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**Fast and reliable re-association  
mechanism for IEEE 802.15.4/ZigBee**

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# Introduction

- Typical Applications of WSNs
  - Health care sector
    - Mobile patient monitoring in hospitals (Measuring: blood pressure, ECG, diabetes, etc.)
  - Logistic
  - Control of manufacturing processes
- For most of applications it is important:
  - to avoid abrupt disconnection
  - to shorten re-association time

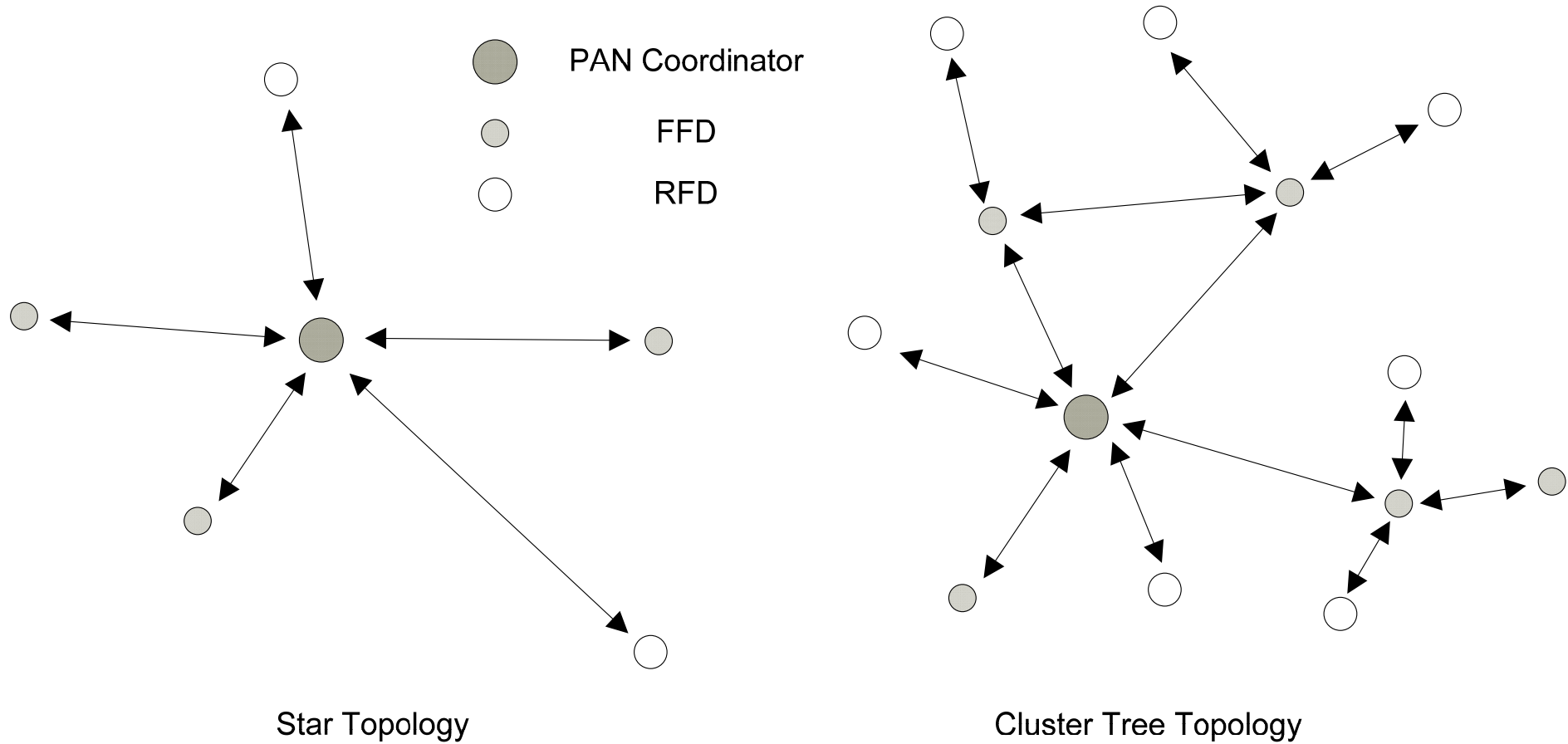


# Introduction

- LR-WPAN IEEE Std 802.15.4-2006
- Specifies PHY and MAC Layers
- Frequency Bands of Operation
  - 16 channels at 2.4GHz
  - 10 channels at 915MHz
  - 1 channel at 868MHz
- Data rates: 250 kb/s, 40 kb/s, 20 kb/s
- Low power consumption
- Star, Cluster tree and mesh topologies
- Full Function Devices (FFD) and Reduced Function Devices (RFD)

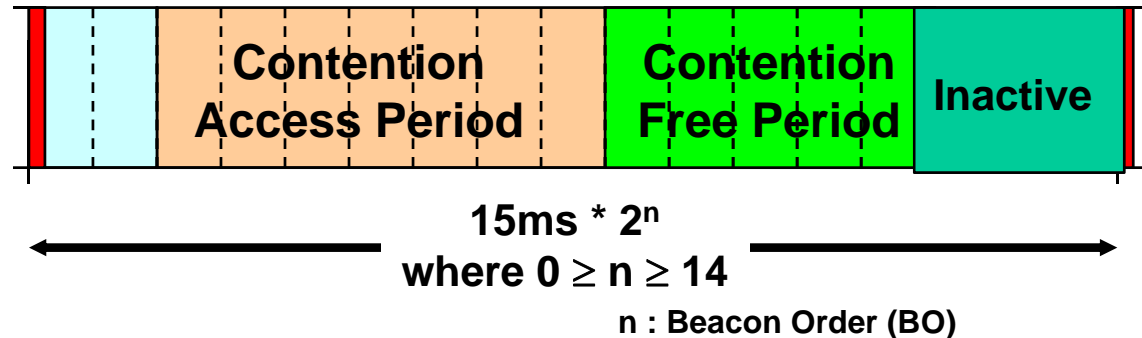


# Introduction



# Beacon-enabled mode

## Superframe Structure



**Beacon**



Sent by network coordinator. Contains network information, frame structure and notification of pending node messages.

**Beacon extension period**



Reserved for beacon growth due to pending node packets

**Contention period**



Used by any sensor with CSMA-CA

**Guaranteed Time Slot**



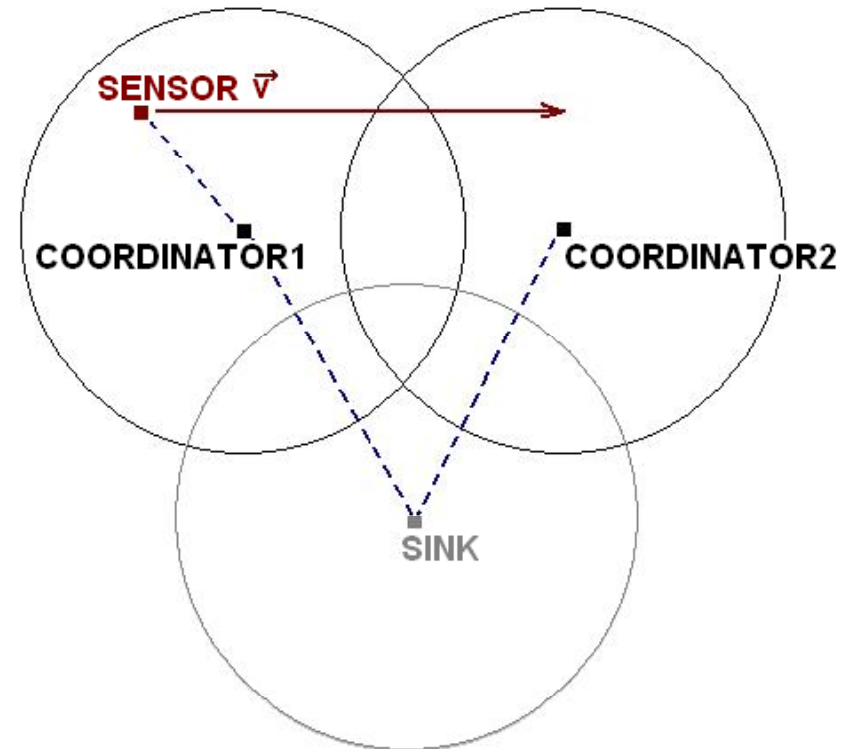
Reserved for nodes requiring guaranteed QoS



# Considered scenario

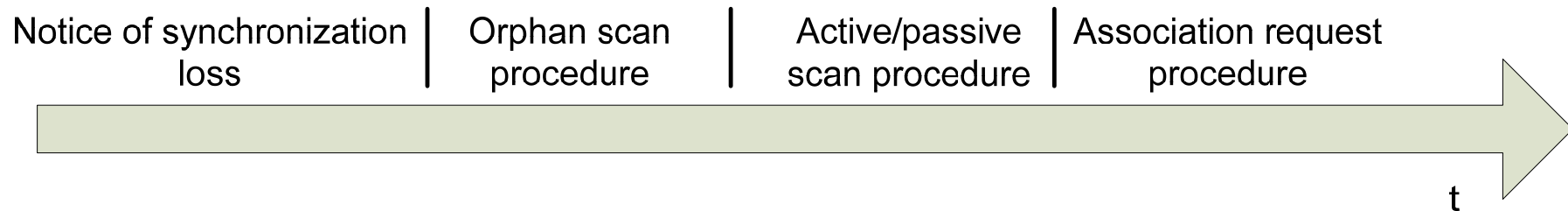
## Mobile sensor

- leaves range of its coordinator
- loses its association
- tries to connect to other coordinator



# Re-association procedure

- Detection of synchronisation lost ( $\text{numLostBeacons} > \text{maxLostBeacons}$ )
- Orphan Scan over predefined channels
- Active Scan
- Association



➔ **High delay and high ratio of lost packets**

## Optimisation goals:

- to avoid abrupt disconnection during switching to other coordinator
- to avoiding extensive re-association procedures (orphan scan and active scan)

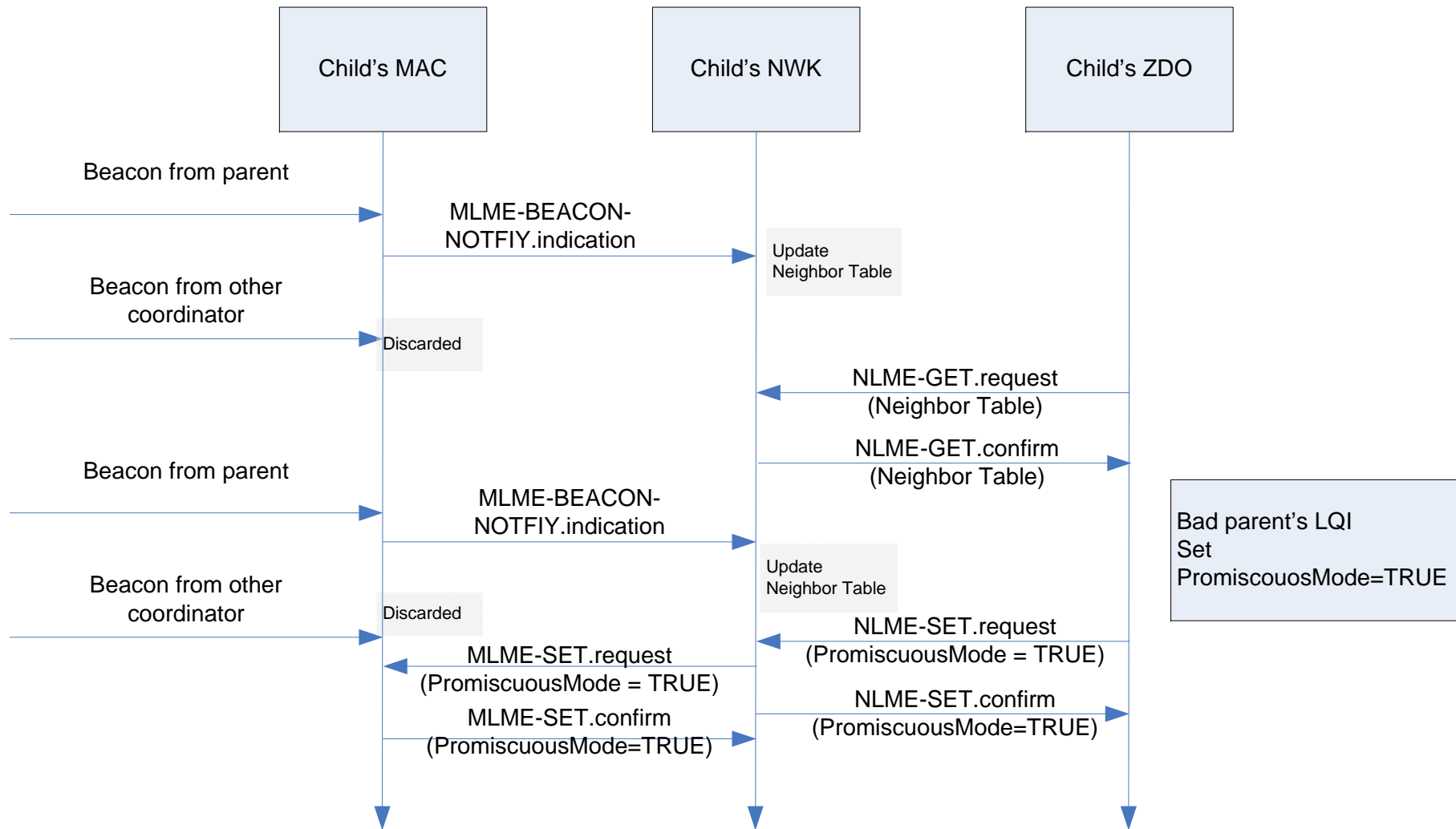


# Used Features

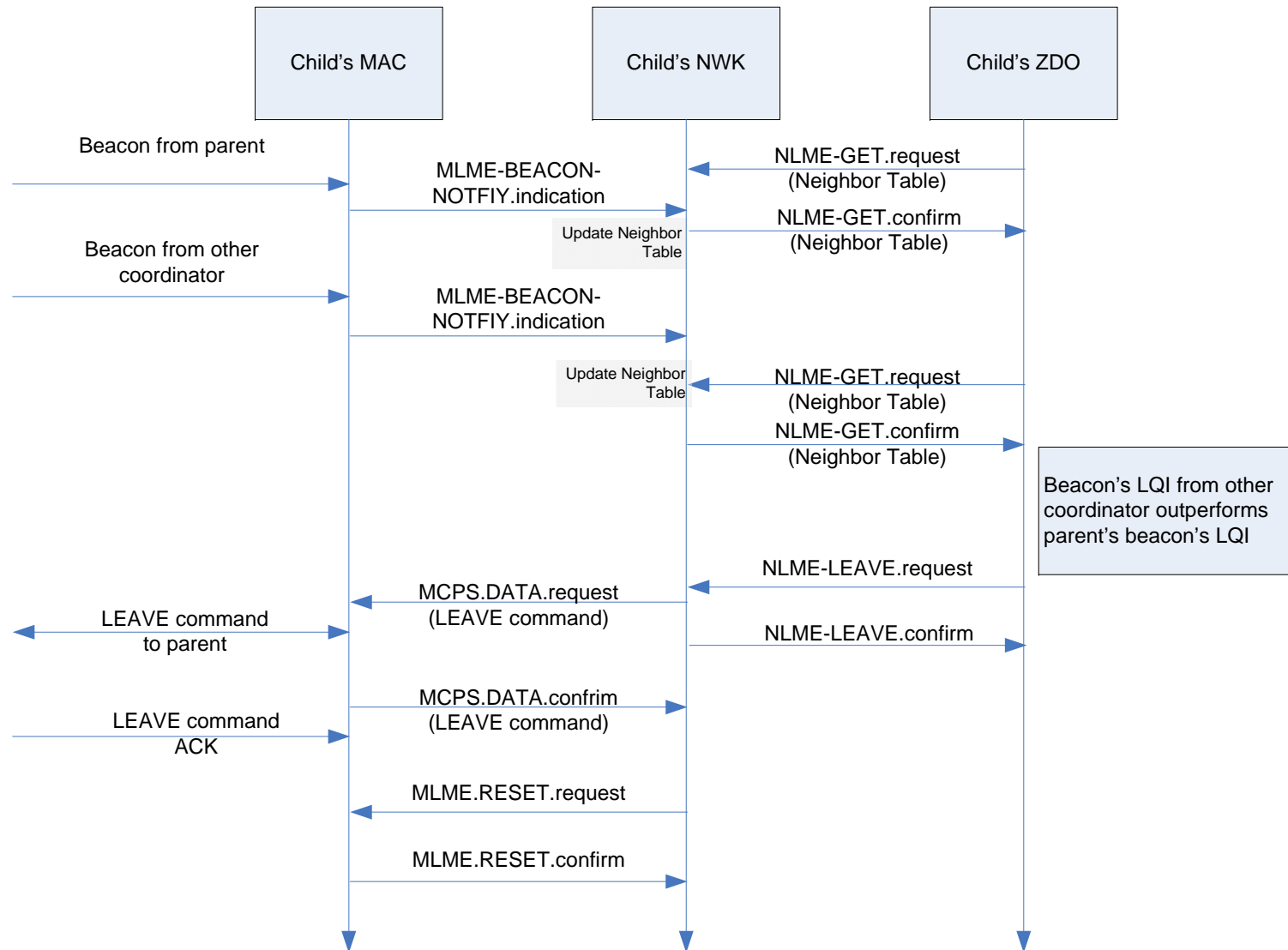
- Synchronization
  - Node tracks beacons
- Link Quality Measurement
  - Receiver energy detection (ED) or Signal-to-Noise Measurement
  - For each received packet MAC provides Link Quality Indication (LQI)
  - LQI 256 integer values
  - Usage of LQI is not specified in standard
- Promiscuous Mode
  - Generally, node rejects frames from other coordinators during transmission
  - PromiscuousMode = TRUE -> all in MAC sublayer received frames sent to next higher layer
  - Mode is set by higher layer
  - Frames include LQI also



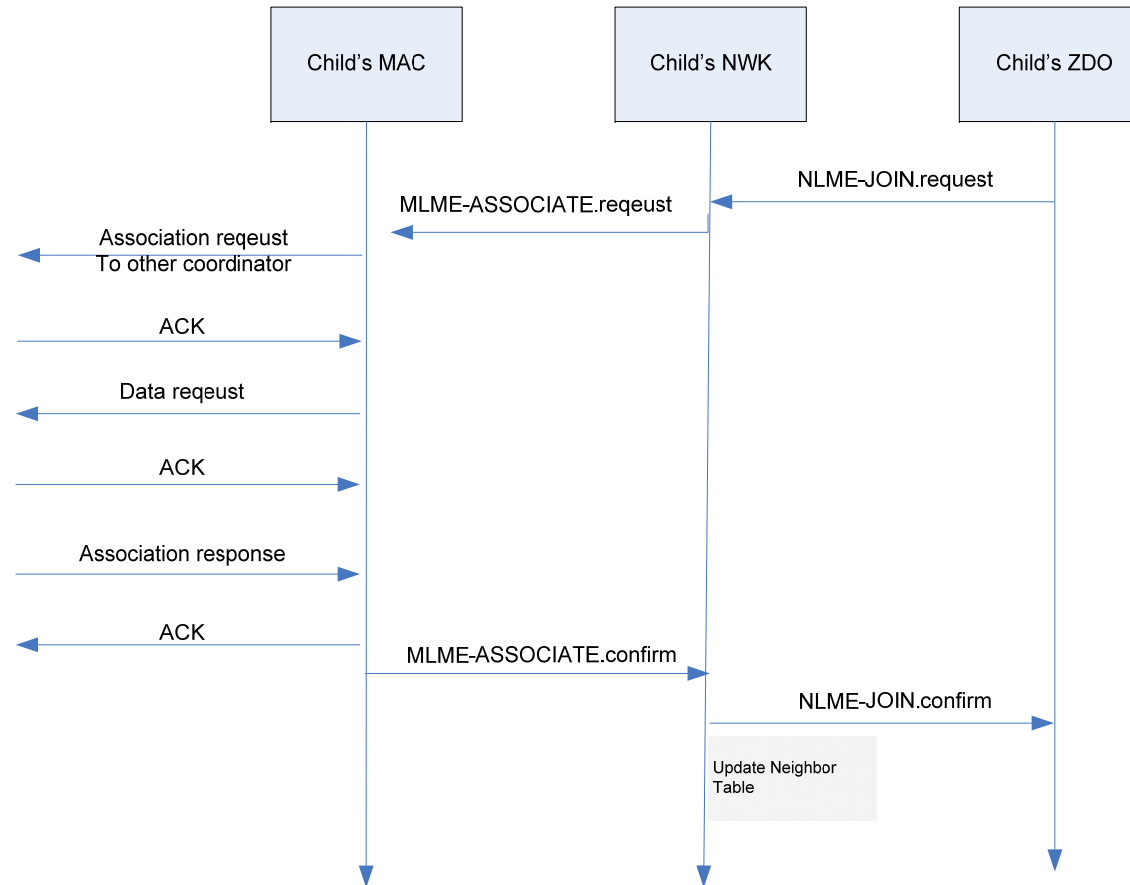
# Step 1 – Detection of bad LQI to Coord.



# Step 2 - Leaving



# Approach – Re-association



# Performance evaluation

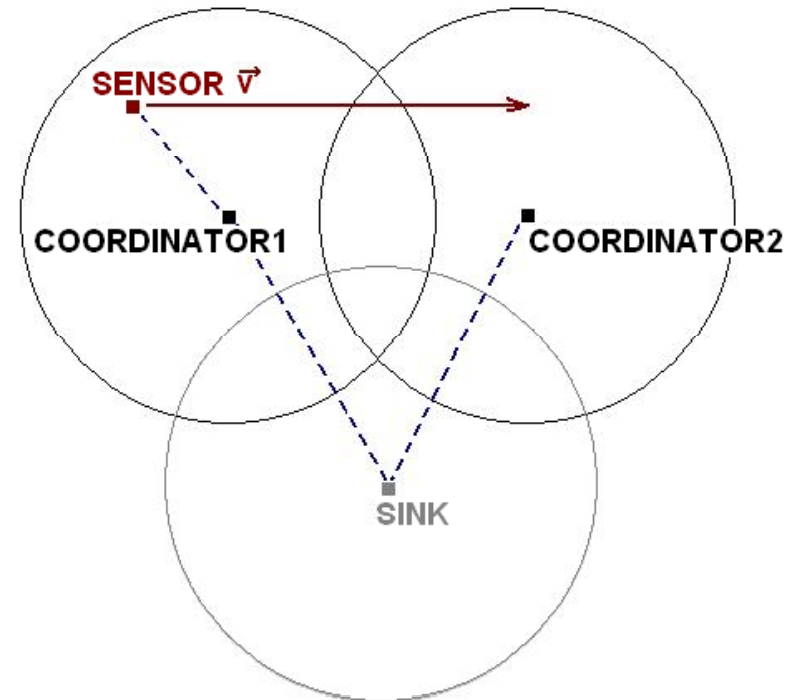
- Approach has been implemented in NS-2
- Evaluated in comparison to standard procedure

## Scenario 1:

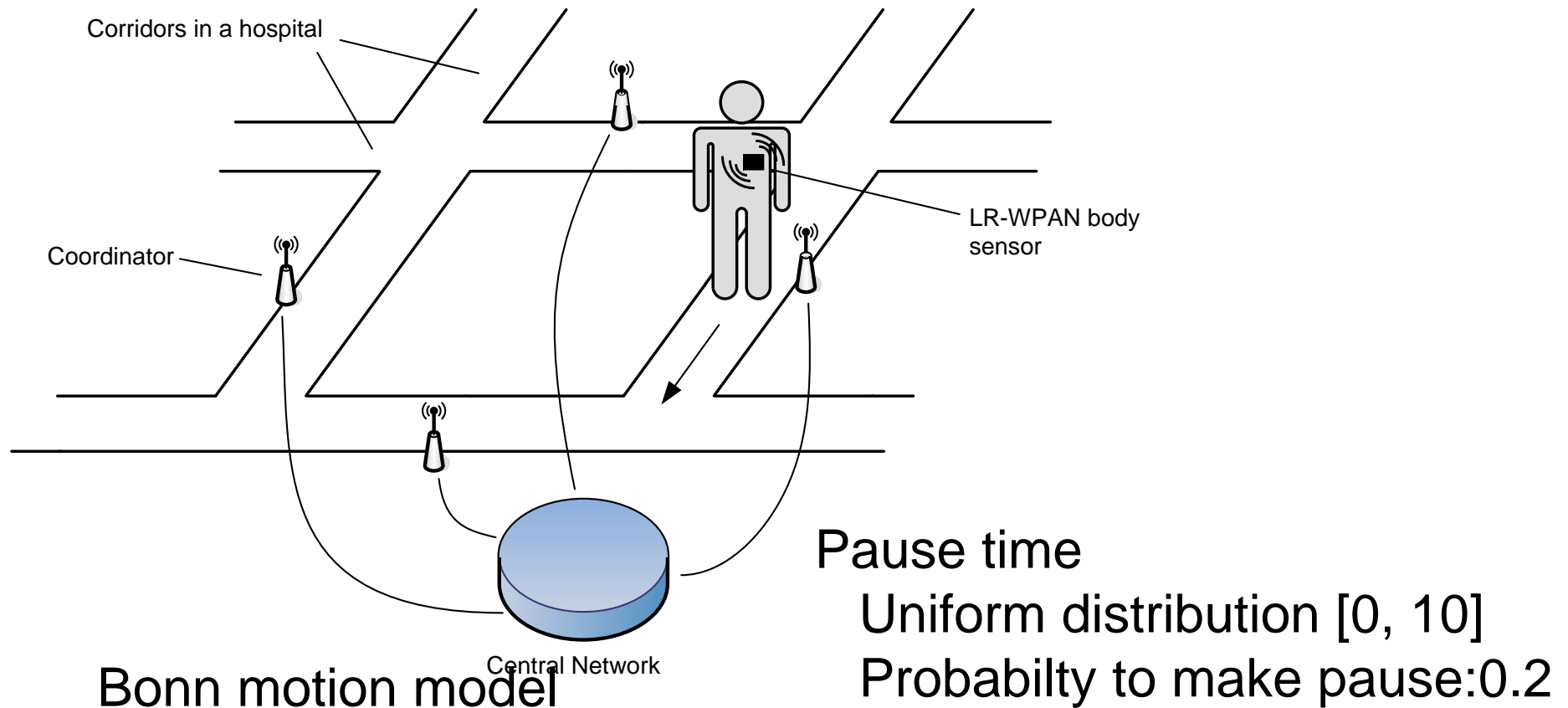
- Two coordinators
- Sensor moving with velocity up to 3 km/h
- Beacon Order (BO) varied from 3 to 6
- Beacon Interval (BI)

$$BI = SD \cdot 2^{BO}$$

$SD$  is the *aBaseSuperframeDuration* (960 symbols)



# Performance evaluation



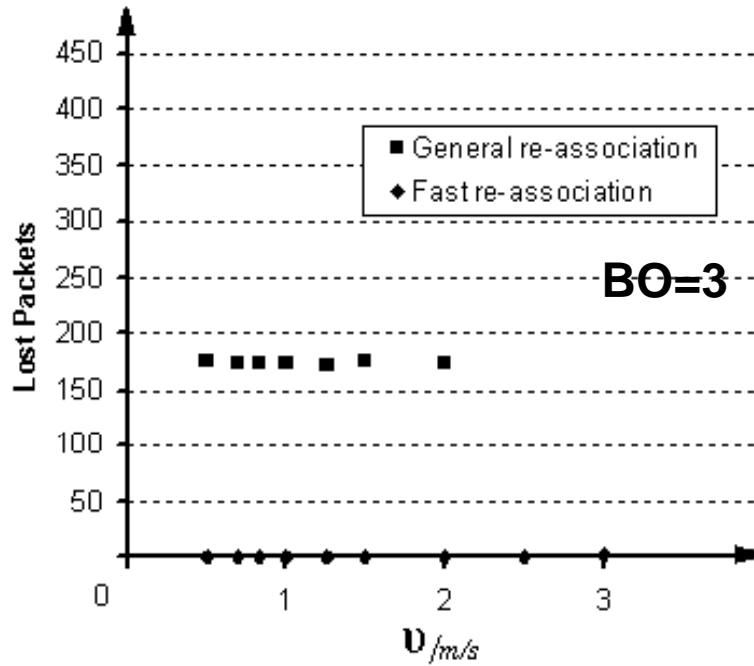
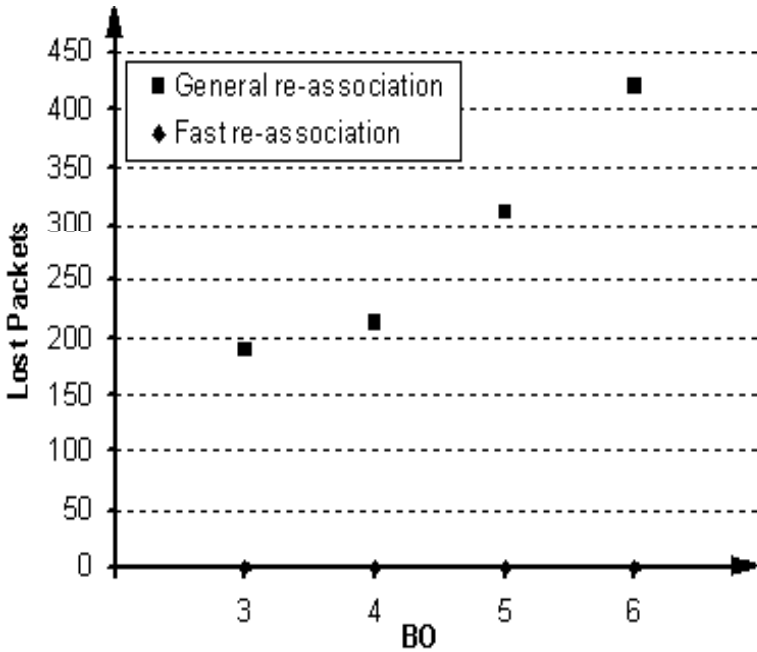
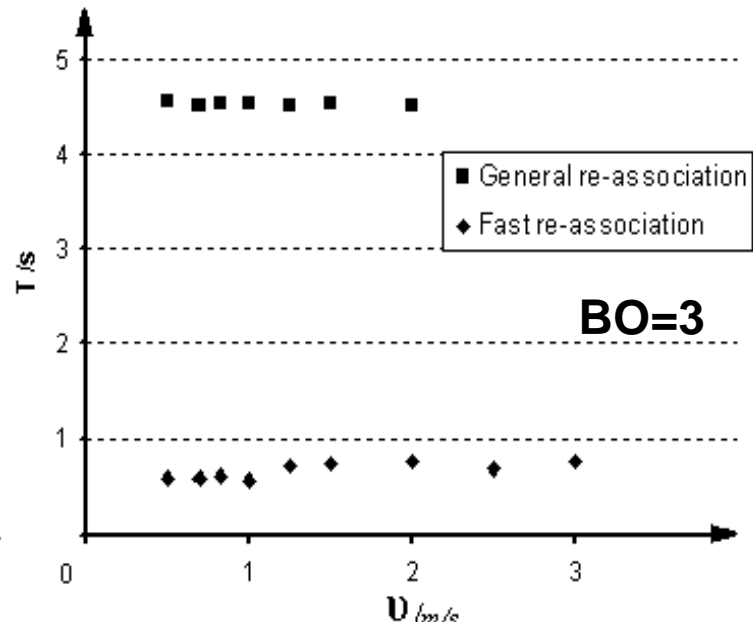
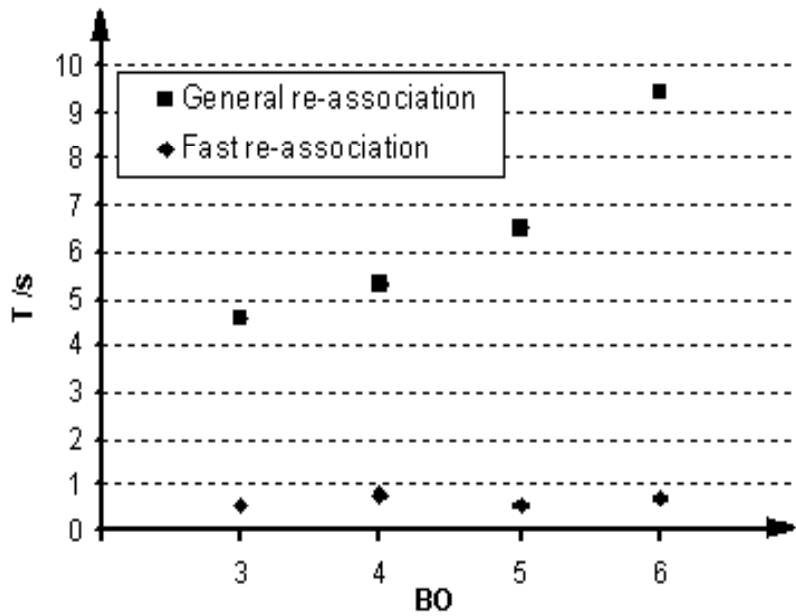
Bonn motion model

Speed: Normal distribution

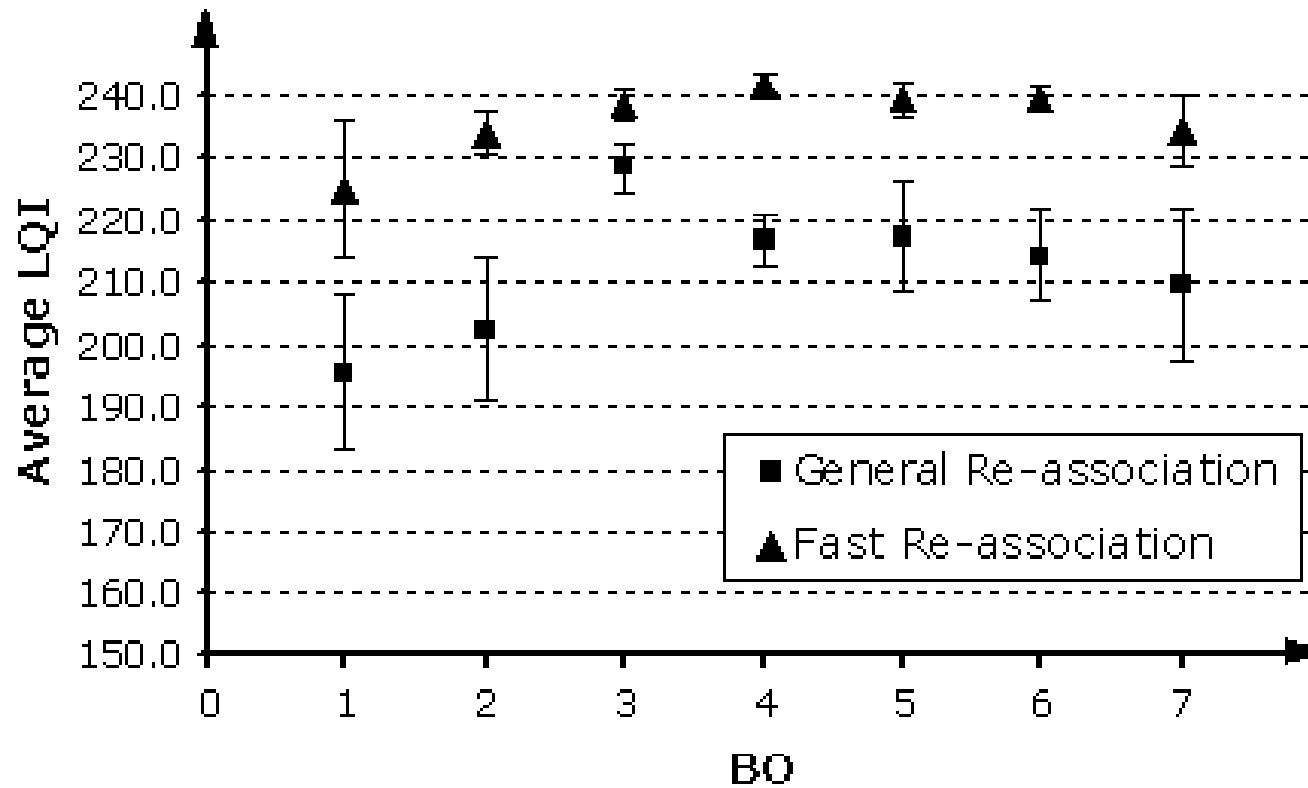
Standard deviation: 0,8 m/s

Mean: 1 m/s





# Average LQI



# Approach - Summary

- Implement an “Handover” strategy
- Taking advantage of higher layer capability
- Observing LQI of the current coordinator
- Bad LQI -> PromiscuousMode = TRUE (Observing LQI of other coordinators, too)
- “Passive Scanning” before loosing association
- Store a set of possible coordinators
- Change to other coordinator if the other coordinator's LQI outperforms that of associated coordinator



# Summary

- Advantages
  - Avoiding abrupt connection breakdowns (Switching to other coordinator before)
  - Avoiding extensive re-association procedures (Orphan scan and possible active scan)
  - No modifications of MAC and NWK necessary
- Drawback
  - Increasing complexity of device
- Future work
  - Tests for more complex scenarios with more nodes and coordinators
  - Comparison the obtained results with that from a realistic test (Joint Research Work with University of Cyprus)



Thank you!

