

Updates to 802.3bn EPoC Upstream Framing Proposal

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Changes From Previous Version

- Adapt proposal to the decision to reduce RTT spread to less than a symbol size
 - All CNU's are located at the far end of the HFC fiber
 - Single RB for the PHY Discovery Window
 - Remove option for PDW to cross Superframes
 - Collapse PHY Discovery and Fine Ranging to a single PHY signal structure
 - Present an alternative to use PHY Discovery Window and Fine Ranging as part of the Probe periods
- Add a proposal to withdraw the option for 12 symbols RB

Some definitions and Conventions

- **Upstream subcarrier (SC) Types**
 - Allocated SC:** a SC which is assigned to a RB to be used for US data transmission (either MAC data or PHY Link)
 - Unallocated SC:** a SC which is used for Probe symbols but is not allocated to any RB
 - Excluded SC:** a SC in which no transmissions is allowed (zero corresponding inputs to iFFT)
- **Active SC**
 - A SC that is not excluded (either Allocated or Unallocated)
- **Resource Element (RE)**
 - One allocated Sub-carrier in one symbol
- **Resource Block (RB)**
 - Contiguous spectrum of 1, 4, or 8 SC's
 - Not including Unallocated SC's
 - Not including Excluded SC's
 - Duration of an RB
 - 8, 12 or 16 symbols

Parameter conventions

“D” (for Duration) measured in us (ms if appropriate)

“S” (for Spectrum) measured in kHz (MHz if appropriate)

Subscripting convention

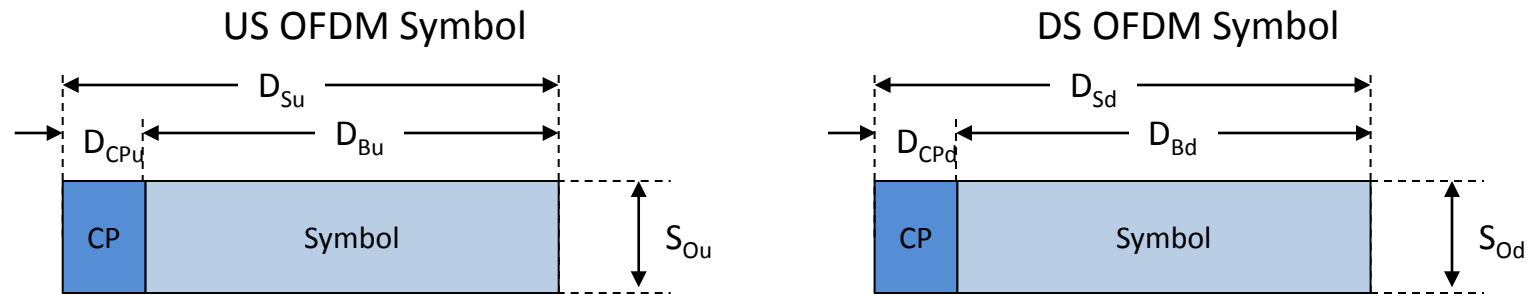
Uppercase subscript(s) – describe object

(S = Symbol, CP = Cyclic Prefix, B = useful Symbol, O = OFDM, PL = PHY Link, PLW = PHY Link Window,

RB = Resource Block, SF = Superframe)

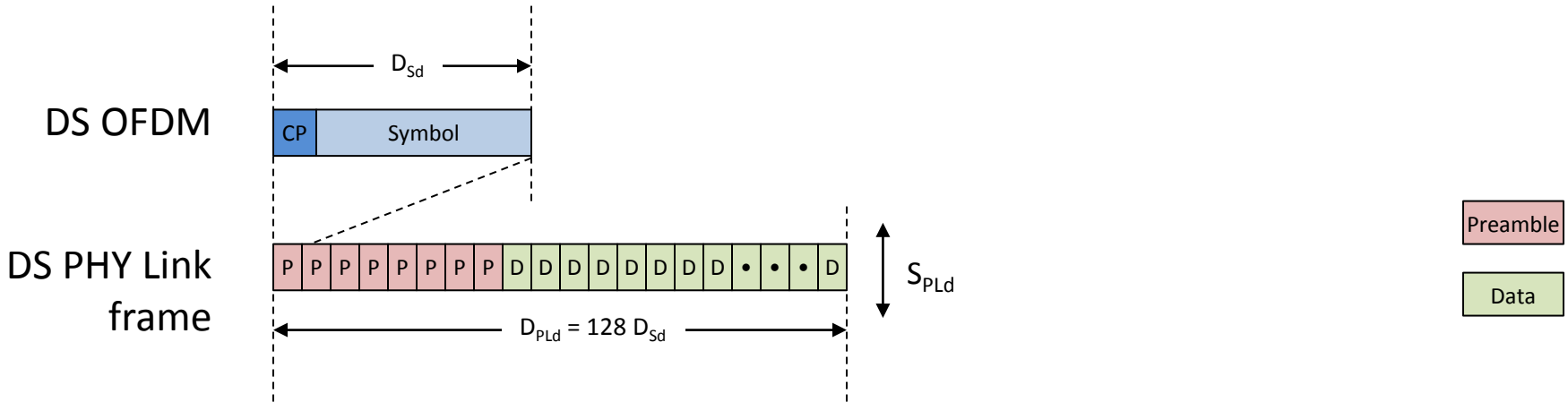
Lowercase subscript – direction (u = upstream, d = downstream)

EPoC OFDM Symbols



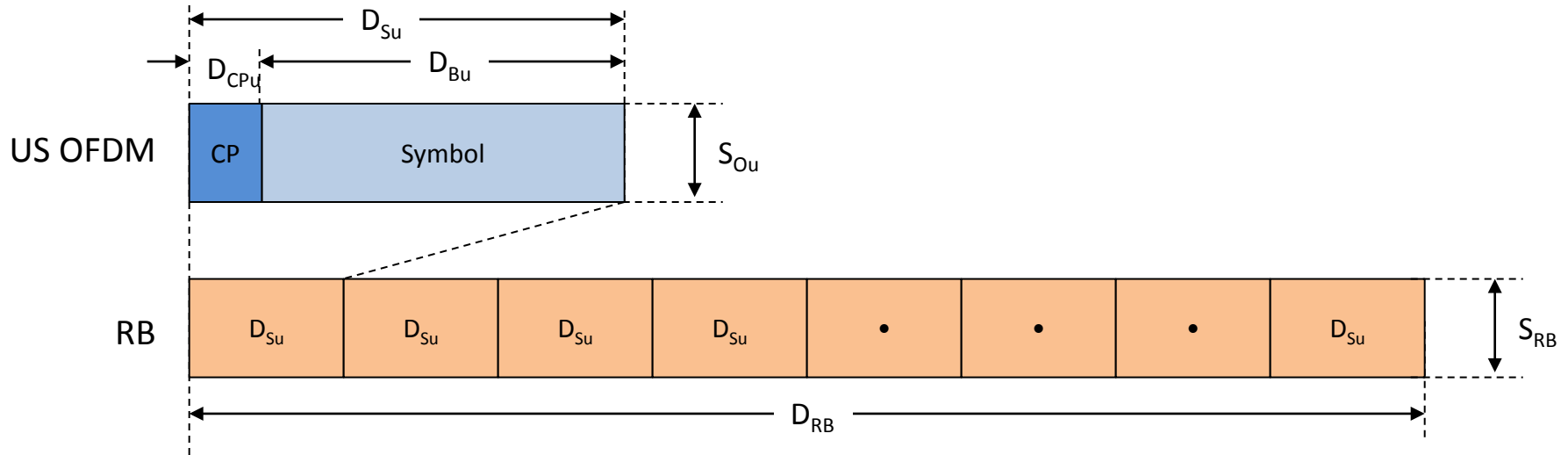
- OFDM Symbol parameters
 - Symbol duration (D_{Su} , D_{Sd}) composed of
 - Useful Symbol duration (D_{Bu} , D_{Bd}); fixed at 20 us
 - Cyclic Prefix duration (D_{CPu} , D_{CPd}); configurable (Ref CI 45.2.1.108/110)
 - US {1.25, 1.875, 2.5, 3.125, 3.75 us}
 - DS {1.25, 2.5, 3.75 us}
 - OFDM Channel Spectrum (S_{Od} , S_{Ou});
 - The range of frequencies from the lowest active subcarrier to the highest active subcarrier
 - Measured between center frequencies of the subcarriers
- OFDM symbol parameters are set at network provisioning (requires network restart to change)

EPoC Downstream Frame



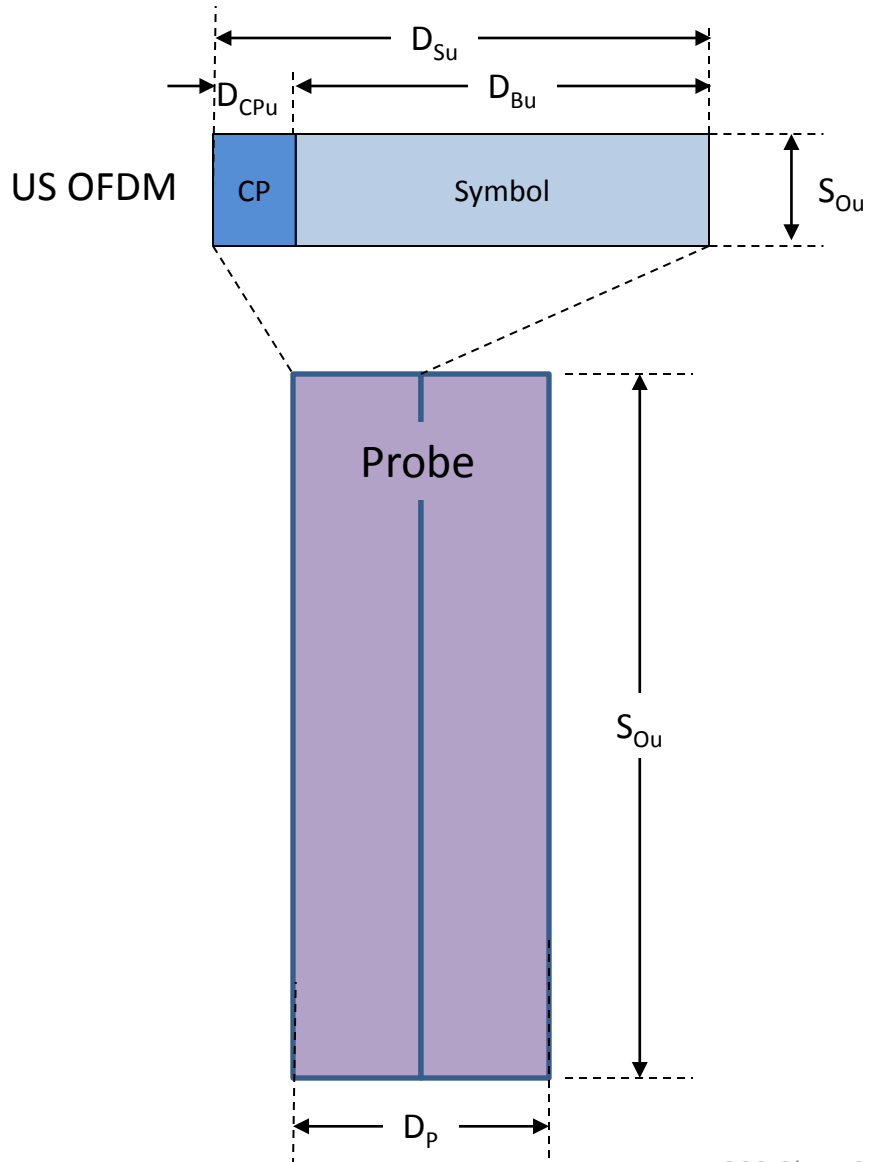
- Downstream framing composed of two items
 - Downstream Symbol Time (D_{Sd}) composed of
 - Useful symbol time (D_{Bd}); fixed at 20 us
 - Downstream CP time (D_{CPd}); variable {1.25, 2.5, 3.75 us}, set at network initialization (Ref Cl 45.2.1.108)
 - Downstream PHY Link Frame (D_{PLd})
 - Fixed at $128 * D_{Sd}$
 - $2.72 \text{ us} \leq D_{PLd} \leq 3.04 \text{ us}$ (given D_{Bd} and range of D_{CPd})
 - PHY Link channel uses eight subcarriers

Upstream Framing: EPoC Resource Block



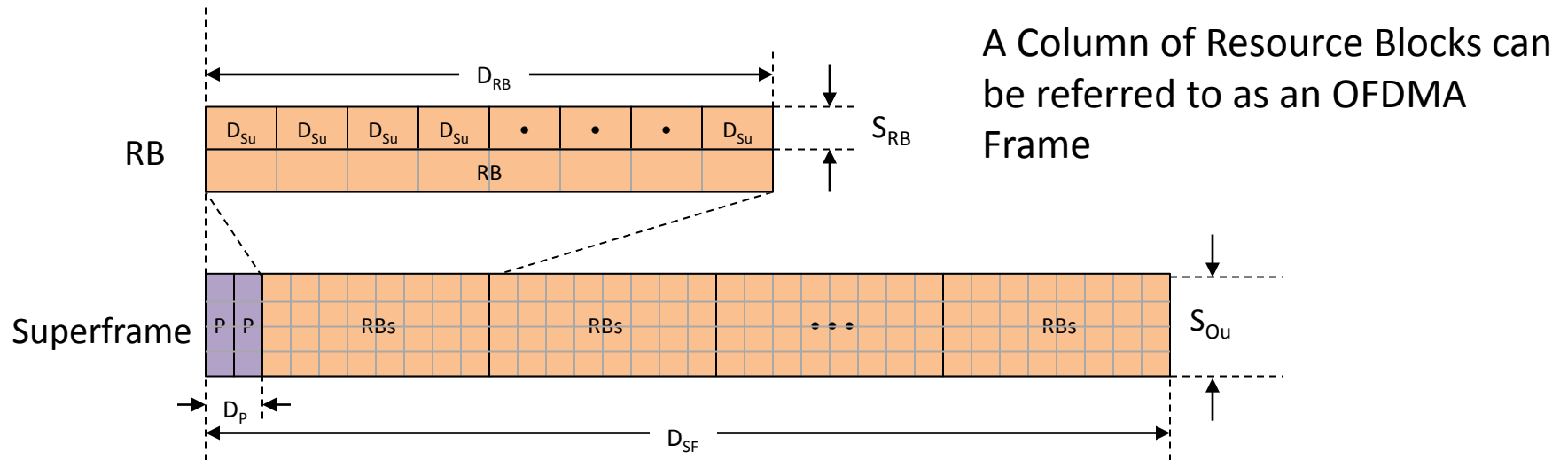
- Upstream OFDM frame parameters
 - RB duration (D_{RB}); configurable: 8, 12, 16 symbol durations (D_{Su})}
 - RB spectrum (S_{RB}); configurable: {1, 4, or 8} contiguous Allocated SC's
 - Proposed registers in 4/16 call
 - RB Volume; $V_{RB} = D_{RB} * S_{RB}$
- Resource Block Constraints
 - All RB's have same number of symbols and the same number of subcarriers
- Resource Block parameters are set at network initialization

Upstream Framing: Probes



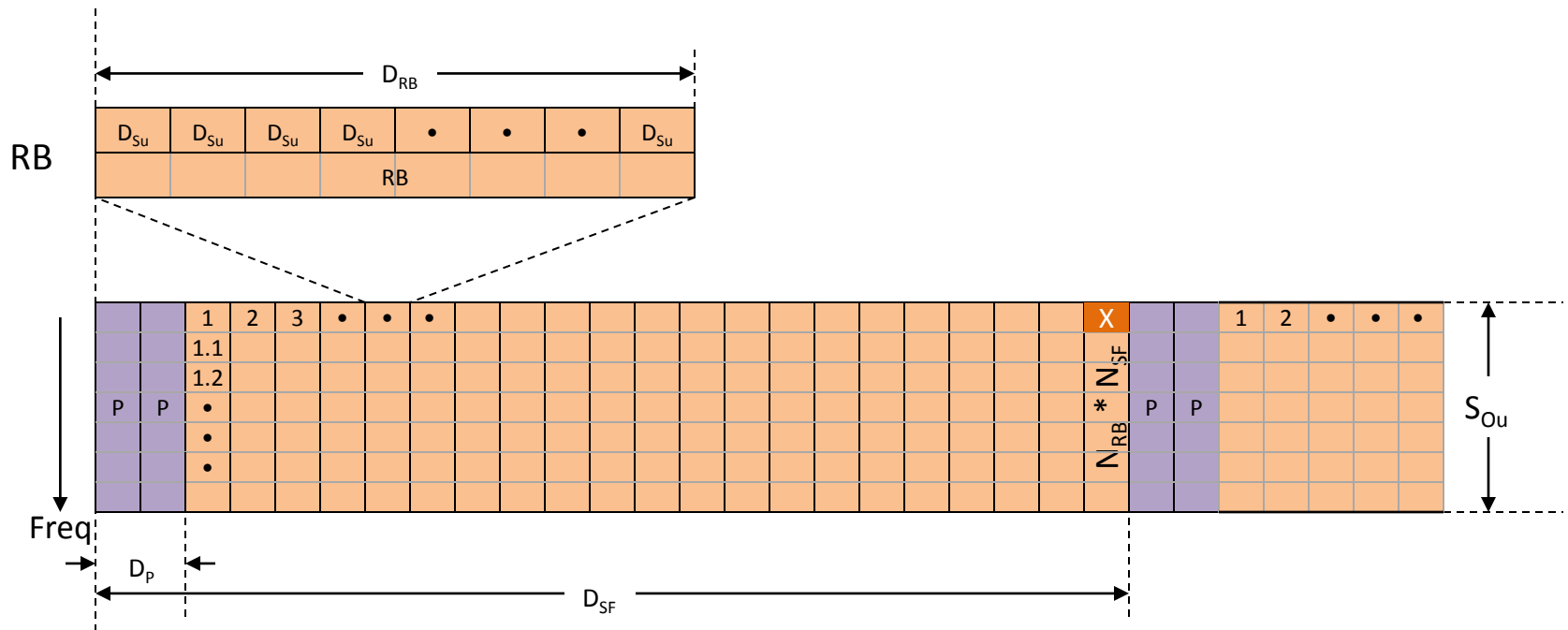
- Parameters
 - Probe duration;
 $D_p = N_p * D_{su}$
 - Probe Spectrum; same as symbol (S_{Ou})
- Probes Constraints
 - $2 \leq N_p \leq 4$
- Set at network initialization

Upstream Superframe



- Upstream Superframe comprises of Probe symbols followed by an integer number (N_{SF}) of RB columns
- Upstream Superframe Parameters
 - SF Duration; $D_{SF} = D_P + N_{SF} * D_{RB}$
 - Duration is the Probes plus an integer number of US Resource Blocks
 - Spectrum; S_{Ou} – set via US Profile descriptor (Ref CI 45.2.7a.2)
- Superframe parameters are set at network initialization

OFDMA Frame Numbering



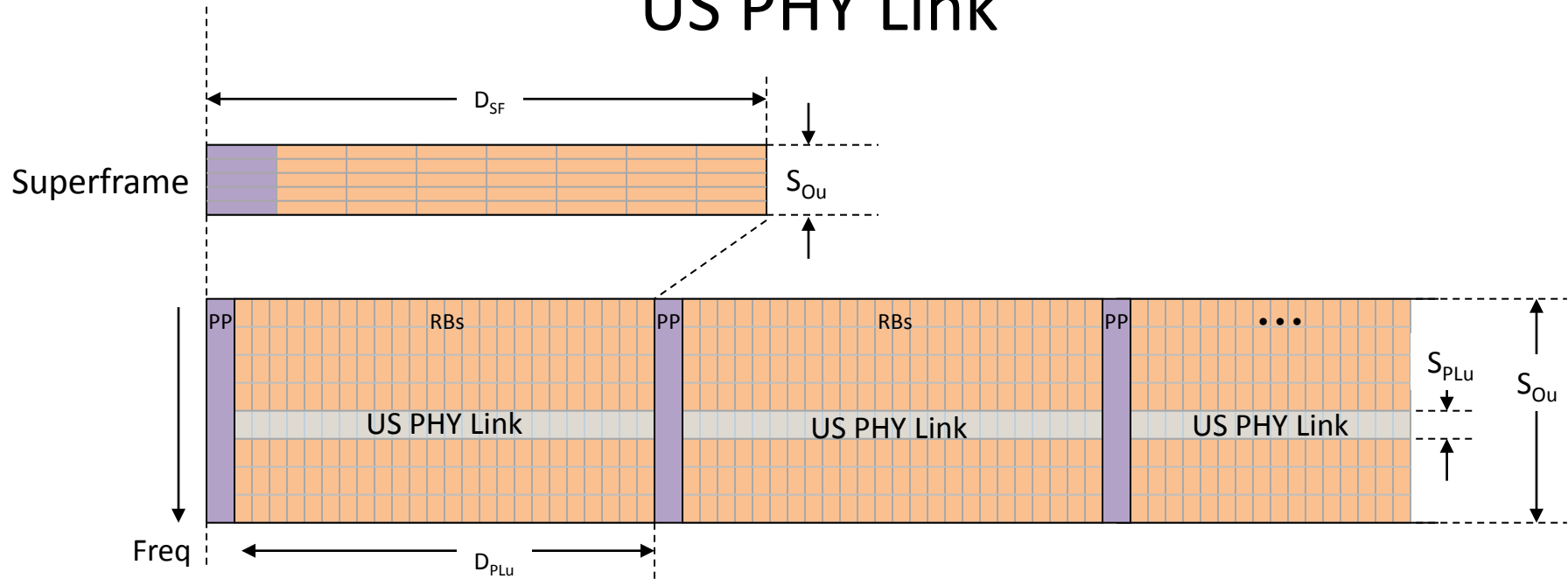
- OFDMA Frame numbering

- Each OFDMA Frame (a column of RBs) is numbered using an integer
- Individual Resource blocks within an OFDMA Frame can be referenced using a decimal if needed – numerated from lowest frequency to highest frequency

Superframe RBs Usage

- US Superframe RBs contains
 - Data RBs
 - Upstream PHY Link RBs
 - Including: PHY Discovery RBs and Fine Raging response RBs
 - Probes
- RB usage constraints
 - Number of MAC data resources in a Superframe is constant for all Superframes
 - A SF may include either:
 - Data RBs and PHY Link
 - Data RBs and PHY Discovery RBs and PHY Link
 - Data RBs and Fine Ranging response RBs and PHY Link
 - Number of resources consumed by US PHY Link plus PHY Discovery Window plus Fine Ranging response is constant for all Superframes
- RB usage parameters are set at network initialization
 - May differ between superframes with the above constraints

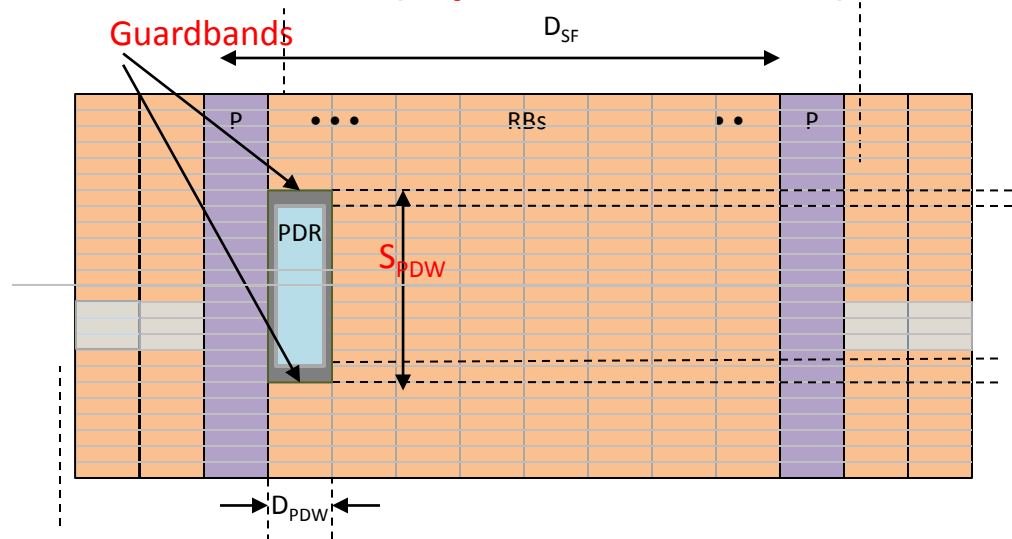
US PHY Link



- **Upstream PHY Link frame Parameters**

- Duration; $D_{PLu} = D_{SF} - D_p$
- Spectrum; $S_{PLu} = N_{PLu} * S_{RB}$ (S_{PLu} is a constant [consider 400 kHz])
- Starting SC is determined by parameter US PHY Link Start (Ref CI 45.2.1.114) provisioned before network initialization
- Not transmitted during Probe Symbols
- Starting OFDMA Frame for any given US transmission indicated in DS PHY Link header
- Volume; $V_{PLu} = (D_{SF} - D_p) * S_{PLu}$

PHY Discovery Window Embedded in a Superframe (updated slide)



- PHY Discovery Window parameters

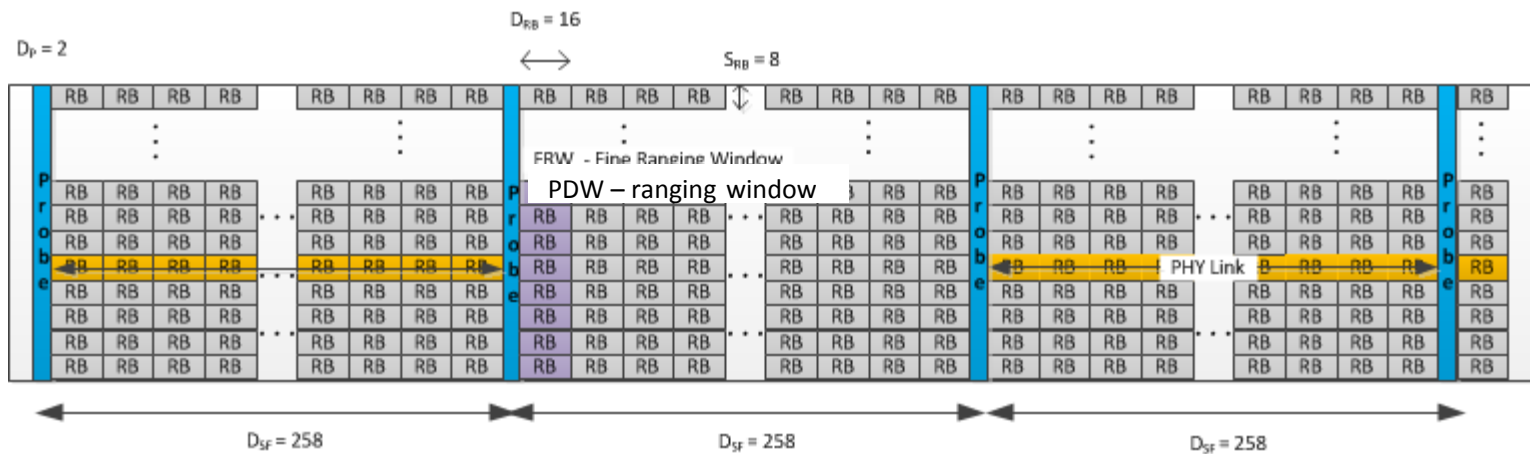
- Duration: $D_{PDW} = D_{RB}$
 - determined by parameter PHY Discovery duration (Ref Cl 45.2.1.115)
- Spectrum; $-S_{PDW}$ fixed at 128 * 50 kHz (inc. guard band)
- Volume; $V_{PDW} = S_{PD} * D_{PDW}$ (may include an additional 2 symbols if overlapping Probes)
- Starting Symbol is determined by parameter PHY Discovery start (Ref Cl 45.2.1.115)

Numerical Examples: PHY Discovery and US PLC with Superframe size of 254-258 Symbols

(Updated slide with a single RB PD window)

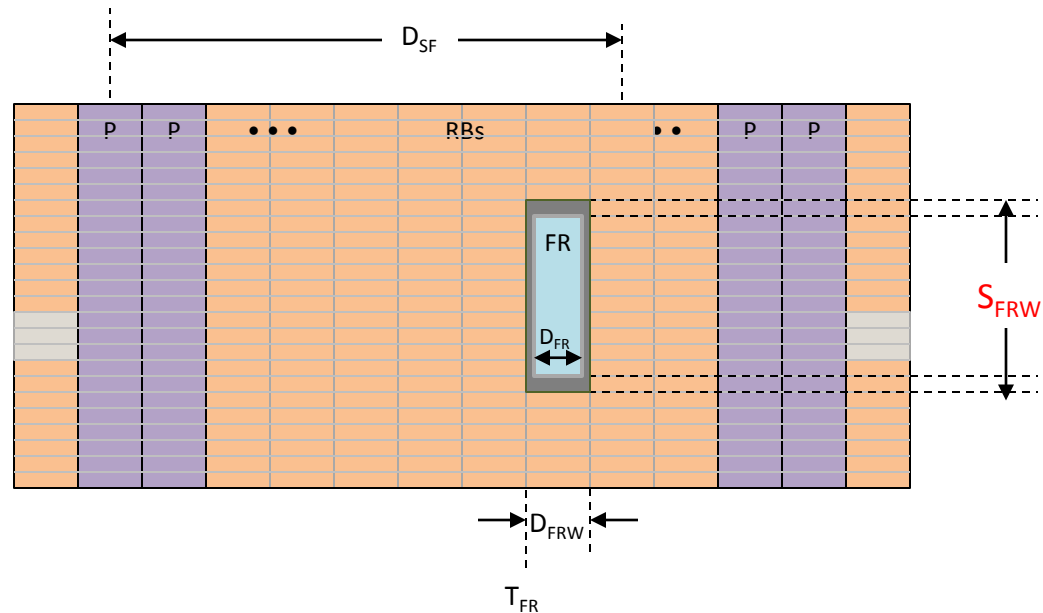
- PHY Discovery Window in a single Superframes
 - SF duration is between 5.4 mSec to 6.1 mSec
 - PDW durations \ll Single RB

| D-PDW (uSec) | D-RB (symbols) | D-SF (symbols) | Dp (Symbols) | D-PD (symbols) | S-PDW (SC) | S-PLu (SC) | V-FR | V-PLu | D-PDW 1 (Symbols) | D-PLu1 (Symbols) |
|--------------|----------------|----------------|--------------|----------------|------------|------------|------|-------|-------------------|------------------|
| 340 | 16 | 258 | 2 | 16 | 128 | 8 | 16 | 2048 | 16 | 0 |
| 255 | 12 | 254 | 2 | 12 | 160 | 8 | 12 | 2016 | 12 | 12 |
| 170 | 8 | 258 | 2 | 8 | 128 | 8 | 8 | 2048 | 8 | 128 |



Superframe with $D_{RB} = 16$

Fine Ranging Window (Updated Slide)



- Fine Ranging window parameters
 - Duration and spectrum similar to PD window
 - Start; T_{FR} determined by a parameter passed over DS PHY Link
- Constraints
 - aligns to same boundary and placement conditions as RBs

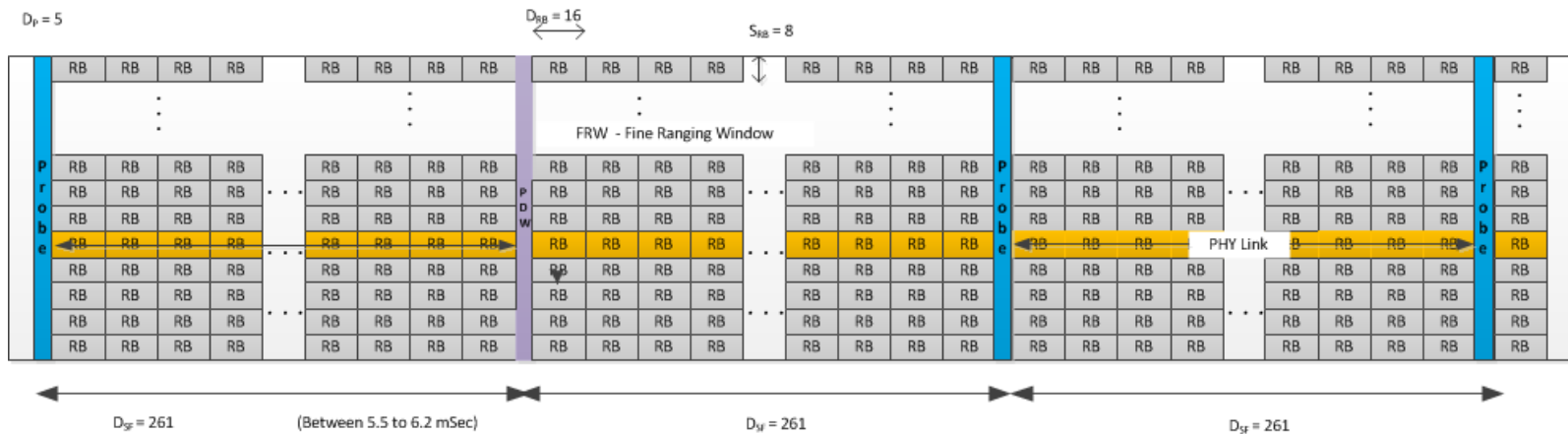
Use Probes Period for PHY Discovery and Ranging

(New Slide)

- Six Probe symbols are required for PDW
 - Two symbols for Preamble
 - Two symbols for data
 - One symbol for time ambiguity
 - Additional time for RTT range (~ 12 uSec?)
- Advantages:
 - Allows more flexibility with Probe rate vs. overhead
 - Number of bits per superframe always the same
 - No need to use idle bits
- Disadvantage:
 - Increase Probe overhead to 2.3% with 256-symbol plus probes Superframes
 - Increase period with no data transmission to about 142.5 uSec
 - Instead of 47.5 uSec with 2-symbol probes
 - Increase data buffer size accordingly

Frame Structure with PDW Using Probe Periods (New Slide)

- PHY Discovery Window in a single Superframes
 - SF duration is between 5.5 mSec to 6.2 mSec
 - PDW durations < single OFDMA symbol



Probe overhead and SF size

| min D-PDW (uSec) | D-RB (Symbols) | D-SF (Symbols) | Dp (Symbols) | D-SF (uSec) | Probe Overhead | Probe Duration (uSec) |
|------------------|----------------|----------------|--------------|-------------|----------------|-----------------------|
| 21 | 16 | 262 | 6 | 6223 | 2.3% | 142.5 |
| 21 | 16 | 134 | 6 | 3183 | 4.5% | 142.5 |

Questions?

Comments?

THANK YOU