

# EPoC Framing – Rev 2

Authors:

Avi Kliger; Broadcom

## Changes From Previous Version

- Single RB for the PHY Discovery Window
  - Similar to Fine Ranging
- Option for PDW to cross Superframes withdrawn

# 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

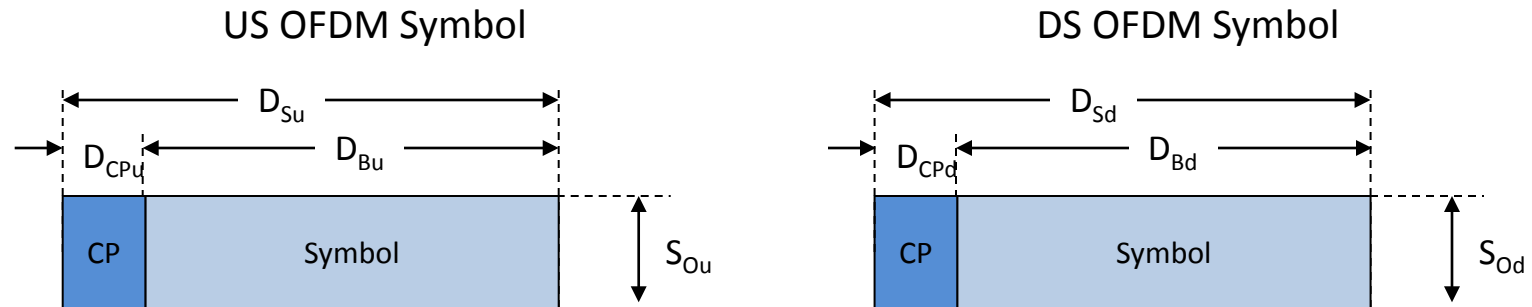
Uppercase subscript(s) – describe object

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

Resource Block, SF = Superframe)

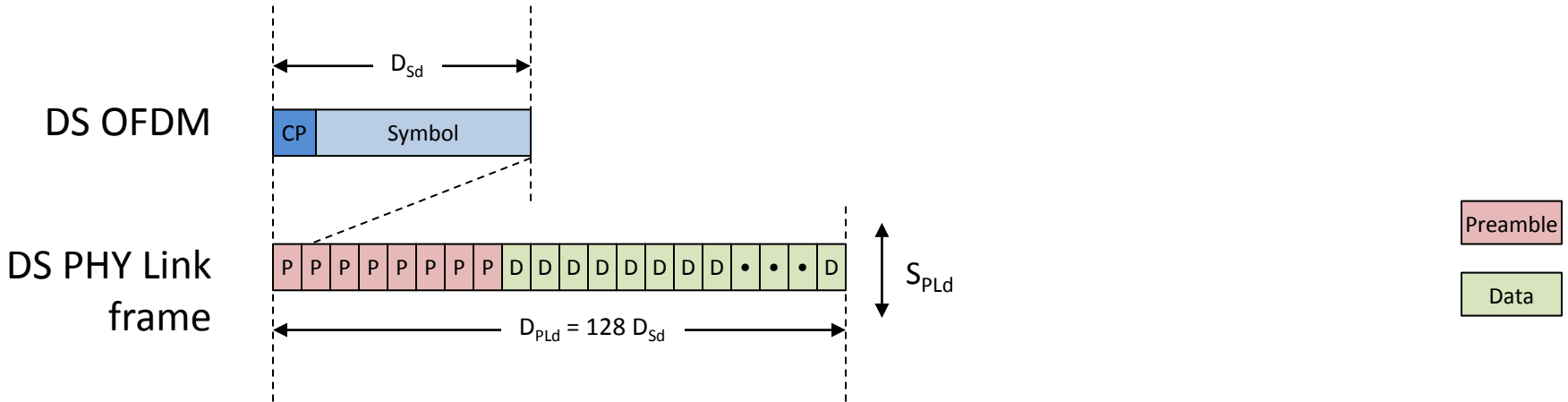
Lowercase subscript – direction (u = upstream, d = downstream)

# EPoC OFDM Symbols



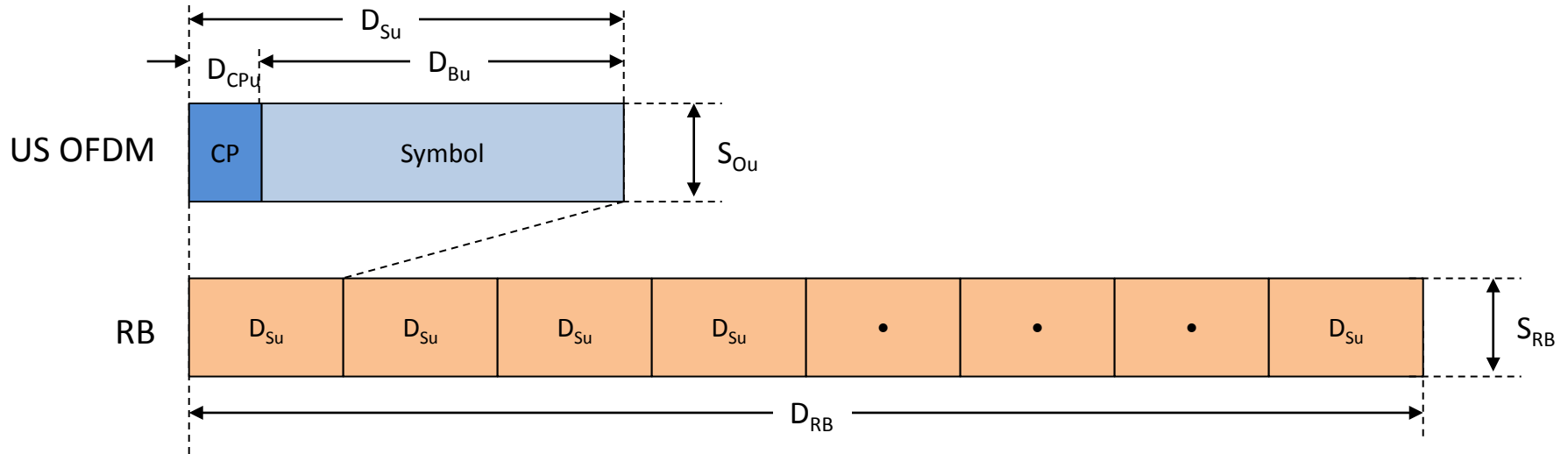
- OFDM Symbol parameters
  - Symbol duration ( $D_{Su}$ ,  $D_{Sd}$ ) composed of
    - Useful Symbol duration ( $D_{Bu}$ ,  $D_{Bd}$ ); fixed at 20 us
    - Cyclic Prefix duration ( $D_{CPu}$ ,  $D_{CPd}$ ); configurable (Ref CI 45.2.1.108/110)
      - US {1.25, 1.875, 2.5, 3.125, 3.75 us}
      - DS {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



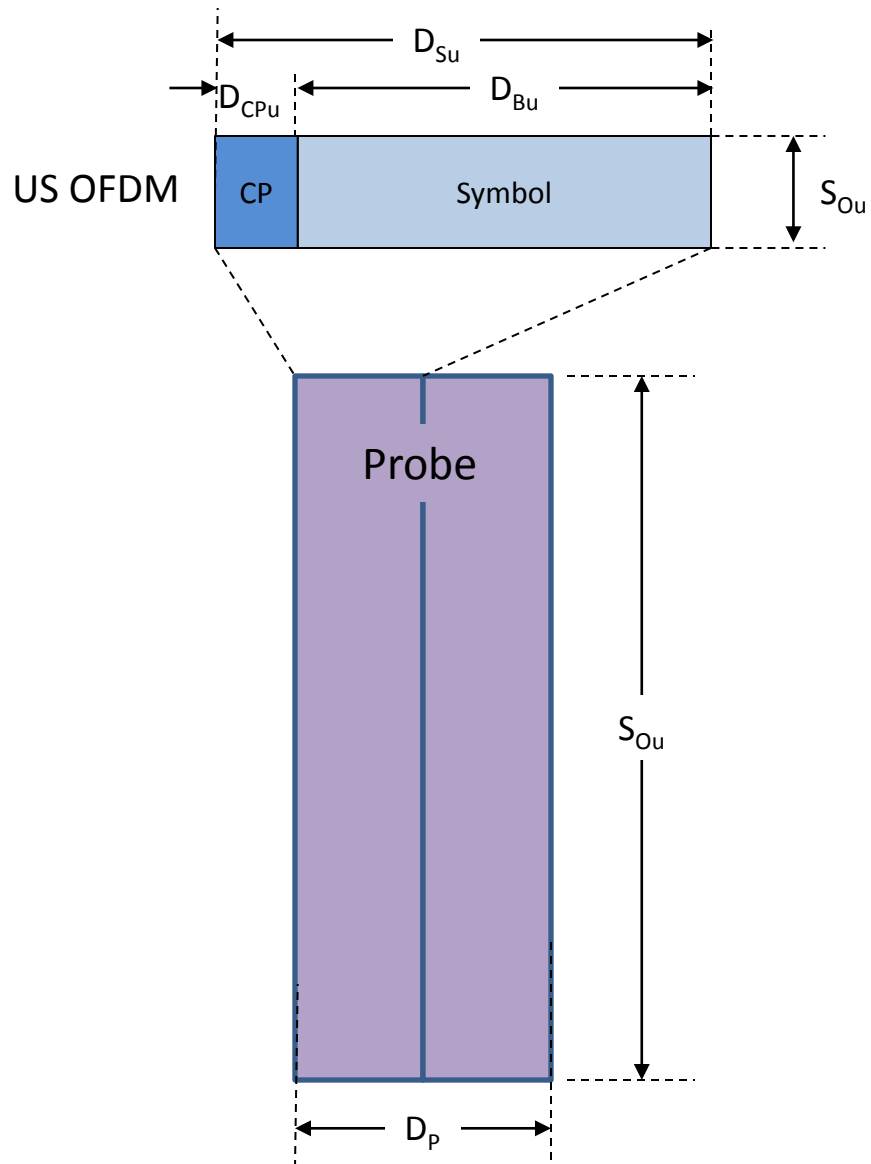
- Downstream framing composed of two items
  - Downstream Symbol Time ( $D_{Sd}$ ) composed of
    - Useful symbol time ( $D_{Bd}$ ); fixed at 20 us
    - Downstream CP time ( $D_{CPd}$ ); variable {1.25, 2.5, 3.75 us}, set at network initialization (Ref Cl 45.2.1.108)
  - Downstream PHY Link Frame ( $D_{PLd}$ )
    - 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



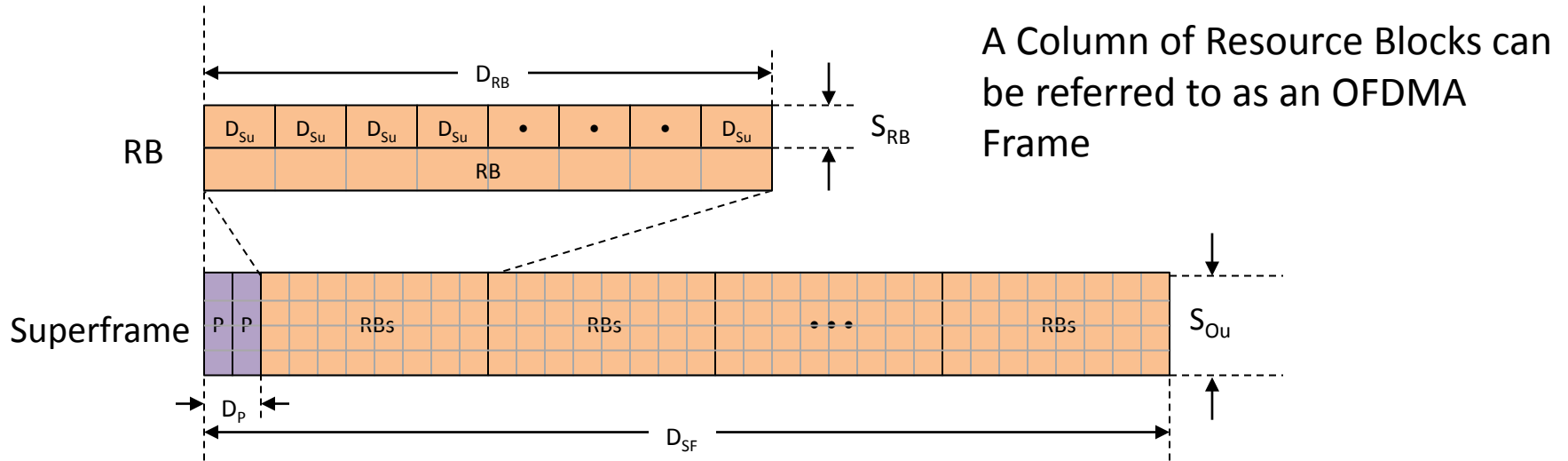
- Upstream OFDM frame parameters
  - RB duration ( $D_{RB}$ ); configurable: 8, 12, 16 symbol durations ( $D_{Su}$ )}
  - RB spectrum ( $S_{RB}$ ); configurable: {1, 4, or 8} contiguous Allocated SC's
    - Proposed registers in 4/16 call
  - RB Volume;  $V_{RB} = D_{RB} * S_{RB}$
- Resource Block Constraints
  - 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

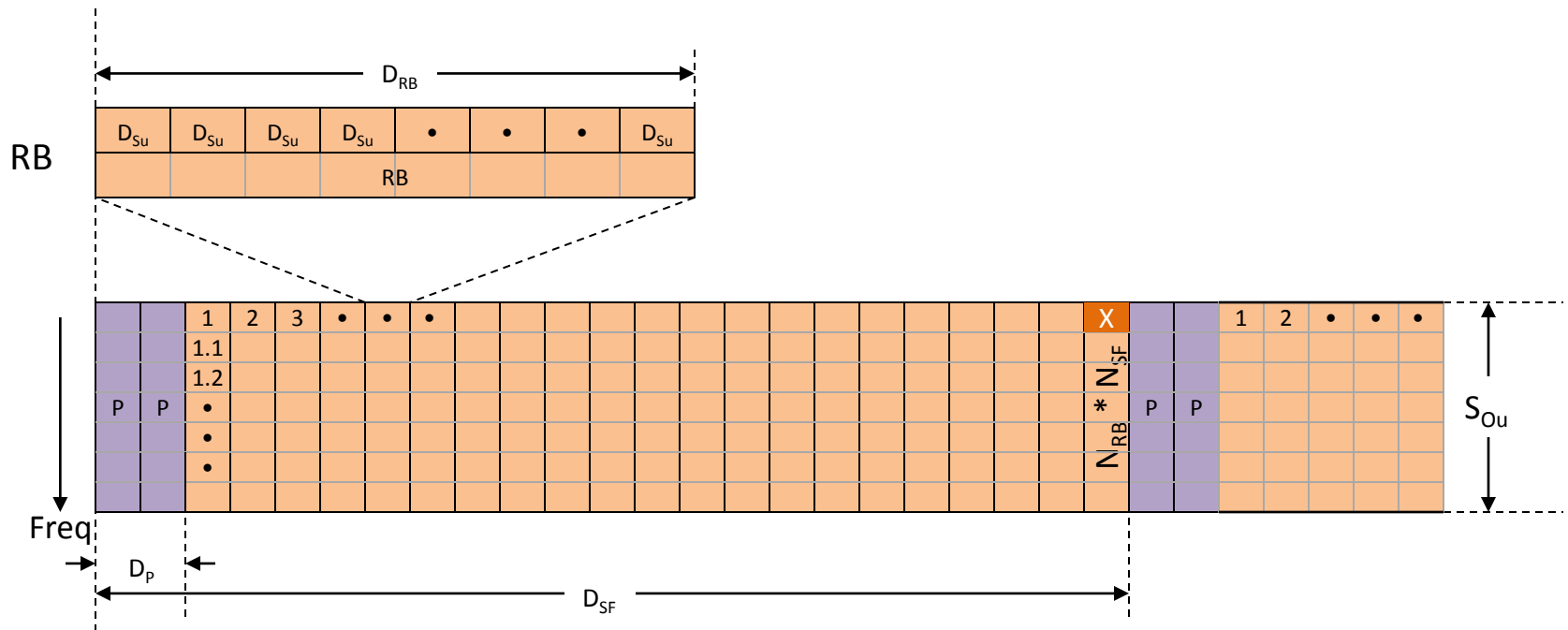
# Upstream Superframe



- 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



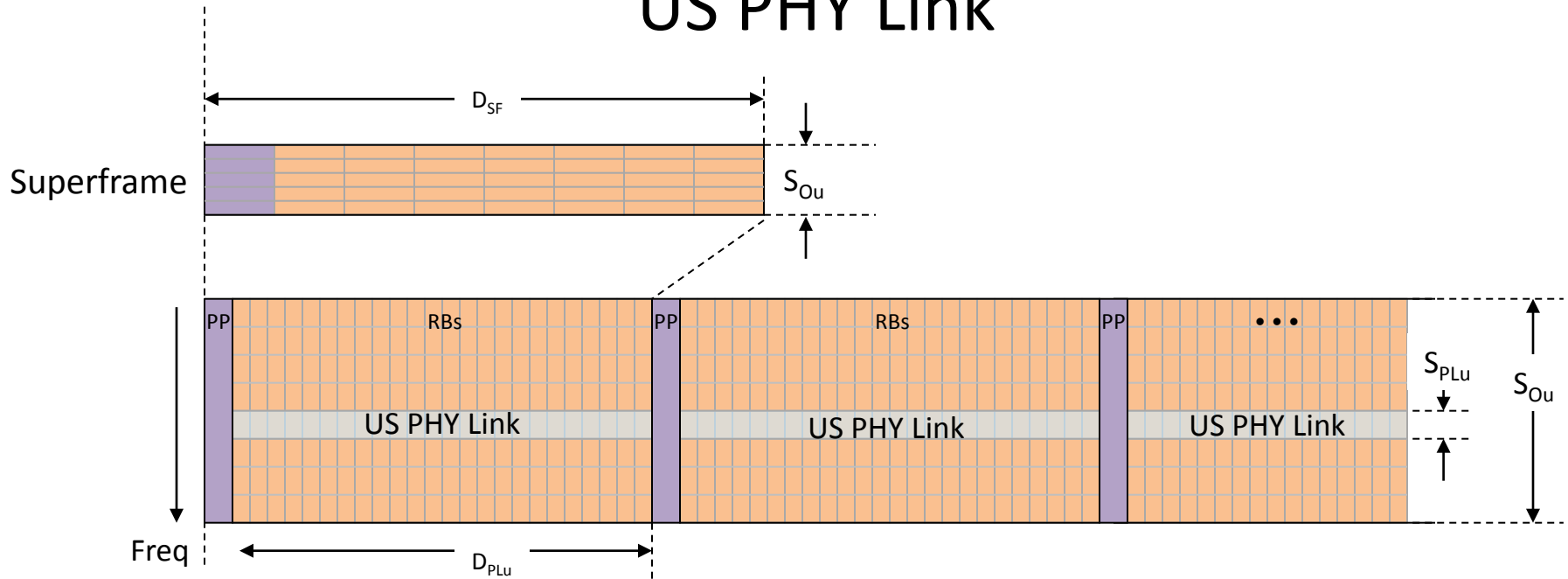
- OFDMA Frame numbering

- 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
- 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

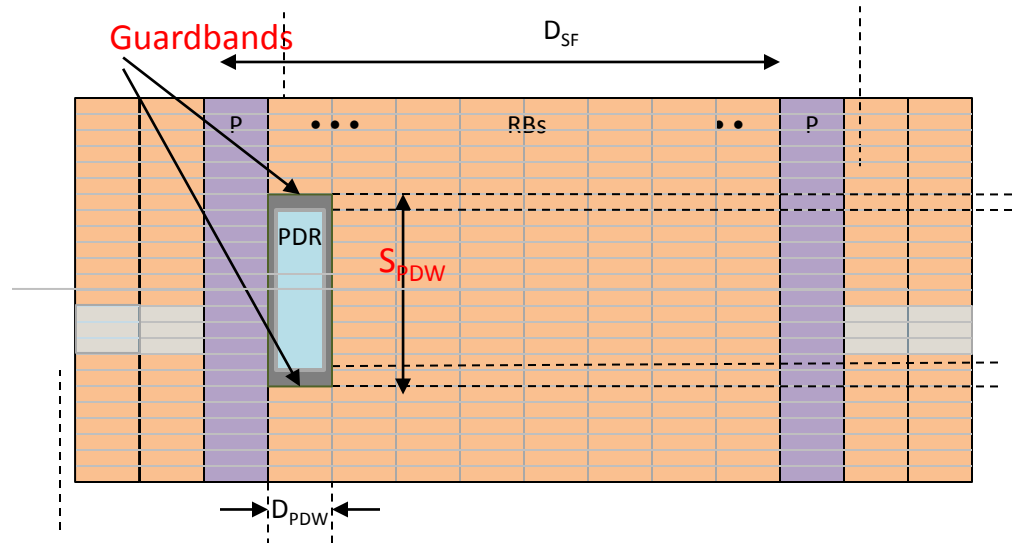
# US PHY Link



- **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



- PHY Discovery Window parameters

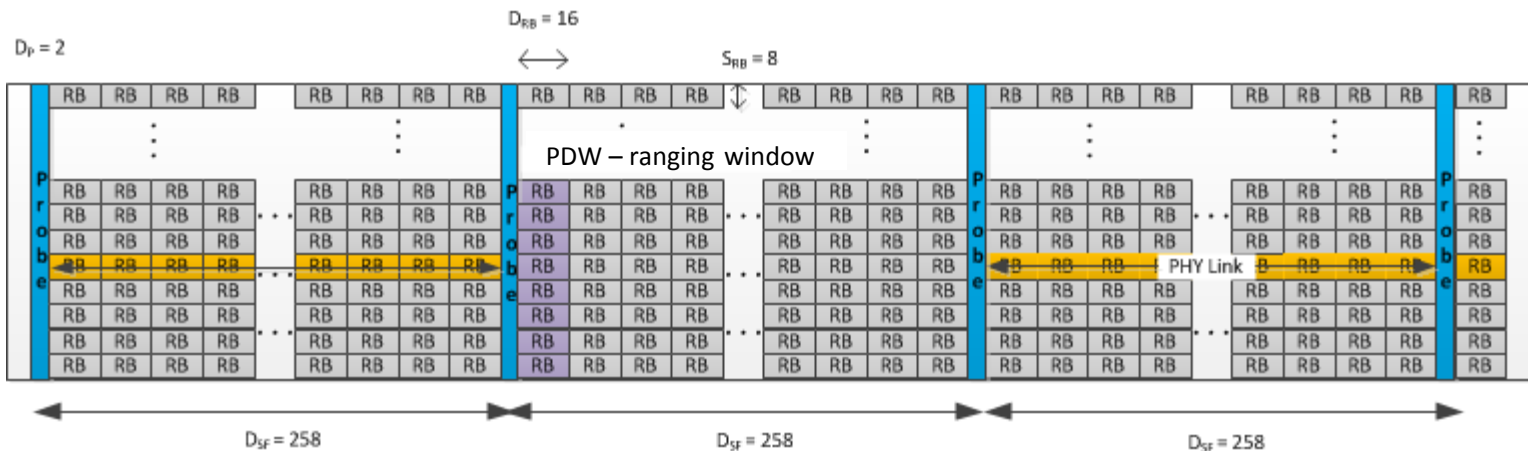
- Duration:  $D_{PDW} = D_{RB}$ 
  - determined by parameter PHY Discovery duration (Ref Cl 45.2.1.115)
- Spectrum;  $-S_{PDW}$  fixed at  $128 * 50$  kHz (inc. guard band)
- Volume;  $V_{PDW} = S_{PD} * D_{PDW}$  (may include an additional 2 symbols if overlapping Probes)
- Starting Symbol is determined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

## (Corrected slide with a single RB PD window)

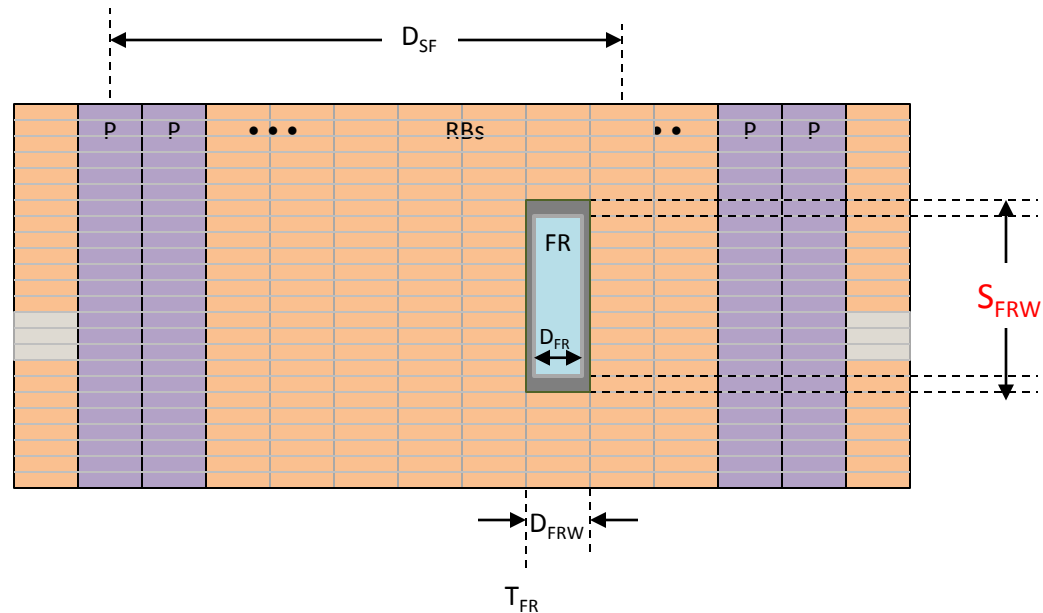
- PHY Discovery Window in a single Superframes
  - SF duration is between 5.5 mSec to 6.2 mSec
  - PDW durations < A single RB

D-PDW (uSec)	D-RB (symbols)	D-SF (symbols)	Dp (Symbols)	D-FR (symbols)	S-FR (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	160	8	8	2048	8	96



Superframe with  $D_{RB} = 16$

# Fine Ranging Window



- 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

Questions?

Comments?

**THANK YOU**