3GPP TSG-RAN Meeting #88 **R1-1702374**
Athens, Greece, 13th-17th February 2017

Source: **Cohere Technologies**
Title: **NR SS Burst Composition and SS Time Index Indication**
Agenda item: **8.1.1.1.2**
Document for: **Discussion and Decision**

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1. Introduction

In the last 3GPP RAN 1 meetings, initial access and namely Synchronization Sequences (SS) and Physical Broadcast Channel (PBCH) transmission as a SS burst were discussed. In the last 3GPP NR Ad Hoc meeting the following agreements were done with regards to SS burst composition and with regards to the time indices from which UE will derive symbol timing [1].

Agreements:

- For a given frequency band, an SS block corresponds to *N* OFDM symbols based on the default subcarrier spacing, and *N* is a constant.
  - The signal multiplexing structure is fixed in a specification
- UE shall be able to identify at least OFDM symbol index, slot index in a radio frame and radio frame number from an SS block.
  - The signals included in the SS block are FFS between
    - Alt 1: PSS, SSS and PBCH; and
    - Alt 2: PSS, SSS, TSS and PBCH.
    - Note 1: it does not preclude possibility of multiplexing MRS and/or data transmission in the SS block.
    - Note 2: It does not preclude the possibility of skipping PBCH in other SS blocks.

Agreement:

- For initial cell selection, UE may assume default SS burst set periodicity which may be frequency band-dependent.
- UE may assume that a given SS block is repeated with a SS burst set periodicity
  - Note that NR-PBCH contents in a given repeated SS block may change
- A single set of possible SS block time locations is specified per frequency band.
  - FFS whether the set is defined with respect to SS burst set or radio frame
  - FFS whether idle/connected UE can be configured with additional information about which SS blocks in a SS burst set are transmitted

Agreements:

- The time index/indices of an SS block from which UE will derive symbol, slot index in a radio frame is/are to be down-selected from the following alternatives:
  - Alt.1: One time index for every SS-block within an SS-burst set
  - Alt.2: One time index that is specific to each SS-block within an SS-burst, and an SS burst index that is specific to each SS burst within an SS-burst set. SS burst index is common across SS blocks in each SS-burst.
- Possible mechanisms to indicate the SS block index includes
  - Implicit indication by PBCH
  - Explicit indication by PBCH
  - Indication by an additional SS, if such an additional SS is introduced
  - Indication by NR-SS
  - Note that this does not preclude other mechanisms
- By default, the UE may neither assume the gNB transmits the same number of physical beam(s), nor the same physical beam(s) across different SS-blocks within an SS burst set.

In this contribution, the SS burst composition, the requirements for its transmission as well as the SS time index indication will be discussed.

2. Discussion

In the last 3GPP RAN 1 NR Ad Hoc meeting, SS burst and SS burst set were defined and an agreement was achieved [1]. Considering that both single and multi-beam operations are considered for NR, RAN 1 should try to provide common SS design for both single and multi-beam operations with regards to SS burst composition. Or, at least target for an SS design with as many common features as possible for both single beam and multiple beam operation ([2], [3]).

In this context, the SS burst should consist of at least Primary Synchronization Sequence (PSS), Secondary Synchronization Sequence (SS) and Physical Broadcast Channel (PBCH) for both single beam and multiple beams operation. PSS for the initial OFDM symbol synchronization and CFO correction, PSS together with SSS will give the cell ID and eventually the synchronization at subframe level. PBCH will give the necessary information to UEs for camping to the right cell and for attempting random access, as well as information related to System Frame Number (SFN).

Considering that Cell Specific Reference Signals (CRS) are not going to be a part of NR, then, there is a need to specify how PBCH channel estimation is going to happen. Several options have been described in the previous RAN 1, NR Ad Hoc meeting, as for example in [4].

Options are to use specific DMRS for PBCH, or synchronization sequences or a combination of DMRS for PBCH and of SSs ([1]).

In terms of PSS and SSS multiplexing the agreement is that TDM is adopted for at least single beam operation. The working assumption for multiplexing of PSS & SSS is TDM for multiple beams operation ([1]).

The most sensible TDM option for PSS, SSS, and PBCH is transmission in consecutive OFDM symbols. Considering that the agreement for SS block is that SS block is consisted of N symbols and for sake of simplicity of the initial search algorithm, it is proposed that each of PSS, SSS and of PBCH is transmitted in 1 OFDM symbol. Very likely the transmission bandwidth for PSS, SSS and PBCH is going to be larger than 1.08 MHz even for systems operating at carrier frequencies below 6 GHz ([1]) and therefore it is assumed that PBCH in 1 symbol is sufficient for carrying System Frame Number (SFN), a pointer to another downlink channel carrying system information and eventually basic cell access information ([5]).

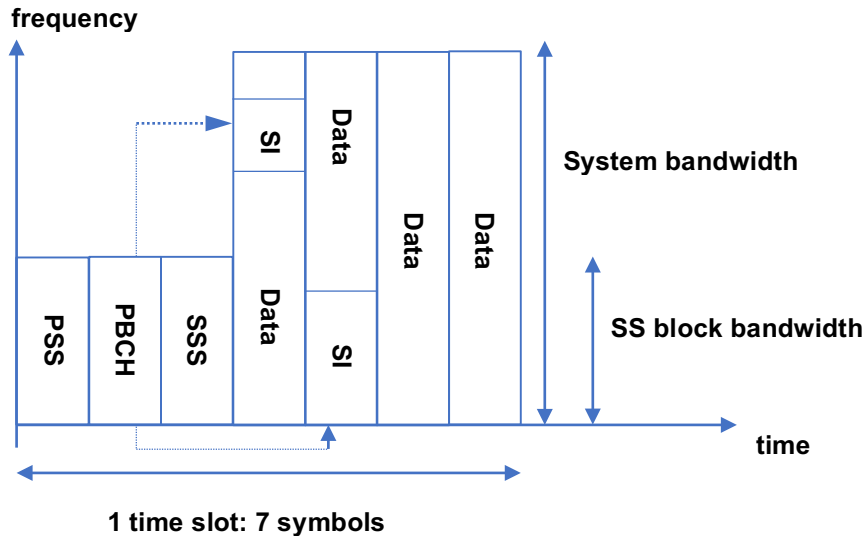

Figure 1: Example 1 of specific TDM for an SS block. Channel estimation for PBCH is achieved with the help of PSS and SSS. PBCH pointing to system information.

The proposal is that PSS, PBCH and SSS are transmitted within consecutive OFDM symbols as in Figure 1. PBCH is transmitted in the middle of PSS and SSS. In addition, an example of mapping from PBCH to additional SI time and frequency resource elements is illustrated.
In the example of Figure 1, PSS is transmitted prior to SSS. However, the option of transmitting SSS prior to PBCH, as the one of the example of Figure 2 should also be considered. The same bandwidth and band is considered for PSS, SSS and PBCH transmission. Of highest importance is that PBCH is transmitted in the middle of PSS and SSS or of SSS and PSS and PBCH channel estimation is achieved with the help of PSS and SSS.

Proposal 1: PSS, SSS and PBCH should be transmitted in consecutive symbols and PBCH should be in the middle of PSS and SSS (or in the middle of SSS and PSS). PSS, SSS and PBCH are transmitted at the same band.

In the examples of Figure 1 and Figure 2, PBCH is transmitted without specific DMRS. Another option would be to include PBCH specific DMRS, that the UE has to use for decoding PBCH. This option is discussed in the previous 3GPP RAN 1 NR Ad Hoc meeting ([1], [4]). An example with this option can be seen in Figure 3.

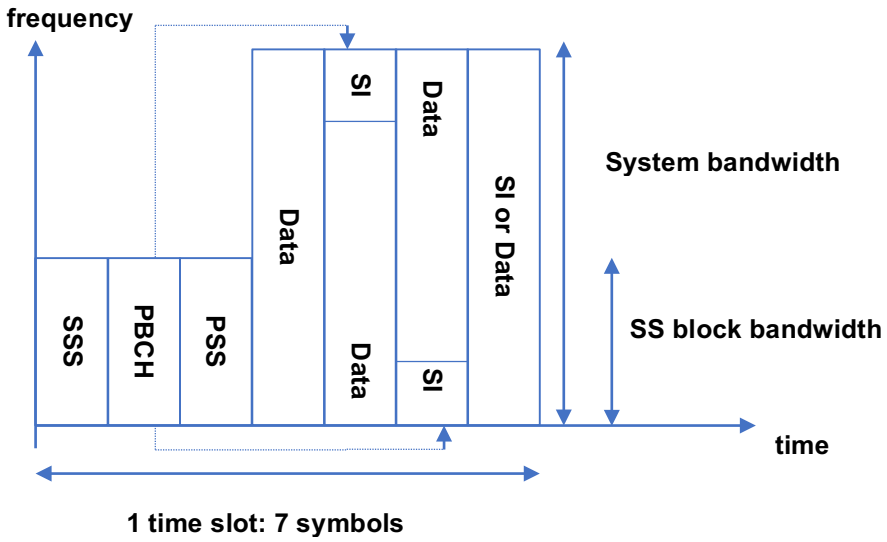

Figure 2: Example 2 of specific TDM for an SS block. Channel estimation for PBCH is achieved with the help of PSS and SSS. PBCH points to addition time and frequency resources for System Information (SI).

Transmission of PBCH specific DMRS together with PBCH implies that UEs performing initial access for the first time in the specific cell must deduce the DMRS to apply from the combination of PSS and SSS.The details of mapping of PSS & SSS combinations to Cell IDs and eventually to PBCH specific DMRS are not yet specified. It is noted that DMRS are going to be transmitted by either one or two different antenna ports with a transmission scheme that must be decided ([1]). Although the UE will not have to perform blind detection of the transmission scheme to be applied for PBCH transmission, as in previous releases, the target is to design an initial access procedure in general of low complexity. Mapping of PSS and SSS to certain DMRS sequence for PBCH requires standardization effort and the misdetection probability is always present. Moreover, the gain in channel estimation by using additional to PSS and SSS symbols is in most of the cases negligible. It is mentioned here that UEs should continuously listen to PSS, SSS and PBCH within a given SS burst set, to reduce the misdetection probability. Therefore, the proposal is that PBCH channel estimation is performed with the aid of PSS and SSS.

Proposal 2: PBCH channel estimation is achieved with the help of PSS and SSS.

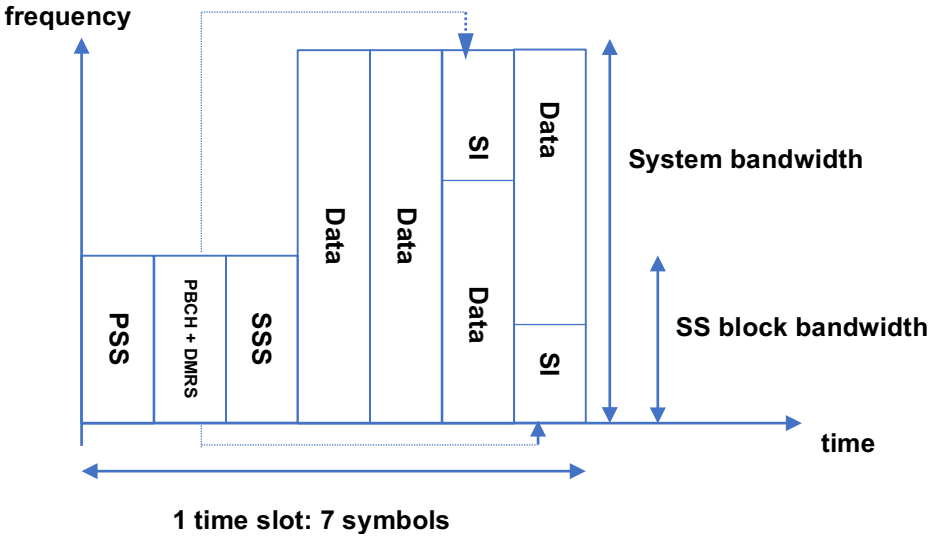

Figure 3: Example 3 of specific TDM for an SS block. PBCH pointing to system information.

Another open issue with regards to SS burst composition is whether any other signals other than PSS, SSS and PBCH are needed ([1], [2]). The agreement was that the concept of SS burst set is applicable to both single beam and multiple beam operation and that for initial cell selection, “UE may assume default SS burst set periodicity which may be frequency band dependent” ([1]). In case default SS burst set periodicity is used with default time indexes for PSS, SSS and PBCH within an SS block and with fixed indexes for all blocks in the SS burst as well as with default periodicity of SS bursts within an SS burst set, then, no additional to PSS, SSS and PBCH signals are needed.

Proposal 3: In case of default SS burst set configuration for initial cell selection, an SS block is consisted of PSS, SSS and PBCH.

In case flexibility in the SS block time index, SS block periodicity and SS burst periodicity within one SS burst set is required and supported, then, TSS, i.e. signals indicating the SS block, SS burst and SS burst configuration must be included in the SS block.

Proposal 4: In case flexibility in SS burst set configuration is supported, an SS block is consisted of PSS, SSS, PBCH and TSS.

In case flexibility in SS burst set configuration is supported, a restriction has to be applied so as UEs in the system get synchronized in the system and acquire system information independently of the number of beams transmitted in the cell. As is discussed, different numbers of beams for different types of TRPs are going to be considered. Figure 4 shows an example of three different cells where different numbers of beams are applied for transmission, due to different types of network nodes covering these cells. For all of the users in these cells, the requirement in terms of delay of synchronization in the system and in terms of system information acquisition is the same. Therefore, the configuration of the SS burst set should take into account the beam configuration in each cell.

Proposal 5: In case flexibility in SS burst set configuration is supported, the SS burst set configuration must take into consideration the beam configuration of the cell.

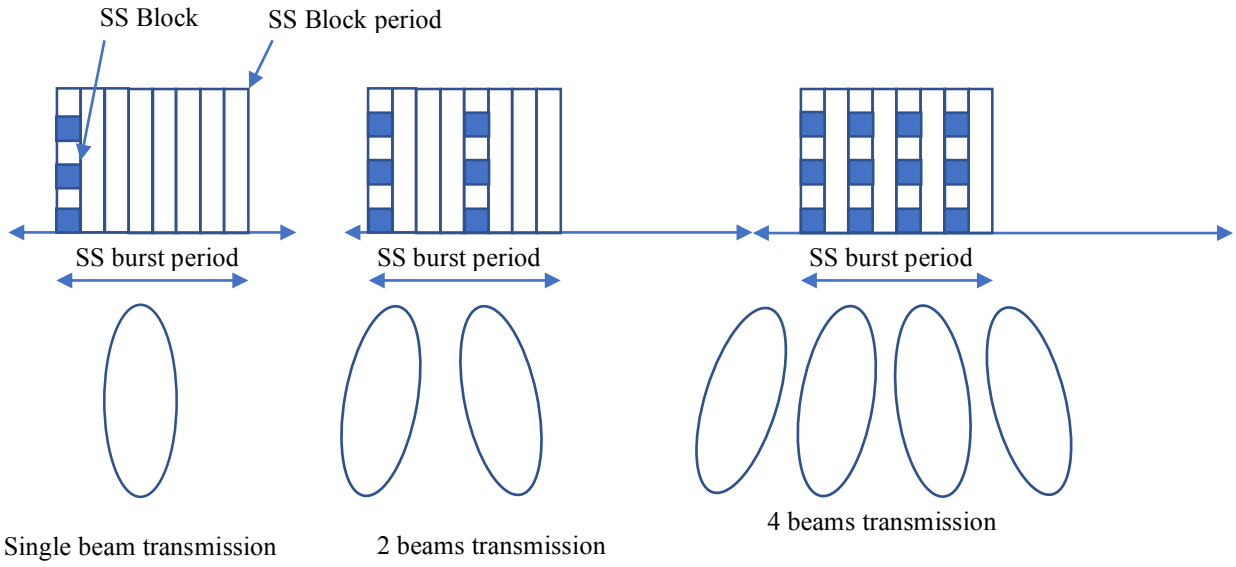

Figure 4: Example of 3 different cells with 1, 2, and 4 beam transmission supported. The requirement is that for every UE in any cell the synchronization and system information acquisition is the same independently of the number of beams in the cell.

3. Conclusion

In this contribution, the SS burst set composition is discussed. The following proposals are made:

Proposal 1: PSS, SSS and PBCH should be transmitted in consecutive symbols and PBCH should be in the middle of PSS and SSS (or in the middle of SSS and PSS). PSS, SSS and PBCH are transmitted at the same band.

Proposal 2: PBCH channel estimation is achieved with the help of PSS and SSS.

Proposal 3: In case of default SS burst set configuration for initial cell selection, an SS block is consisted of PSS, SSS and PBCH.

Proposal 4: In case flexibility in SS burst set configuration is supported, an SS block is consisted of PSS, SSS, PBCH and TSS.

Proposal 5: In case flexibility in SS burst set configuration is supported, the SS burst set configuration must take into consideration the beam configuration of the cell.

4. References

[1]. RAN1# NR Ad-Hoc Meeting, January 2017, Chairman's notes

[2]. R1-1700884, "SS Bandwidth & Multiplexing", Samsung, 3GPP RAN 1, NR Ad Hoc Meeting, January 2017.

[3]. R1-1700608, "Discussion & Evaluation on NR-PSS/SSS Structure", NTT DoCoMo, 3GPP RAN 1, NR Ad Hoc Meeting, January 2017.

[4]. R1-1700159, "TDM Based Unified SS Block Design for Both Above and Below 6 GHz", MediaTek, 3GPP RAN 1, NR Ad Hoc Meeting, January 2017.

[5]. R1-1700151, "Broadcast Channel System Design for System Acquisition", MediaTek, 3GPP RAN 1, NR Ad Hoc Meeting, January 2017