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

**Submission Title:** [Multihop Extension for IEEE 802.15.4e]

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**Re:** [IEEE P802.15.4e Call For proposal]

**Abstract:**  [This document proposes an enhancement to IEEE 802.15.4-2006 MAC Layer with modified superframe structure, GTS request/response and data transmission method.  It corresponds to 'superframe  structure' and 'mesh support'.]

**Purpose:**  [This document is a response to call for  preliminary proposals. ]
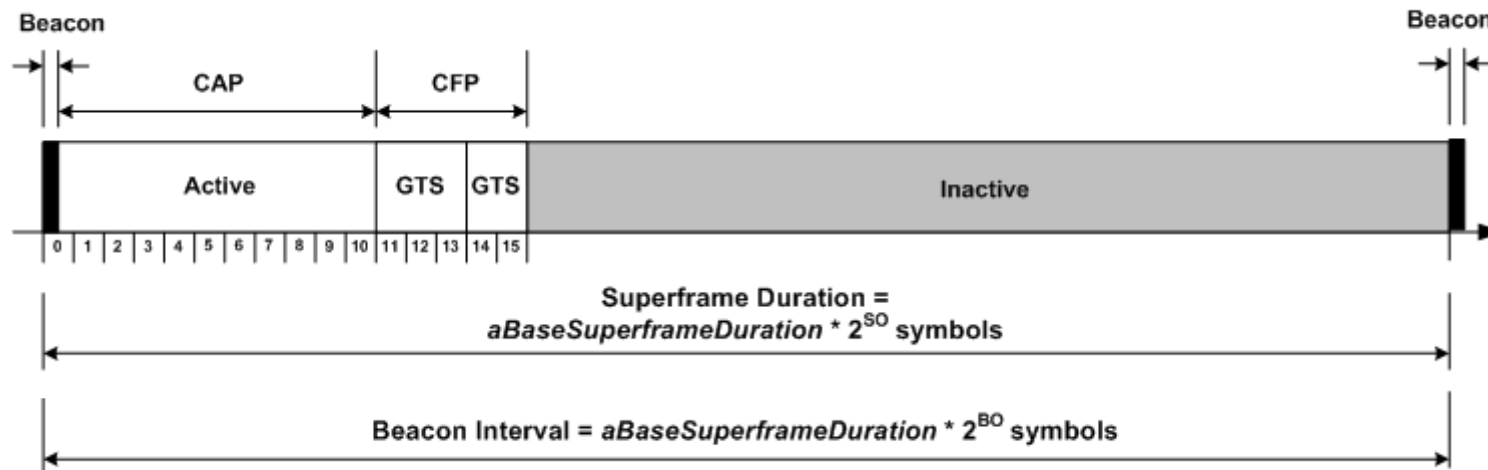
# Multi-hop Extension for IEEE 802.15.4e

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# IEEE 802.15.4 - 2006

- Superframe structure on the periodic beacon enables

  – Energy saving of Coordinator by defining a long inactive period

  – Guaranteed time services

  – Efficient indirect communication

# Multi-hop Extension

- IEEE 802.15.4-2006
  - Scheduling outgoing superframe duration in the inactive period of a parent suprframe
- Issues
  - Beacon collision problem
    - Requiring scheduling algorithm and long enough inactive duration
  - GTS time allocation
    - Limited to one hop of PNC
  - Limited transmission scope and method
    - Only communication among nodes in family
    - Only indirect communication to children

# Example
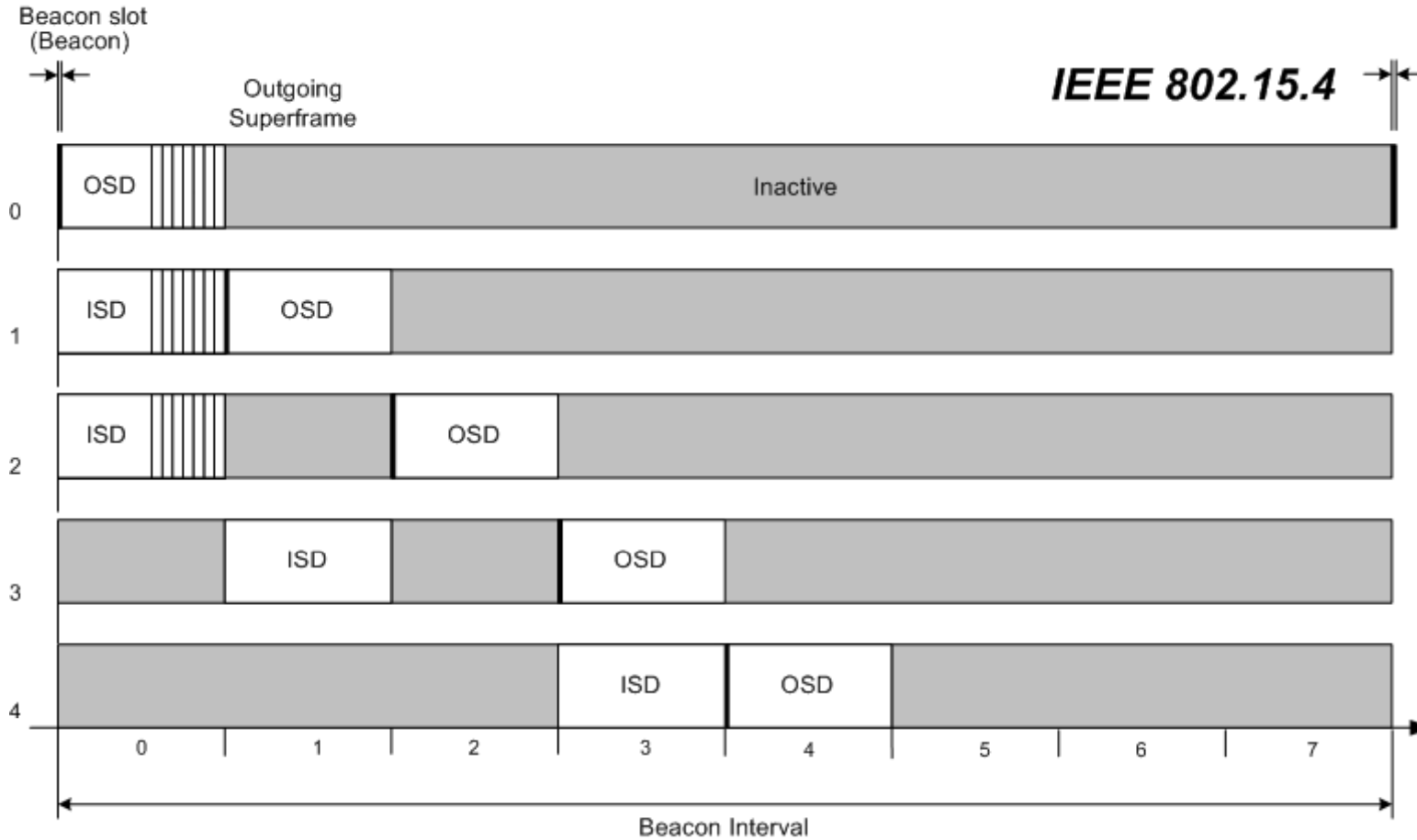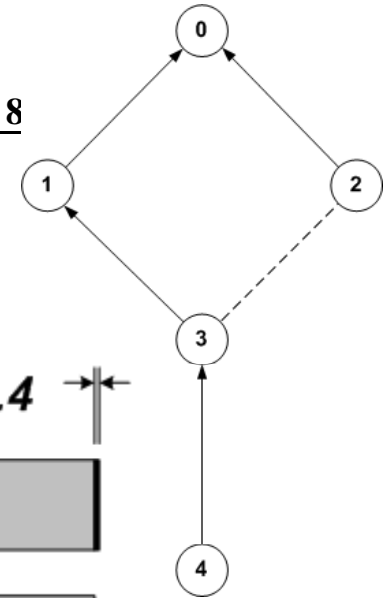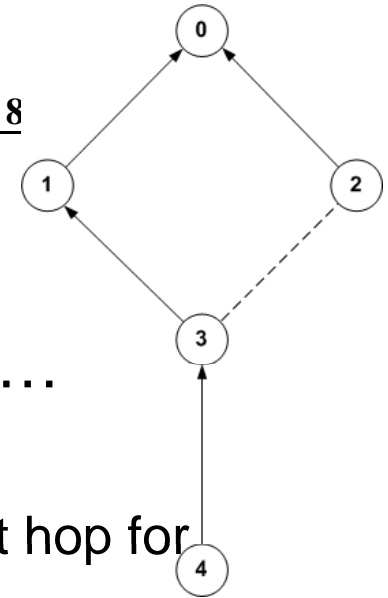
# Latency

▶ Although we believe that the architecture works…

▶ At each hop

  ◦ A node has to wait for the superframe frame of the next hop for $t_{BI}/2$ on average

▶ Long beacon interval ($t_{BI}$) is expected for

  · 1) easy scheduling

  · 2) energy saving

▶ Ex. From node 4 to 0  (3 hops), when BO=6 (0.983s)

  ◦ If the data is generated at 0,

    · (3/8 + 6/8 + 7/8)*0.983 = 1.966s

  ◦ On average : $t_{BI}$ $*h$ $=1.474$s

# Discussion

- Fundamental remedy for latency
  - To take a small beacon interval
  - To use the inactive time

- Acceptable?
  - Energy consumption
    - Trade off relation. More energy is unavoidable.
    - Hopefully acceptable in 4e scenarios
  - Scheduling complexity
    - Unless it requires more intelligent than current one.

# Shared Superframe Duration
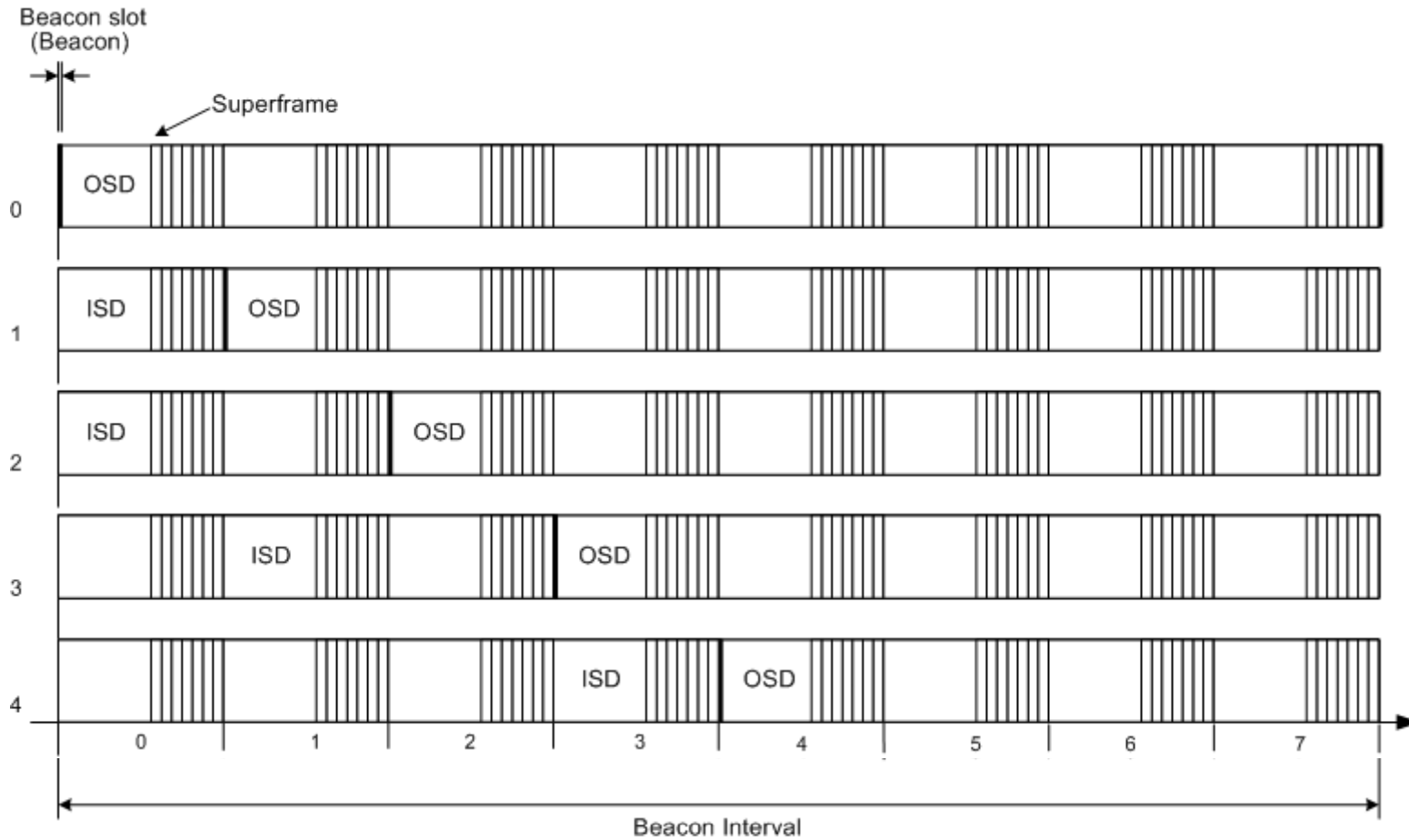
# Shared Suprframe Duration

▶ Requirement
  ◦ Slotted scheduling of superframe durations
  ◦ Superframe scheduling algorithm for 802.15.4-2006

▶ Protocol
  ◦ Create 'superframe image' from the outgoing superframe
  ◦ Transmit a beacon at the scheduled outgoing superframe
  ◦ Repeat the superframe image at the other time
    • Wait for a beacon for a while
  ◦ Modified data transmission
  ◦ Modified GTS

# Modified Data Transmission

▶ **Among 4e devices**
  ◦ Same as existing transmission used in an incomming superframe duration
    • General frame: directly transmission
    • GTS frame: using TxOption of GTS transmission

▶ **To 15.4-2006 devices**
  ◦ If 4b dev is a child
    • Option1) Indirect communication
    • Option2) Adding new SDT (Superframe Dependent Transmission) in TxOption of MCPS-DATA.request
      • Keeping the data in the queue
      • Transmitting OSD of mine or the child's
  ◦ If 4b dev is a parent or a neighbor
    • Similar to the Option2) but transmitting only in OSD of the dev's → *Superframe Dependent Transmission*

<July 2008>

# GTS Allocation

- **EGTS request**
  - From a src to a dst with available slot list

- **EGTS reply**
  - From a dst to one hop nodes → CTS
  - Broadcasting an assigned GTS slot number

- **EGTS notify**
  - From a src to one hop nodes → RTS
  - Broadcasting an assigned GTS slot number

- **Schedule notification**
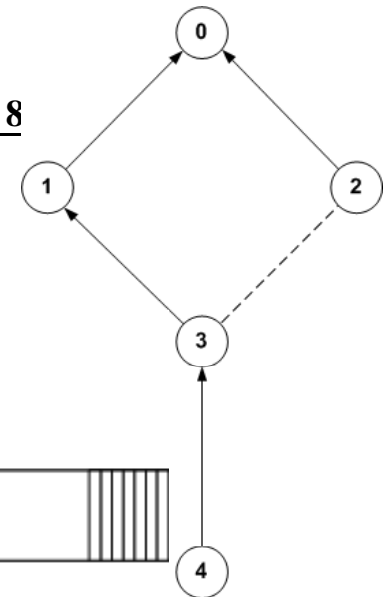  - Beacons of the src and the dst

# GTS Allocation Example
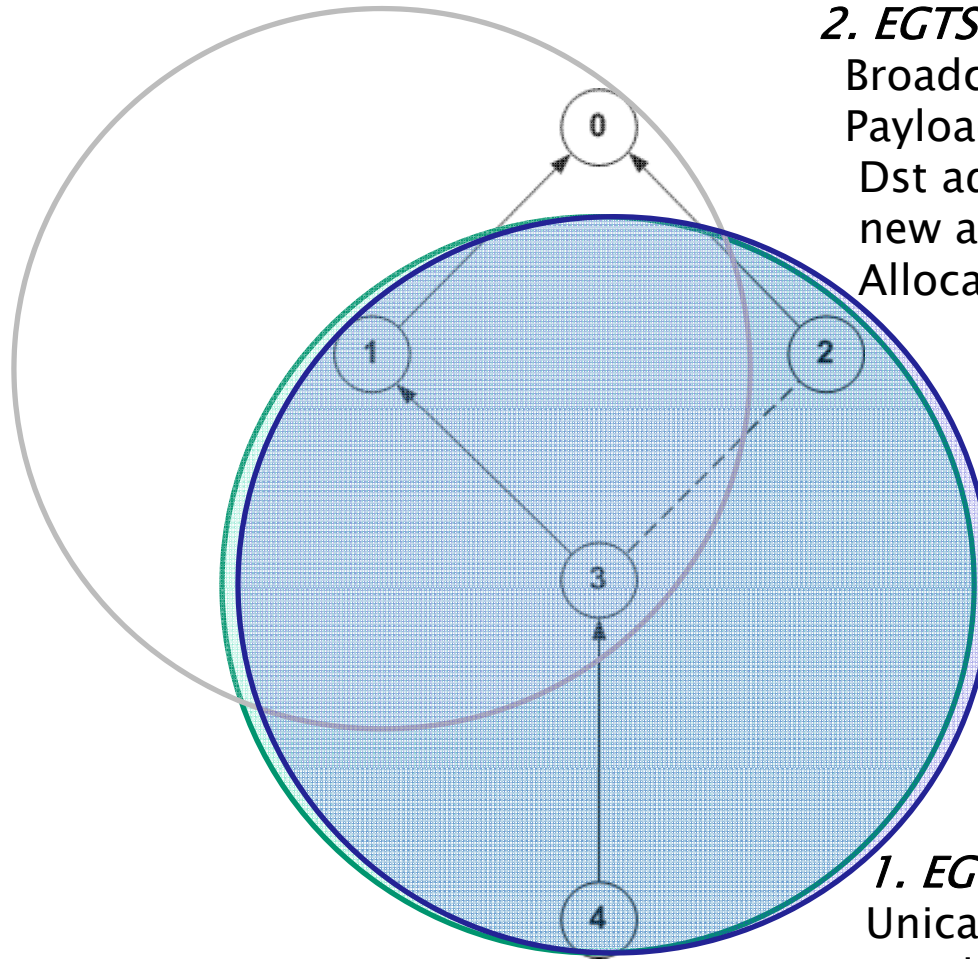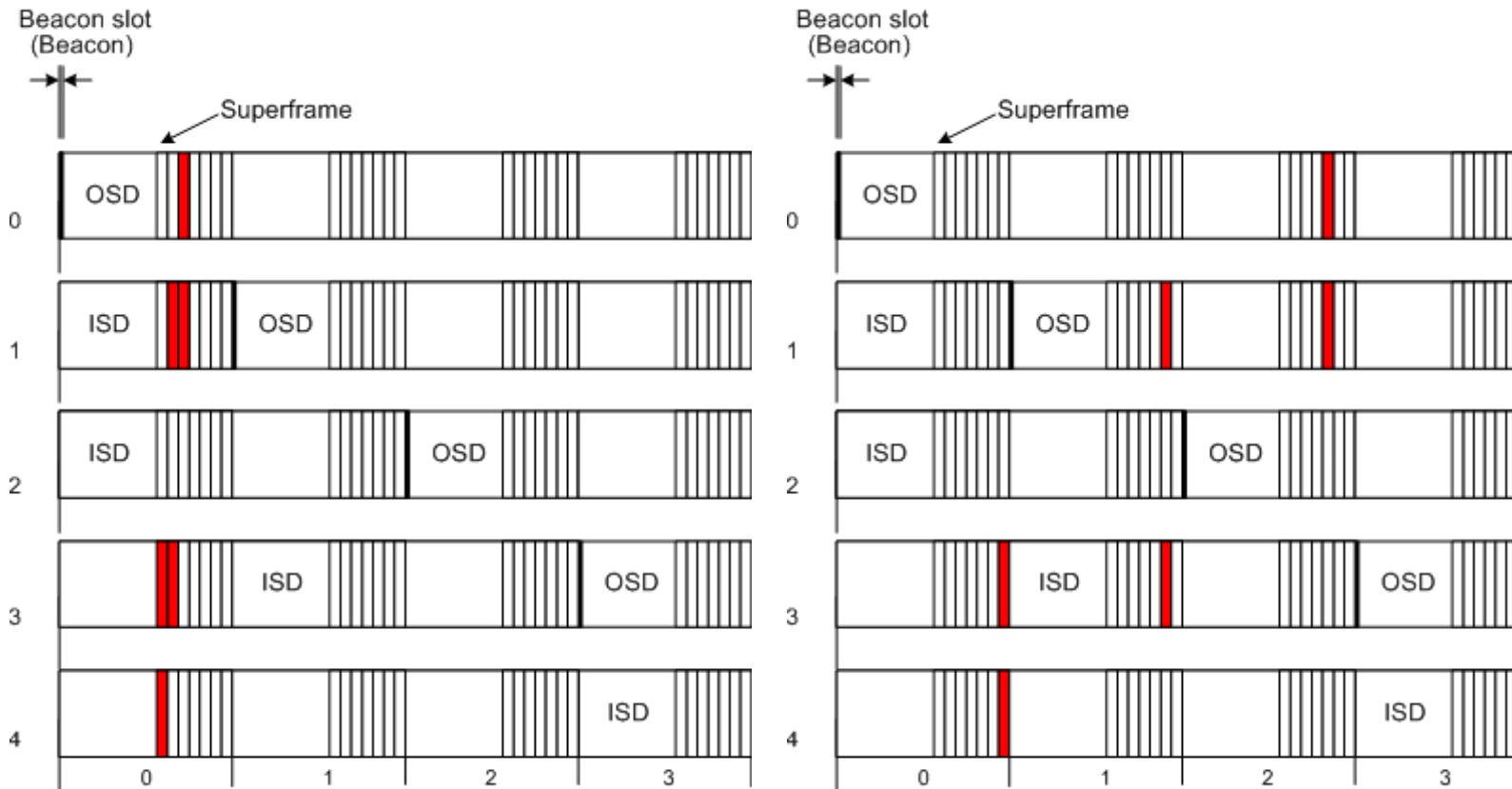


2. *EGTS reply*,
  Broadcast
  Payload :
   Dst addr (3)
   new allocated slot number: 2
  Allocated GTS slots (0b0100000)

3. *EGTS notify*,
  Broadcast
  Payload :
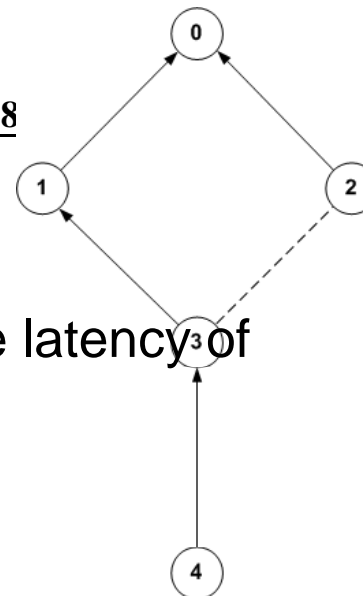    Allocated GTS slots
    (0b1100000)

1. *EGTS request*,
  Unicast to 1
   Payload :
    Available GTS slots  (0b1000000)
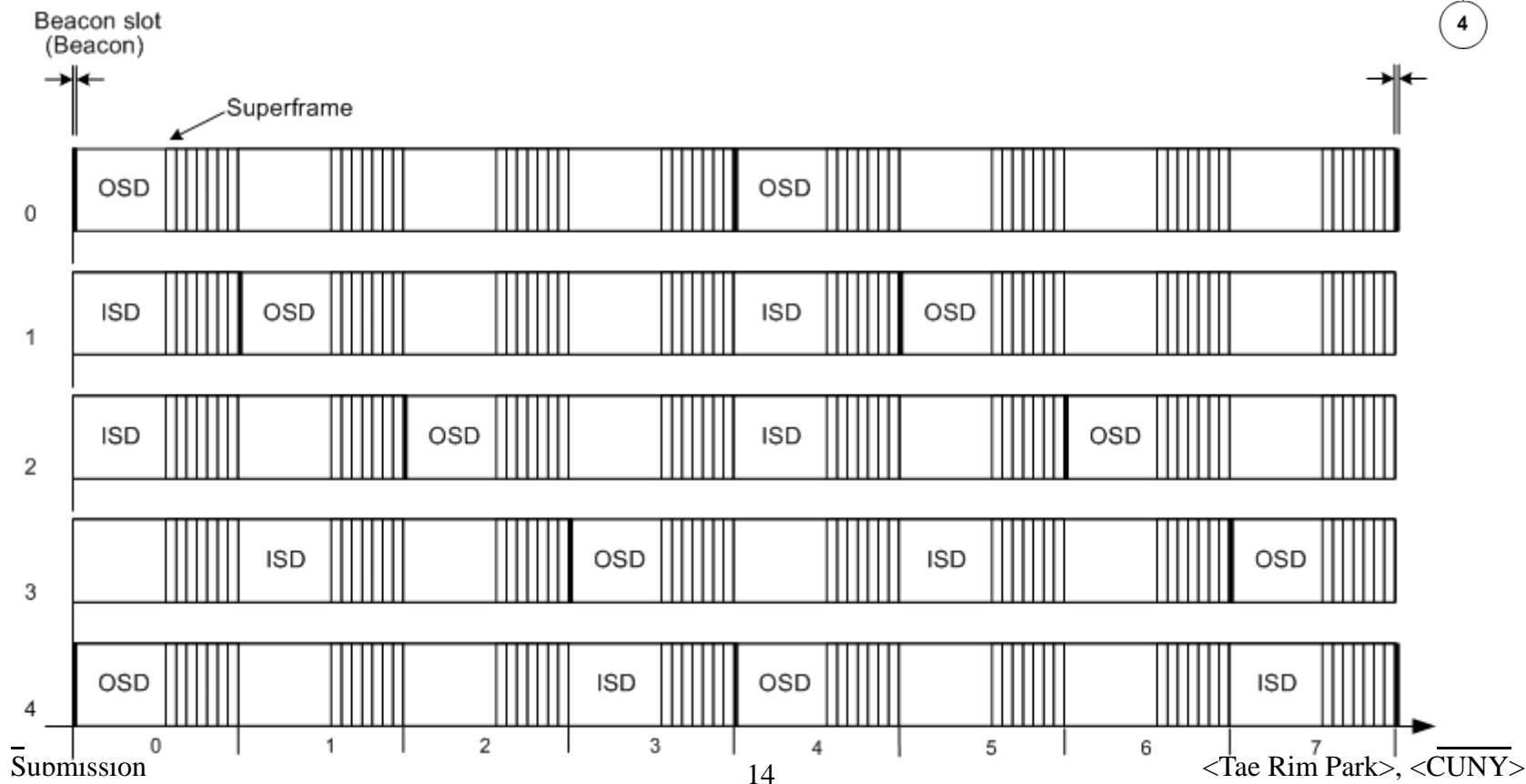
<Tae Rim Park>, <CUNY>

# Two Examples



▶ If data is generated at 0
  ◦ Minimum latency; $t_{SD}*9/16 + t_{SD}/16*2 = 69.12+15.36 = 84.48$ ms
  ◦ Maximum latency; $t_{SD}*15/16*3 = 345.6$ ms

# For Better Beacon Services

- Efficient beacon scheduling (OSD scheduling) can reduce latency of services related beacons
  - Ex. Association, indirect transmission

# Considering Energy Consumption

- Transmission method is similar to 15.4-2006 devices
  - In my OSD, transmit to any device
  - In other ODSs, transmit to the device
- Also, saving energy in unassigned GTS slots.

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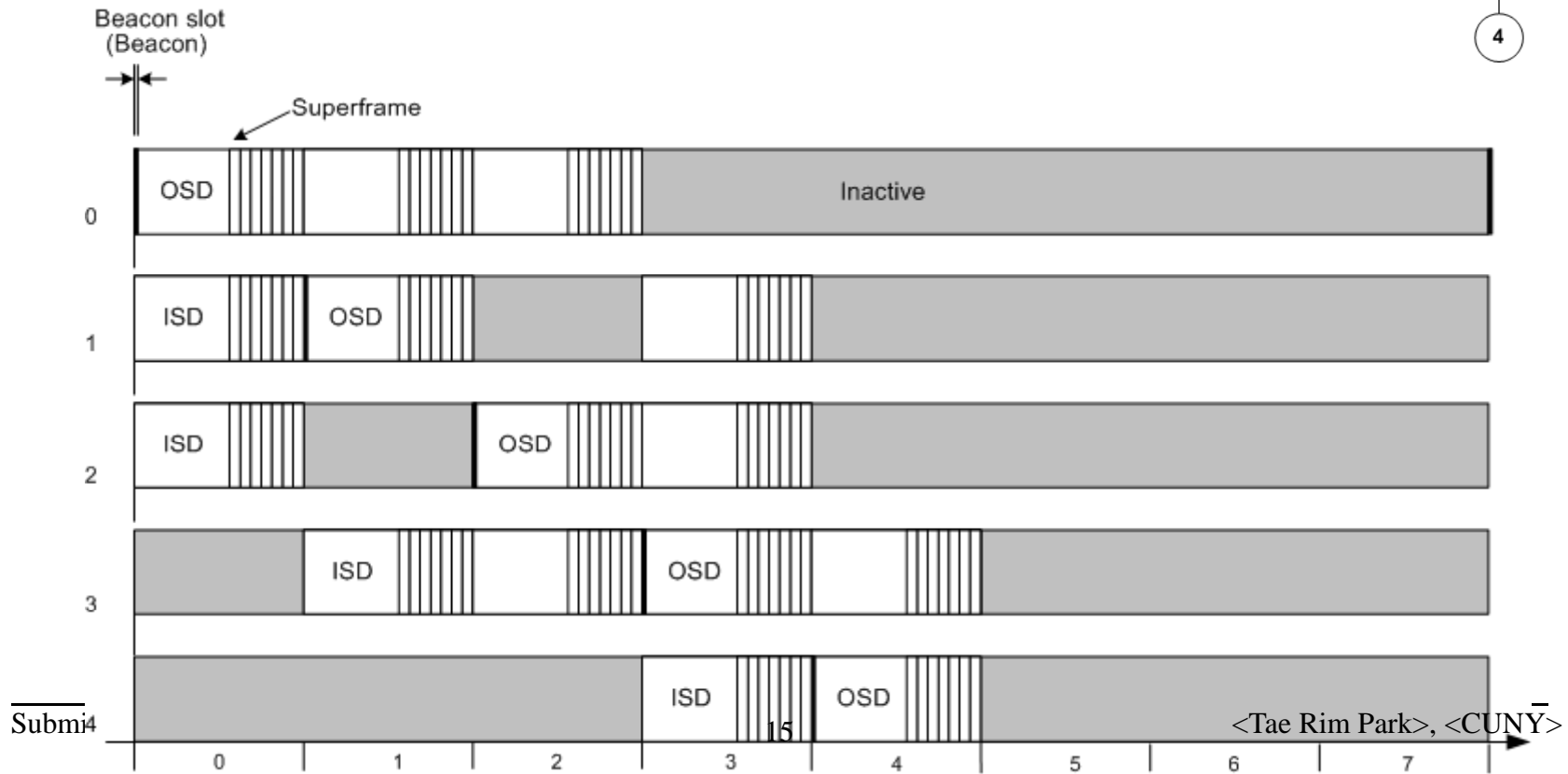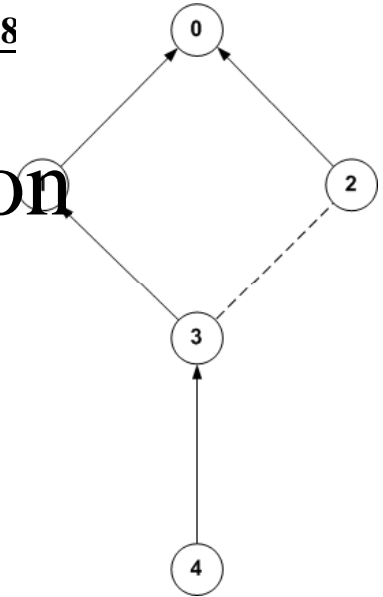
# Summary

▸ Three proposals for multihop communication
- ○ 1. <span style="color:red">Enhancing superframe structure</span> for multi hop latency problem
  - ・ Using existing beacon transmission time scheduling
  - ・ Shared superframe without transmitting beacon
- ○ 2. <span style="color:red">Enhancing GTS allocation</span>
  - ・ Three command frames
    - ・ EGTS request/ EGTS reply/ EGTS notify
- ○ 3. <span style="color:red">Superframe dependent transmission</span>
  - ・ For co-existing with 15.4-2006
  - ・ For saving energy
- ○ More discussion
  - ・ Spatial reuse
  - ・ Energy saving