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

Submission Title: [A PHY proposal for PAC operating in synchronous mode (ppt)]
Date Submitted: [July 7th, 2013]
Source: [Seokki Kim, Hyungjin Kim, Seungkwon Cho, Soojung Jung, and Sungcheol Chang]
Company: [ETRI]
Address: [218 Gajeong-ro, Yuseong-gu, 305-700, Republic of Korea]
Fax: [+82-42-861-1966] **E-Mail:**[kimsk0729@etri.re.kr]

Re: [In response to call for proposals to TG8]

Abstract: [This document contains a PHY proposal for PAC operating in synchronous mode]

Purpose: [Materials for Proposal in 802.15.8 TG]

Contents

- Proposal Outline
- PHY Overview
- PHY Proposals
- Conclusion

Proposal outline

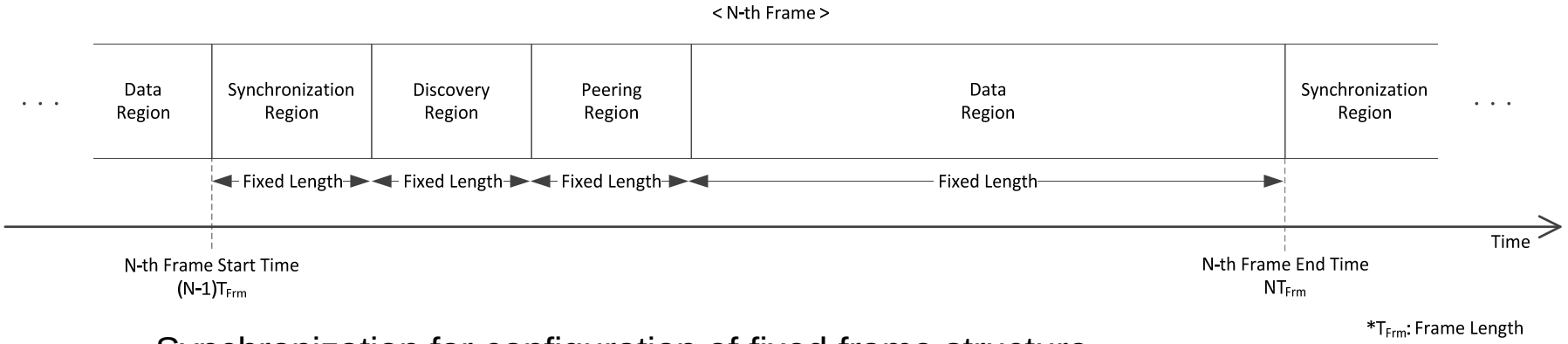
- In May, we presented a preliminary example in licensed bands for PAC in synchronous mode.
  - The presentation(DCN: 15-13-0273-00-0008) covered both PHY and MAC for PAC in licensed bands operates in synchronous mode

- In July, we propose both PHY and MAC in unlicensed bands for PAC in synchronous mode.
  - DCN 15-13-0391-00-0008 or the latest version: Overview of proposal (ppt)
  - DCN 15-13-0393-00-0008 or the latest version: PHY proposal (This document)
  - DCN 15-13-0390-00-0008 or the latest version: MAC proposal (ppt)
  - DCN 15-13-0392-00-0008 or the latest version: Proposal details (doc)

PHY Overview

Fixed and Sectionized Frame Structure

- PAC Operation with fixed and sectionized frame structure to meet PAC requirement
  - A large number of devices
    - High spectral efficiency
    - Low signaling overhead
  - Power saving



- Synchronization for configuration of fixed frame structure
  - Fully distributed synchronization scheme known as firefly synchronization

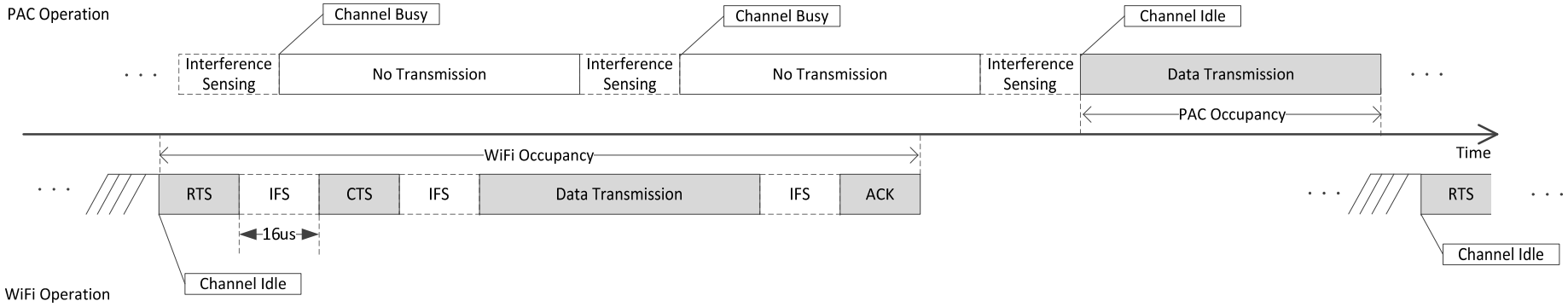
Coexistence Methodology

- Coexistence criteria
  - Avoidance of conflict between different kinds of devices
  - Prevention of exclusive resource occupancy of specific kinds of devices
  - No critical impact each other between different kinds of devices

- Coexistence policy: Concession, Preoccupancy and low power transmission
  - Concession
    - if other devices are using a resource, PDs give up the transmission
    - Implemented by *'Interference Sensing'*
  - Preoccupancy
    - Before transmission, PDs conduct prior occupancy of a resource
    - Implemented by *'Blocking Signal'*
  - *'Low power transmission'*
    - If the transmit power is sufficiently low, PDs can use any resource whenever PDs need it
    - To guarantee the presences of essential control signal (i.e. synchronization) at the fixed position, this scheme can be applied
    - For reliability of the transmitted signal, time domain repetition can be applied

Interference Sensing

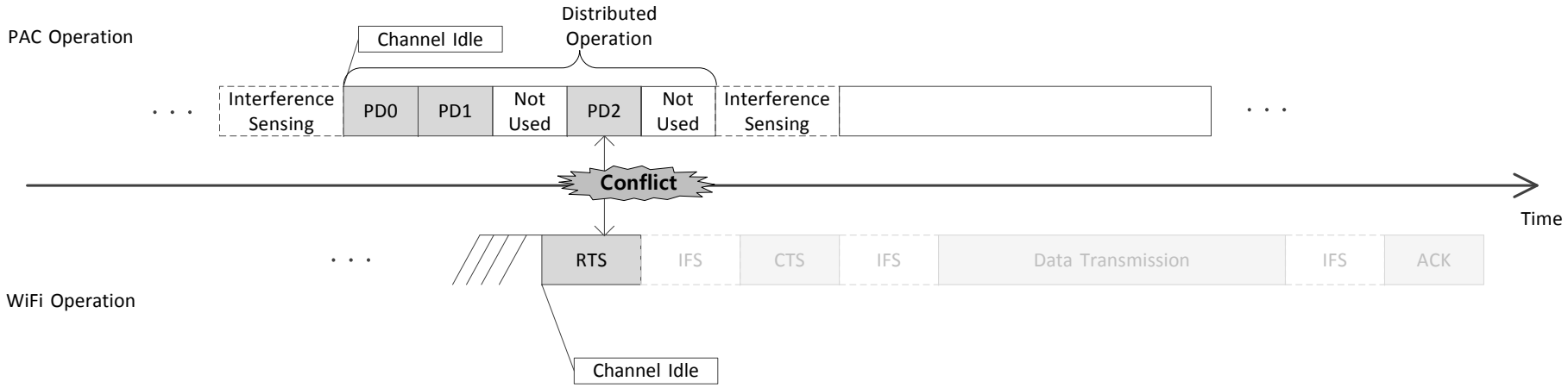
- Basic coexistence scheme using interference sensing
  - If other devices are using a resource, PDs give up the transmission
  - Recommended interference sensing interval: Short IFS interval(16us) of WiFi or longer



- Applied throughout the frame

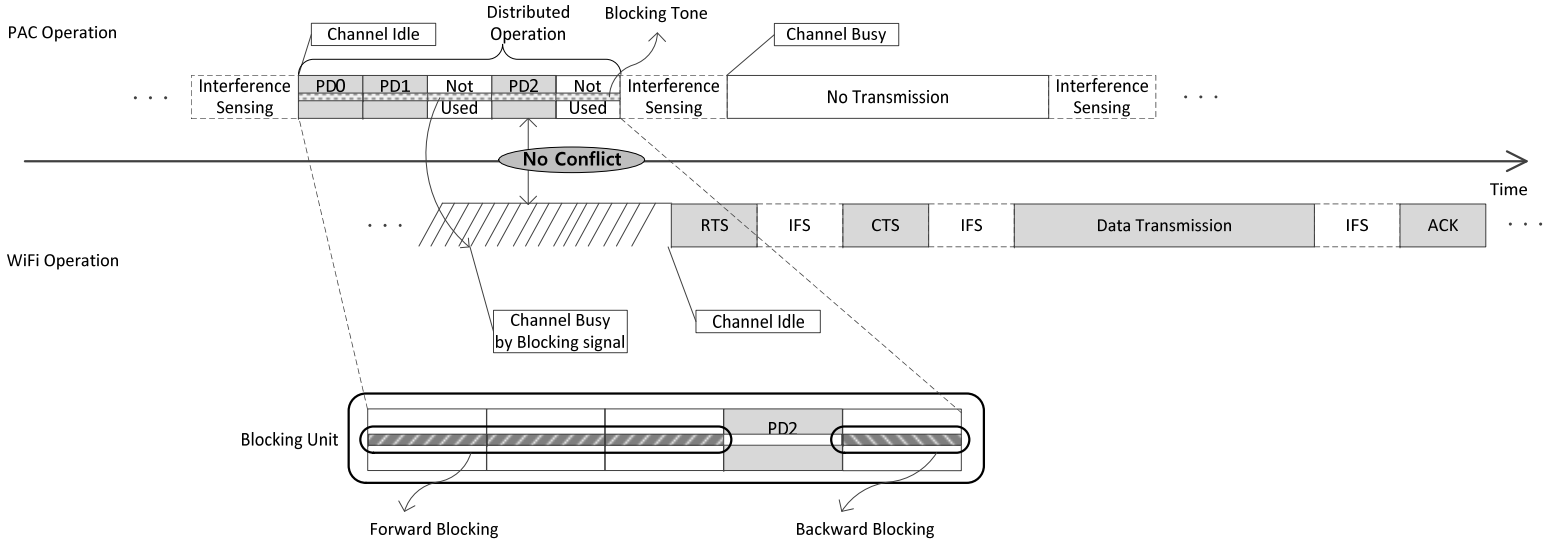
Blocking Signal

- Issue
  - Because of the fully distributed operation of PAC devices, there may be some unused resources
  - In this case, other kinds of devices can try to occupy the resources, even though the PAC devices already begin the data transmission after interference sensing



Blocking Signal

- Blocking scheme
  - To prevent resource occupancy of different kinds of devices, Blocking signal can be transmitted by PAC devices which is going to use the resource within a blocking unit
  - Blocking unit
    - Size of the resource which PAC devices want to reserve prior to different kinds of devices
    - Consist of multiple resource blocks for multiple PAC devices but not too long
  - One or more subcarriers can be allocated for transmission of blocking signal
  - PAC devices can transmit the blocking signal, before data transmission(Forward Blocking) and after data transmission(Backward Blocking)

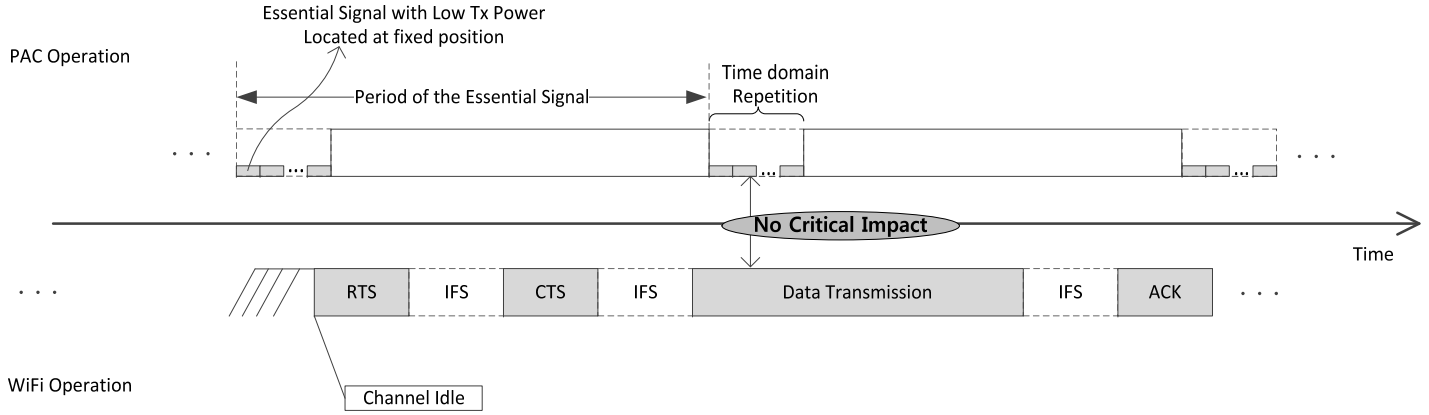


- Applied to control(Discovery, Peering, Scheduling) signal transmission

Low Power Transmission

- Issue
  - There are important signal which need to be always presence at fixed position such as synchronization signal
  - In the basic operation based on the interference sensing, the presence of the essential signal cannot be guaranteed

- Low power transmission scheme
  - Essential control signal is always transmitted at the fixed position regardless of the different kinds of devices
  - To minimize inference between different kinds of device, the essential signal is transmitted with low power
  - To enhancement reliability of the signal, it is repeatedly transmitted in time domain

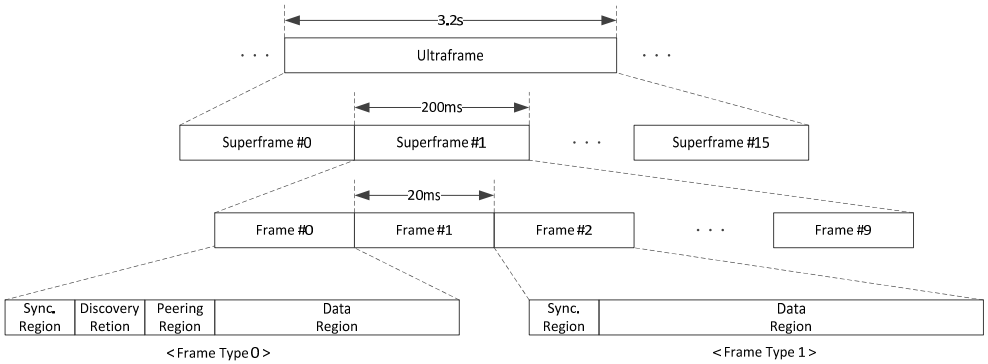


- Applied to synchronization preamble transmission

PHY Proposals

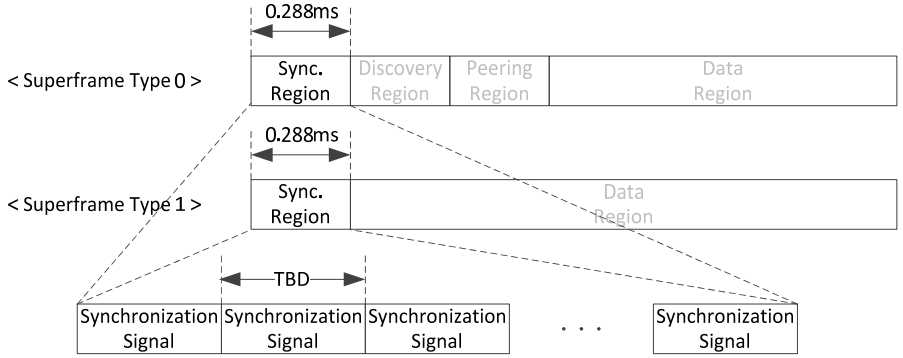
Frame Structure

- Ultraframe
  - Consist of 16 superframes
- Superframe
  - Consist of 10 frames
- Frame
  - Consist of Synchronization, Discovery, Peering and Data region
  - Two kinds of frame: Type 0 and Type 1
    - Type 0 is used if frame number is 0
    - Type 1 is used Otherwise



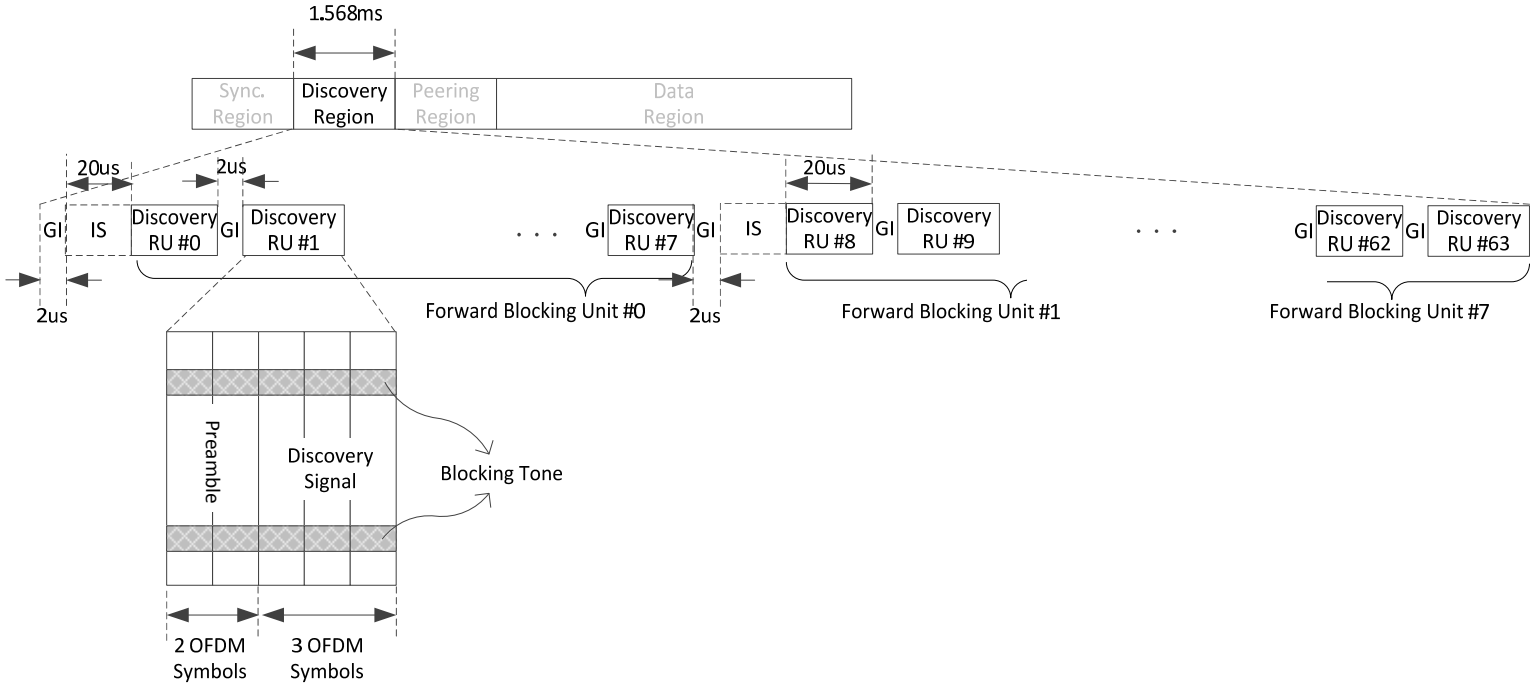
Synchronization Region

- Located at the head of a frame
- Conduct distributed synchronization procedure by transmitting or receiving synchronization signal during the synchronization region
- Synchronization signal can be transmitted whenever PDs need it, regardless of the difference kinds of devices
  - Low power transmission scheme is applied
  - Synchronization preamble is transmitted repeatedly([TBD] times) for reliability of synchronization
  - Transmit power is [TBD] deboosted
- Two kinds of synchronization signals are used to distinguish start of ultraframe



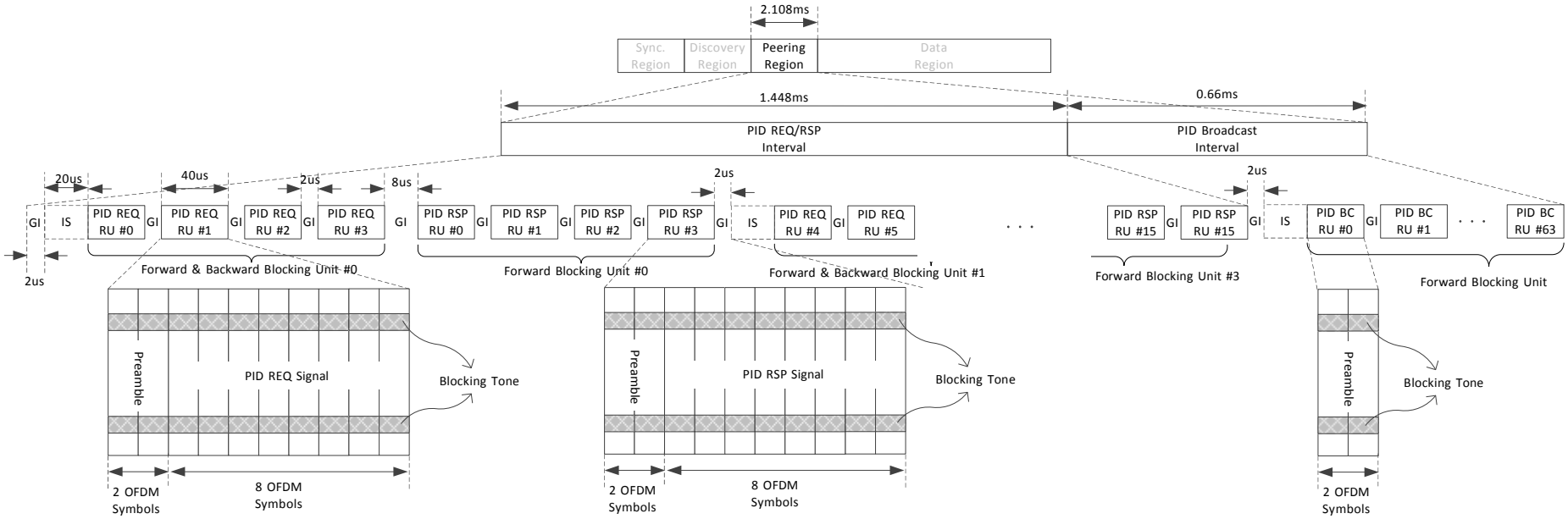
Discovery Region

- Consist of IS, GI, Preamble and Discovery signal
  - IS: Interference Sensing
  - GI: Transition time, Propagation delay and Synchronization error
  - Preamble: AGC, Timing and Frequency Sync. and Channel estimation
  - Discovery Signal: Payload(61 bits) + CRC (8bits)



Peering Region

- Consist of IS, GI, PID REQ/RSP interval and PID broadcasting interval
  - IS: Interference Sensing
  - GI: Transition time, Propagation delay and Synchronization error
  - Preamble: AGC, Timing and Frequency Sync. and Channel estimation
  - PID REQ signal: Payload(176 bits) + CRC (8 bits)
  - PID RSP signal: Payload(176 bits) + CRC (8 bits)
  - PID Broadcast RU: only preamble for indication of used PID

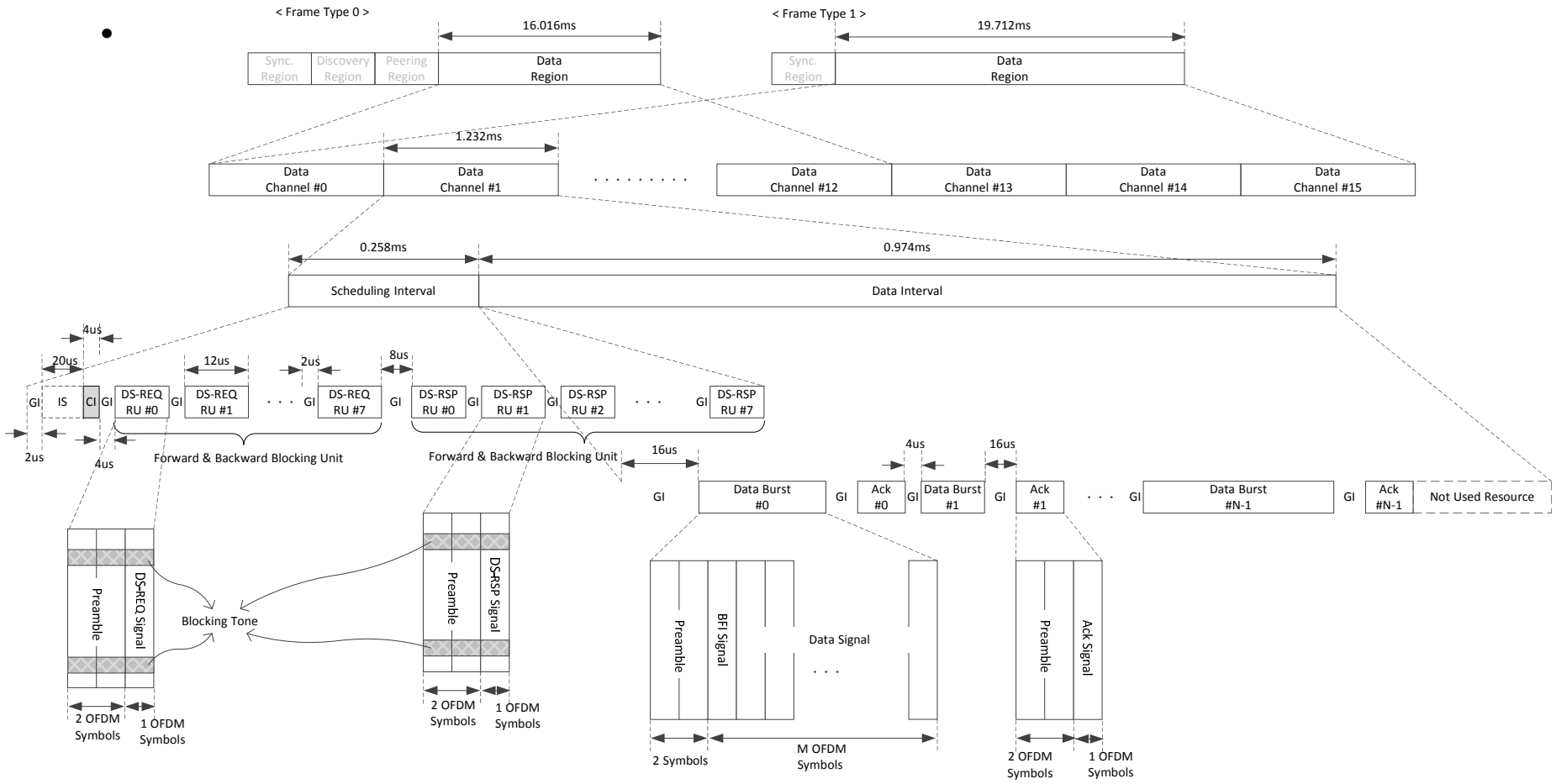


Data Region

- Consist of IS, CI, GI, DS-REQ/RSP Interval and Data Interval
  - IS: Interference Sensing
  - CI: Contention Indicator
  - GI: Processing delay, Transition time, Propagation delay and Synchronization error
  - Preamble: AGC, Timing and Frequency Sync. and Channel estimation
  - DS-REQ Signal: Payload(15 bits) + CRC (8 bits)
  - DS-RSP Signal: Payload(15 bits) + CRC (8 bits)
  - BFI (Burst Format Indicator): MCS Index (7 bits) + Length (10 bits) + Parity (1 bits) + Reserved (6 bits)
  - Data Signal: Payload(variable bits) + CRC (8 bits)
  - Ack Signal: Payload(15 bits) + CRC (8 bits)

- Distributed scheduling
  - Multiple pairs of data burst and Ack can be allocated
  - The number of pair and burst size depend on the result of the distributed scheduling

Data Region


< Frame Type 0 >
16.016ms
Sync. Region
Discovery Region
Peering Region
Data Region
< Frame Type 1 >
19.712ms
Sync. Region
Data Region
1.232ms
Data Channel #0
Data Channel #1
Data Channel #12
Data Channel #13
Data Channel #14
Data Channel #15
0.258ms
0.974ms
Scheduling Interval
Data Interval
4us
20us
12us
2us
8us
GI
IS
CI
DS-REQ RU #0
DS-REQ RU #1
DS-REQ RU #7
DS-RSP RU #0
DS-RSP RU #1
DS-RSP RU #2
DS-RSP RU #7
2us
4us
Forward & Backward Blocking Unit
Forward & Backward Blocking Unit
16us
4us
16us
Data Burst #0
Ack #0
Data Burst #1
Ack #1
Data Burst #N-1
Ack #N-1
Not Used Resource
Preamble
DS-REQ Signal
Blocking Tone
Preamble
DS-RSP Signal
2 OFDM Symbols
1 OFDM Symbols
2 OFDM Symbols
1 OFDM Symbols
Preamble
BFI Signal
Data Signal
2 Symbols
M OFDM Symbols
Preamble
Ack Signal
2 OFDM Symbols
1 OFDM Symbols

Conclusion

Conclusion

- PAC operation with fixed and sectionized frame structure to meet PAC requirement
- Fully distributed operation and synchronization
- Signaling resource
  - 1024 Discovery per 3.2 sec => up to 1024 PDs / 3.2s
  - 128 PIDs broadcasting per 0.8 sec => up to 256 active PDs
  - 16 PID REQ and RSP per 0.2 sec => average 29.6 paring / s
- Signaling overhead: 26.5%
  - Interference sensing + CI + GI + Synchronization + Discovery + Peering + Scheduling + Ack + Preamble + BFI
- Consideration of coexistence
  - Interference sensing, blocking signal and low power transmission