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

Submission Title: [Additional Considerations for Maximizing the benefits of an OFDM PHY for SUN]

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Source: [Shusaku Shimada] Company [Yokogawa Co.]
Address [2-9-32 Nakacho-town Musashino-city Tokyo, 180-8750 Japan]
Voice:[+81-422-52-5543], FAX: [+81-422-55-7311], E-Mail:[shusaku@ieee.org]

Re: []

Abstract: [To encourage the constructive discussions and their fruitful merger of OFDM PHY proposals, then to consolidate a few PHY technologies including NB-FH PHY, some considerations regarding OFDM PHY are submitted.]

Purpose: [Contribute to the 15.4g SUN standardization process.]

Additional Considerations for Maximizing the Benefits of an OFDM PHY for SUN

Considerations is primarily based on “Affordable OFDM for SUN” proposal (15-09-0289-00-004g) by Steve Shearer, but also relating to all OFDM PHY proposals and other PHY proposals including NB-FH PHY as well.

Shusaku Shimada

Back Ground

- Needs of relaxing the selectivity requirements like as 15.4-2006.
  - Wider channel spacing relative to the signal bandwidth.
  - 0dB adjacent channel rejection and 30dB alternate channel rejection in term of RX.
  - -20dBm max. interferer have to be handled.
- Be accommodated in several international regulatory domains.
  - Channel spacing: 150kHz, 200kHz, 600kHz, 2MHz, or more.
- Perspective of message timeliness and extreme low power.
  - Generator utilities (Solar Panel, Wind Gen., Plugged in/out HEV.) have to communicate timely.
  - Timely alert messaging by energy harvesting or scavenging, e.g. fuel/liquid flow meter.
  - Collective “Commissioning” for deployment / maintenance.
- Enhance reliability and cell radius of tower top BS.
  - Provisioning of Multi-antenna system
- Needs of diverse deployment scenarios by multi-radio node.
  - Multiple radio device belongs to multiple mesh networks (UCG) for diverse service in the future.
  - Segregating a few service networks each other or to enhance traffic engineering.

Flexibility for Global Channel Plan by OFDM (1)

- Maintain sub-carrier spacing of 18.75kHz and allow,
  - Full 14 sub-carriers 300kHz signal for 400 or 600kHz channel-spacing with stringent ACPR in Japan.
  - 8 sub-carrier for 168.75kHz signal for 200kHz (world wide active RFID band) channel spacing.
  - 6 sub-carrier for 131.25kHz signal for 150kHz channel spacing for a few regulatory domains.

  - Consequently, SFD need to be either Length-11 Barker or Length-5 Barker with null sub-carriers.

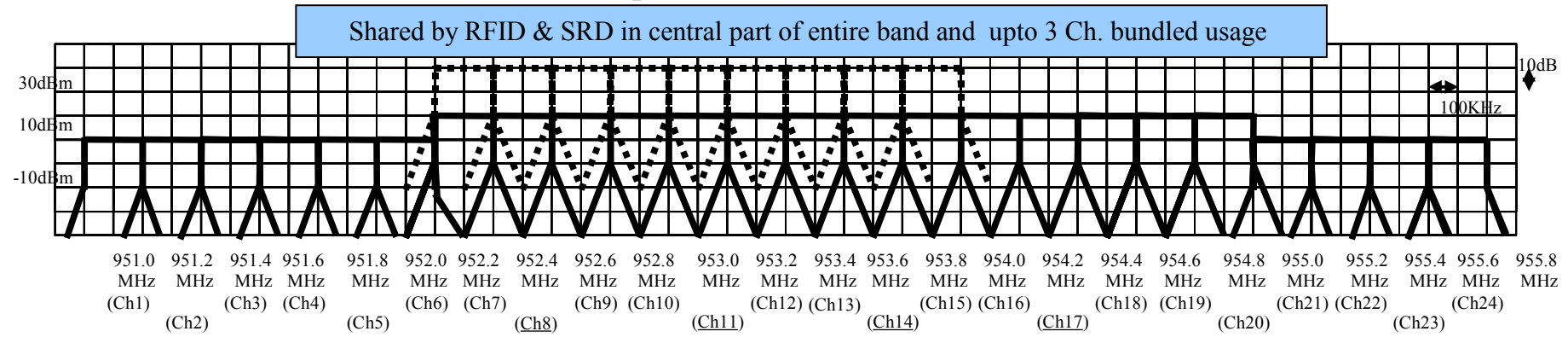
- Flexible sub-carrier usage for each channel plan to facilitate,
  - Adjacent channel rejection performance of TRX.
  - Alternate (next to adjacent) channel rejection performance of TRX.
  - Alleviate RX blockage due to strong interferer.

- Simple windowing at both TX and RX alleviate,
  - SOP performance degradation, since the sub-carriers at band edge are nulled out as guard band.
  - Co-channel interference impediment due to asynchronous specular reflection.

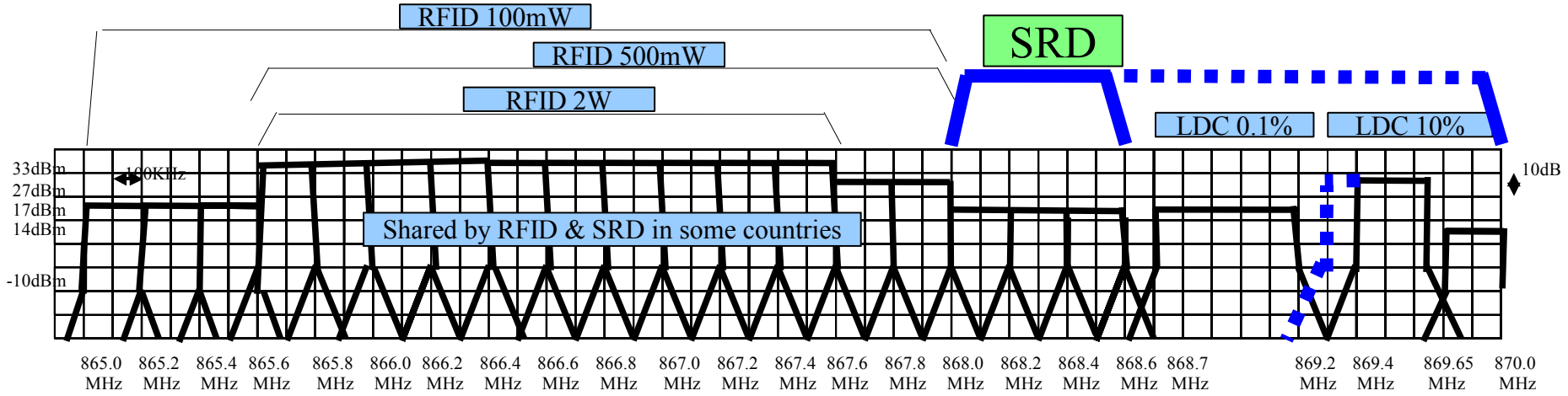
Flexibility for Global Channel Plan by OFDM (2)

< IEEE 802.15-07-0621-03-wng0 >

[Japanese 950-956MHz Band]



[ECC/ERO 865-870MHz Band]



Flexibility for Global Channel Plan by OFDM (3)

< IEEE 802.15-07-0621-03-wng0 >

[Chinese 779-787MHz Band]

SRD only usage

- Frequency : 779MHz – 787MHz (License Exempt Band)
- Bandwidth : No restriction
- Modulation : Digital Modulation
- No other requirement known :
  no LDC (Low Duty Cycle), no LBT (Listen Before Talk)
- Transmit Power : 10mWe.i.r.p.

[Korean 908.5-914MHz Band]

Shared by RFID & SRD

- Frequency : 908.5 - 914MHz < 200kHz channelization >
- Modulation : FHSS or Narrow Band Modulation
- Other requirement known :
  FHSS only, FHSS + LBT (Listen Before Talk), LBT only
- Transmit Power :
  Maximum Power 1W with 6dBi max. Antenna Gain

Extreme Low Power by 16 point OFDM (1)

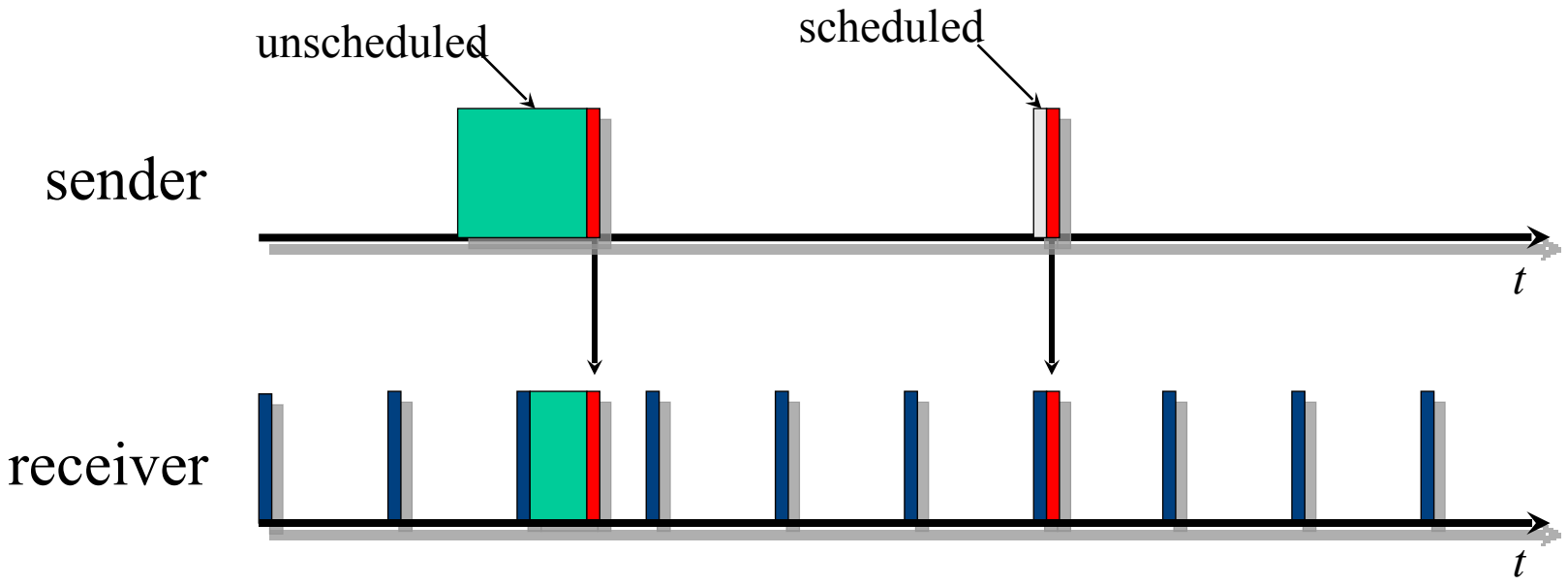
- Ensuring extreme low power by,
  - low complexity of 16 point iFFT/FFT.
  - OFDM inherent parallelism, e.g. multi-carrier parallel processing system.
  - relatively low symbol rate and subsequent reduced clock frequency of signal processing.
- Alleviated analog linearity requirements by,
  - relaxed PAPR of 12 or less sub-carriers and possible peak cancellation by extra sub-carrier.
  - MCS without higher order linear modulation like 64 QAM.
- Full function node with relay capability also enjoys,
  - 16 point OFDM to combine with “Coordinated Sample Listening” and resulting low power.
  - prepended of repetitive OFDM headers to work as “Wake up frame”.
  - reduced function node to hear reliably and detect smartly the wake up frame. e.g. robust MCS.
  - supporting on going IEEE802.15.4 TG-e MAC amendment activities.

Extreme Low Power by 16 point OFDM (2)

Coordinated Sample Listening and Local Scheduling

By Wei Hong, et al. < IEEE 802.15-15-09-0211-02-04e>

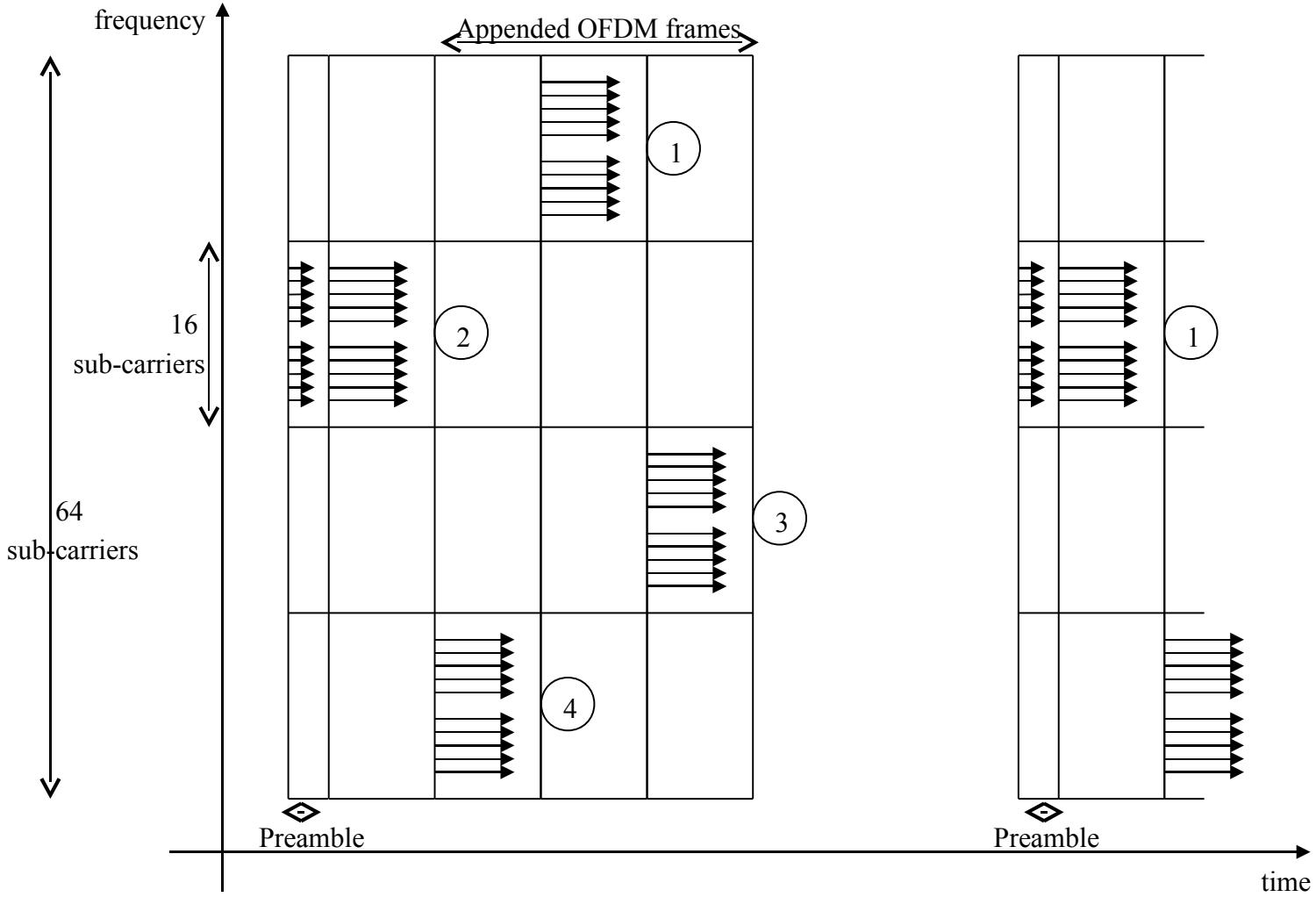
- Include channel sampling phase and period in ACK payload
- Sender wait to transmit right before receiver's next channel sampling time



Introduce 64 points sequenced OFDM (1)

- Optional 64 point sequenced OFDM to allow,
  - 4 basic 16 pts OFDM signals to be used in time-alternate manner for enhanced timeliness.
  - in other words, slow frequency hopping to increase reliability without time synchronization.
  - Orthogonal freq. Sequences (4 basic 16 pts OFDM: 1,2,3,4) : e.g. 2-4-1-3, 3-1-4-2, 1-3-2-4, 4-2-3-1
  - Preamble only prepend at first signal, and SFD for all 4 sequenced signals.
- Co-channel interference avoidance to alleviate,
  - Mesh capacity degradation by interference between multi-hop links.
  - Network-wide synchronization requirement especially for urban dense deployment scenario.
- Improve timeliness and reliability by,
  - reducing multi-hop latency and retry transaction latency.
  - “Retry in advance” using series of 16 pts OFDM signals by enhancing time & frequency diversity.
  - decoding two or more orthogonal puncturing patterns in combined reduced rate, e.g. 2/3 x 2 = 1/3

Introduce 64 points sequenced OFDM (2)



Provisioning of Multiple Antenna Node for future

- Tower-top base station in case of tree topology.
  - OFDM alleviates the complexity of possible MRC.
  - OFDM facilitates possible transmitter side antenna selection using the channel reciprocity.
- Leaf node with multiple antenna.
  - 16 points OFDM alleviates the channel estimation of each antenna chain by sharing DSP functions.
  - Resulting receiver side antenna selection using SFD.
  - Select identical antenna as resulting receive side antenna selection.
- STBC
  - If any antenna selection or RX-MRC is not possible, of course STBC may be feasible.

Provisioning of Multi-radio Node for future

- Diverse deployment scenarios by multi-radio node.
  - OFDM system could append the additional communication capacity on existing NB-FH systems.
  - Multi-radio handheld tool for collective commissioning and maintenance, e.g. Electricity, Gas, Water.
  - Multi-radio device would share parallel processing resource by each radio systems, e.g. Viterbi.
- Traffic eng. to adapt with the node population and its trend.
  - Multi-radio gateway node to backhaul : OFDM on OFDM, OFDM on NBFH.
  - restructuring UCG (Unified Channel Graph) to merge or separate by multi-radio node, e.g. OFDM.
  - Relatively easy overlay deployment using plurality of available frequency channels.

Thank you

[Reference]

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