e-VLBI Status in CVN

Shanghai Astronomy Observatory
Chen Zhong

Hokkaido University, SAPPORO, JAPAN
EVAN 2015, 2015.07.08
Outline

- CVN e-VLBI Network
- CVN e-VLBI Application
- Conclusion
e-VLBI

- **e-VLBI**
  - **electronic-VLBI**
    - High-speed network connecting stations & data center
    - Digital backend System
    - Data Recording & Transmitting System
  - **Modes**
    - Real-time: memory buffering
    - Near Real-time: huge memory or disk buffering
    - e-Transfer: Disk recording(buffering) then post transfer
  - **Advantages**
    - Real-time: Short turn around time
    - ‘WYSIWYG’ : Correlator output, Station devices status, …
    - High data rate: network evolving faster than hard disk
    - automation, distributing processing, software correlator
Outline

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CVN e-VLBI Network

**Stations**
- Sh – Shanghai Sheshan, 25m, 1987
- Ur – Xinjiang Urumuqi, 25m, 1993
- Bj – Beijing Miyun, 50m, 2006
- Km – Yunnan Kunming, 40m, 2006
- Tm – Shanghai Tianma, 65m, 2013

**Data Center**
- Shanghai VLBI data center
  - C&C center of VLBI tracking system for CLEP, 2007
  - IVS Correlator Center, 2012
  - Scientific: astrophysics, pulsar, …

**History**
- Started: 2006
- Supported by CLEP Project
CVN e-VLBI Map
CVN e-VLBI Sites

Ur, XAO

VLBI C&C Hall
ShAO

Bj, NAOC

Sh, ShAO

VLBI Center
Server Room

Km, NAOC

Tm, ShAO
Outline

- CVN e-VLBI Network

- e-VLBI Applications
  - CLEP Phase I/II/III
  - Shanghai IVS Correlator

- Conclusion
e-VLBI for CLEP

VLBI Tracking and Measurement System

- Service for M&C system
- Phase I(CE-1), Phase II(CE-2/3/4), Phase III(CE-5T1/CE-5/6)
- Real-time Requirement

Additional Function
- Receiving & recording & distributing data to HW/SW Correlators in data center
# CLEP e-VLBI Statistics

<table>
<thead>
<tr>
<th>Mission</th>
<th>Mode</th>
<th>Network Line</th>
<th>Raw Data rate</th>
<th>Network Failover</th>
<th>Realtime Requirement</th>
<th>Performance</th>
</tr>
</thead>
<tbody>
<tr>
<td>CE-1</td>
<td>Near realtime</td>
<td>Telecom/CNC (SDH 34Mb/s)、CSTNET IP-VPN (100Mb/s)</td>
<td>16Mb/s</td>
<td>Manually, &gt;30m</td>
<td>&lt;10m</td>
<td>&lt;6m</td>
</tr>
<tr>
<td>CE-2</td>
<td>Near realtime</td>
<td>Telecom/CNC MSTP (100Mb/s)</td>
<td>32Mb/s</td>
<td>Manually, &gt;15m</td>
<td>&lt;10m</td>
<td>&lt;4m</td>
</tr>
<tr>
<td>CE-3</td>
<td>Realtime</td>
<td>Telecom/Unicom (SDH 155Mb/s)</td>
<td>64Mb/s</td>
<td>Automatically, &lt;3s</td>
<td>&lt;1m</td>
<td>&lt;40s</td>
</tr>
<tr>
<td>CE-5T1</td>
<td>Realtime</td>
<td>Telecom/Unicom MSTP (100Mb/s)</td>
<td>64Mb/s</td>
<td>Automatically, &lt;3s</td>
<td>&lt;1m</td>
<td>&lt;40s</td>
</tr>
<tr>
<td>CE-5</td>
<td>Realtime</td>
<td>Telecom/Unicom (SDH 155Mb/s)</td>
<td>128Mb/s</td>
<td>Automatically, &lt;3s</td>
<td>&lt;1m</td>
<td>2017</td>
</tr>
</tbody>
</table>
CE-3 e-VLBI High Availability Network

- **Km, Ur, Bj, Sh, Tm**
  - Long Range Network
    Backbone not so reliable
  - OSPF+BFD protocol to detecting and switching backbone network link when unscheduled fail:
    switch time < 3s
  - Backbone failovers > 20
  - Buffer data for short time, when switching, retransmit after link recover
  - TCP Protocol Performance Tuning
e-VLBI Transfer System

- **Stations**
  - CDAS
  - Mark5B+ (2/station)
  - Modified Mark5B+ software
  - Two level buffer: HW/SW

- **Data center**
  - Data Distribute Unit
  - COST Servers (5+1)+DAS
  - Data Receiving
  - Data Distribution
  - Ring Buffer

- **Protocol:** TCP *(UDP, IPv6)*

- **Control**
  - Script Control
e-VLBI Network flow

- e-VLBI
Outline

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- e-VLBI Applications
  - CLEP
  - Shanghai Correlator for IVS

- Conclusion
Shanghai Correlator for IVS

- IVS Correlator Center
  - Bonn, Haystack, IAA, Kashima, Tsukuba, Washington, Shanghai (2012, Madrid, IVS GM Meeting)

- Data Processing
  - DiFX
  - CVN Software correlator

- Data Transfer
  - Internet based e-Transfer: from most stations & correlators
  - Disk Shipping: Kokee, …
CVN Internet B/W

- Via CSTNET (Chinese Science & Technology Network, CAS)
- IPv6 supported in CVN

Diagram showing network connections and data rates between various locations including Beijing, Shanghai, KunMing, Xujiaihui, and others. The network nodes are connected with lines indicating the bandwidth in Gb or Mb.
<table>
<thead>
<tr>
<th>Country</th>
<th>Institutes</th>
<th>Network B/W</th>
<th>To/From Shanghai</th>
</tr>
</thead>
<tbody>
<tr>
<td>Germany</td>
<td>Bonn MPRiFR</td>
<td>900Mb/s</td>
<td>800Mb/s</td>
</tr>
<tr>
<td>Japan</td>
<td>NICT</td>
<td>10Gb/s</td>
<td>1Gb/s</td>
</tr>
<tr>
<td>Japan</td>
<td>GSI</td>
<td>10Gb/s</td>
<td>1Gb/s</td>
</tr>
<tr>
<td>South Korea</td>
<td>NGII</td>
<td>1Gb/s</td>
<td>800Mb/s</td>
</tr>
<tr>
<td>Italy</td>
<td>IRA</td>
<td>10Gb/s</td>
<td>800Mb/s</td>
</tr>
<tr>
<td>South Africa</td>
<td>Hartebeesthoek</td>
<td>10Gb/s</td>
<td>550Mb/s</td>
</tr>
<tr>
<td>Australia</td>
<td>University of Tasmania</td>
<td>10Gb/s</td>
<td>800Mb/s</td>
</tr>
<tr>
<td>New Zealand</td>
<td>Auckland University of Technology</td>
<td>10Gb/s</td>
<td>800Mb/s</td>
</tr>
<tr>
<td>Brazil</td>
<td>IPNE</td>
<td>1Gb/s</td>
<td>200Mb/s</td>
</tr>
<tr>
<td>Netherlands</td>
<td>JIVE</td>
<td>10Gb/s</td>
<td>1Gb+/s</td>
</tr>
<tr>
<td>Russia</td>
<td>IAA</td>
<td>1Gb/s</td>
<td>500Mb/s</td>
</tr>
<tr>
<td>USA</td>
<td>Haystack</td>
<td>1Gb/s</td>
<td>600Mb/s</td>
</tr>
<tr>
<td>Malaysia</td>
<td>University of Malaya</td>
<td>100Mb/s</td>
<td>90Mb/s</td>
</tr>
</tbody>
</table>
International e-VLBI Testing/Transfer

- **Sheshan/Tinama→JIVE**
  - 2015.4.17
  - e-EVN
  - Sh:1Gb/s
  - Tm:500Mb/s

- **Sejong→Sh**
  - 2015.05
  - e-Transfer
Conclusion

- Deep space exploration e-VLBI
  - High reliability, Low data rate

- Science observation e-VLBI
  - High data rate, Distributed Processing

- Applications
  - CVN e-VLBI for CLEP is very successful, continuous services
  - IVS Shanghai Correlator connecting more worldwide stations & centers, providing geodesic data processing service officially, as well as astrophysics

- Challenges
  - Future technical requirement: VGOS, SKA
  - CVN
    - R&E backbone network bandwidth limitation: CSTNET, Km, Ur
    - Last mile to stations: Bj, FAST, QTT
Thanks!