LTE PCI Planning

www.Telecom-Cloud.net

Harish Vadada
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, $\text{PCI}_i = 3S_j + P_k$
  - $i = 0 \ldots 503$
  - $j = 0 \ldots 167$
  - $k = 0 \ldots 2$ \ ID

- The sequence for the SSS signal is generated as follows:
  - $m_0 = m' \mod 31$
  - $m_1 = [m_0 + \text{INT}(m'/31) + 1] \mod 31$
  - $m' = S_j + q(q+1)/2$
  - $q = \text{INT}((S_j + q'(q'+1)/2)/30); q' = \text{INT}(S_j/30)$

- 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, $\text{PCI}_i = 0 \Rightarrow \text{PCI}_i = 3, 6, \ldots 498, 501$ 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
There are six possible frequency shifts of RSs.

The frequency shift is given by $\nu_{\text{shift},i} = \text{PCI}_i \mod 6$.

Different $\nu_{\text{shift},i}$ 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 $\nu_{\text{shift},i}$ in adjacent cells.
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

- Table 1

<table>
<thead>
<tr>
<th></th>
<th>0</th>
<th>1</th>
<th>2</th>
<th>......</th>
<th>162</th>
<th>163</th>
<th>164</th>
<th>165</th>
<th>166</th>
<th>167</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0</td>
<td>3</td>
<td>6</td>
<td>......</td>
<td>486</td>
<td>489</td>
<td>492</td>
<td>495</td>
<td>498</td>
<td>501</td>
</tr>
<tr>
<td>1</td>
<td>4</td>
<td>7</td>
<td>10</td>
<td></td>
<td>490</td>
<td>493</td>
<td>496</td>
<td>499</td>
<td>502</td>
<td>1</td>
</tr>
<tr>
<td>2</td>
<td>8</td>
<td>11</td>
<td>14</td>
<td></td>
<td>494</td>
<td>497</td>
<td>500</td>
<td>503</td>
<td>2</td>
<td>5</td>
</tr>
</tbody>
</table>

- Table 2

<table>
<thead>
<tr>
<th></th>
<th>0</th>
<th>1</th>
<th>2</th>
<th>......</th>
<th>162</th>
<th>163</th>
<th>164</th>
<th>165</th>
<th>166</th>
<th>167</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0</td>
<td>3</td>
<td>6</td>
<td>......</td>
<td>486</td>
<td>489</td>
<td>492</td>
<td>495</td>
<td>498</td>
<td>501</td>
</tr>
<tr>
<td>1</td>
<td>8</td>
<td>11</td>
<td>14</td>
<td></td>
<td>494</td>
<td>497</td>
<td>500</td>
<td>503</td>
<td>2</td>
<td>5</td>
</tr>
<tr>
<td>2</td>
<td>16</td>
<td>19</td>
<td>22</td>
<td></td>
<td>502</td>
<td>1</td>
<td>4</td>
<td>7</td>
<td>10</td>
<td>13</td>
</tr>
</tbody>
</table>

- 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

- 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
Wanna Learn More?  
Your free source 
www.telecom-cloud.net