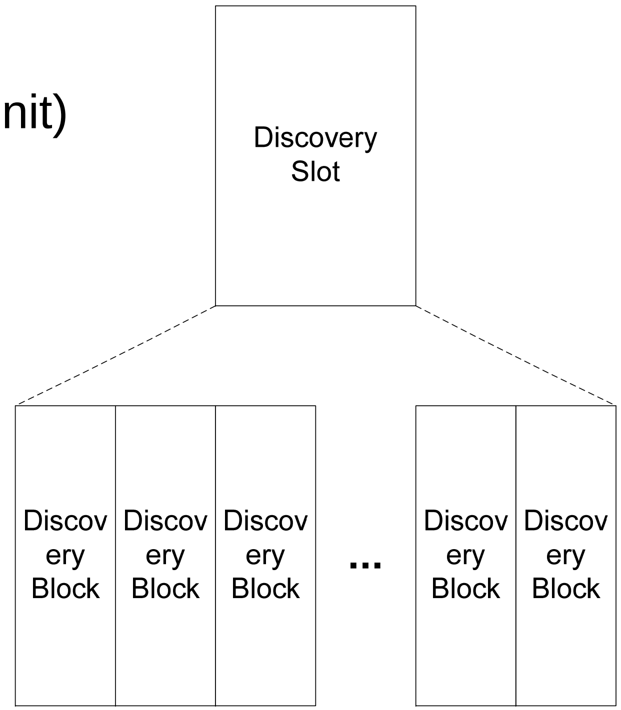
- Protocol Stack for Peer Discovery
  - MAC/PHY Discovery Data Unit (MDDU/PPDU)

Discovery Type
- Advertisement
- Publish/Subscribe
- Query/Reply



3. Peer Discovery

- Discovery Slot
  - It is comprised of multiple Discovery Blocks (DBs)
  - Basic procedure
    - PD selects one DB in a Discovery Slot
    - PD broadcasts DDU (Discovery Data Unit)
      - At selected DB
- Proposal
  - Congestion-aware DB selection
  - Hashing-based DB selection

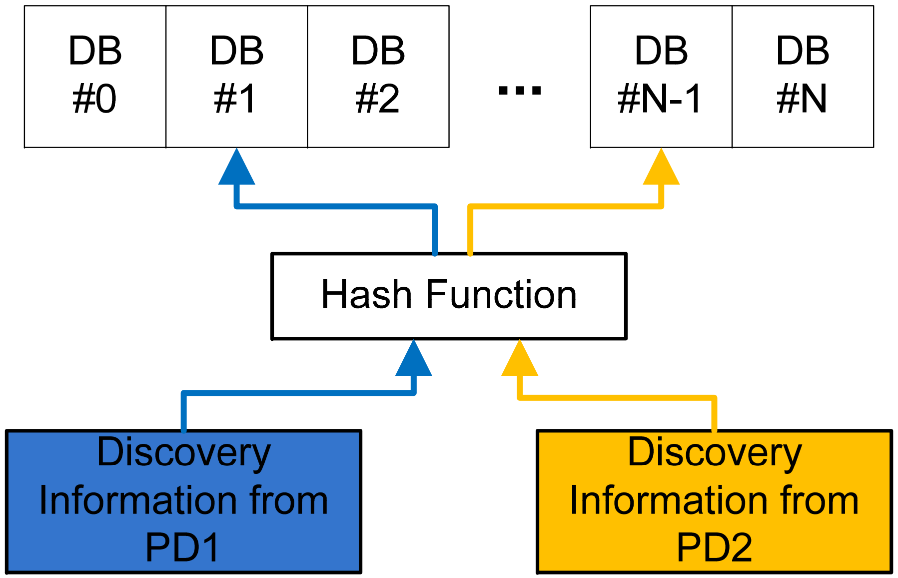


3. Peer Discovery

- Congestion-aware DB selection
  - Based on the received power
    - Compare received power between current DB and candidate DB
    - Details referred from 15-13-0376-01
  - Based on congestion condition
    - Discovery Transmission Interval (DTI) control
    - Depending on the number of detected DDU
      - e.g.) DTI is increased when the number of detected DDU is high

3. Peer Discovery

- Hashing-based DB Selection
  - DI index is determined based on the hashed DI
    - A receiving PD monitors only DB with hashed index based on monitoring DI
    - Benefit for receiver PD in power consumption perspective



3. Peer Discovery

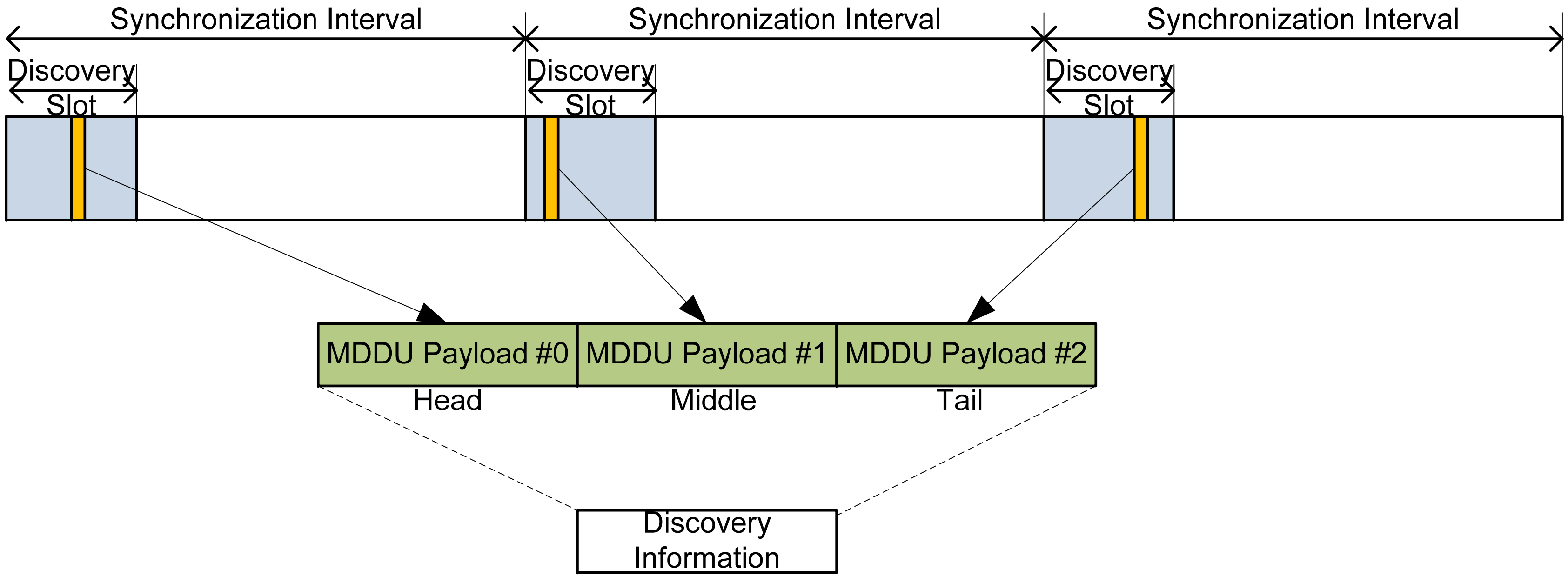
- Technical Issues
  - Support of various length of discovery information
  - Subject to provide low power discovery

- Background
  - Current distributed middleware platform in the industry

Platform	Feature	Required size of discovery information
XMPP[1]	Decentralized protocol for instant messaging and presence	Up to 3071 bytes
UUID[2]	Distributed systems to uniquely identify information without significant central co ordination	16 bytes Preferred for wireless network

3. Peer Discovery

- Proposal
  - Discovery information fragmentation
    - to support long discovery information
    - Discovery Information is divided into multiple MDDU payloads



3. Peer Discovery

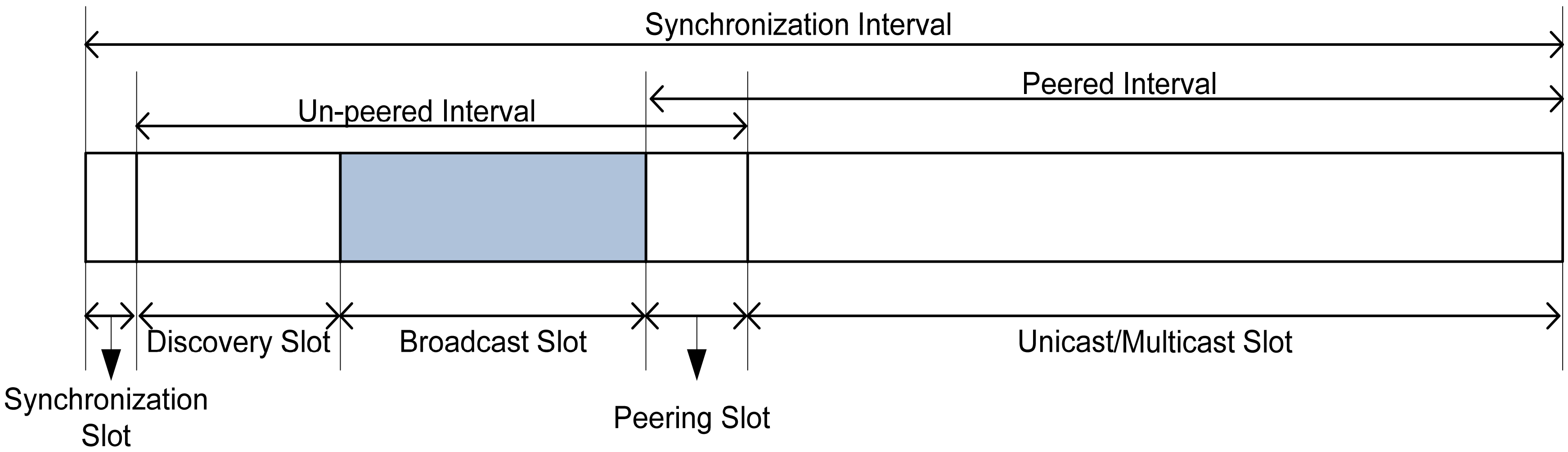
- Design Consideration to link MDDU Payloads
  - MDDU payload size is defined to fit minimum length of DI
    - 16 bytes (e.g. UUID)
  - TX ID (MAC Address) is large compared to the length of MDDU
    - MAC address: 6 bytes
    - The size of DI: from 16 to 3071 bytes
  - Overhead analysis when using TX ID
    - To support 3071 bytes fragmentation, DI is fragmented to 192 MDDU payloads
    - TX ID overhead: 6 x 192 = 1152 bytes ➔ **37 % overhead** !

3. Peer Discovery

- Possible Solution to Link MDDU Payloads
  - Low overheads required
  - Option 1
    - Discovery Flow ID (DFID)
      → to distinguish different DIs from different PDs as well as same PD
    - Potential problem
      - Who coordinates and assign DFID?
      - How to guarantee collision avoidance when using small length of DFID?
  - Option 2
    - Location Indicator
      - Each MDDU indicates the location of next MDDU
      - Receiving PD can aggregate based on the known location

4. Broadcast

- Features of Broadcast
  - Broadcast data transmission within un-peered PDs
  - Contention-based access scheme
  - No multi-hop allowed
    - (because it happens before peering for authentication)

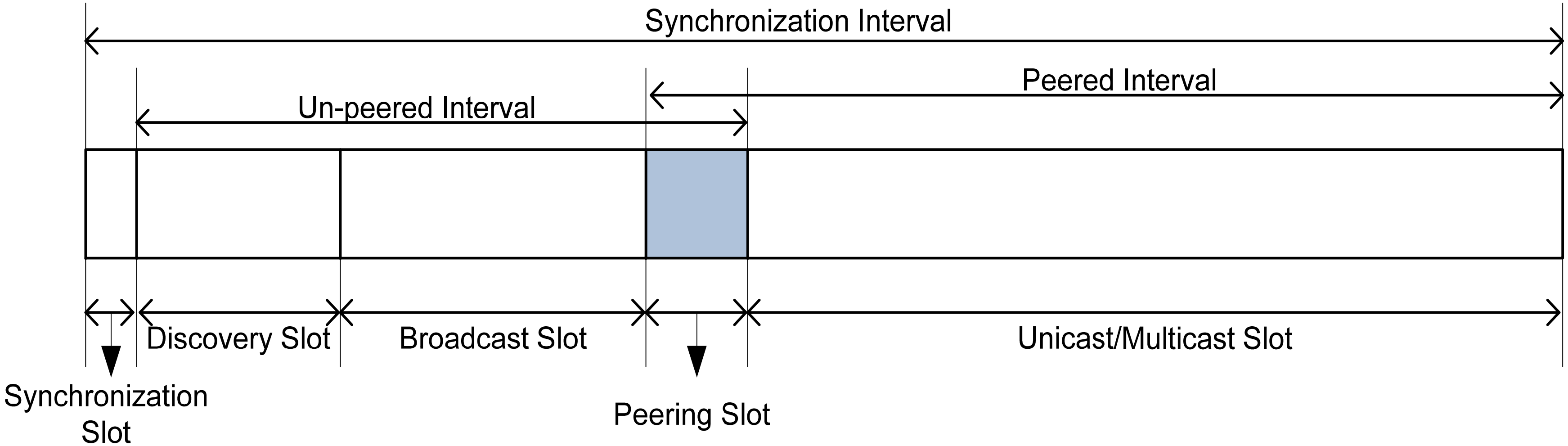


5. Peering

- The role of Peering
  - A procedure to connect to discovered peer
    - Triggered by application automatically or by user manually
    - **No MAC-level triggering**
  - Link establishment for unicast/multicast link
    - Between a TX PD and RX PD(s)
    - Exchange of information for setup
      - TX/RX ID (MAC address), capability, authentication or etc
    - Determine link related parameters
      - Link ID, QoS class, link range, or etc
  - Messages
    - Peering Request
    - Peering Response

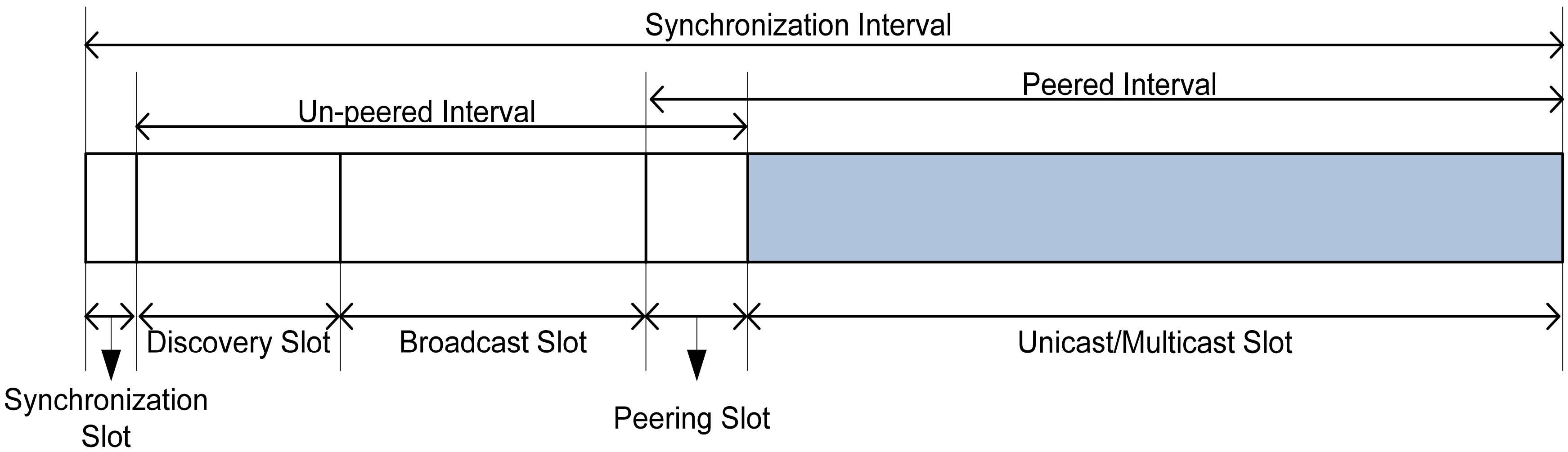
5. Peering

- Design Consideration for Peering Slot
  - Small radio resource comparing to Discovery Slot
    - Peering happens sparsely
  - Handling of multiple peering response to peering requests
  - Possible channel access scheme
    - Contention-based access



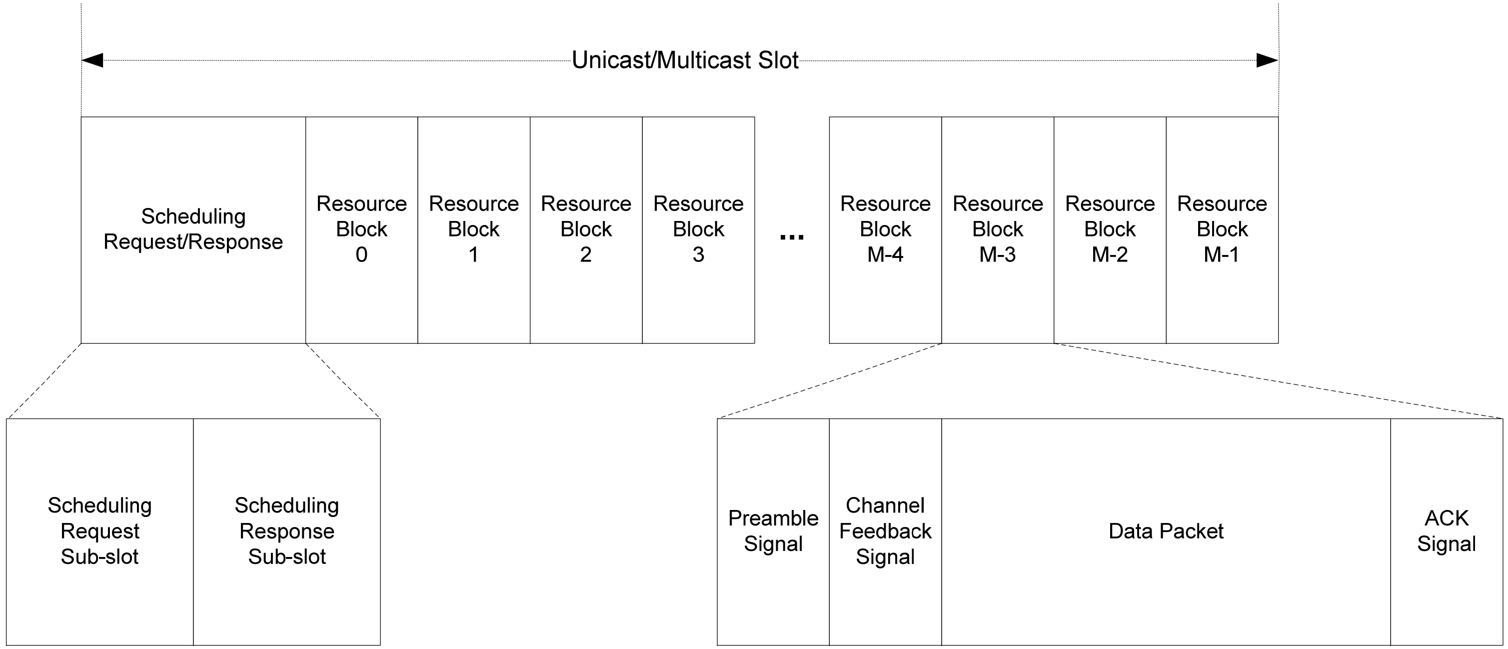
6. Unicast/Multicast

- Features of Unicast/Multicast Slot
  - Only accessed by peered PDs
  - Signaling reduction using Link ID
    - No necessity of sending multiple MAC addresses of both TX PD and RX PD(s)
  - Multi-hop allowed within PDs successfully authenticated



6. Unicast/Multicast

- Unicast/Multicast Slot comprises
  - Scheduling Request/Response Sub-slots
  - Resource Blocks (RBs)



6. Unicast/Multicast

- Design Approach
  - Contention-free channel access
    - Low signaling overhead & high spatial reuse
  - Distributed scheduling
    - Scheduling Request and Scheduling Response
    - These signaling messages contain resource information
      - Related to RB assignment
      - Broadcasted to nearby PDs

Scheduling Request :

Link ID	Resource Block Start Index	Resource Block Demand

Scheduling Response :

Link ID	Resource Block Adjusted Index	Resource Block Adjusted Demand

6. Unicast/Multicast

- Required Features of Distributed Scheduling
  - Resource conflict avoidance [referred from 15-13-0376-01]
    - Throughput can be increased by high spatial reuse
    - Link assignment based on the SIR of receiving PD's
  - Utilizing channel-state information
    - A RX PD gives feedback to peered TX PD
    - TX PD controls the size of resources based on feedback
  - Congestion-aware resource assignment
    - Resource is assigned according to results of congestion monitoring

7. Summary

- Key Design Considerations
  - Frame structure
  - Distributed synchronization
  - Peer discovery
    - Protocol stack
    - Discovery Block selection
  - Broadcast
    - Contention-based access within un-peered PDs
  - Peering
    - Contention-based access to establish links
  - Unicast/Multicast
    - Contention-free access within peered PDs
    - Distributed scheduling by request and response

8. References

- [1] XMPP (Extensible Messaging and Presence Protocol)
  http://xmpp.org/
- [2] UUID (Universally Unique Identifier)
  http://en.wikipedia.org/wiki/Universally_unique_identifier