WiMAX Synchronization

Synchronization for WiMAX Networks

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Content:

- Architecture
- TDD versus FDD
- Frequency and Phase Sync
- WiMAX requirements
- BS Design requirements
- GPS Clocks
- Integration of GPS Clocks
- Evolutions
Applications:

- Fixed applications:
  - Last mile
  - 2G/3G base station backhaul
- Portable applications (low speed): hot spots, hot zones
- Mobile applications (up to 120 km/h)

User data rate:

- up to 70 Mbit/s (depends on configuration)

- 2 different duplexing Technics, FDD and TDD

- Supports Adaptative Antenna Systems

- Supports Non Line of sight

Standards:

- Fixed/portable IEEE 802.16-2004
- Mobile IEEE 802.16e
WiMAX Synchronization at the edge (Access Network)

- CPE: Wireless Access Network WiMAX Radio
  - NEED SYNCH

- BS: IP Backhaul Network
  - No stringent SYNCH Requirements

- Core Networks: SDH synch does not propagate through the IP infrastructure
**WiMAX:**

TDD Time Division Duplexing  
FDD Frequency Division Duplexing

<table>
<thead>
<tr>
<th>TDD</th>
<th>Down link</th>
<th>Up link</th>
<th>Down link</th>
<th>Up link</th>
<th>Down link</th>
<th>Up link</th>
</tr>
</thead>
<tbody>
<tr>
<td>FDD</td>
<td>Down link</td>
<td>Up link</td>
<td>Down link</td>
<td>Up link</td>
<td>Down link</td>
<td>Up link</td>
</tr>
</tbody>
</table>

**TDD is chosen for Mobile WiMAX**

- Optimal for asymmetric traffic
- Can handle both Paired and non Paired Spectrum
- Better use of Adaptative Antenna System (AAS)
- Simpler duplexing mechanisms (lower cost Base station)
Frequency & Phase synchronisation

**BS A**

Clock signal of BS A

\[ T_A = \frac{1}{f_A} \]

\[ f_A = f_B \]

**BS B**

Clock signal of BS B

\[ T_B = \frac{1}{f_B} \]

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**TDD**

Requires frequency and Phase synchronisation

- Down link
- Up link
- Down link
- Up link
- Down link
- Up link

**FDD**

Requires frequency synchronization

- Down link
- Down link
- Down link
- Up link
- Up link
- Up link
WiMAX: Why is synchronization needed?

Frequency

Radio carrier frequencies must be synchronized precisely in order to prevent cross-talk.

Phase

Successful handover requires synchronisation between base stations (BS).
WiMAX Synchronization requirements

WiMAX requirement IEEE 802.16

Channel Frequency Accuracy
The frequency accuracy of the base station shall be within $\pm 8 \times 10^{-6}$ of the selected RF carrier over an operating temperature range of -40 to +65°C, up to ten years from the date of equipment manufacture.

Frame Duration Codes (TDD)
Both RTG and TTG shall be no less than 5 μs in duration.

RTG = Receiver Transition Gap
TTG = Transmission Transition Gap
WiMAX Synchronization requirements

Constraints coming from the BS design and performance/cost level

• 1PPS only or 1PPS + 10 MHz reference signals

• Several Frequency outputs (2..4) to feed directly Base Band Units

• Phase noise requirements 10 MHz reference (used to generate 3.5 GHz)

• Holdover 24 hours (High End BS for Metro area)

• Temperature profile (Outdoor BS versus Indoor Base Stations)

• Zero crossing 1PPS / 10 MHz when both are used

• Time Of Day
GPS Clock: Phase tracking loop

GPS

OCXO

Vc

PPS

10MHz

Tracking

Div N

10MHz

10MHz

OCXO

PPS'

Base Station

Phase Comp

PPS

Vc

GPS Clock: Phase tracking loop

GPS

OCXO

Vc

PPS

10MHz

Tracking

Div N

10MHz

OCXO

PPS'

Base Station
GPS Clock: Low Pass filter when Tracked to GPS

- GPS signal w/SA
- Output signal from '4530'

100,000 s
GPS Clock: Holdover

Phase deviation versus Frequency deviation

Frequency error

Frequency Noise

Frequency Deviation over time: Ageing and Thermal

Holdover (effect of aging and Temperature)
Holding 10 µsec (10^{-5}) phase deviation during 10’000 second requires 10^{-9} frequency accuracy.
## GPS Clock: Holdover

<table>
<thead>
<tr>
<th></th>
<th>dF/F vs T 0-70 °C</th>
<th>Ageing Per day</th>
<th>Phase lock time constant</th>
<th>Holdover @ 1 day D.T. 20°C</th>
</tr>
</thead>
<tbody>
<tr>
<td>TCXO</td>
<td>1 ppm</td>
<td>5e-9</td>
<td>1s</td>
<td>20000 μs</td>
</tr>
<tr>
<td>DIL OCXO</td>
<td>5 e-8</td>
<td>1e-9</td>
<td>10s</td>
<td>2000 μs</td>
</tr>
<tr>
<td>SO OCXO</td>
<td>5 e-9</td>
<td>1e-10</td>
<td>200s</td>
<td>200 μs</td>
</tr>
<tr>
<td>DO OCXO</td>
<td>6 e-10</td>
<td>1 e-10</td>
<td>2000s</td>
<td>10 μs</td>
</tr>
</tbody>
</table>
Integration of GPS clocks

- Module level integration
  - Fast integration, external to the Base Station
  - Single frequency outputs

- Rack level integration
  - 19” & ETSI
  - Multiple Frequency outputs
  - Direct feed of Base Band Units
  - Immediate integration

- Board level integration
  - Minimal cost
  - Dedicated for larger scale networks reaching lowest costs
  - Single or multiple frequency outputs
WiMAX Synchronisation : Evolutions

- Toward ever lower cost **board level** integration

- **High sensitivity GPS** engines to lower installation costs

- **PTP Clocks** with strong filters for small / medium size IP networks (5 hops from P.t.P. server).
  - Oscillator with 5’000 sec constant loop to filter Wander
  - Holdover capability: mitigation of network congestion
WiMAX Synchronisation

- Thank you -