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Encounter with Leap Second –

Experience in Indian WAMS

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Outline

- **Indian WAMS**
- **Encounter with Leap Second**
  - 30th June 2012
  - 28th June 2015
  - 30th June 2015
- **Conclusion**

Indian WAMS

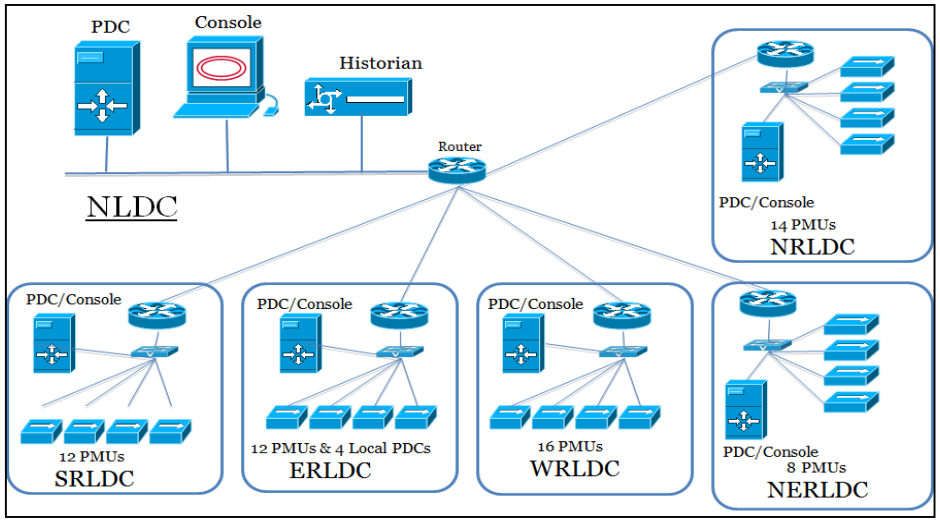


Figure-1 Architecture of Indian WAMS

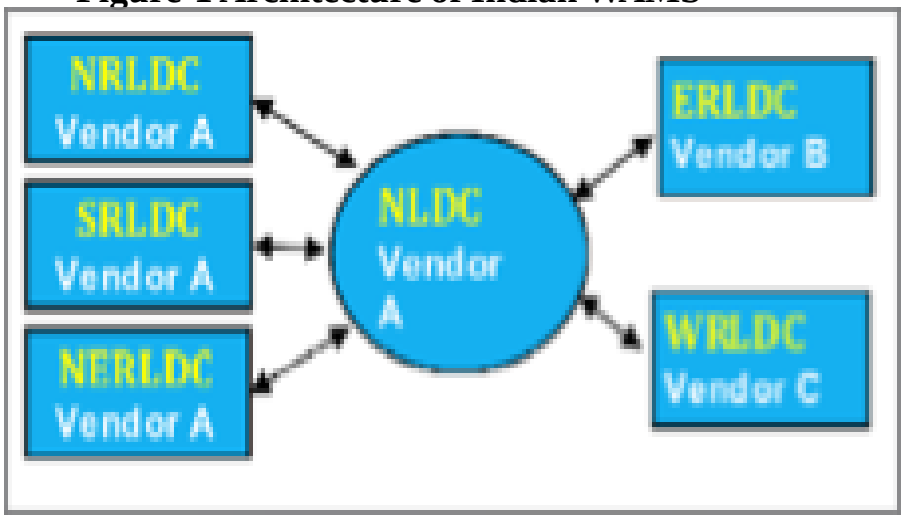


Figure-2 Vendors for Projects

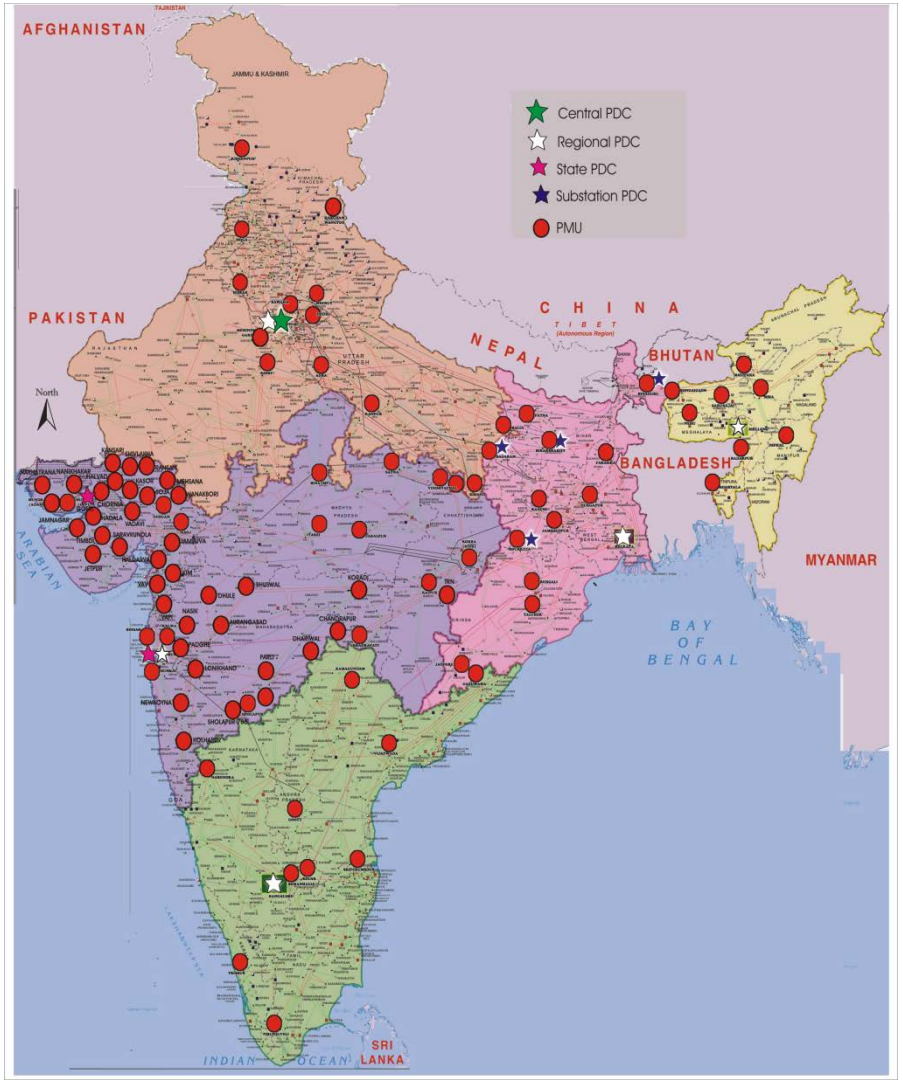


Figure-3 PMU Deployment in India

Introduction

- Angular Difference
  - Difference in voltage phase angle
  - Phase must be w.r.t a common time reference

- Leap second may disturb time reference causing
  - Erratic values
  - Misleading the operator

- Leap Second is:

  "A positive or negative one-second adjustment to the Coordinated Universal Time (UTC) that keeps it close to mean solar time"

- Last leap second event occurred on 30th June 2015 at 23:59 hrs UTC (05:30 hrs, 1st July 2015 IST)

Encounter with Leap Second - *30th June'12*

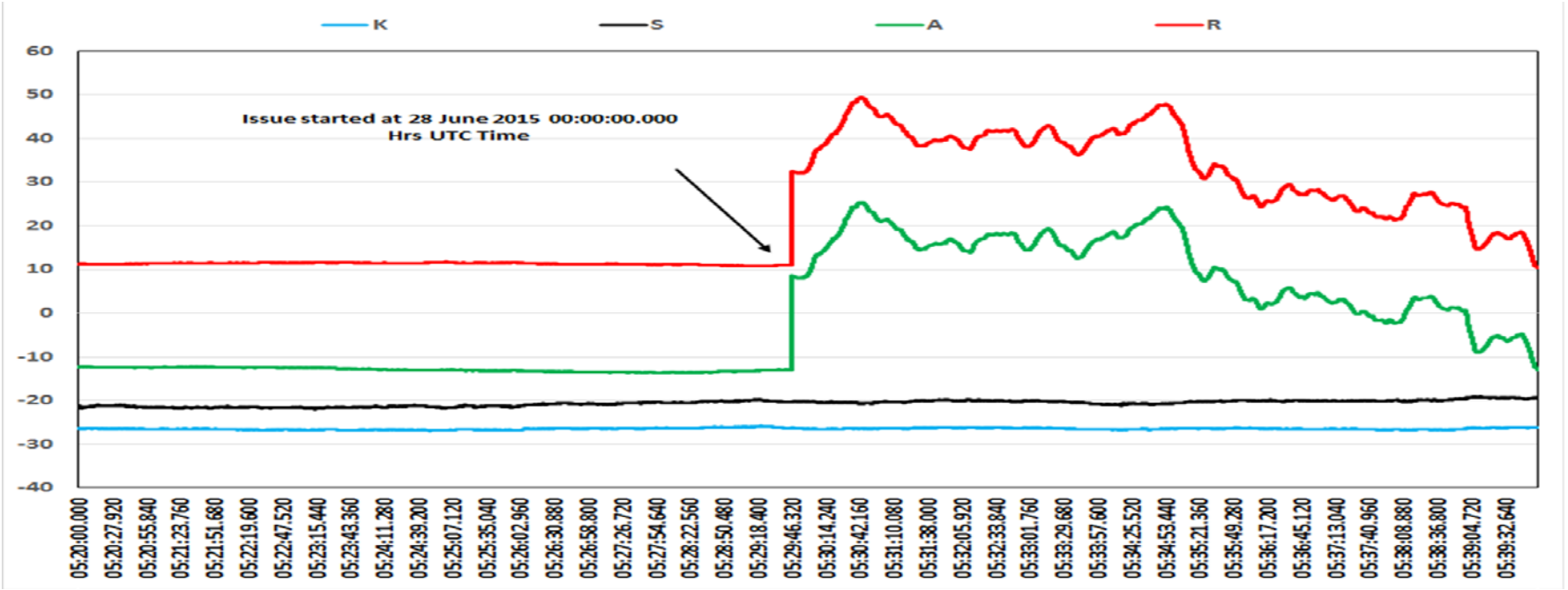
- Regional projects of NR, WR and SR were isolated
- Effect of leap second could not be observed at event time on 30th June due to isolated projects.
- However, later on drift of 1 sec was observed in some PMU data.

Encounter with Leap Second - *28th June'15*

- Random changes observed in trend of angular difference in some PMUs after 23:29 at National Control Center.

Encounter with Leap Second - *28th June'15*

- Operators panicked – but no causing grid events or incidents reported.
- Also no oscillations observed in any part of the grid.
- Erratic behavior was observed in data of some PMUs.



Observations

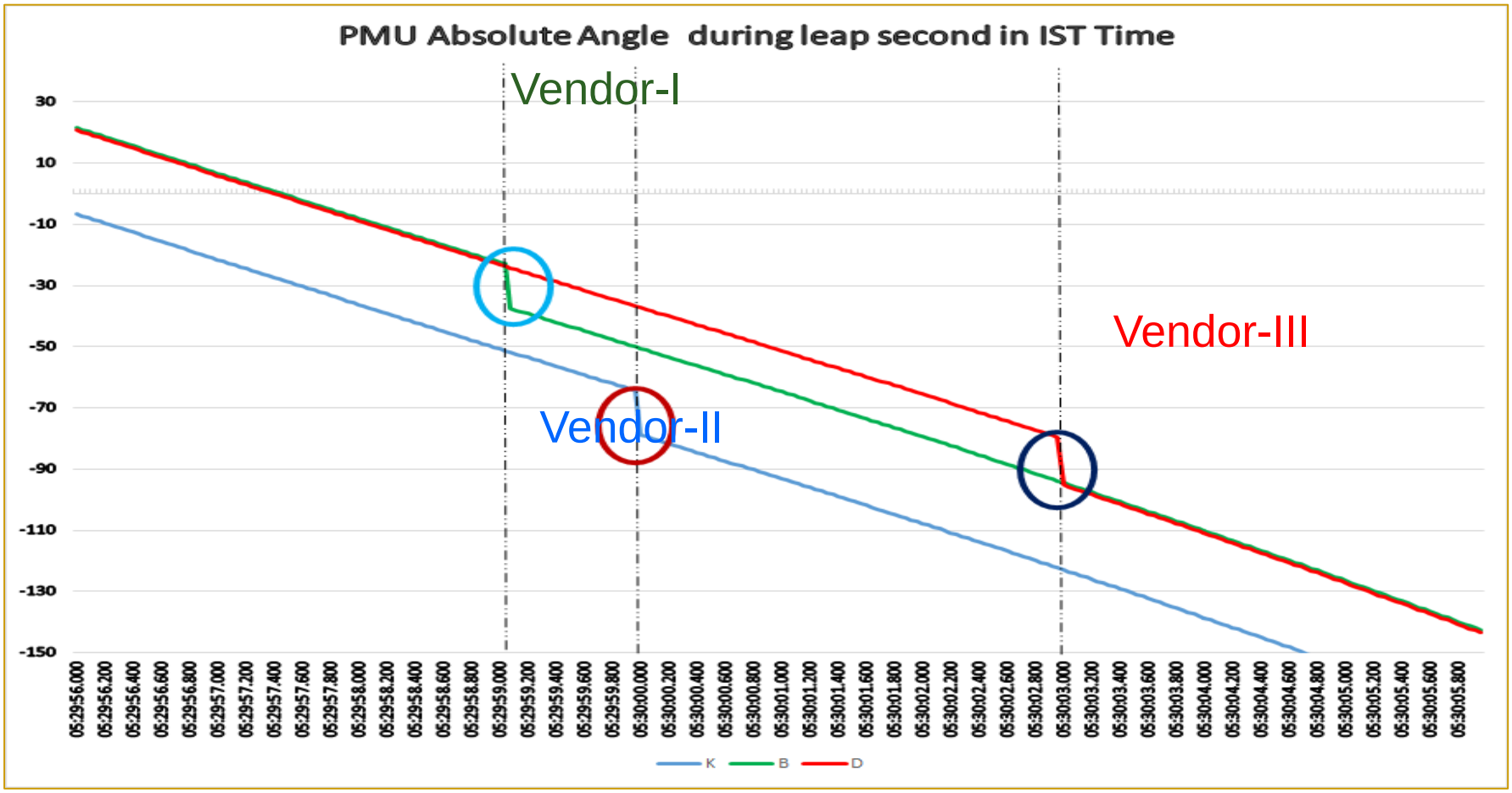
- PMUs got divided into two groups.
- Relative angle between one group of PMU with respect to PMUs from the other group varied considerably.
- Analysis revealed that there is 1 second drift in time of one group of PMUs w.r.t. others.
- It was concluded that some of the PMUs had added the leap second in advance.
- It was strange phenomena to us.
- On restarting GPS, PMU data returned to normal.
- Patch released earlier by the vendor but not applied to these PMUs.

Encounter with Leap Second - *30th June'15*

- On 30 June 2015 23:59 UTC (scheduled leap second addition), PMUs responded differently and there were at least four types of response to leap second insertion:
  1. PMUs which added leap second at 05:29:59.000 IST
  2. PMUS which added leap second 05:30:00.000 IST
  3. PMUS which added leap second 05:30:03.000 IST
  4. PMU which did not do any addition of leap second.

Handling of Leap Second Event

Different make GPS/PMU adding leap second not exactly at 23:59 hrs .



Wire Shark Captures

Packets also confirmed the leap occurrence

```
108907 23:59:01.4157 174.25.18.37        174.25.18.2
108970 23:59:01.4579 174.25.18.37        174.25.18.2
109025 23:59:01.5008 174.25.18.37        174.25.18.2
109058 23:59:01.5341 174.25.18.37        174.25.18.2
109123 23:59:01.5818 174.25.18.37        174.25.18.2
109182 23:59:01.6248 174.25.18.37        174.25.18.2
109213 23:59:01.6608 174.25.18.37        174.25.18.2
109261 23:59:01.6978 174.25.18.37        174.25.18.2
109333 23:59:01.7378 174.25.18.37        174.25.18.2
```

```
⊞ Frame 108907: 224 bytes on wire (1792 bits), 224 by
⊞ Linux cooked capture
⊞ Internet Protocol Version 4, Src: 174.25.18.37 (174
⊞ Transmission Control Protocol, Src Port: 4712 (4712
⊟ IEEE C37.118 Synchrophasor Protocol, Data Frame
  ⊞ Synchronization word: 0xaa01
    Framesize: 156
    PMU/DC ID number: 37
    SOC time stamp (UTC): 2015-06-30 23:59:01
  ⊟ Time quality flags
      .0.. .... = Leap second direction: False
      ..0. .... = Leap second occurred: False
      ...1 .... = Leap second pending: True
      .... 0000 = Time Quality indicator code: Normal
    Fraction of second (raw): 800000
    Measurement data, no configuration frame found
    Checksum: 0xcebf [correct]
```

```
189978 00:00:01.5019 174.25.18.37        174.25.18.2
190010 00:00:01.5379 174.25.18.37        174.25.18.2
190059 00:00:01.5779 174.25.18.37        174.25.18.2
190127 00:00:01.6249 174.25.18.37        174.25.18.2
190158 00:00:01.6599 174.25.18.37        174.25.18.2
190235 00:00:01.7050 174.25.18.37        174.25.18.2
190321 00:00:01.7460 174.25.18.37        174.25.18.2
190370 00:00:01.7824 174.25.18.37        174.25.18.2
190429 00:00:01.8249 174.25.18.37        174.25.18.2
190479 00:00:01.8569 174.25.18.37        174.25.18.2
```

```
⊞ Frame 189858: 224 bytes on wire (1792 bits), 224 byt
⊞ Linux cooked capture
⊞ Internet Protocol Version 4, Src: 174.25.18.37 (174.
⊞ Transmission Control Protocol, Src Port: 4712 (4712)
⊟ IEEE C37.118 Synchrophasor Protocol, Data Frame
  ⊞ Synchronization word: 0xaa01
    Framesize: 156
    PMU/DC ID number: 37
    SOC time stamp (UTC): 2015-07-01 00:00:00
  ⊟ Time quality flags
      .0.. .... = Leap second direction: False
      ..1. .... = Leap second occurred: True
      ...0 .... = Leap second pending: False
      .... 0000 = Time Quality indicator code: Normal
    Fraction of second (raw): 800000
    Measurement data, no configuration frame found
    Checksum: 0xa38e [correct]
```

Conclusion

- PMUs of different manufacturer responded differently to leap second event.
- Mishandling of leap second results in distortion of angular difference even in steady state and drift in voltages/currents/frequency and other parameters during an disturbances or events.
- Time duration of one second - too small to appreciate by Real Time System Operator.
- Actions of SPS, RAPS and WAMPAC controllers based on PMU could have triggered undesired tripping.

Two reports have been published on “Synchrophasor Initiative in India” and Two more on oscillation which are available at:

http://www.posoco.in/2013-03-12-10-34-42/synchrophasors