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

Submission Title: MAC proposal for supporting dependable BAN service classes

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Re: In response to call for technical contributions

Abstract: In this presentation, we consider IEEE 802.15.6-2012 features for supporting possible uses cases of dependable BAN. When using beacon mode with superframes, we can find possible superframe configuration for supporting class 1 and class2. However, number of node served in a BAN may be limited and cyclic transmission of frame can not be guaranteed due to interference from coexisting BANs.

Purpose: Material for discussion in P802.15.6a TG

MAC Proposal for Supporting Dependable BAN Service Classes

Seong-Soon Joo

ETRI

Class of Dependable BAN Services

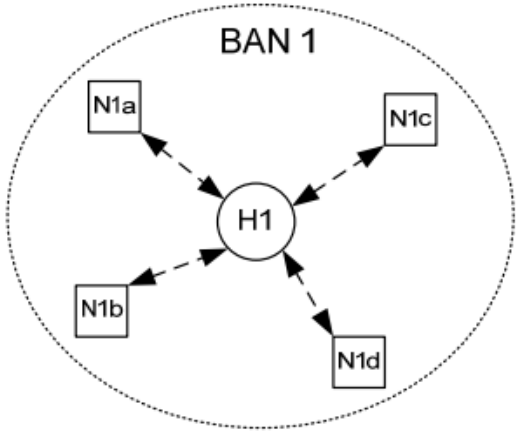
- QoS 1 Class: Highest Priority Level for Demand of Dependability
  - 1.1 Car Internal M2M
  - 1.3 Remote Diagnosis in Factory
  - 2.3 Professional Medicine
  - 3.2 Public Safety
- QoS 2 Class: Middle Priority Level for Demand of Dependability
  - 1,2 Inter-vehicle M2M
  - 2.2 Healthcare
  - 3.1 Life Line (Water/Gas/Electricity Supply)
  - 4.1 Remote Diagnosis of Infra(bridge/bldg./train)
- QoS 3 Class: Low Priority Level for Demand of Dependability

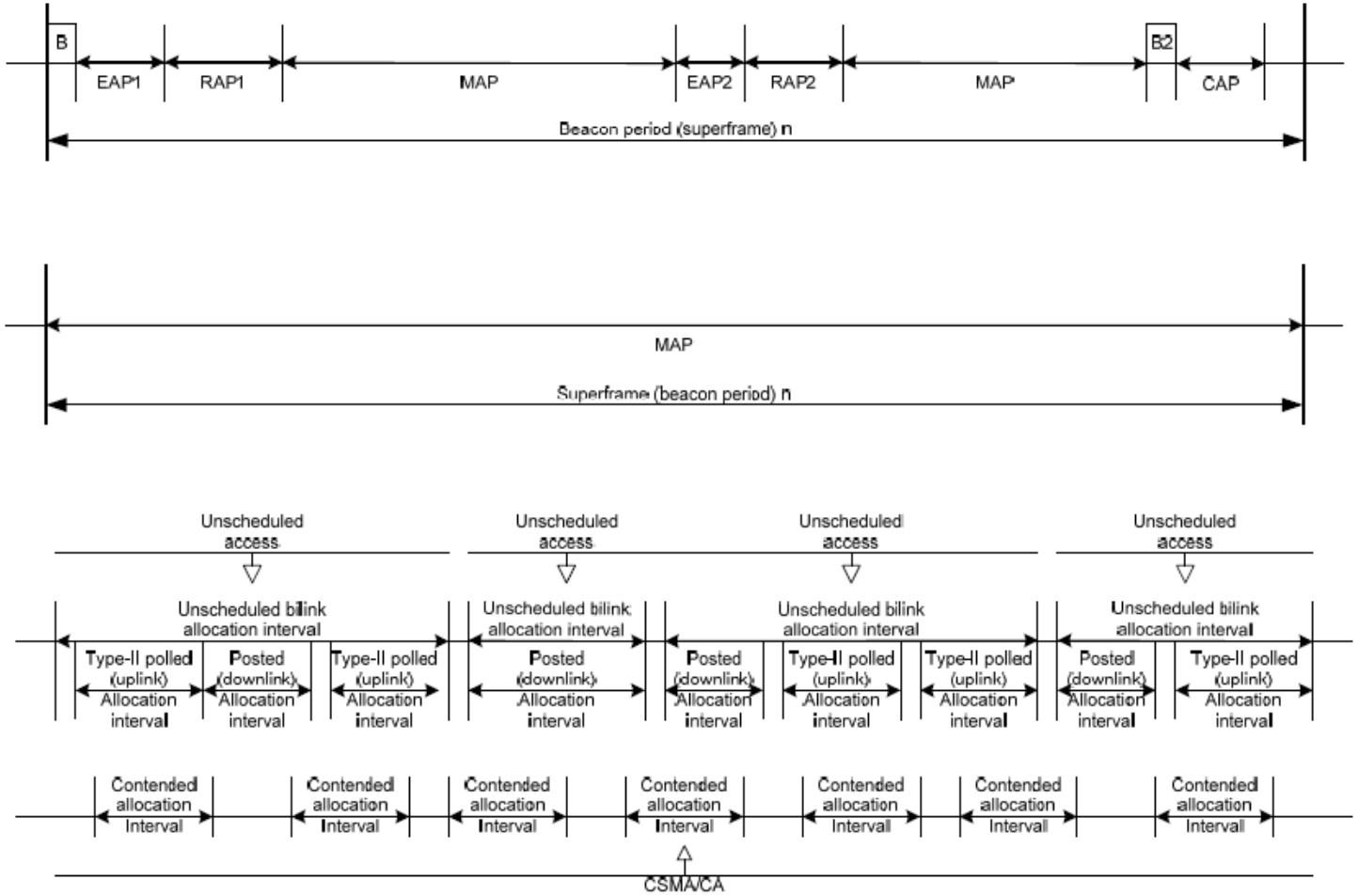
- QoS 1 class requirements
  - latency : few ms to 15 ms (FA in critical)
  - delivery ratio : 99.9% (car)
  - cycle time : 10ms (car)
- QoS 2 class requirements
  - latency : 100 ms (BMI)
  - delivery ratio : 99% (FA)
  - cycle time : 50ms (BMI)
- QoS 3 class requirements
  - latency : 250 ms to 1s (FA in normal)
  - delivery ratio : 95% (BMI)
  - cycle time : 1s (FA)

source: Ryuji Kohno, et al., “Draft Technical Requirement of IEEE802.15.6a for Amendment of 15.6 BAN with Enhanced Dependability”, 15-21-0493-01-006a

IEEE 802.15.6-2012 can support QoS classes?

- IEEE 802.15.6-2012 BAN
  - star topology
    - hub
    - node
    - size < 64
  - three access modes
    - Beacon mode with beacon periods (superframes)
    - Non-beacon mode with superframes
    - Non-beacon mode without superframes





Considerations on MAC for Dependable BAN

- It would be reasonable to focus only on
  - **ultra-wideband**
  - **beacon mode**
  - as they are beneficial to achieving high dependability

- The superframe structure
  - may also be **simplified** by reducing the types of access phases.

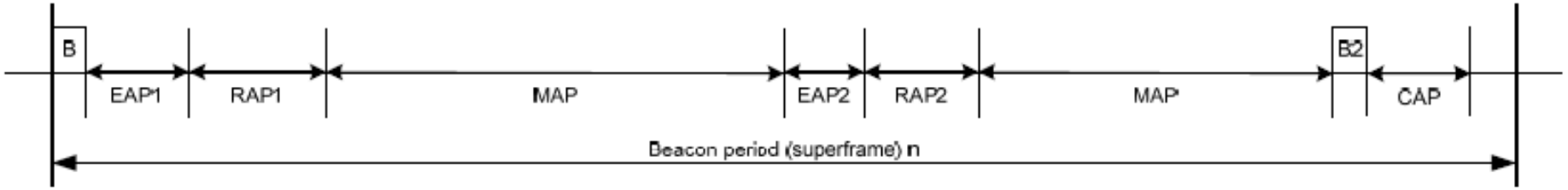
- IEEE 802.15.6-2012 can support QoS classes?
  - if not, which part needs to be modified or newly added?

source: Minsoo Kim, et al., “Considerations for MAC protocol in IEEE 802.15.6 BAN with Enhanced Dependability”, 15-22-0186-01-006a

Beacon mode with beacon periods (superframes)

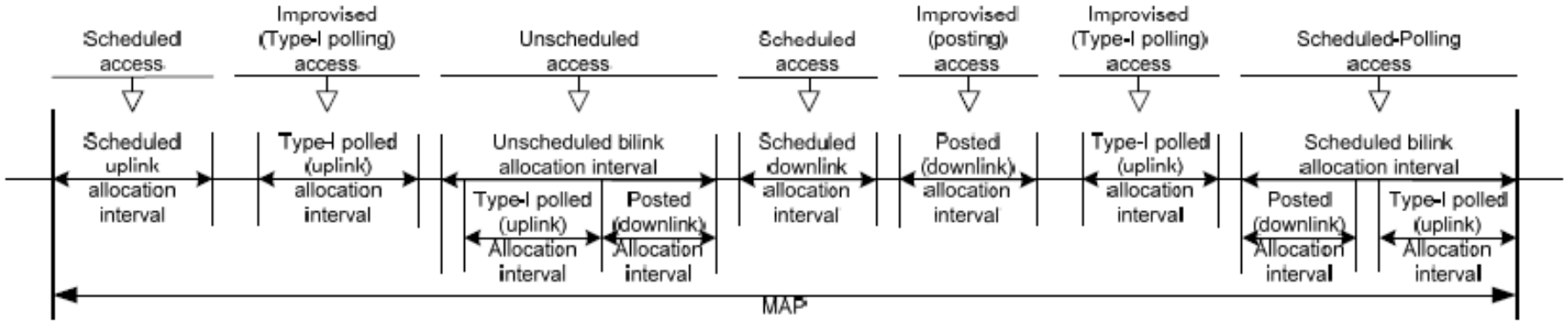
- hub may maintain *I* inactive superframes (beacon periods)
  - after each active superframe (beacon period)

- hub may set to zero the length of any of these access phases
  - exclusive access phase 1 (EAP1)
  - random access phase 1 (RAP1)
  - managed access phase (MAP)
  - exclusive access phase 2 (EAP2)
  - random access phase 2 (RAP2)
  - another managed access phase (MAP)
  - contention access phase (CAP)



Managed Access Phase (MAP)

- hub arrange
  - scheduled uplink allocation intervals
  - scheduled downlink allocation intervals
  - scheduled bilink allocation intervals
- hub provide
  - unscheduled bilink allocation intervals; and improvise type-I,
  - but not type-II, immediate polled allocation intervals and posted allocation intervals starting in this MAP



Beacon Frame – MAC header

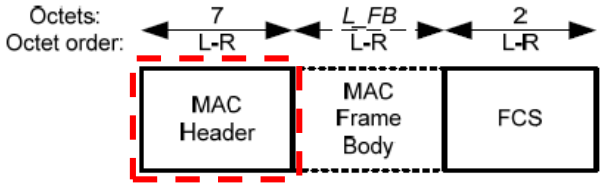


Figure 8—MAC frame format

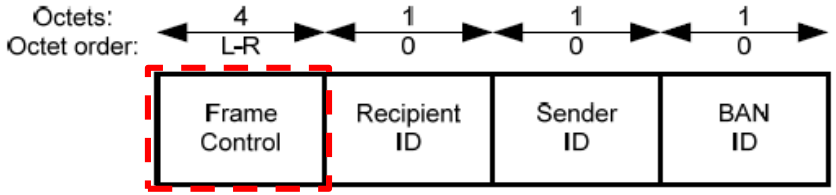


Figure 9—MAC Header format

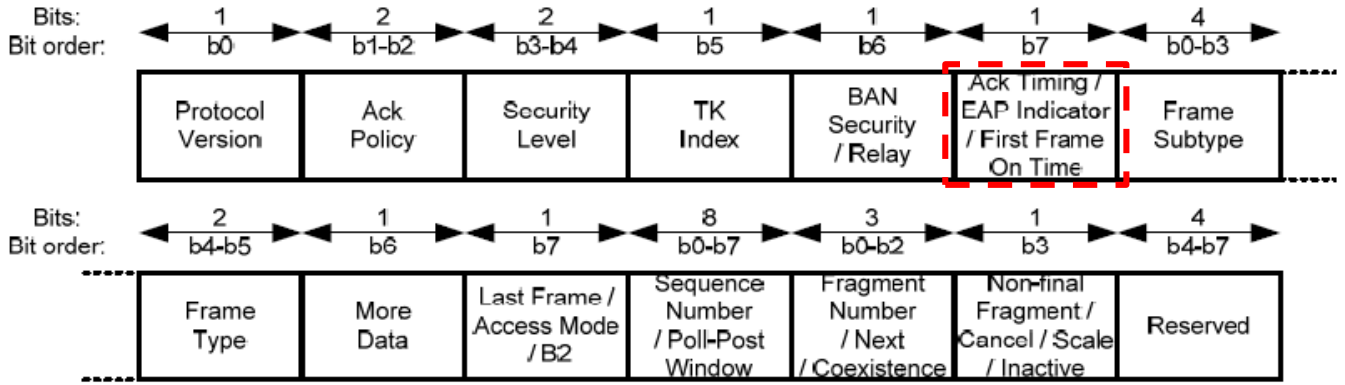


Figure 10—Frame Control format

Frame Type value b5 b4	Frame Type name	Frame Subtype value b3 b2 b1 b0	Frame Subtype name
00	Management	0000	Beacon

Beacon Frame – MAC frame body

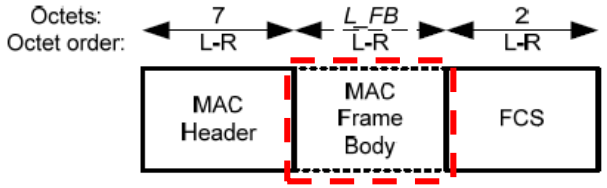


Figure 8—MAC frame format

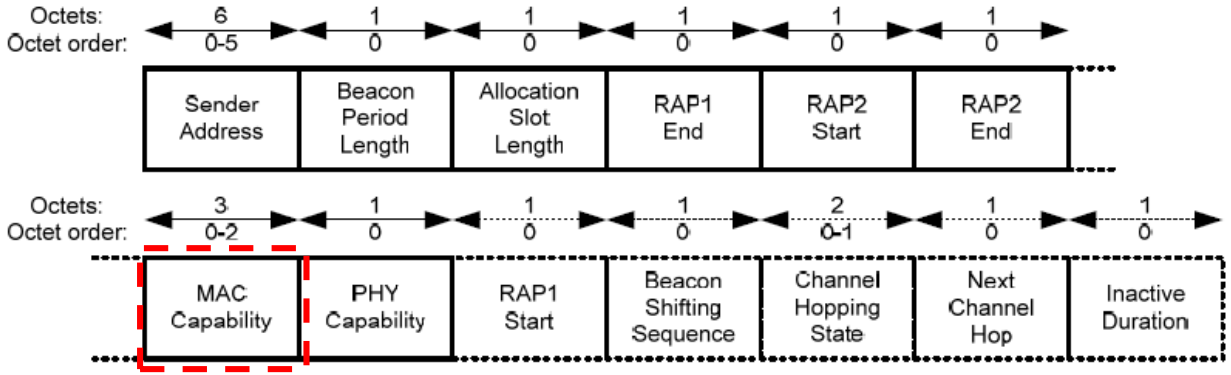


Figure 14—Frame Payload format for Beacon frames

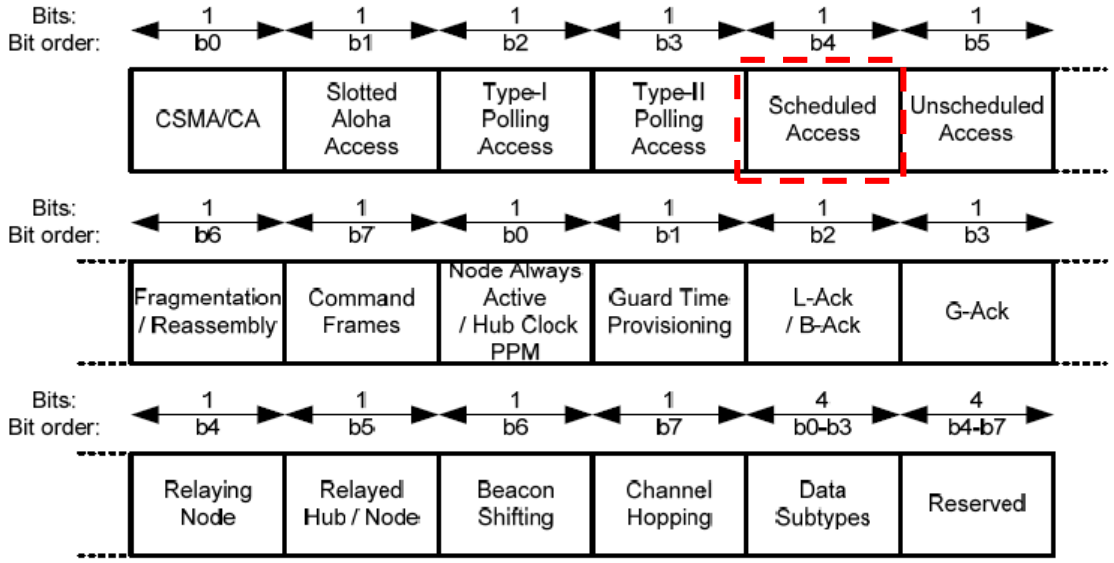


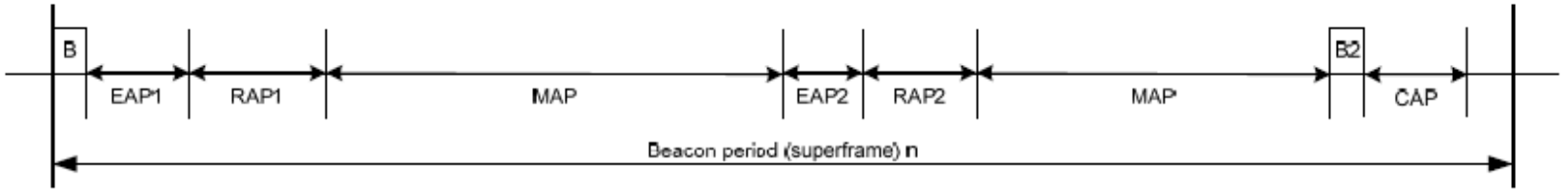
Figure 42—MAC Capability format

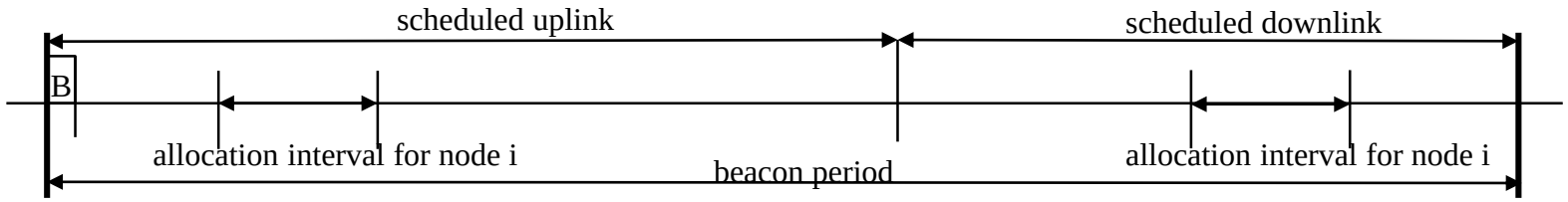
Configure 802.15.6-2012 Superframe for supporting classes

- configuration of superframe
  - class 1
    - cycle time : 10ms
    - latency : few ms to 15 ms
  - class 2
    - cycle time : 50ms
    - latency : 100 ms
  - class 3
    - cycle time : 1s
    - latency : 250 ms
- requirements on deterministic scheduled access
  - class 1
    - up and down transmission every 10 ms with 99.9% possibility
    - accumulated transmitting and receiving latency at hub PHY/MAC and node PHY/MAC < 10 ms
  - class 2
    - up and down transmission every 50 ms with 99% possibility
    - accumulated transmitting and receiving latency < 50 ms
  - class 3
    - up and down transmission every 1 s with 95% possibility

Superframe for deterministic scheduled access

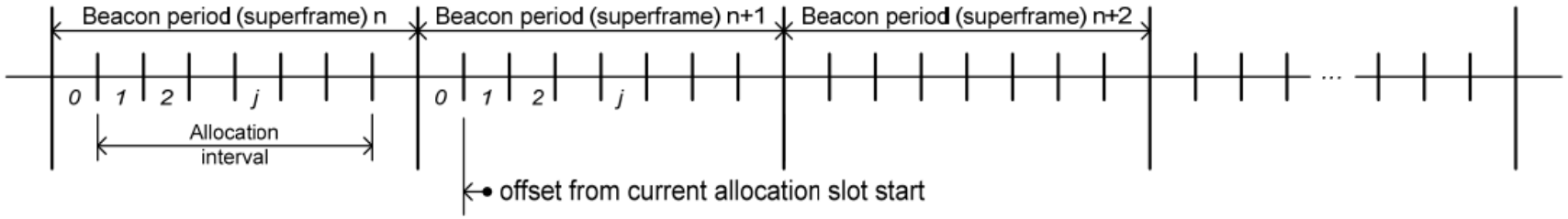
- configure superframe for supporting deterministic scheduled access
  - allocate scheduled access only
    - use MAP
    - set to zero the length of
      - EAP1, RAP1, EAP2, RAP2, CAP
  - configure MAP for supporting deterministic scheduled access
    - allocate resources for hub-node connection
      - scheduled uplink
      - scheduled down link
    - scheduling links
      - 1-periodic allocation
      - m-periodic allocations





Emulate scheduled superframe for class 1 service

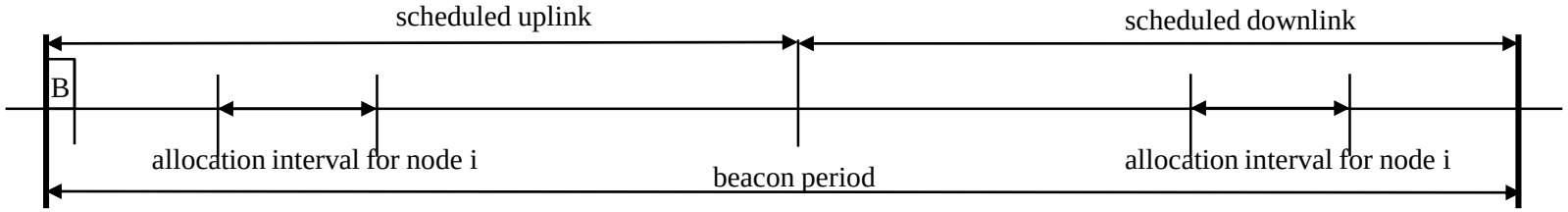
- UWB PHY on-off modulation
  - data rate 0 : 487 Kbps
- class 1
  - up and down transmission every 10ms with 99.9% possibility
    - beacon period length should be less than equal to 10ms
    - allocation slot length should be enough to transmit a frame
- Allocation Slot Length
  - pAllocationSlotMin + *L* × pAllocationSlotResolution
    - pAllocationSlotMin, pAllocationSlotResolution = 16us
    - L = 0 → 16us
    - L = 255 → 4,096us
- Beacon Period Length
  - B x Allocation Slot Length
    - B = 0 (256)
    - B = 1 → 16us, …. , 4,096us
    - B = 256 → 4,096us, …. , 1,048,576us



Emulate scheduled superframe for class 1 service

- for supporting class 1
  - if one interval allocated in a superframe
  - Beacon Period Length =< 10ms
- configuration of superframe
  - beacon period length = (number of allocation slots in superframe x allocation slot length)
  - the number of allocation slots in a superframe is determined by
    - the size of BAN : number of nodes joined
    - length of allocation interval for a node
  - to support 10ms beacon period
    - 10ms/allocation slot length > number of nodes x length of allocation interval for a node

- case
  - 5 nodes in a BAN
  - length of allocation interval for a node to transmit data to up and down = 2ms
    - allocation slot length < 10ms/(5*2)
  - configuration of superframe
    - L = 62 → allocation slot length = 1.008ms
    - B = 10 → beacon period length = 10.08ms



Emulate scheduled superframe for class 2 service

- for supporting class 2
  - cycle time should be less than equal to 50ms
  - Beacon Period Length =< 50ms

- configuration of superframe
  - 5 nodes in a BAN
  - length of allocation interval for a node to transmit data to up and down is 2 ms
    - allocation slot length < 50ms/(5*2) → max. 5 ms
  - configuration of superframe
    - L = 62 → allocation slot length = 1.008ms, B = 50 → beacon period length = 50.4ms
    - L = 187 → allocation slot length = 3.008ms, B = 17 → beacon period length = 51.1ms

Allocation Request

- node shall send a Connection Request frame to the hub
  - Uplink Request IE if scheduled uplink allocations are needed
  - Downlink Request IE if scheduled downlink allocations are needed
  - Bilink Request IE if scheduled bilink allocations are needed
    - In these IEs, the Minimum Length and Allocation Length fields

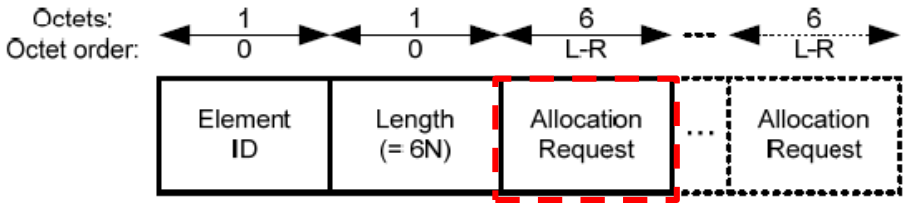


Figure 47—Uplink Request, Downlink Request, Bilink Request, or

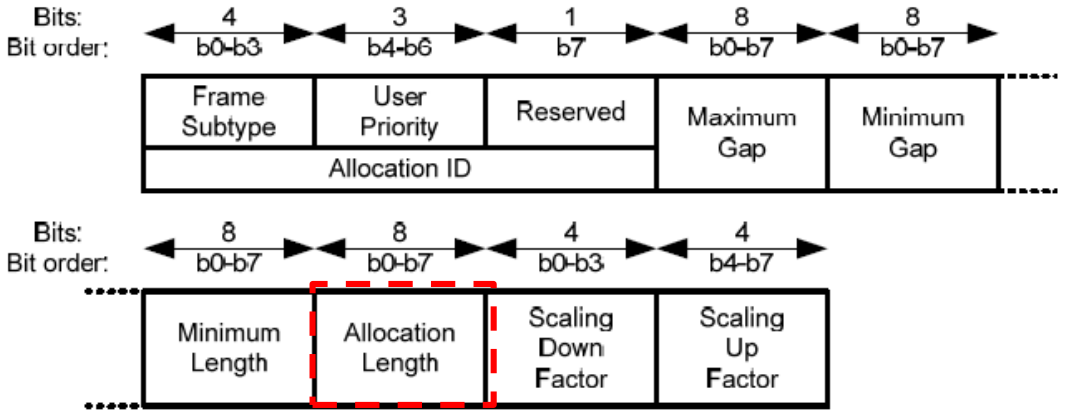


Figure 48—Allocation Request format

Allocation Grant

- hub shall send a Connection Assignment frame to the node, including the following
  - Uplink Assignment IE if scheduled uplink allocations are granted
  - Downlink Assignment IE if scheduled downlink allocations are granted
  - Bilink Assignment IE if scheduled bilink allocations are granted.

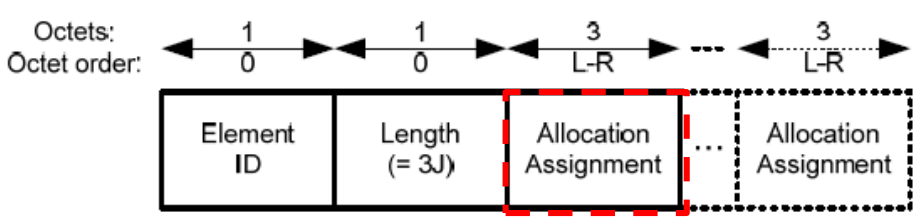


Figure 51—Uplink Assignment, Downlink Assignment, Bilink Assignment,

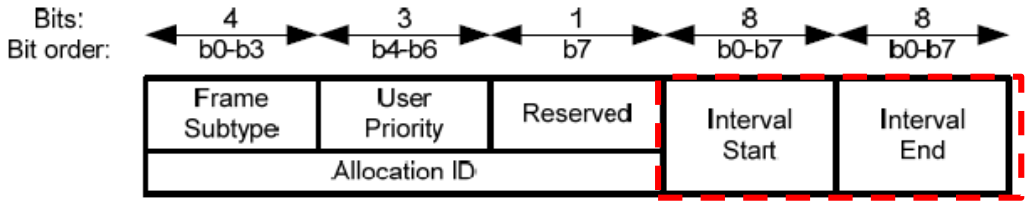


Figure 52—Allocation Assignment format

Constraints on Superframe Configuration

- configuration of superframe
  - the shortest allocation slot length is 16us
  - the longest allocation slot length is 4,096us
  - the longest beacon period length is 1,048.576ms
- number of allocation slots is determined by
  - the length of allocation interval for a node
    - number of node served in a BAN is determined by the length of allocation interval for a node
  - in class 1 BAN, number of nodes served in a BAN may be small
- when beacon period is interfered by coexisting BANs
  - cyclic transmission of frame can not be guaranteed

Summary

- IEEE 802.15.6-2012 can support dependable BAN service classes?
  - Yes, it's possible to configure superframe for service classes
    - number of node served in a BAN may be limited
      - according to the cycle time and length of allocation interval for a node
  - But, cyclic transmission of frame can not be guaranteed
    - if beacon period is interfered by coexisting BANs
- Interference avoidance in coexisting dependable BANs is required