IEEE 802.16e Mobility Enhancements

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Purpose:

This document presents the needed enhancements that can be done to the IEEE802.16a standard in order to support mobility operation.

IEEE802.16e Mobility Enhancements

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Contents

- MAC related PHY enhancements
- Power consumption reduction
- Hand-Off

MAC related PHY enhancements

- Extended OFDMA forward APC range
  - The Forward Automatic Power Control (FAPC) should have more degrees of freedom
  - Finer control of variations in the mobile channel
  - Simple addition by extending the 2 **boosting** bits into **3** bits:

➢000: normal (not boosted)

➢001: +3dB

➢010: +6dB

➢011: -3dB

➢100: -6dB

➢101: -9dB

➢110: -12dB

➢111: -15dB

MAC related PHY enhancements

- Fast correction of uplink power, frequency and timing
  - Enables fast frequency and timing correction in the uplink
  - Better tracking of the variations introduced by the mobile channel
  - Each Indication byte shall correspond to one unicast allocation-IE that has indicated an allocation of an uplink transmission slot in the previous UL_MAP.
  - The order of the indication bytes shall be the same as the order of the unicast allocation-IE in the UL-MAP.

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Power Consumption Reduction

- Motivation
  - Mobile Terminals may be battery powered
  - Traffic nature implies on idle periods in which the SS shall not receive or transmit information
  - Minimizing the energy usage of each mobile SS

  - Do not waste power in the Idle periods → Sleep Mode

Sleep Mode

- SS may be in two modes:
  - Awake
  - Sleep
- When SS is in *awake-mode*, it is receiving and transmitting PDUs in a normal fashion.
- When SS is in a *sleep-mode*, it does not send or receive PDUs. In *sleep-mode* the SS may power down.

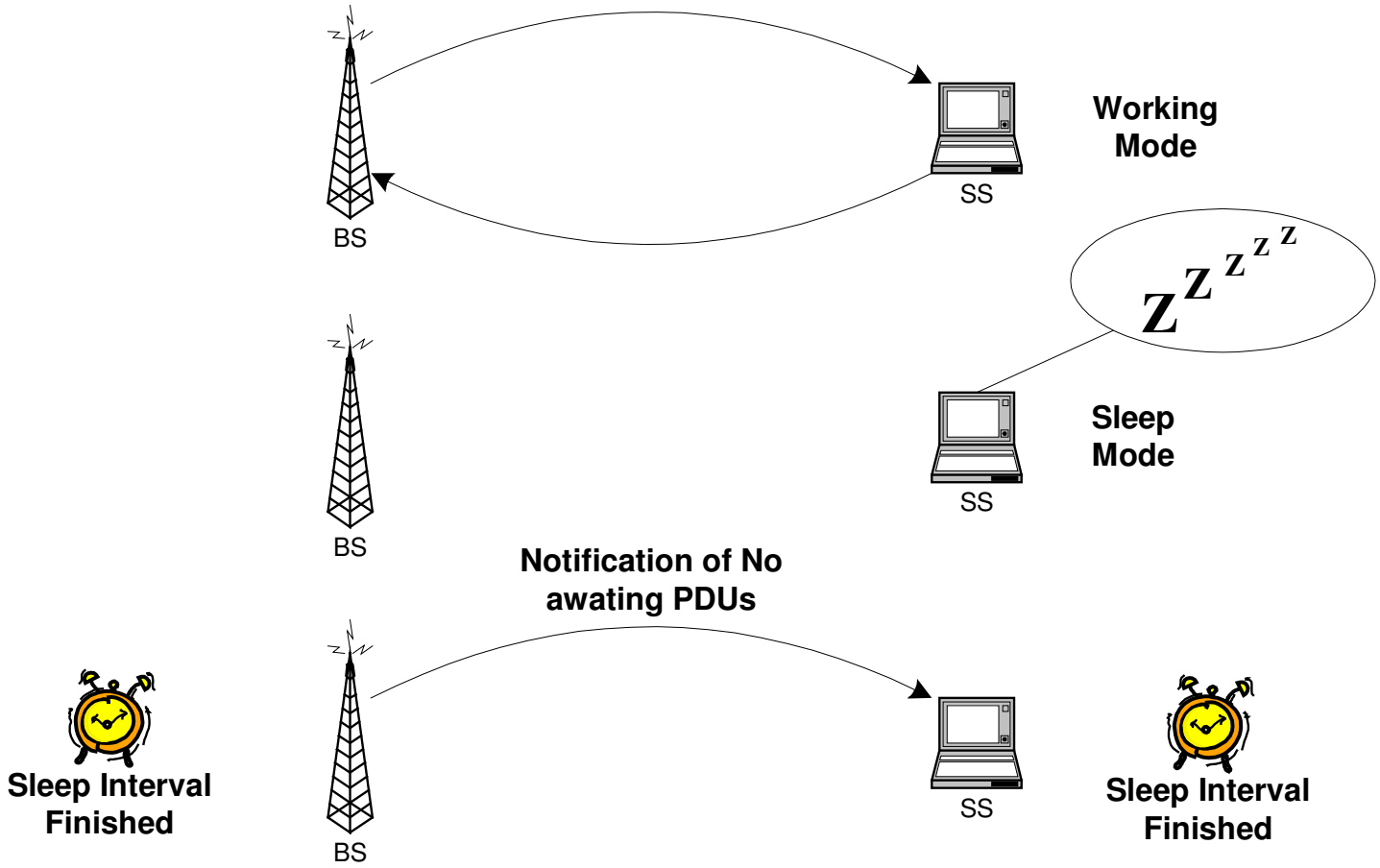
Sleep Mode - Parameters

- ***Sleep-interval*** – The time duration from the point the SS has entered *sleep-mode* until it returns to *awake-mode*.
  - Interval is increased by an exponential backoff algorithm
- ***Listening-interval*** – The time duration during which the SS, after waking up and synchronizing with the DL transmissions, can demodulate downlink transmissions and decides whether to stay awake or go back to sleep.

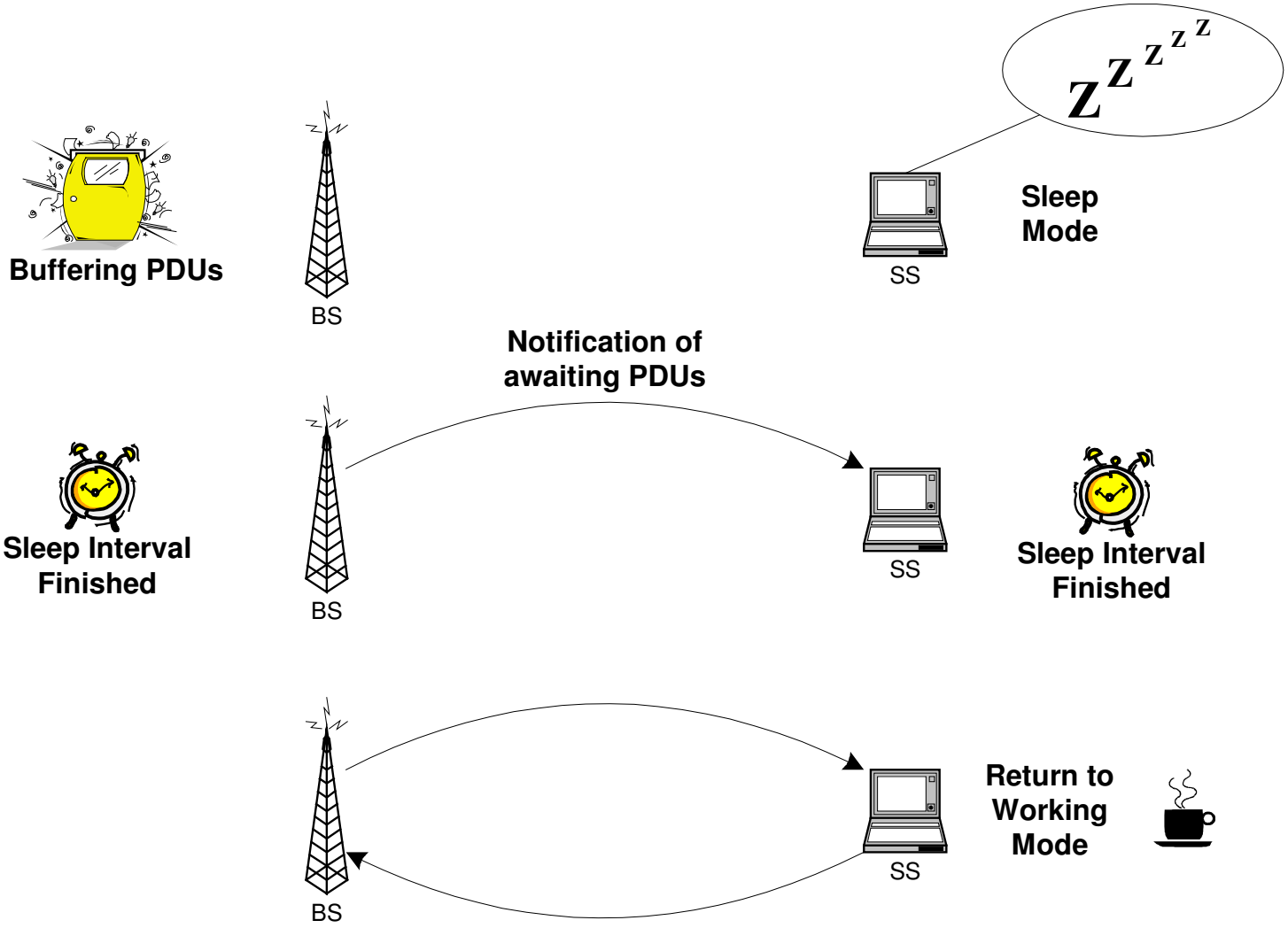
Sleep Mode - Operation

- SS Requests BS to enter into a *Sleep Mode*
- The BS may buffer (or it may drop) incoming PDUs addressed to a sleeping SS.
- BS will send notification to the SS in it's awakening periods (positive or negative)
- The SS will awake according to the *sleep-interval* and will check BS notifications.
- If PDUs are awaiting, the SS will remain awake.
- SS may terminate *sleep-mode* and return to *awake-mode* anytime.

Sleep Mode Example



Sleep Mode Example – cont'



Sleep Mode - Notes

- Exponential increase of *Sleep-Interval*
  - Optimize the power consumption when Idle periods are much higher than the agreed *Sleep-Interval*
  - Dynamic adaptation through time
  - Should have a top limit for reducing expected delays in worse case scenarios.
  - Flexible settings, per SS, according to the expected traffic profile

Sleep Mode - Notes

- *Listening-interval*
  - Used by an SS that have returned into working mode after reception of a packet.
  - Used as kind of a assurance interval that no more expected traffic is scheduled to the SS.
  - Used to compensate on delay differences between the air-link and peer-to-peer traffic (e.g. TCP session)
  - Flexible settings, per SS, according to the expected traffic profile

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Handoff - Target

- Allow mobile SSs to move efficiently between BSs.
- Provide smooth BSs transitions with minimal loss of PDUs
- Provide fast BSs transitions to guarantee QoS.

Handoff Methods

- A BS will advertise information about neighbor BSs
  - Neighbor ID
  - DCD and UCD info (center frequency, Tx power, burst profiles etc.)
  - (N+I) floor
  - Allows SS to fast synchronize with neighbor BSs
- A BS will allocate time for each SS where it may listen to neighbor BSs
  - Process can be similar to Sleep Mode handshake (both sides can initiate)
  - Allocated time should be long enough for SS to synchronize with neighbor and estimate quality of PHY link

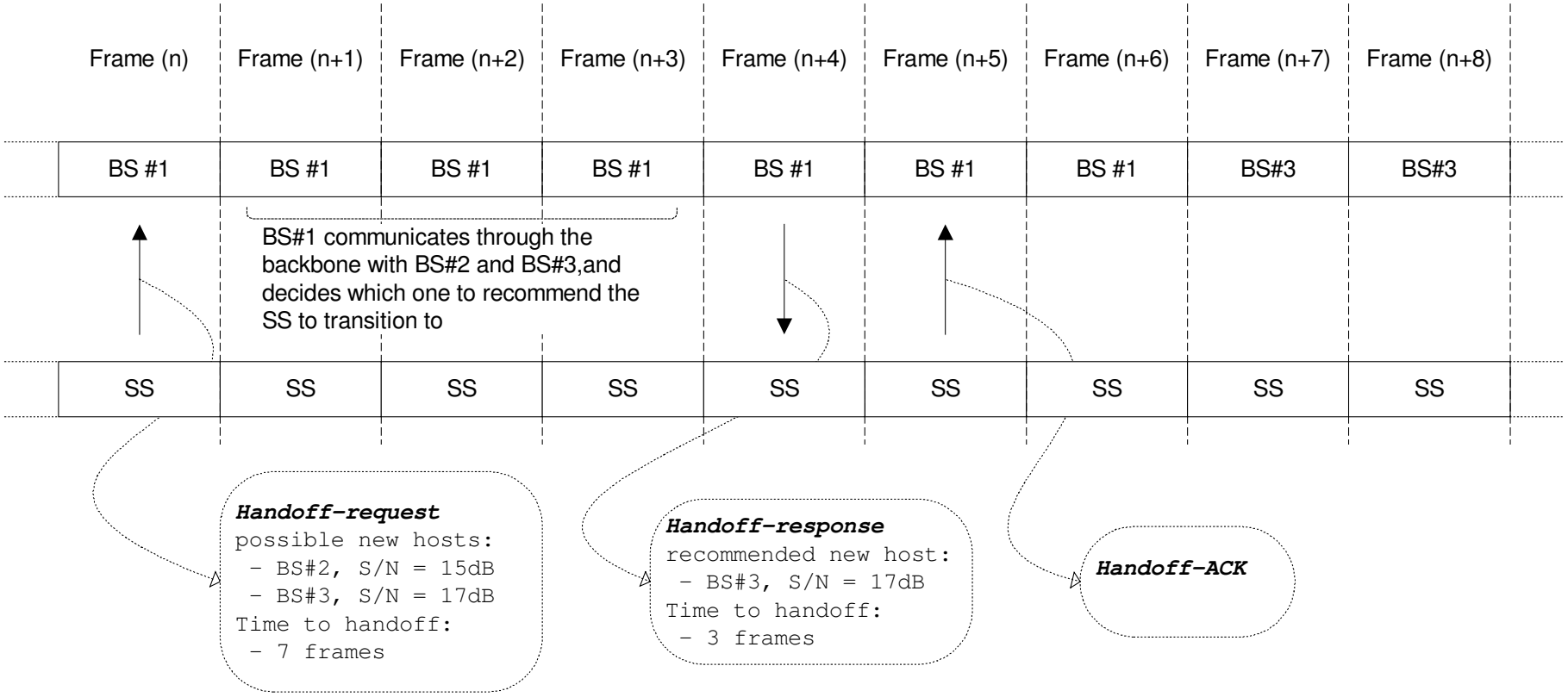
Handoff Methods - cont'

- A SS will listen to neighbor BSs while connected to it's working BS. Will gather signal information for neighbor BSs.
- Either BS or SS can initial Handoff process
- BS authorizes Handoff to SS, and recommend on a "good" neighbor (e.g. one that can guarantee SS's QoS requirements).
- Shorten network entry process for SS that is performing Handoff
  - Fast authorization
  - Reestablish the connections (CID space is not global)

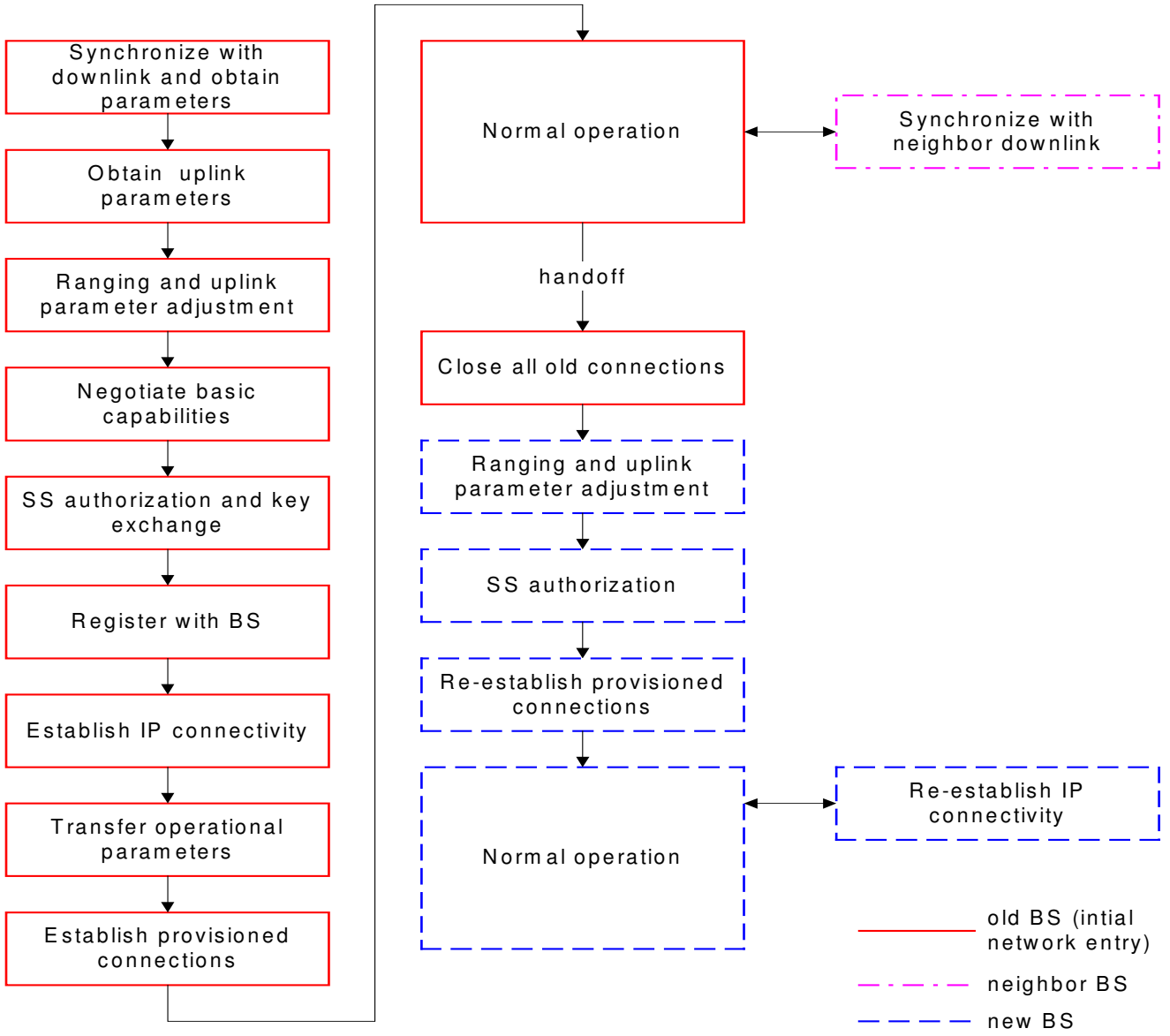
Handoff Methods – cont'

- BSs communicate though backbone and coordinates handoffs.
  - All the information concerning the SS (capabilities, security, registration information, connection information, etc.) is transmitted via the backbone to the neighbor BS.
- Handoff indications are provided by L2 to L3

Handoff Methods - example



Handoff Methods - cont'



Summary

- MAC related PHY enhancements
  - Specific changes have been suggested
  - Fast UL tracking same for OFDM/OFDMA
- Sleep Mode – specific messages have been suggested, proposed to be adopted.
- Handoff
  - Proposed concept
  - Designed to optimize L2 handoff
  - Should provide triggers to L3
  - Backbone activity between BSs to exchange management information (and not over the air)