LTE PCI Planning

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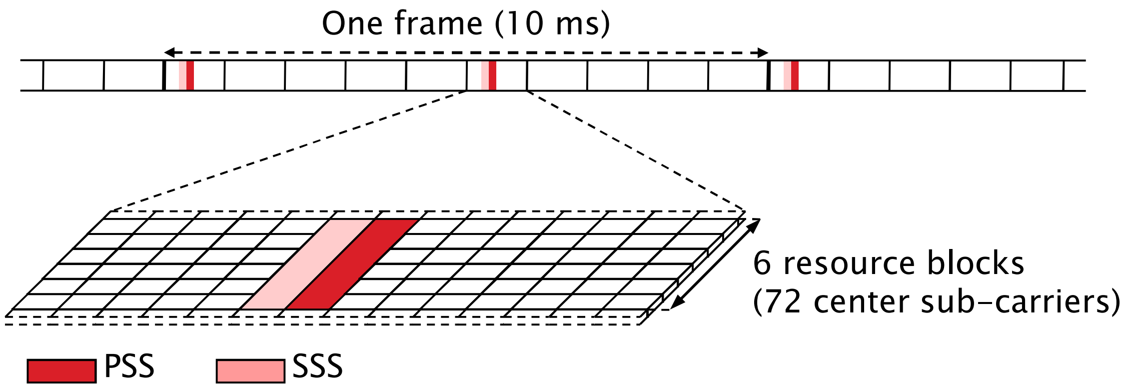
Synchronization signals

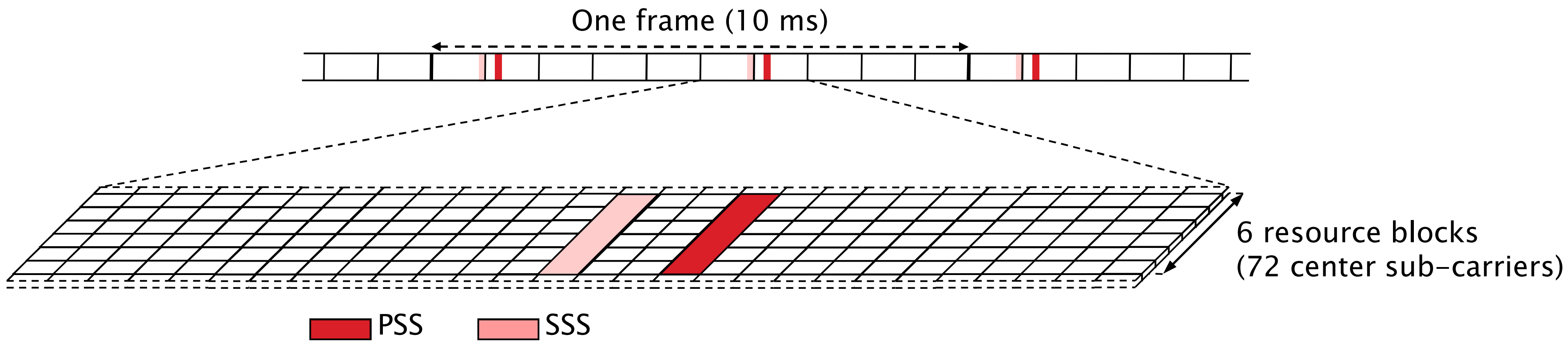
– Technical background to PCI



- Two *synchronization signals* transmitted once every 5 ms
- Primary Synchronization Signal (PSS)
  - Subframe #0 and #5
  - Mapped on 72 subcarriers in the middle of the band
  - OFDM symbol #6
- Secondary Synchronization Signal (SSS)
  - Subframe #0 and #5
  - Mapped on 72 subcarriers in the middle of the band
  - OFDM symbol #5

Synchronization signals – TDD

– Technical background to PCI



- Two *synchronization signals* transmitted once every 5 ms
- Primary Synchronization Signal (PSS)
  - Subframe #1 and #6
  - Mapped on 72 subcarriers in the middle of the band
  - OFDM symbol #2
- Secondary Synchronization Signal (SSS)
  - Subframe #0 and #5
  - Mapped on 72 subcarriers in the middle of the band
  - OFDM symbol #13

Cell search

– Technical background to PCI

PSS

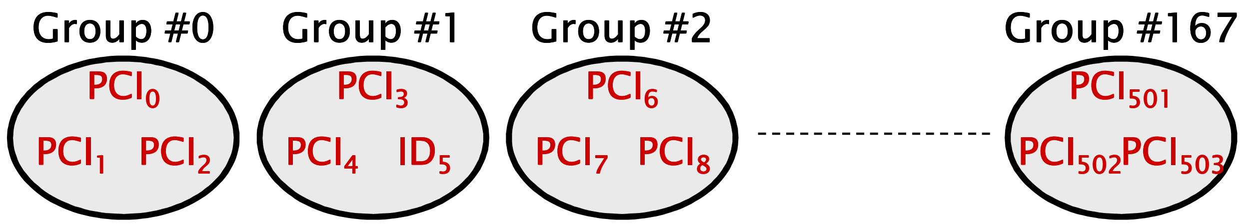
- Detection of carrier frequency
- Detection of SCH symbol timing
- Identification of cell ID (0–2)

SSS

- Detection of radio frame timing
- Detection of cell ID group (0–167) ⇒ PCI
- Detection of MIMO & CP configuration

- Read System Info & RS
  - timing
  - sequence
  - frequency shift

Physical-layer Cell Identity (PCI)



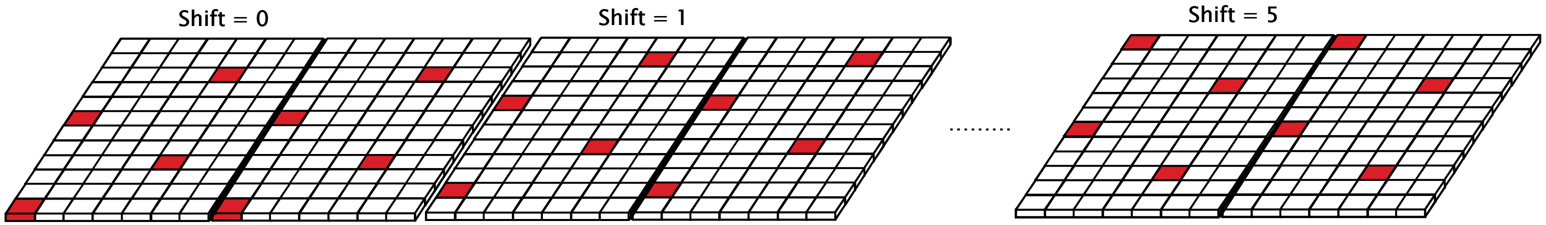
- PSS signal
  - 3 different sequences called Physical-Layer Identities (0-2)
- SSS signal
  - 168 different sequences called Physical-Layer Cell-Identity groups (0-167)

- 168 Physical-Layer Cell-Identity groups with 3 Physical-Layer Identities per group
  - $168 \times 3 = 504$ Physical-Layer Cell Identities

PSS and SSS combinations

- For each cell, $PCI_i = 3S_j + P_k$
  - i = 0 … 503
  - j = 0 … 167group
  - k = 0 … 2   ID
- The sequence for the SSS signal is generated as follows:
  - $m_0 = m' \bmod 31$
  - $m_1 = [m_0 + INT(m'/31) + 1] \bmod 31$
  - $m' = S_j + q(q+1)/2$
  - $q = INT((S_j + q'(q'+1)/2)/30)$; $q' = INT(S_j/30)$
- Simulations hint that the following combinations at adjacent cells will give bad performance, i.e. long synchronization times and high interference:
  - Same ID, i.e. same k
  - Same m_0
  - Same m_1
- For example, $PCI_i = 0 \Rightarrow PCI_j = 3, 6, \ldots 498, 501$ and 1, 2, 90, 91, 92, 177, 178, 179, 261, 262, 263, 342, 343, 344, 420, 421, 422, 495, 496, 497 are not optimal combinations for adjacent cells
- This is valid for the case when cells are synchronized

Cell specific frequency shifts



- There are six possible frequency shifts of RSs
- The frequency shift is given by $\nu_{shift,i} = PCI_i$ mod 6
- Different $\nu_{shift,i}$ should be used in adjacent cells
- However, if applying the rule that k should be different in adjacent cells, this will also lead to different $\nu_{shift,i}$ in adjacent cells

PCI planning

– Main strategy options

There are two main strategy options:

- Neighboring sites are grouped into clusters, and each cluster is assigned a limited number of Code Groups. Each site is assigned a specific Code Group and each sector a specific Color Group

- Random planning i.e. PCI plan that does not consider PCI grouping and does not follow any specific reuse pattern

The first strategy option is recommended to use in order to avoid non-optimal PCI combinations for adjacent cells

PCI planning – Continued

– Color/code groups

	0	1	2	……	162	163	164	165	166	167
0	0	3	6	……	486	489	492	495	498	501
1	4	7	10		490	493	496	499	502	1
2	8	11	14	……	494	497	500	503	2	5

Alt. 1

	0	1	2	……	162	163	164	165	166	167
0	0	3	6	……	486	489	492	495	498	501
1	8	11	14		494	497	500	503	2	5
2	16	19	22	……	502	1	4	7	10	13

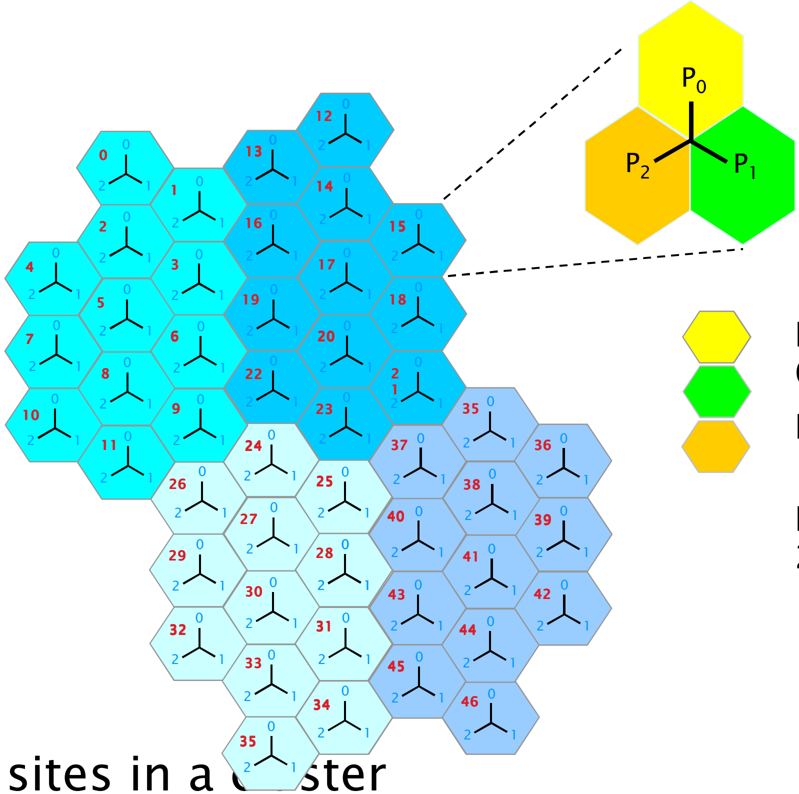
Alt. 2

- PCIs should be split into 3 different color groups and 168 code groups
- Code groups should be reserved for special purposes, e.g. in-building and PLMN borders or for future expansions
- If a color group is assigned per sector and a code group is assigned per site, this will eliminate the risk of having the same k or frequency shift in the same site, in adjacent cells or pointing at each other

PCI planning

– Site clusters

Assign a color group to each sector and a code group per site



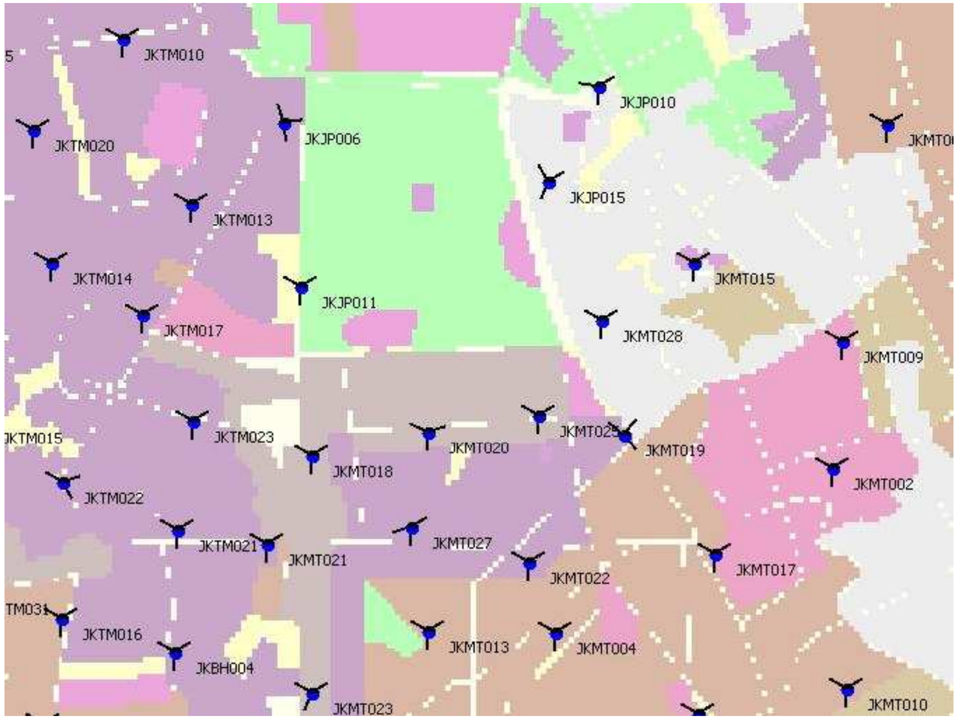
k=0 ⇒ Color group 0

k=1 ⇒ Color group 1

k=2 ⇒ Color group 2

- Typically 10-15 3-sector sites in a cluster
- Use a subset of the code groups in each cluster
- If there are ~70 code groups available, PCIs may be repeated every fifth or sixth cluster
- Structured planning like this eliminates the risk of having conflicting k or frequency shift in the same site, in adjacent cells or pointing at each other
- Also the risk of having conflicting SSS sequences in adjacent cells is reduced – although this may appear at cluster borders

Cluster ...



- Irregular pattern for site-to-site distances and sector angles
- 3-sector sites, 6-sector sites and Omni sites may be mixed in same area

⇒ It may not be possible to follow a strict planning pattern
⇒ Priority orders need to be followed

PCI planning

– Priority orders

When planning PCI:s the following priority orders are recommended:

1. The same PCI:s should be avoided within the same site and as neighbors
2. PCI:s with conflicting k values should be avoided within the same site and as neighbors
3. PCI:s with conflicting m_0 and m_1 values should be avoided within the same site and as neighbors

Reasons for not following these rules strictly:

- Will not work in an irregular pattern (see previous slide)
- Will cause a lot of limitations on neighbors and neighbor lists have to be shortened

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