3GPP TSG RAN WG1 Meeting #86bis **R1-1608808**
Lisbon, Portugal 10th – 14th October 2016

Agenda Item: 8.1.2.2
Source: Fujitsu
Title: Discussion on subframe design with symbol level alignment
Document for: Discussion/Decision

1 Introduction

In RAN1#86 meeting, the agreements about the subframe design are shown as follows [1]:

- *Subframe duration in ms for a reference numerology with subcarrier spacing (2^m*15)kHz is exactly $1/2^m$ ms*
- *A subframe duration is defined by the duration of x OFDM symbols given a reference numerology*
  - *With the same CP overhead, a single value of x is specified irrespective of the subcarrier spacing value chosen for the reference numerology*
  - *This does not preclude multiple data transmission opportunities in time within a subframe duration*
  - *This does not preclude multiple control transmission opportunities in time for both DL and UL within the subframe duration*
  - *This does not prclude one data transmission to span over multiple subframe durations*
- *A UE has one reference numerology in a given NR carrier which defines subframe duration for the given NR carrier*
  - *FFS: In a given NR carrier, whether different UEs may have different reference numerologies or may not*

In addition, a working assumption about the symbol alignment is given as

- *Alignment within a subframe*
  - *Symbol level alignment across different subcarrier spacings with the same CP overhead is assumed within a subframe duration in a NR carrier*
  - *FFS: Unlicensed spectrum case*

Based on the agreements, different UEs using a given carrier may have the same or different reference numerologies. Thus, in this contribution, we will address the subframe design with respect to cases with one common reference numerology and with different reference numerologies.

2 Observations from the existing agreements

Based on the existing agreements, we can have the following observations:

- ***Observation 1****: subframe is defined based on reference numerology with the duration of* $1/2^m$ *ms*
- ***Observation 2****: a subframe of 1ms includes 14 symbols for the reference numerology with the subcarrier spacing of 15KHz*
- ***Observation 3****: 14 will be one of possible number of symbols for the subframe irrespective of subcarrier spacing*
- ***Observation 4****: symbol alignment should be achieved for different subcarrier spacings as long as the CP overhead is the same.*

3 Subframe design for the reference numerology

In this section, we will discuss the subframe design for two cases: 1) different UEs have the same reference numerology; and 2) different UEs have different numerologies.

3.1 Case 1: different UEs with the same reference numerology

In this case, we can consider the reference numerology with the subcarrier spacing of 15KHz as an example. As LTE, the subframe of 1ms includes 14 symbols, which consists of 2 long symbols (2208Ts for each, Ts is the sampling interval), and 12 short symbols (2192Ts for each). If the symbols with different numerologies are multiplexed in the same NR carrier, a half of subframe, i.e., 0.5ms, can be illustrated as Fig. 1 considering the symbol-level alignment.

Proposal 1: the LTE based subframe design can be applied to the case that different UEs have the same reference numerology.

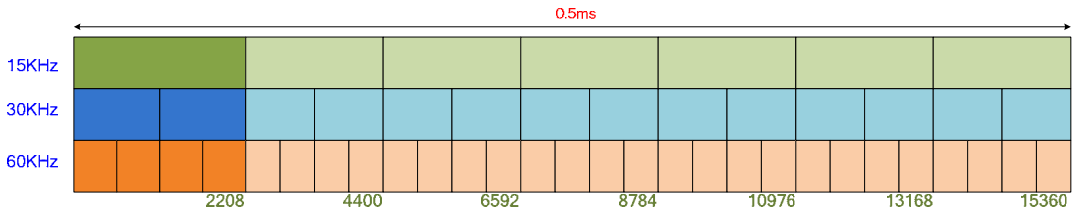

Fig. 1 A half subframe (or slot) multiplexing different UEs with the same reference numerology but different subcarrier spacings (the numbers in the figure indicates the number of Ts)

3.2 Case 2: different UEs with different numerologies

In this cases, as an example, we consider three reference numerologies with subcarrier spacings being 15kHz, 30kHz, and 60kHz, respectively. For the same CP overhead, by using LTE-like subframe design, the subframe duration for those three reference numerologies are 1ms, 0.5ms, and 0.25ms, respectively. If those subframes are multiplexed in the same NR carrier, the subframes located in a period of 0.5ms can

be illustrated as Fig. 2. From the figure, it can be seen that the target of symbol-level alignment cannot be satisfied.

Observation 5*: The LTE based subframe design cannot satisfy the symbol-level alignment for the case that different UEs have different reference numerologies.*

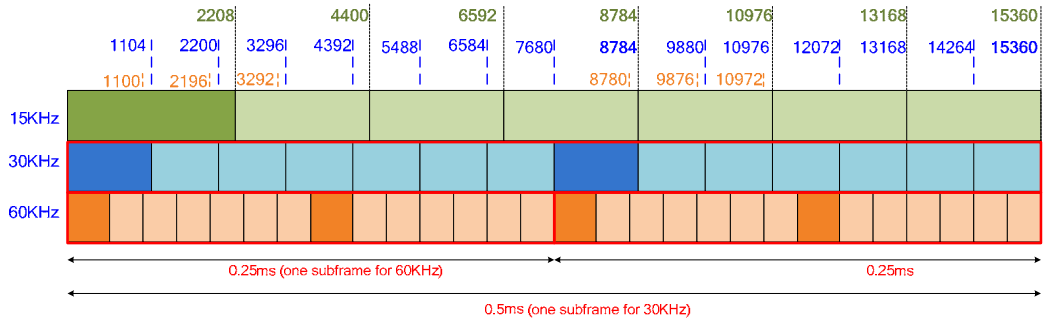

Fig. 2 Period of 0.5ms multiplexing different subframes with LTE like design (the numbers in the figure indicates the number of Ts)

To achieve the aim of symbol level alignment, and also having subframe (or slot) durations that do not vary in time for a given numerology, we give two possible designs of a subframe as follows:

a. A subframe contains symbols with the equal length and some reserved duration(s)

In this design, the symbols within a subframe have the same length, as shown in Table 3.1. In addition, the subframe has at least one reserved duration. Fig. 3 illustrates the period of 0.5ms multiplexing different subframes for different reference numerologies. For large subcarrier spacing (e.g., 60kHz, 120kHz, 240kHz), the locations of the reserved duration(s) in the neighbouring subframes are different.

Table 3.1 Symbol length for different reference numerologies

Reference numerologies	15kHz	30kHz	60kHz	120kHz	240kHz
Symbol length (Ts)	2192	1096	548	274	137

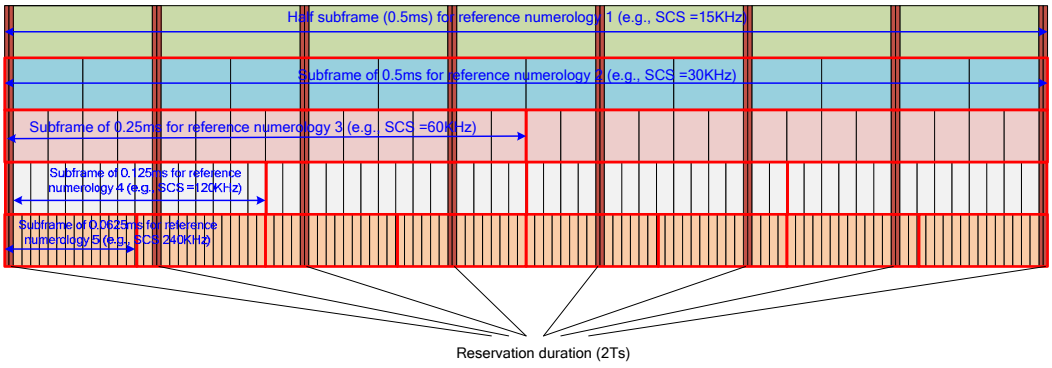

Fig. 3 Period of 0.5ms multiplexing different subframes (the symbol length within the subframe is the same for the same reference numerology)

b. A subframe contains symbols with different lengths

In this design, for each reference numerology, a subframe consists of long symbol(s) and short symbols, as given in Table 3.2. Fig. 4 illustrates the period of 0.5ms multiplexing different subframes for different reference numerologies. For large subcarrier spacing (e.g., 60kHz, 120kHz, 240kHz), the locations of long symbol(s) in the neighbouring subframes are different.

Table 3.2 Lengths of long symbol and short symbol for different reference numerologies

Reference numerologies	15kHz	30kHz	60kHz	120kHz	240kHz
Long Symbol length (Ts)	2208	1104	560	288	152
Short symbol length	2192	1088	544	272	136

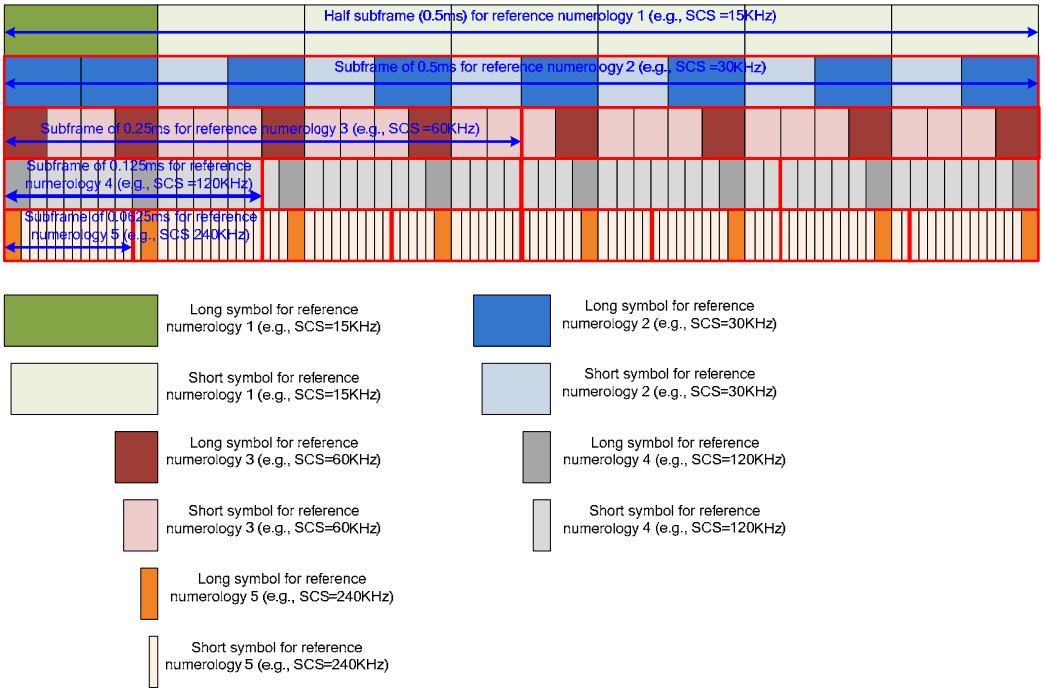

Fig. 4 Period of 0.5ms multiplexing different subframes (the symbol length within the subframe is different for the same reference numerology)

Proposal 2: The following two subframe designs can be applied to align symbol boundaries in the case that different UEs have different reference numerologies.

- **A subframe contains the symbols with the same length and reserved duration(s)**
- **A subframe contains symbols with different lengths**

4 Conclusions

This contribution discussed the subframe design regarding to the cases of a common reference numerology and different reference numerologies, and we propose:

Proposal 1: The LTE based subframe design can be applied to the case that different UEs have the same reference numerology.

Proposal 2: The following two subframe designs can be applied to align symbol boundaries in the case that different UEs have different reference numerologies.

- **A subframe contains the symbols with the same length and reserved duration(s)**
- **A subframe contains symbols with different lengths**

5 References

[1] "Draft_Minutes_report_RAN1#86_v20", RAN1#86, Aug. 2016.