Virtual Multi-Carrier Operation for IEEE 802.16m

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Purpose: Discussion and consideration for 802.16m SDD

Background

- Sub-carrier spacing alignment
  - In multi-carrier operation, if adjacent carriers have well aligned sub-carrier spacing, the mutual interference can be reduced
- Guard band saving
  - When adjacent carriers are aligned in sub-carrier spacing, the guard band originally reserved for each carrier may be used with reduced interference
- Three proposals in March meeting
  - C80216m-08_208r2 (Samsung): propose to change channel raster to 175kHz to align the neighboring carriers and reuse the guard band
  - C80216m-08_143 (MediaTek): propose to shift the center frequency of neighboring carrier to align sub-carrier spacing
  - C80216m-08_236r3 (ZTE): change sub-carrier spacing to 12.5kHz to ensure subcarrier spacing is always aligned

Interference with Non-Aligned Sub-carrier Spacing

OFDM Signal (N: FFT size, M: used sub-carreris):

$$y(t) = \sum_{k=0}^{M-1} X(k) e^{j2\pi q_k \Delta f t}, \quad 0 \le t \le T_u, \quad T_u \Delta f = 1, \quad q_k : \text{integers} \in [-\tfrac{N}{2}, \tfrac{N}{2} - 1]$$

Frequency Expression (T_u: useful symbol duration):

$$Y(f) = T_u \sum_{k=0}^{M-1} X(k) Sinc((f - q_k \Delta f) T_u) e^{-j\pi (f - q_k \Delta f) T_u}\}$$

Average Power Spectrum:

$$E\left\{\left|Y(f)\right|^2\right\} = \sigma_s^2 \sum_{k=0}^{M-1} \left|Sinc((f - q_k \Delta f) T_u)\right|^2$$

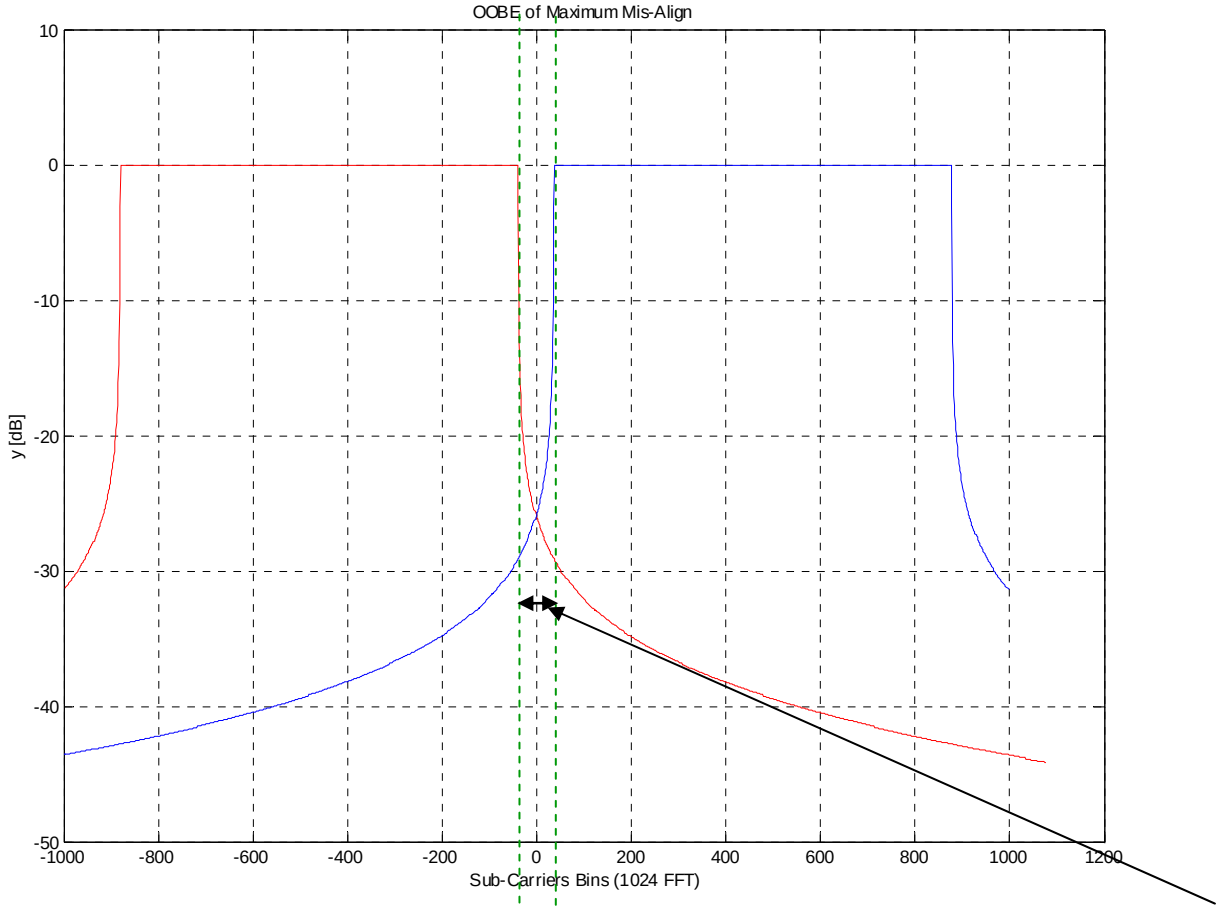
Evaluate the power spectrum at $f_n = \frac{\beta}{T_s} + n\Delta f$

$$E\left\{\left|Y(f_n)\right|^2\right\} = \sigma_s^2 \left|\sin(\beta\pi)\right|^2 \sum_{k=0}^{M-1} \frac{1}{\left|\pi (f_n - q_k \Delta f) T_u\right|^2}$$

where β is a misalignment factor in between 0 and 1.

Interference of 0.5 Sub-Carrier Spacing Mis-alignment

10Mhz, 841 data tones, no low-pass filter



0 to -29dB interference signal at guard band, for maximum mis-alignment

Interference with Aligned Sub-carriers

When neighboring carriers are aligned, the alignment factor $\beta = 0$

The power of interference signal from the neighboring carrier is

$$10\log\left(\sigma_s^2 \sum_{k=0}^{M-1} \frac{1}{\left|\pi(f_n - q_k \Delta f)T_u\right|^2}\right) + 10\log\left(\left|\sin(\beta\pi)\right|^2\right)$$

interference signal for maximum mis-alignment, 0 to -29dB at guard band

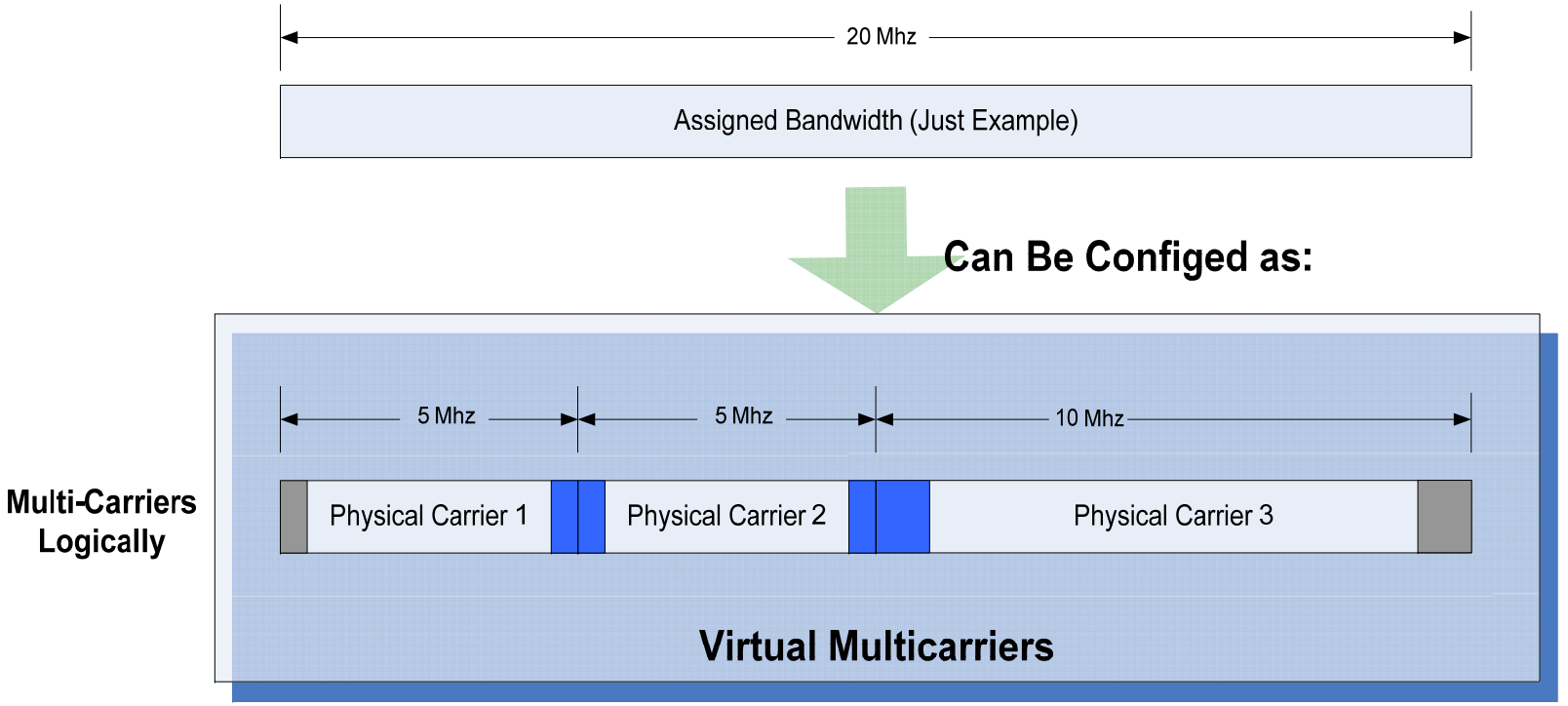
when $\beta = 0$, the value will be $-\infty$

No interference due to OOBE when neighboring carriers are well aligned

Virtual Multi-carrier Concept

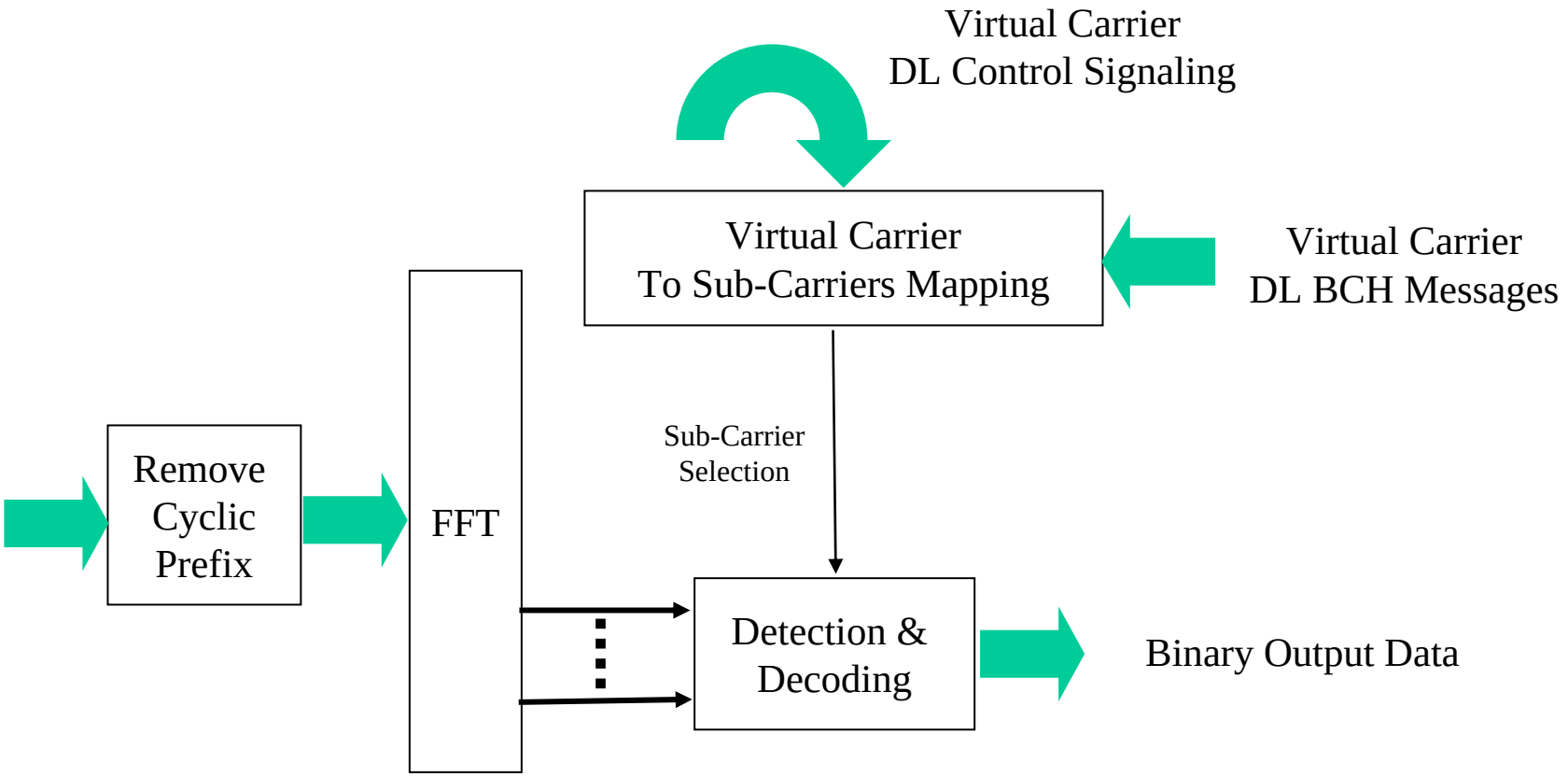
- Define self-contained minimum bandwidth operation
  - Contains essential control information within minimum bandwidth
- Multiple physical carriers deployed with aligned sub-carrier spacing
- Guard sub-carriers are used without impacting terminals operating on a single carrier
- Logical mapping is supported for multi-carrier operation
  - Virtual carriers overlap with real physical carriers
  - Guard sub-carriers may be assigned/used.
  - The bandwidth of a virtual carrier can vary depending on available physical carriers (5 MHz, 10 MHz, 20 MHz, …)
  - Some physical carriers may be configured as data only pipe

Virtual Multi-carrier Example

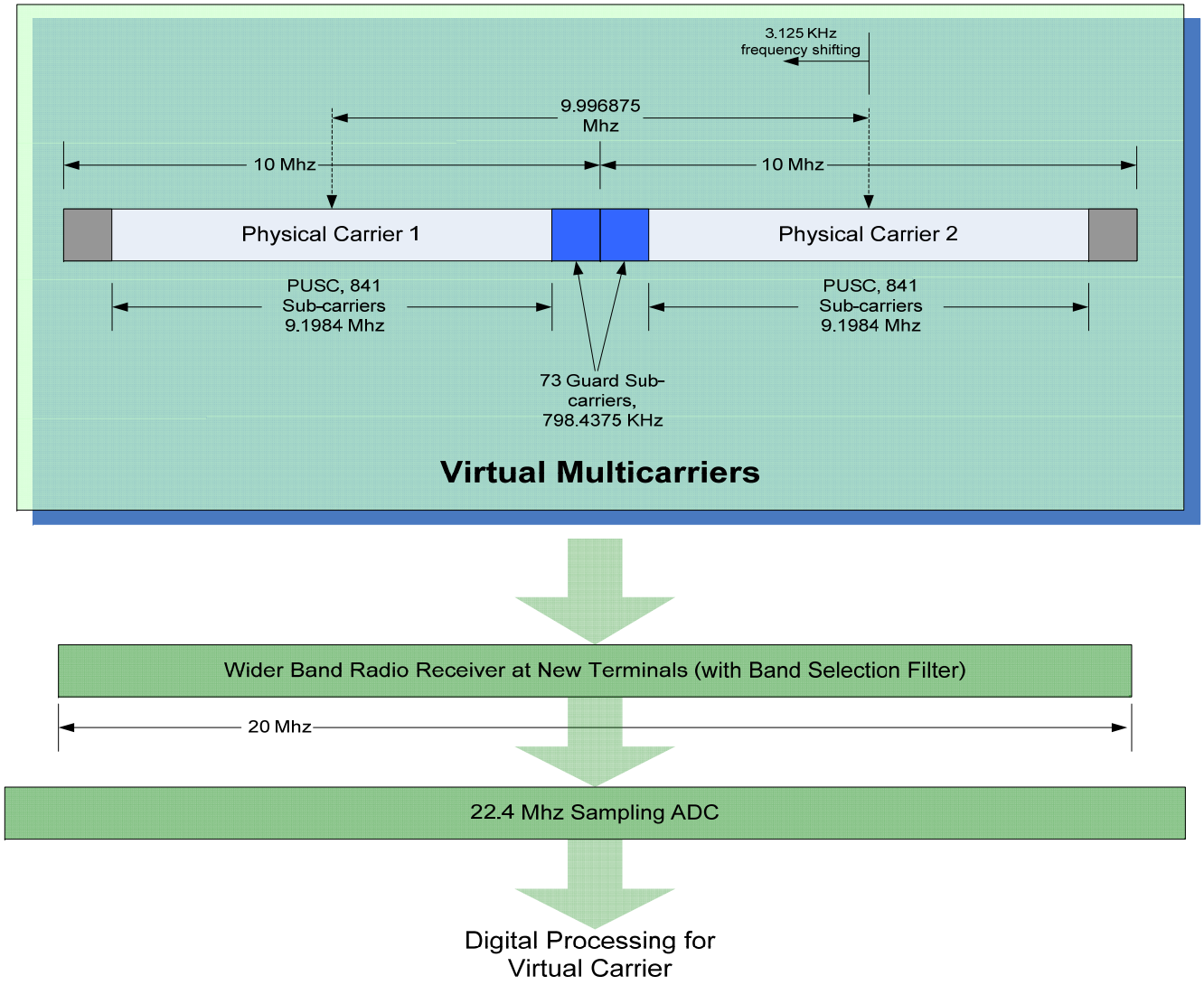


- Virtual Muti-carrier operates on 20MHz continuous band
- Contain two 5MHz and one 10MHz physical carriers
- The guard sub-carriers reserved for physical carriers are used except for the ones on the band edge
- The guard sub-carriers on the edge may vary depending on the Physical carrier bandwidth and filter implementation

Digital Processing to Receive Virtual Carrier

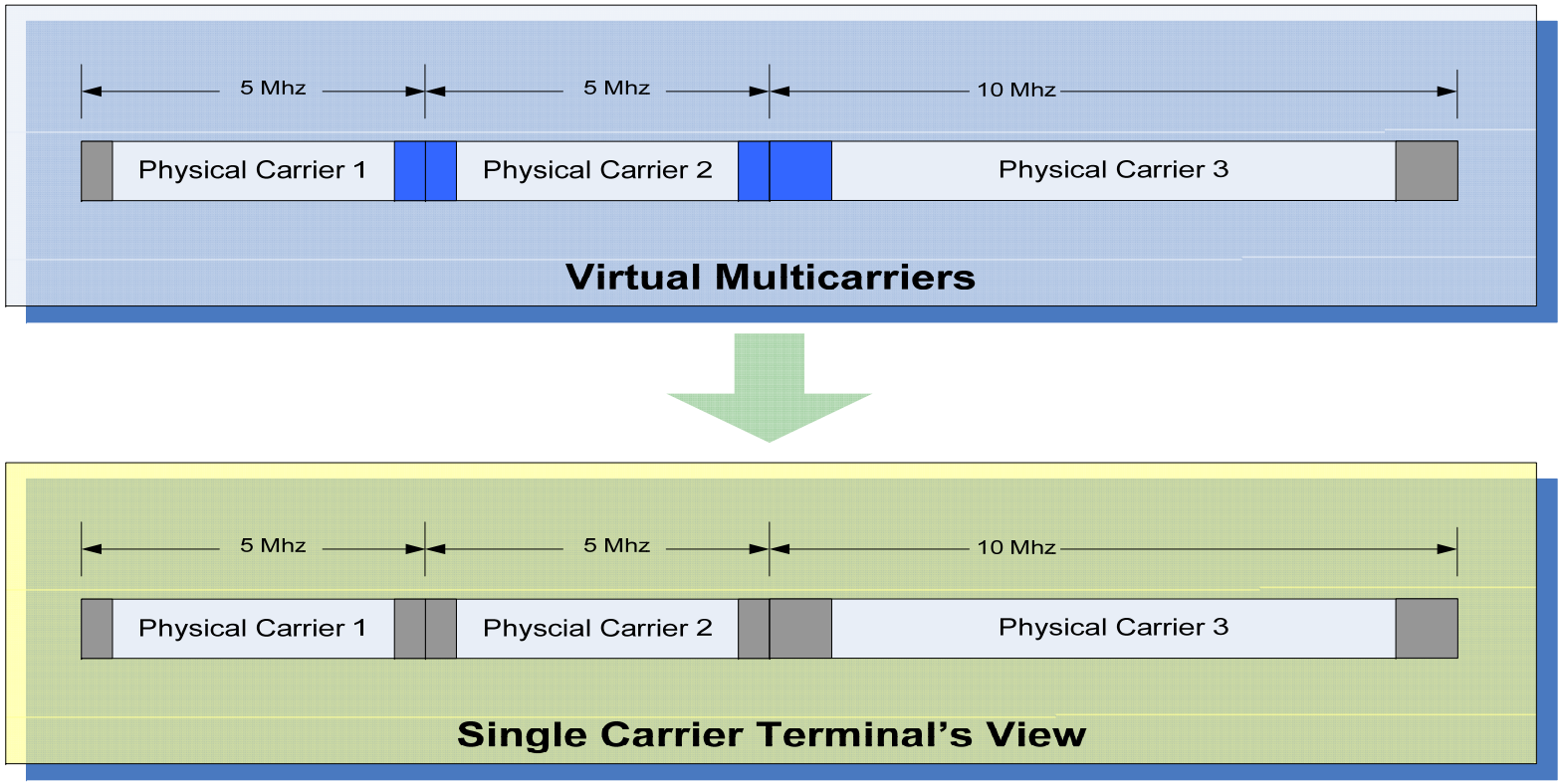


Multi-carrier Terminal Operation



- Sync to the real carrier
- Wider band processing

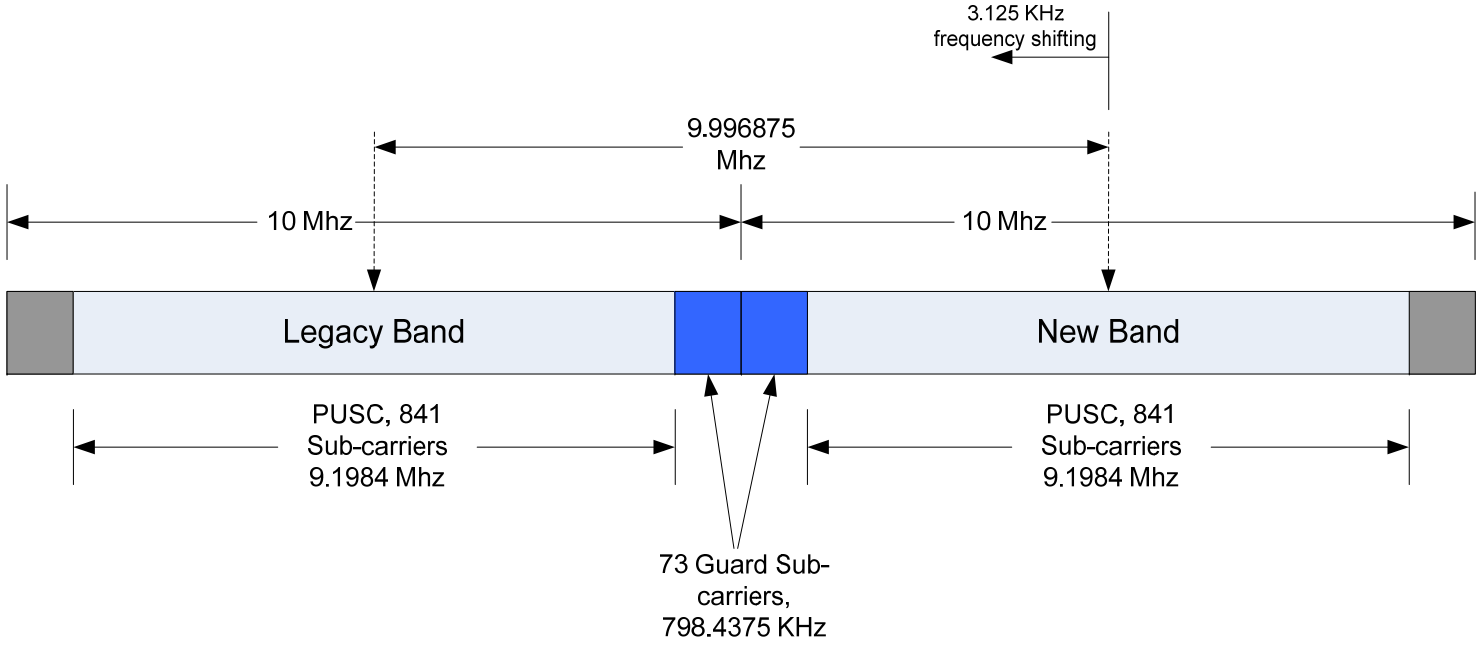
Single Carrier Terminal Operation



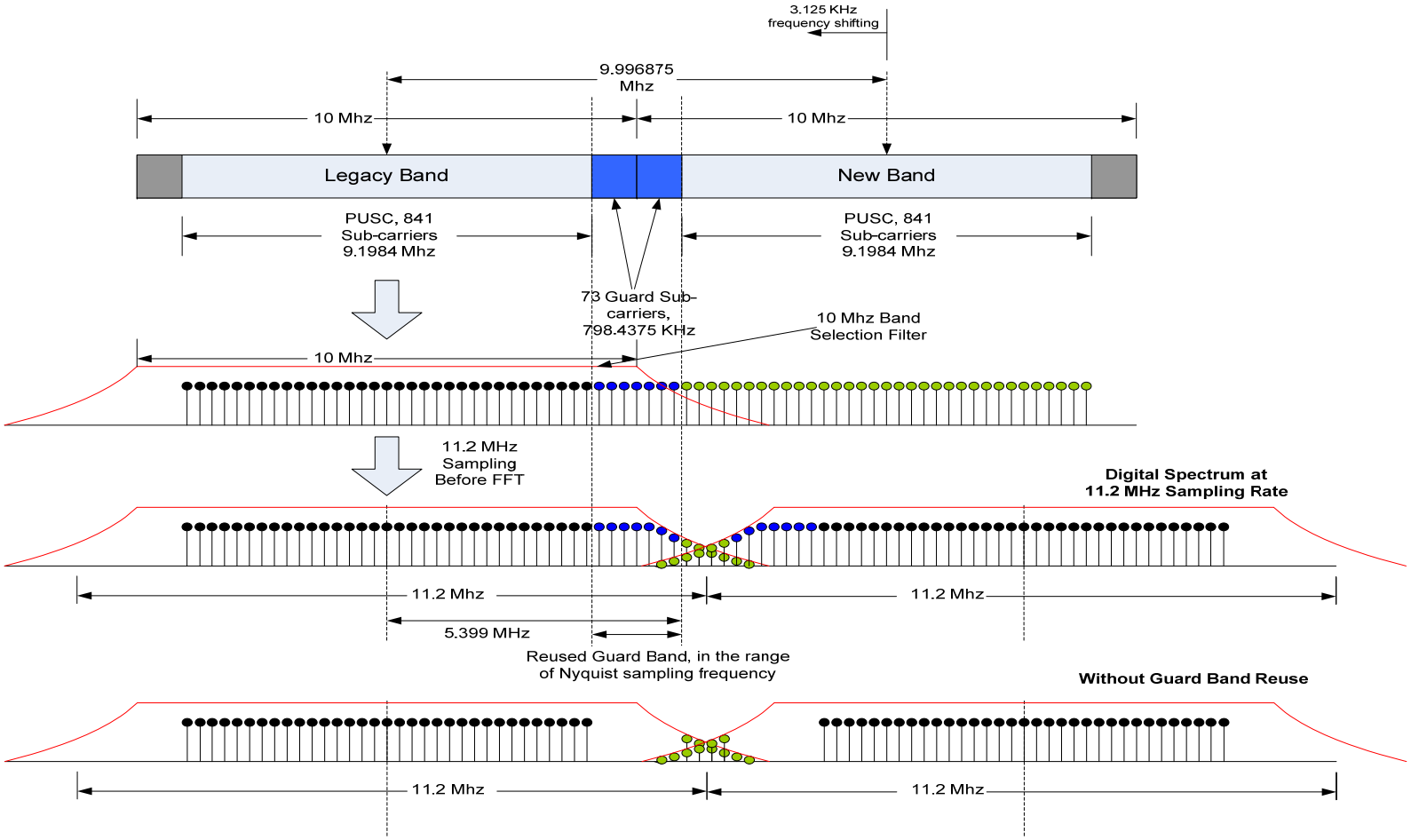
- Any one of the physical carriers can be selected for transferring the essential control information and used for operation with the legacy single carrier terminals.
- The guard sub-carriers are not used by single carrier terminals
- The use of guard sub-carriers for multi-carrier terminals is transparent to single carrier terminals

Legacy Band/Terminal Operation

- One Virtual Multi-carrier contains one 10MHz legacy carrier and one 10MHz 16m carrier
- The middle guard sub-carriers are used
- Any negative impact on legacy band/terminal operation?

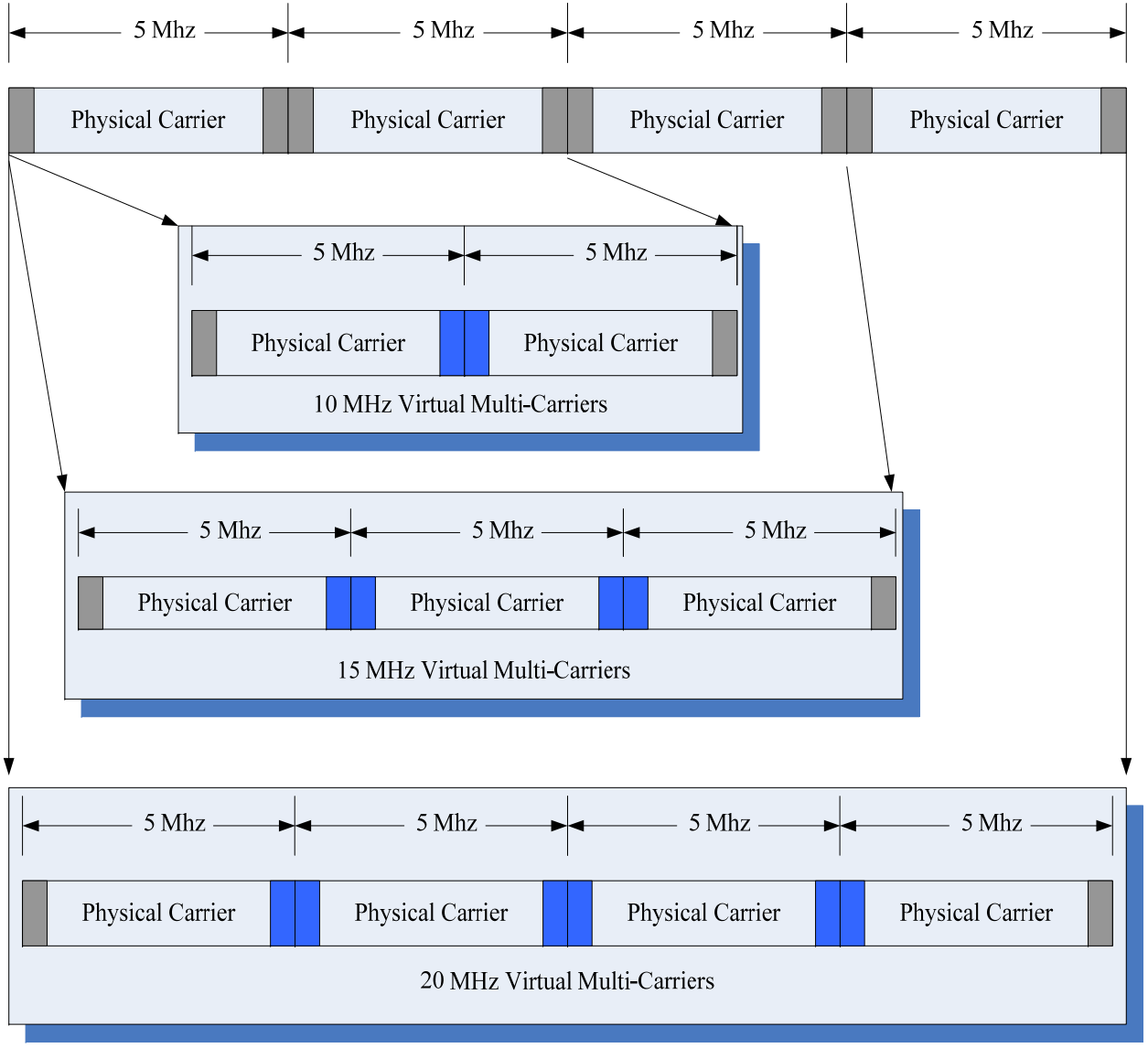


Legacy Terminal Operation Not Impacted

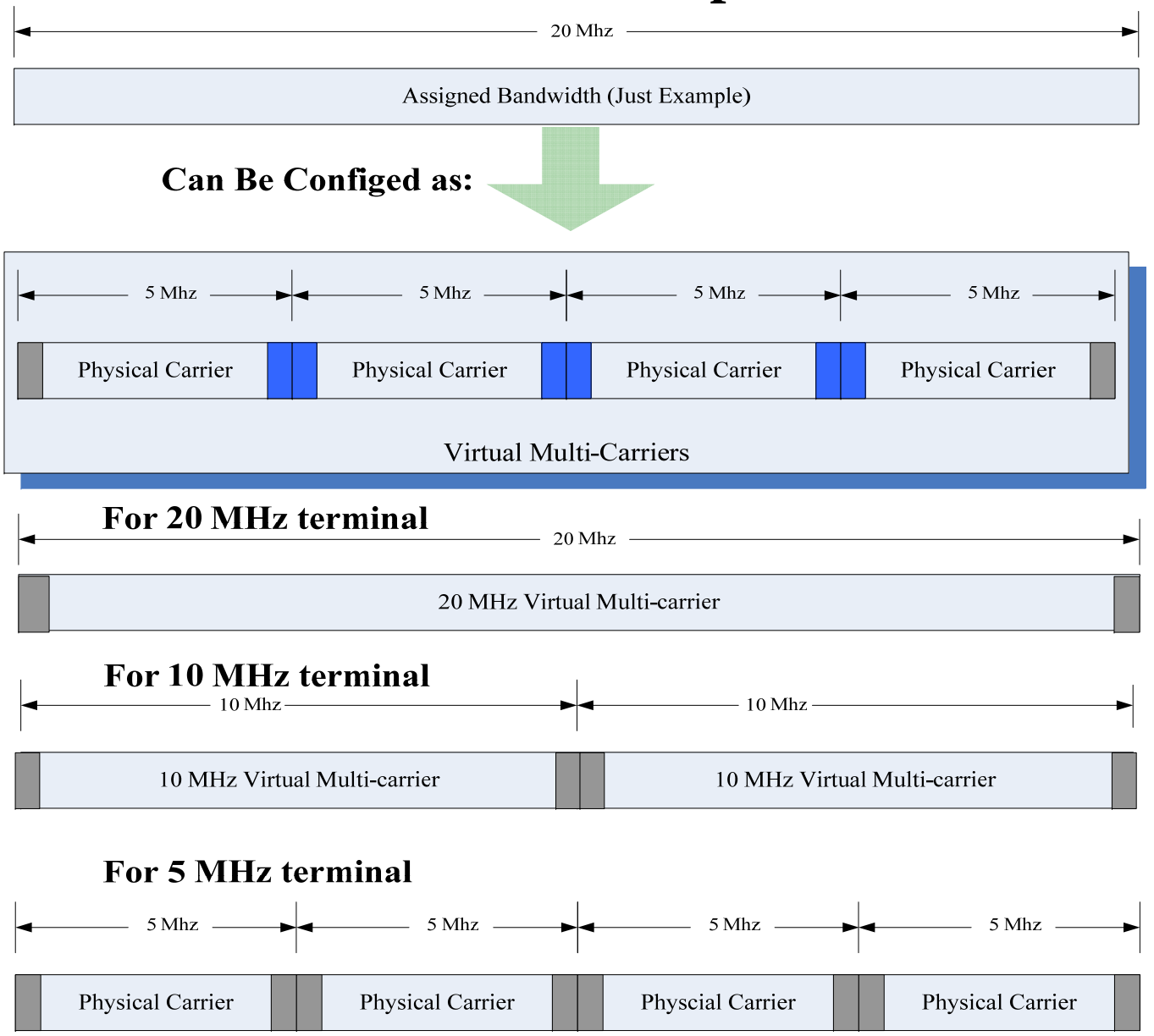


- With standard sampling rate (11.2MHz for 10MHz Carrier), the legacy terminal processing is not impacted by guard sub-carrier reuse
- With Virtual Multi-Carrier, the legacy band/terminals can be supported seamlessly

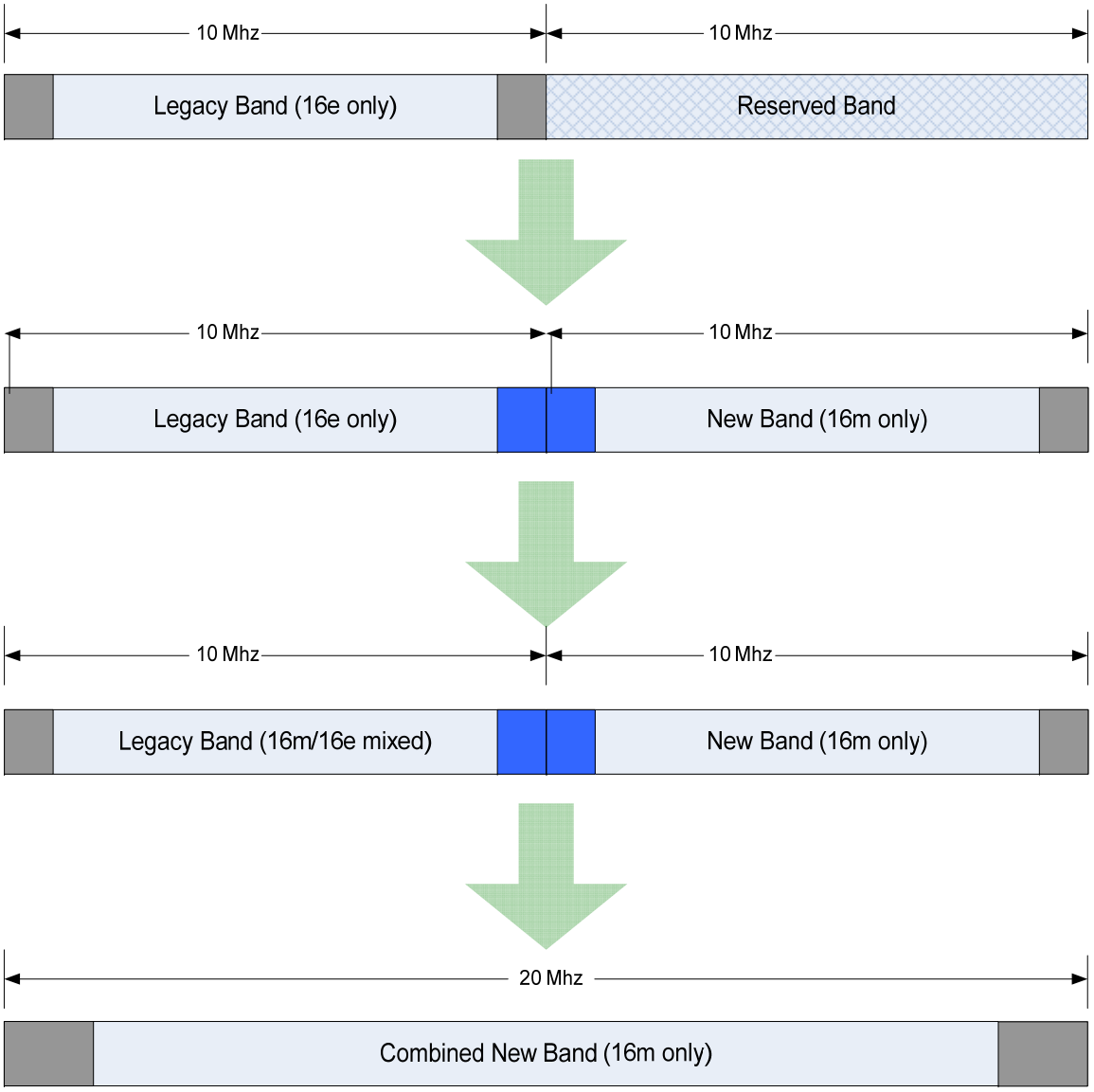
Unlimited BS Bandwidth Scaling



Variable Bandwidth Terminal Operation



Incremental Deployment and Seamless Upgrade



Virtual Multi-carrier Summary

- Support seamless operation with legacy band/terminals
- Support guard band reuse for new terminals
- Support unlimited BS bandwidth scaling
- Support variable MS bandwidth operation
- Support incremental deployment and seamless upgrade