e-VLBI activities in China

Shanghai Astronomy Observatory
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Third International VLBI Technology Workshop

Groningen, 10-13, Nov. 2014

Contents

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- e-VLBI in Chang'E mission
- Demo of IPv6-based e-VLBI
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- Conclusion

CVN e-VLBI Network

❖ Stations

Sh – Shanghai Sheshan, 25m, 1987

Ur – Urumuqi, 25m, 1993

Bj – Miyun, 50m, 2006

Km – Kunming, 40m, 2006

Tm – Tianma, 65m, 2013

❖ Data Center

- Shanghai new VLBI data center, 2013

❖ CVN e-VLBI Applications

- Chinese Lunar Exploration Project Phase I&II&III
- e-EVN, INT3, CMONOC

CVN e-VLBI Sites View

Ur, XAO

VLBI C&C Hall
ShAO

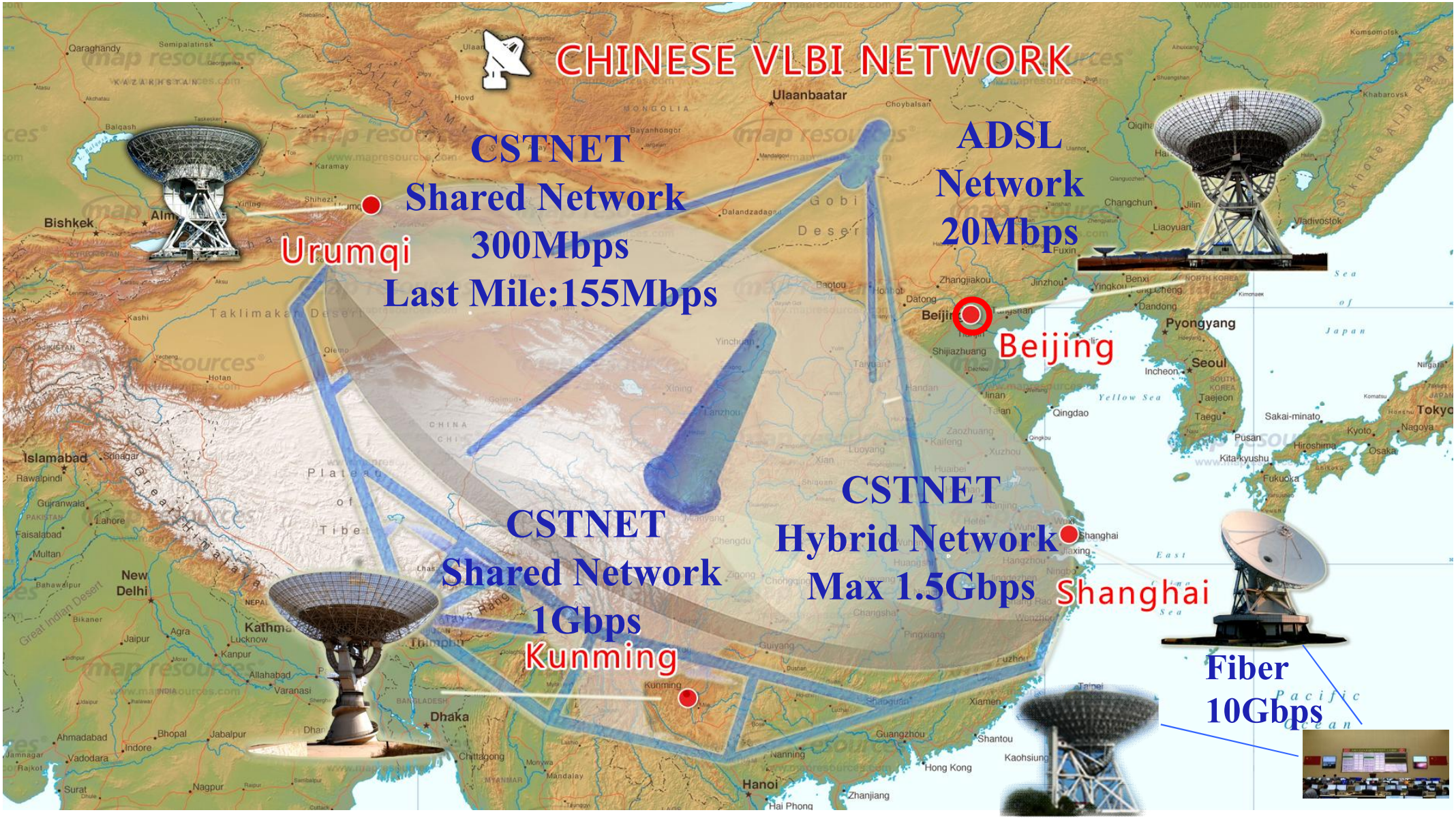
Bj, NAOC

Km, NAOC

Sh, NAOC

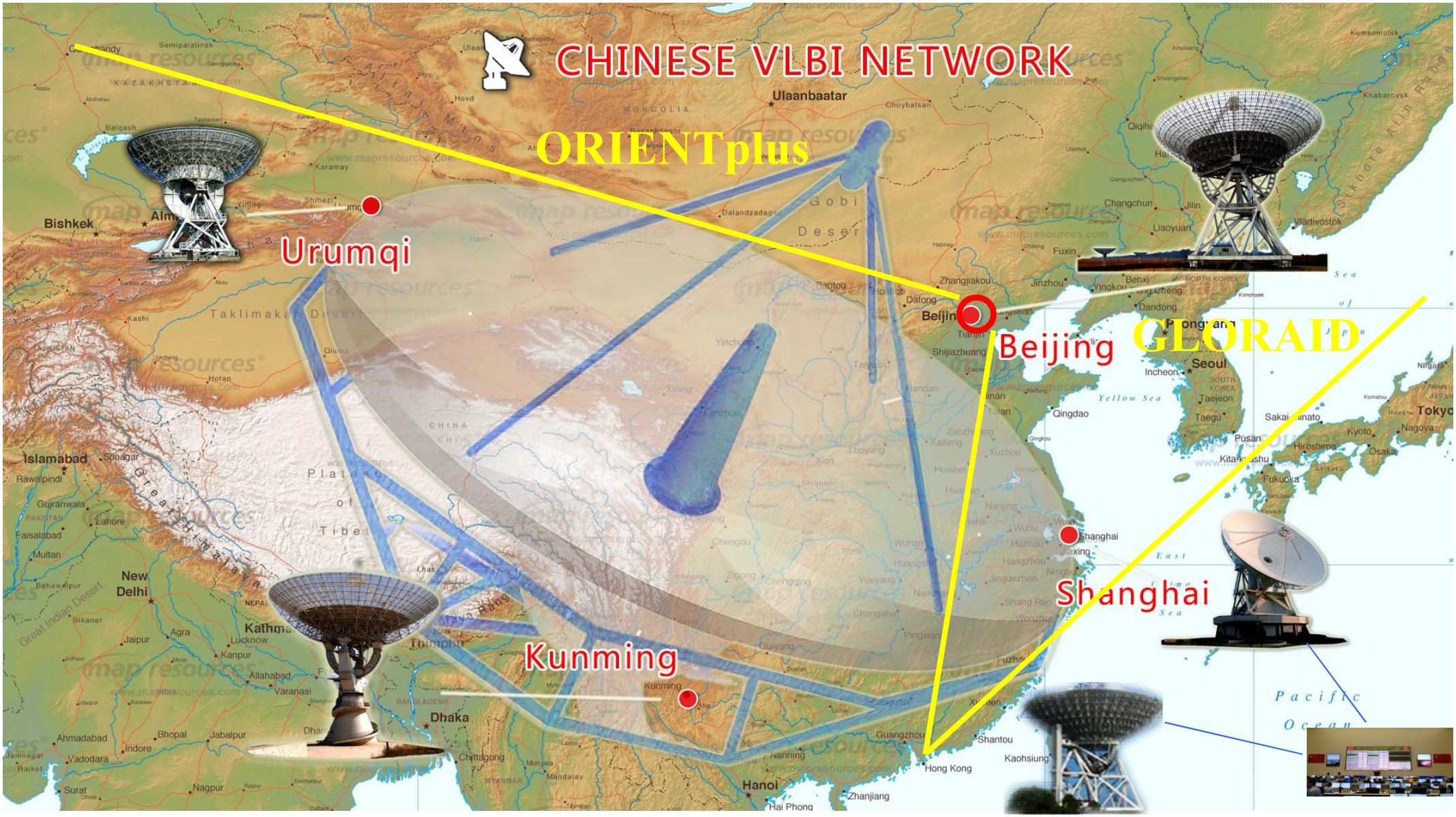
Tm, ShAO

CVN e-VLBI CSTNET Network BW



CSTNET: China Science and Technology Network, Chinese Academy of Sciences

CVN e-VLBI CSTNET Network BW

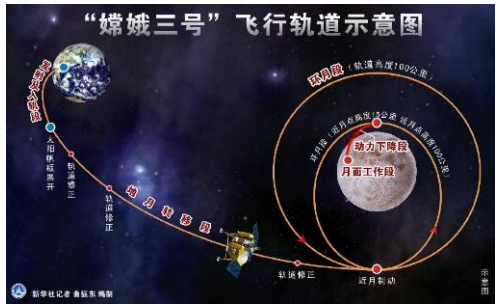


CSTNET: China Science and Technology Network, Chinese Academy of Sciences

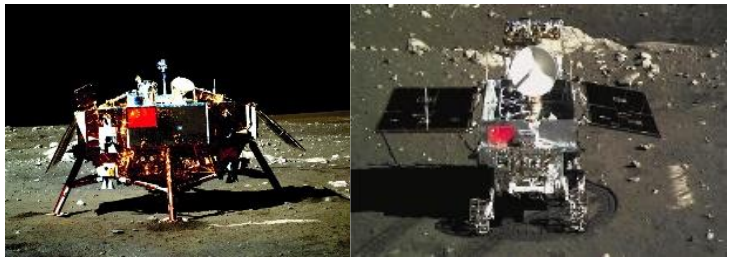
e-VLBI for CLEP CE-3 missions

❖ Chinese Lunar Exploration Project Phase II(CE-3,2013)

- ◆ **Service for measurement and control system**
- ◆ **Real-time Challenge**
  - VLBI Observation System:10min->1min
  - e-VLBI subsystem: 10 seconds, including failure recovery time



- ◆ Additional Function
  - In data center, receiving & distributing
  - Recording data



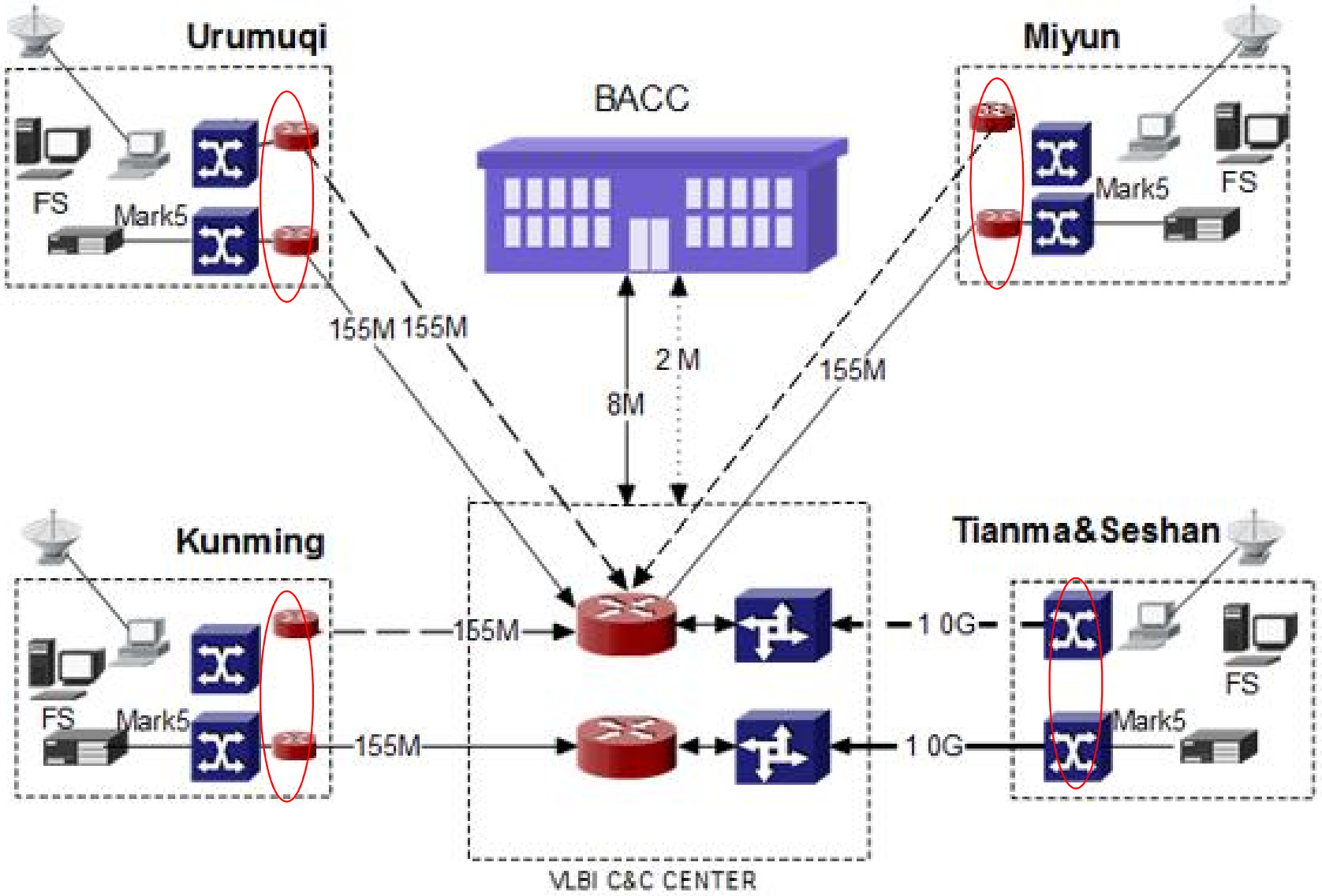
❖ Chinese Lunar Exploration Project Phase III(CE-5)

- ◆ CE-5T1: 64Mbps/stations(Nov, 2014-Now)
- ◆ CE-5: 128Mbps/stations(2017~2018)

CE-3 e-VLBI Network Link

- Data Rate
  - CE-3: 32Mbps/station -> 64Mbps/station, 5 stations
  - CE5-T1: 64Mbps/station, 4 stations
  - CE5: 128Mbps/station, 4 stations+2 deep space stations
- **Network Link Bandwidth**
  - Sh, Tm： 2×1(10)Gbps Fiber
    +100Mbps MSTP (China Telecom)
  - Km, Ur： 155Mbps SDH(China Unicom)
    +155Mb SDH(China Telecom)
  - Bj： 155Mbps SDH(China Telecom)
    +155Mb SDH(China Telecom)
  - Utilization： >92%
  - Cost: ~8k $/month

CE-3 e-VLBI Network Topology



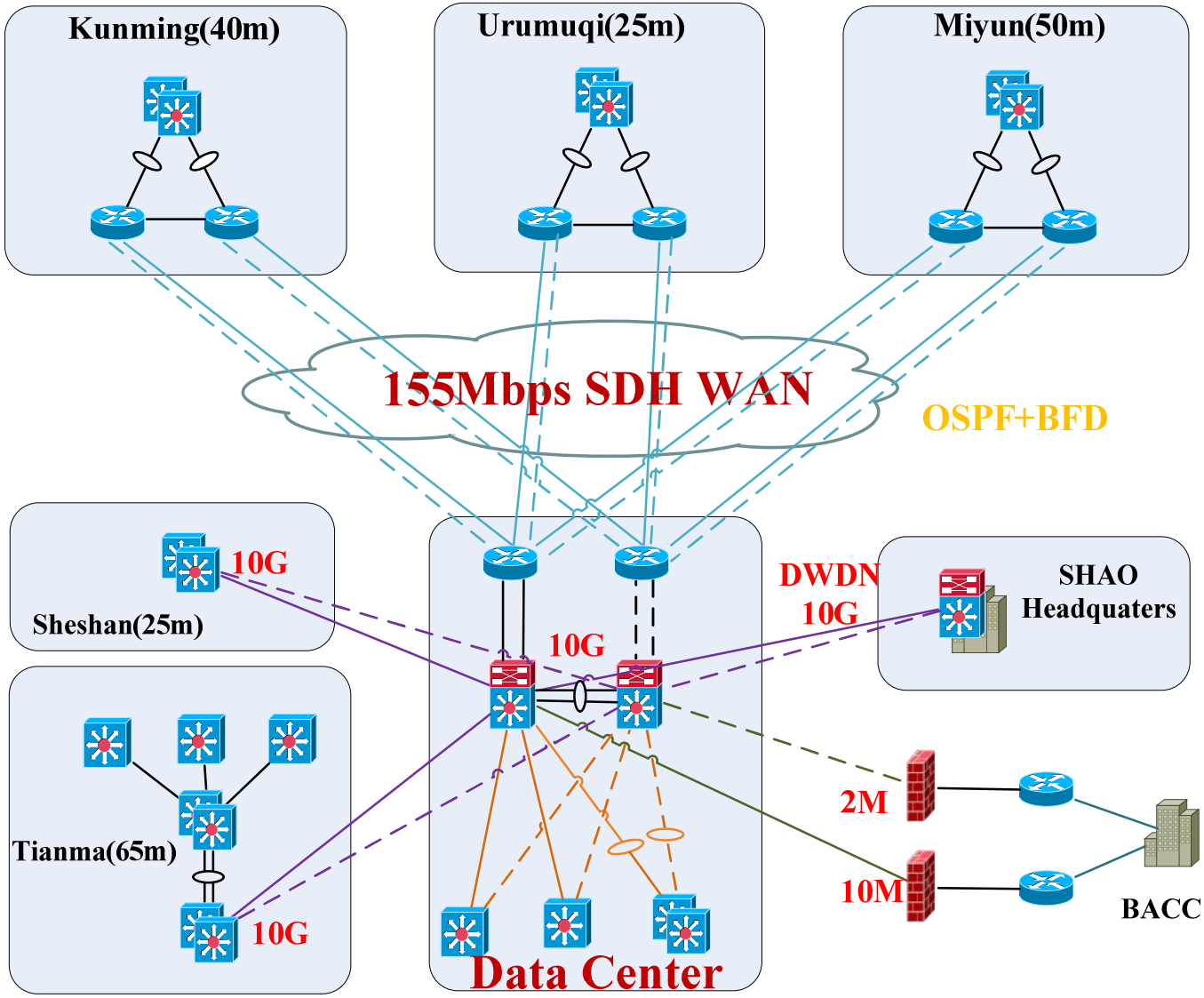
CE-3 e-VLBI Network Reliability Design

- **Network Backup Solutions**
  - **Requirement**
    - e-VLBI subsystem < 6 seconds
    - Network link/router failure switch time < 2 seconds
- **Layer 3**
  - **Stations: Bj, Km, Ur with SDH link**
  - **OSPF (Open Shortest Path First) Protocol**
    - Detect link failure and recovery time : ~10s
  - **+BFD(Bidirectional Forwarding Detection)**
    - Detect link failure and recovery time : ~1s
- **Layer 2**
  - **Stations: Sh, Tm with dedicated fiber link**

e-VLBI CE-3 Network Topology

❖ Km, Ur, Bj

- Long Range Network
- Backbone unscheduled network situation: Link down，routing and router switch to backup without informed
- Reliability Design play and important role for uninterrupted transfer
- Open Shortest Path First Interior Gateway Protocol/Bidirectional Forwarding Detection



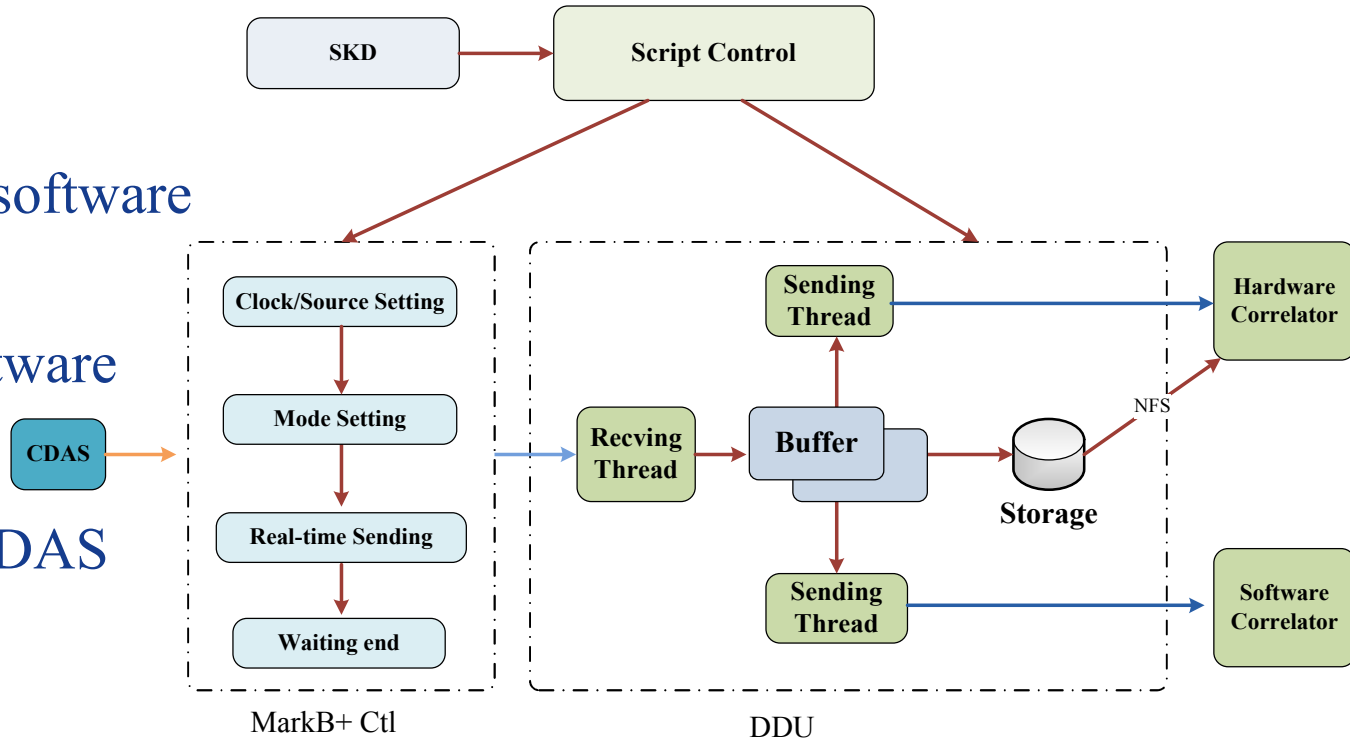
e-VLBI CE-3 Endpoints

❖ Stations

- CDAS
- Mark5B+ (2/station)
- Modified Mark5B+ software
- Two level buffer
  - Amazon card & software

❖ Data center: DDU

- Cost Servers (5+1)+DAS
- Data Receiving
- Data Distribution



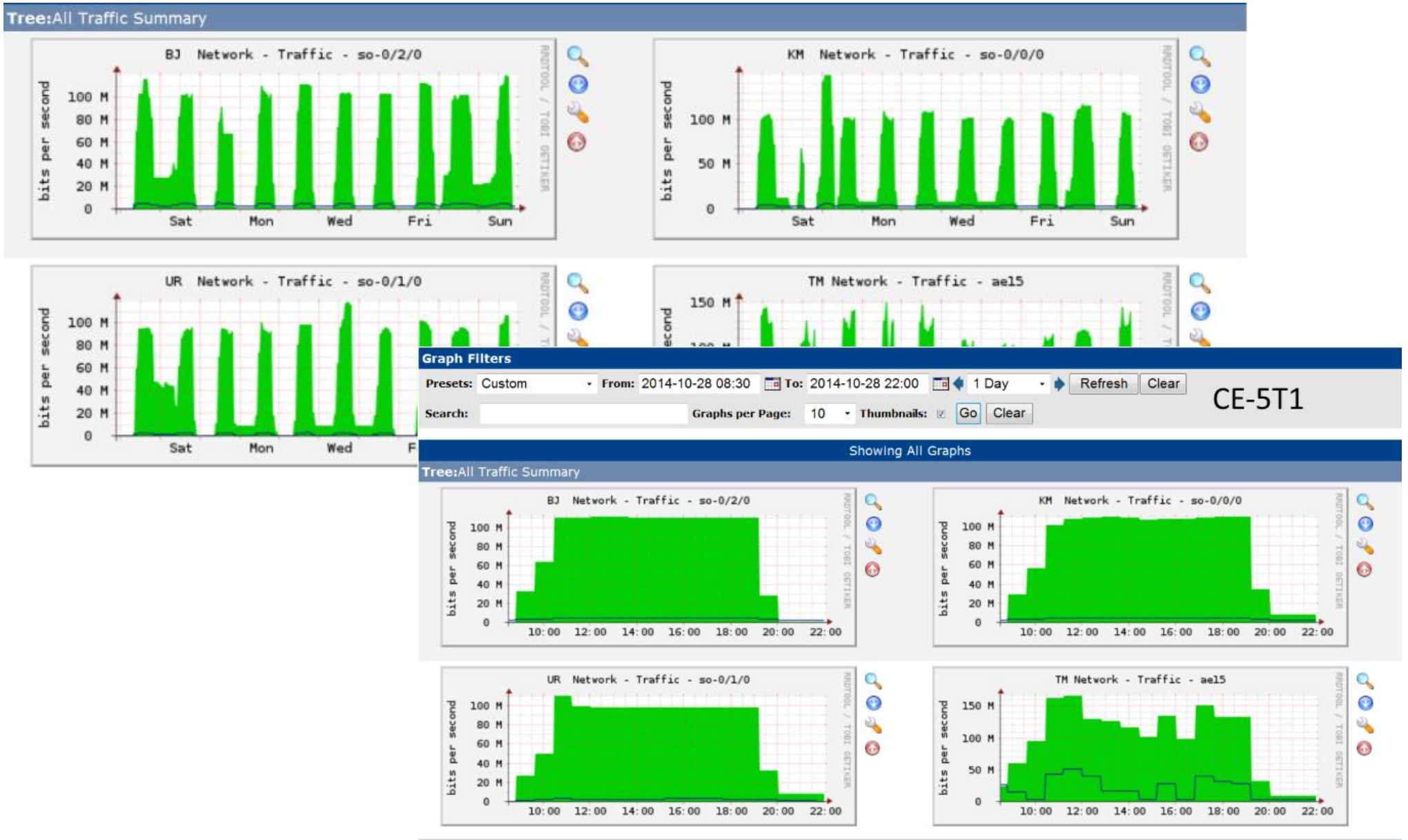
❖ Protocol: TCP(UDP)

❖ Control

- Script Control
- Start all station&center software in one bash script, or separately
- Auto read skd file & set parameter, fast pause and restart running

e-VLBI tracking mission Netflow

❖ e-VLBI



e-VLBI IPv6 Demo

❖ CNGI-IPv6 Network

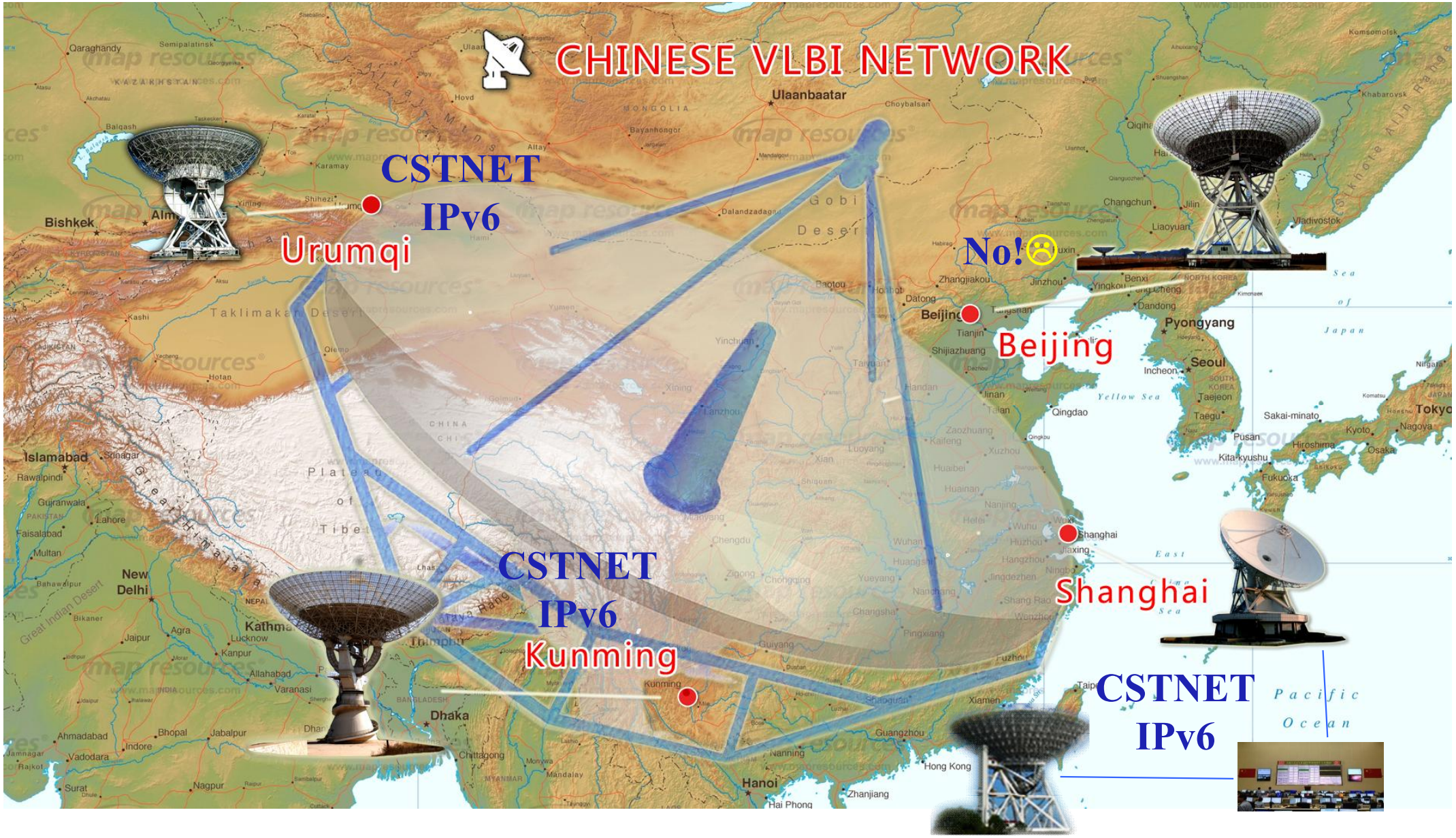
◆ Backgroud

- CNGI: Chinese Next Generation Internet
- Participation：Universities，Institutes，Companies
- Target：Demonstrate and Advance IPv6 network service
- e-VLBI by IPv6

◆ Jobs

- IPv6 network infrastructure construction
- Software modification to utilize IPv6
- Testing & Demonstration
- VLBI Data Center，Sh，Tm，Ur，Km

CVN e-VLBI IPv6 Connectivity



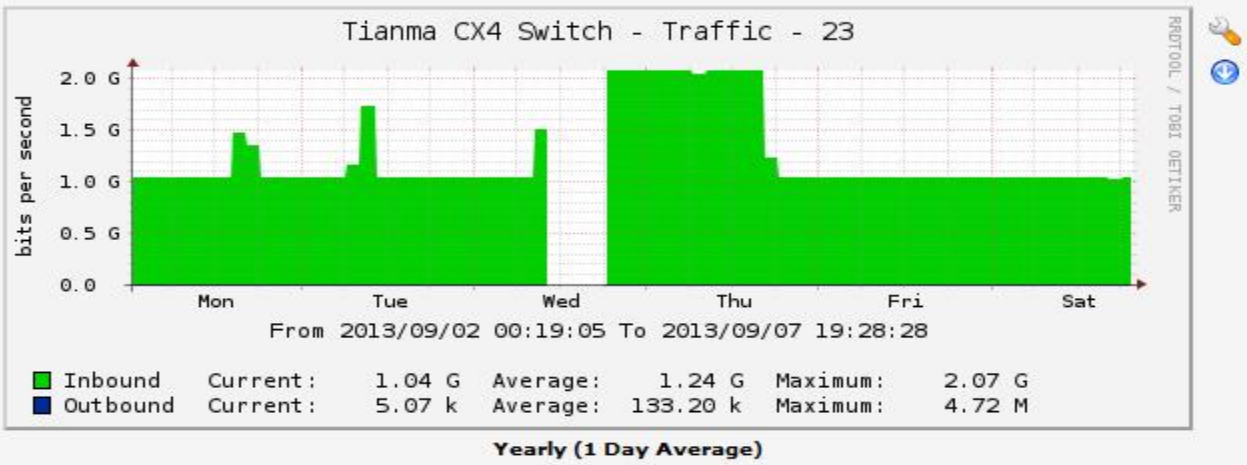
Station IPv6 Connectivity

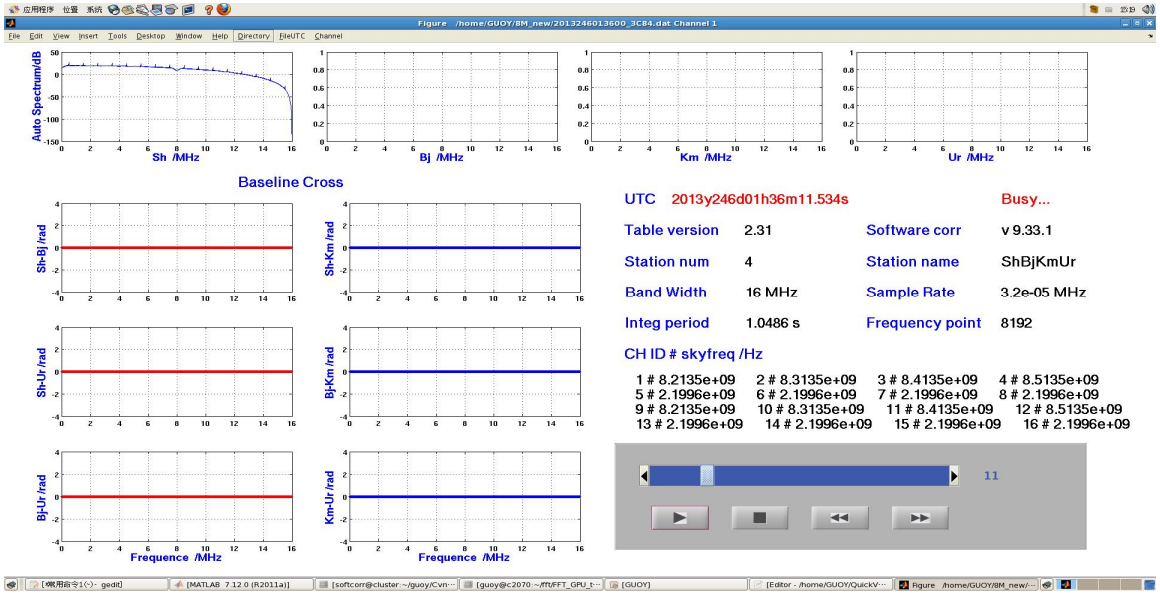
- **CNGI-IPv6 e-VLBI Infrastructure**
  - **Sh、Tm、VLBI Center support IPv6**
    - **Bandwidth：10Gbps**
    - **Sh,Tm → VLBI Center Bench**
    - **VLBI Center→ CSTNET Beijing Bench**
  - **VLBI Data Center - Beijing CSTNET IPv6**
    - **BW: 1024Mbps**
    - **Free use!☺**
  - **Km IPv6 BW：～50 Mbps ☹**
  - **Ur IPv6 BW：～10 Mbps ☹**
  - **Km,Ur can apply for more bandwidth, but budget…**

IPv6 e-VLBI Testing

❖ Tm Observation Test

Real-time Netflow





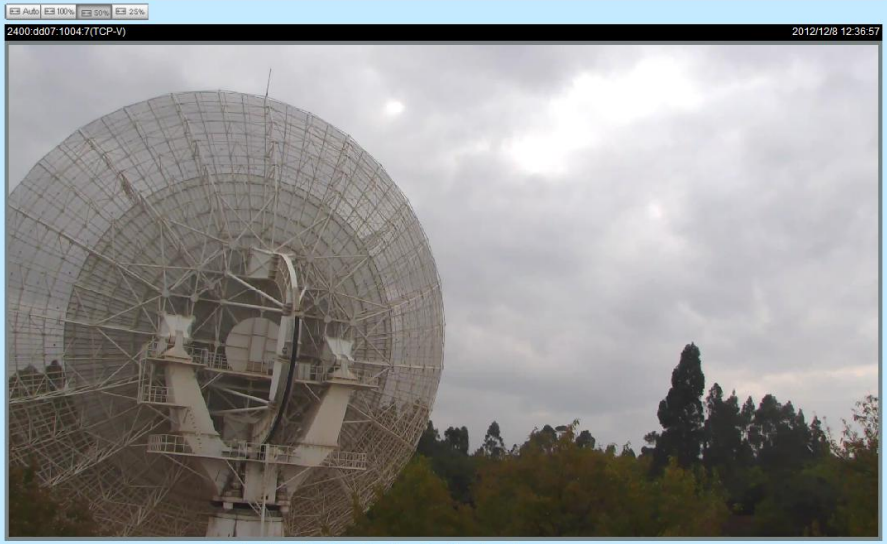
Zero Baseline Testing

IPv6-based Station Webcam

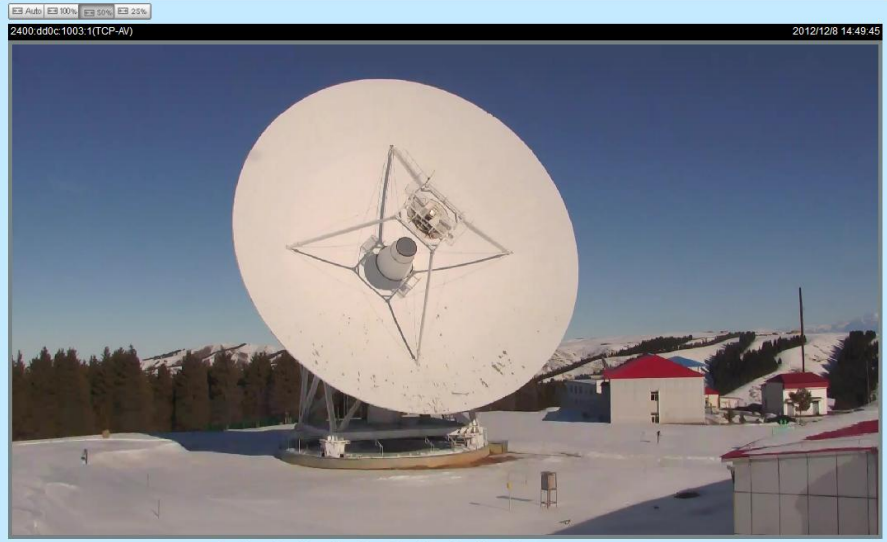
上海佘山25米射电望远镜

上海天马山65米射电望远镜

昆明40米射电望远镜

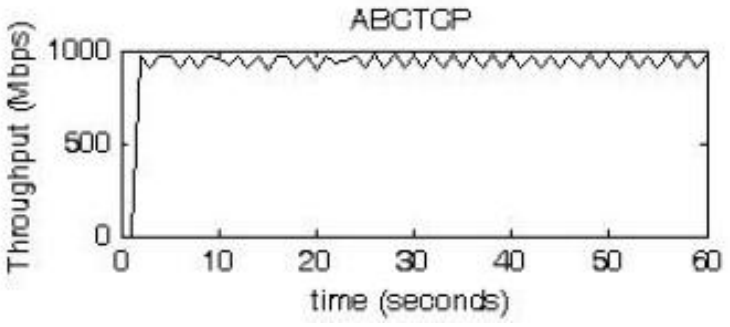


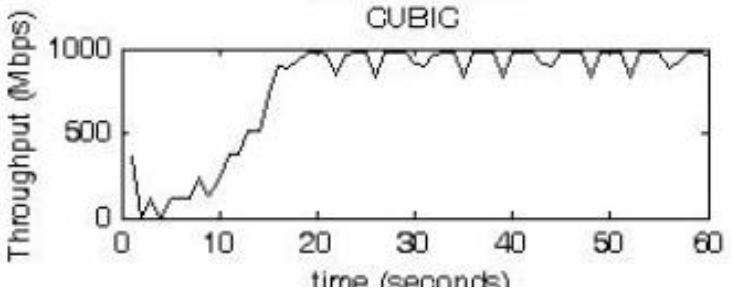
中科院新疆天文台—南山基地

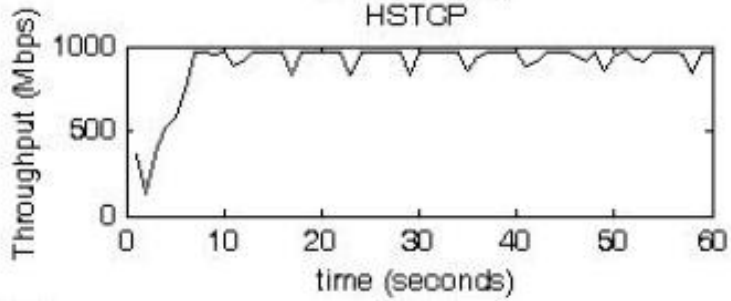


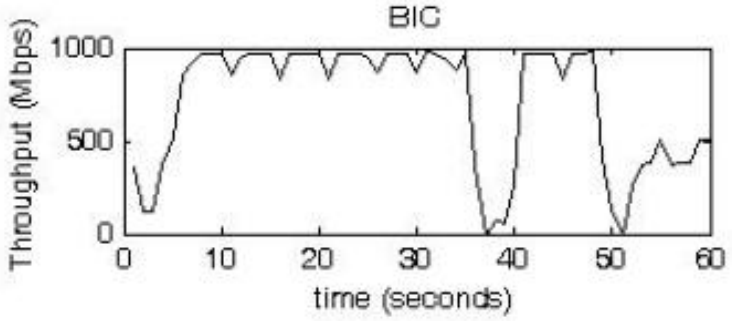
e-VLBI ABC TCP protocol

- **Shared Internet for e-VLBI**
  - **Bandwidth congestion and utilization**
  - **VLBI stable raw date rate**
  - **Done by CSTNET & ShAO**
  - **ABCTCP**
    - Closed-loop control TCP, desired speed as parameter
    - Testing between ShAO-CSTNET(Beijing)Backbone Network



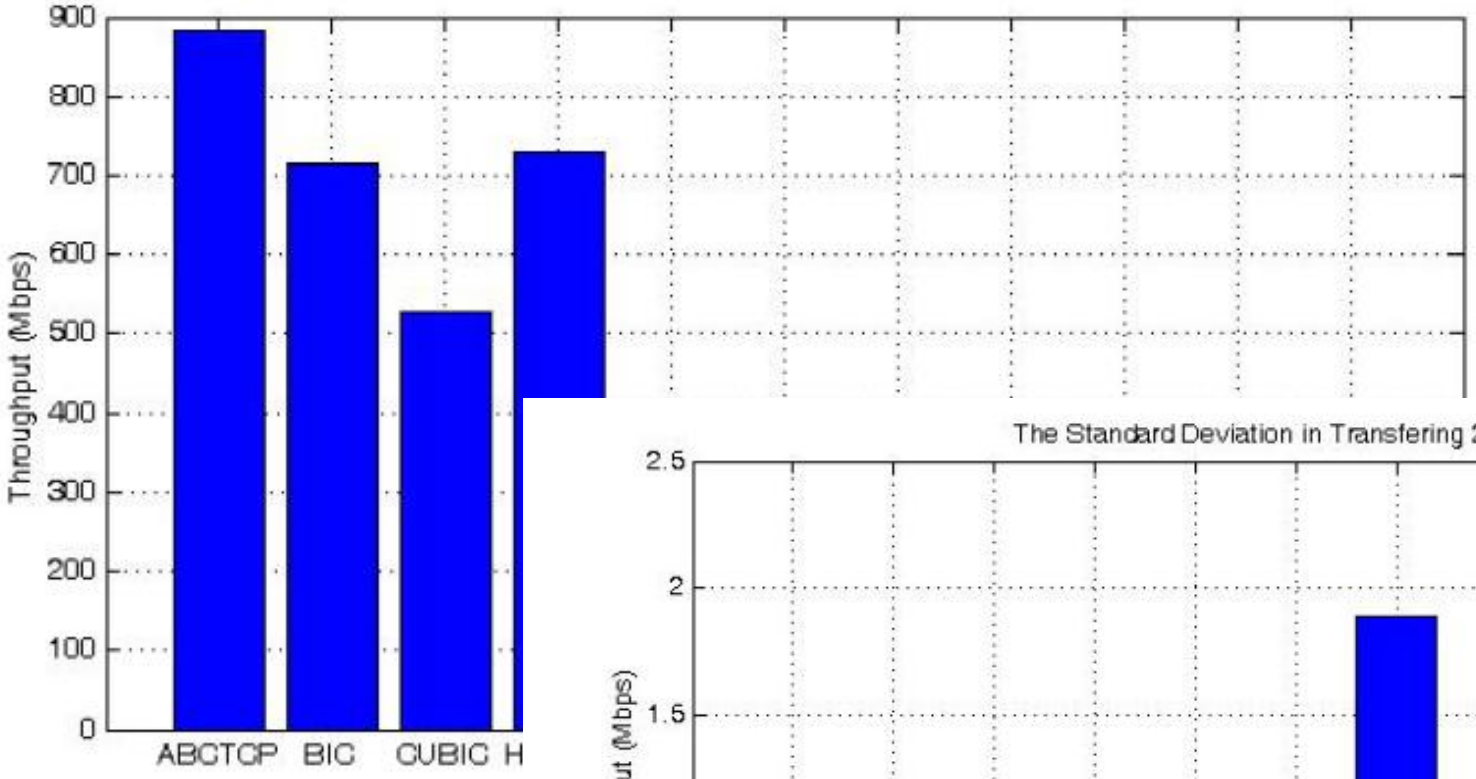


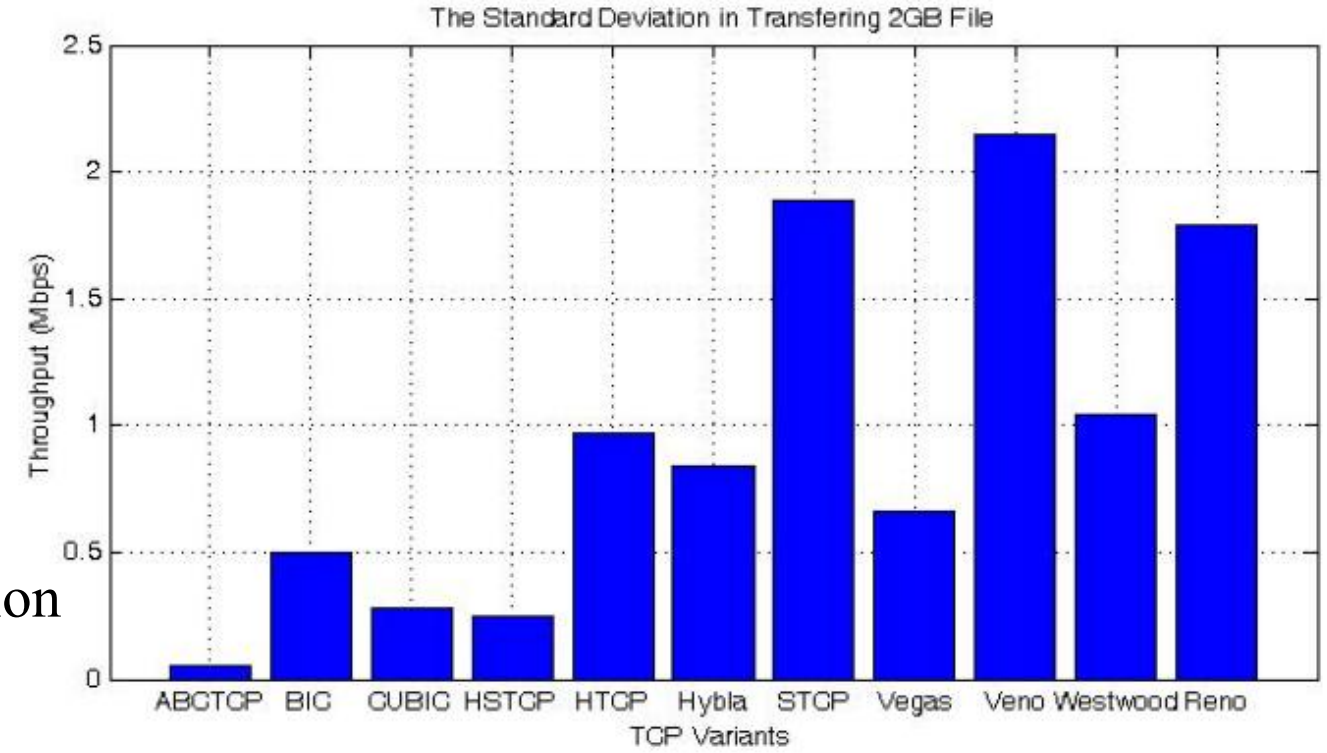




e-VLBI ABC TCP protocol

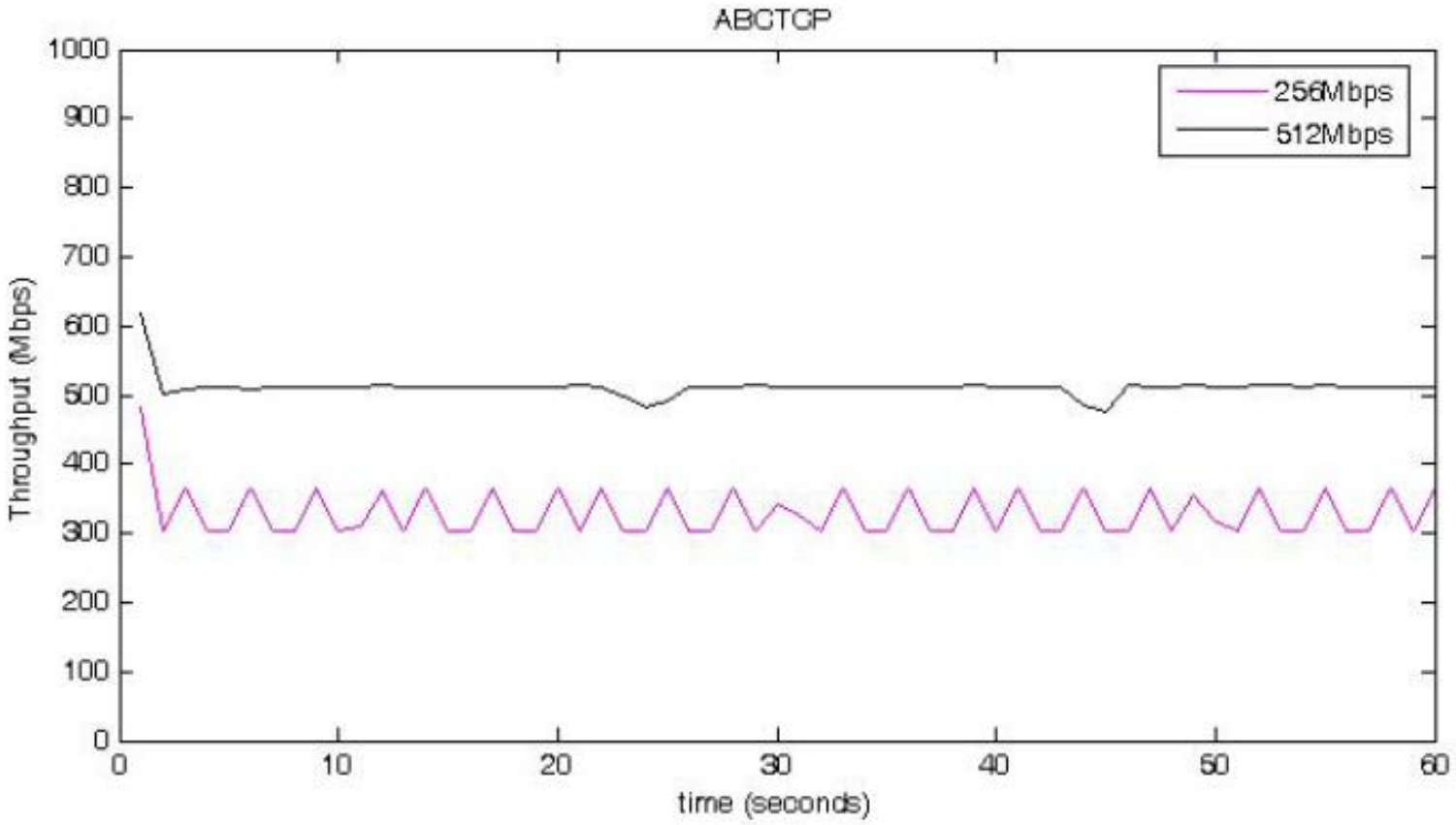
Average throughput





5 times based standard deviation

e-VLBI ABC TCP protocol



Desired Transfer Speed Testing

Networking between China-Malaysia

❖ Backgroud

•Proposing a new VLBI station in Malaysia

❖ Organization

• 1) Malaysia Putra University

• 2) University of Malaya

❖ Network

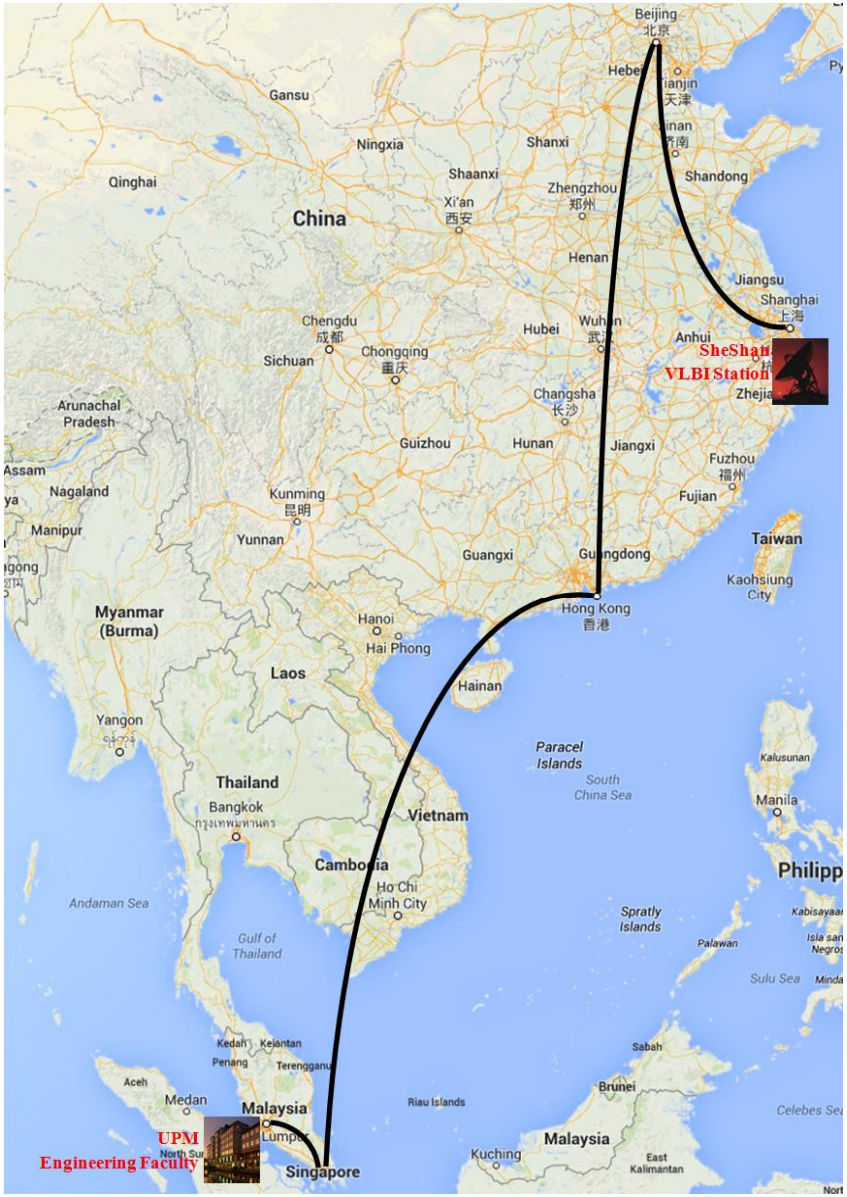
- **MyREN – TEIN - CSTNET**

❖ Network Testing tools

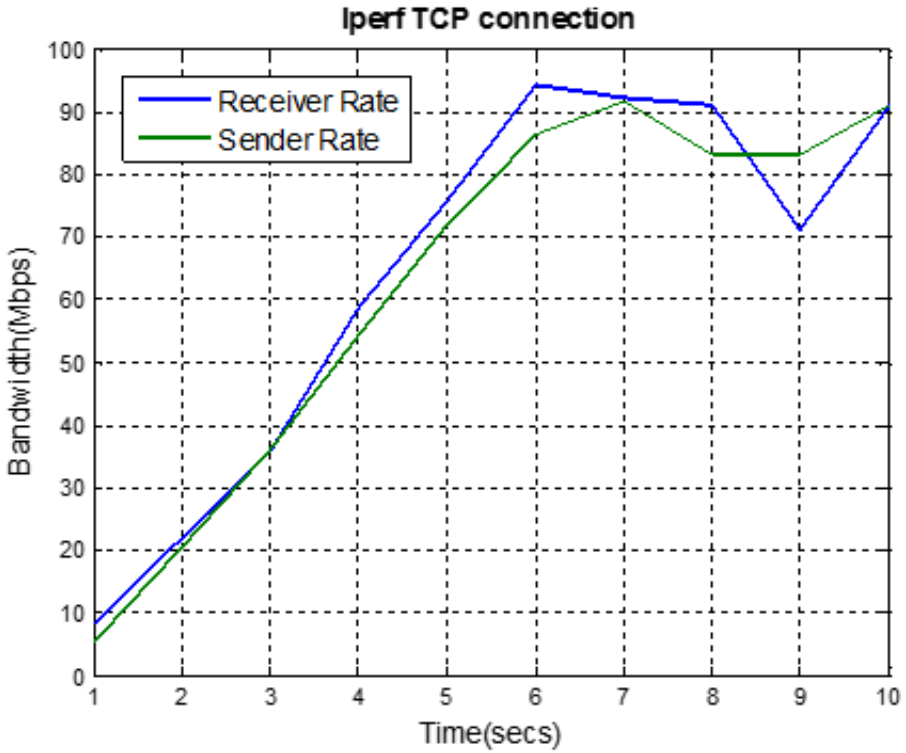
- Iperf TCP&UDP/FTP/UDT/ Tsunami-UDP

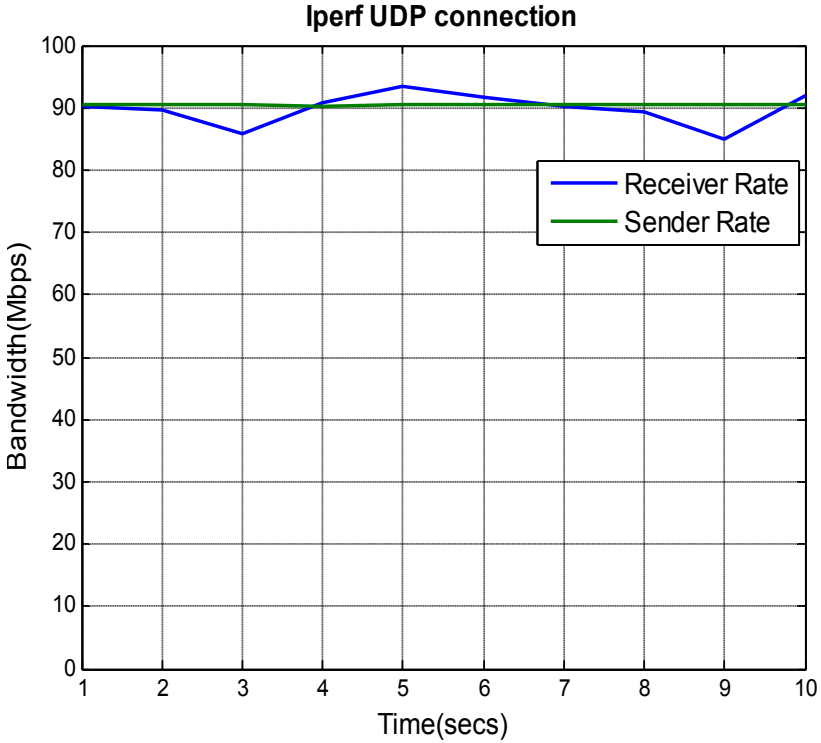
❖ staff

- Lim Yang Wei[12], Chen Zhong, Zamri Zainal Abidin[2], Shaiful Jahari Hashim[2]



China-Malaysia Networking Testing





Protocol	File sizes (bytes)	Speed (Mbps)	Time (s)	Packet loss (%)
FTP	536870912	82.96	50.56	0%
	1073741824	91.98	102.32	0%
Tsunami-UDP	536870912	83.93	48.8	0%
	1073741824	84.80	96.6	0%
UDT	536870912	72.19	59.49	0%
	1073741824	78.45	109.49	0%

New VLBI Center

Command&Control Hall

Main Server Room

Systems in New VLBI Center

- **Computing system**
  - Software correlator(384 Xeon E5 cores, 2.4G, DAS 72TB)
  - DiFX: 48+16 cores, 50TB, 6 Mark5
    → Haswell 2.6G, 400 cores, 360TB
  - Post processing/Orbit/Positoin/
- **Storage**
  - Raw data storage: 300TB
  - Results data storage: 30TB
- **Networking**
  - 10Gb Ethernet Intranet
  - 40Gb Infiniband interconnection in software correlator cluster
- **Distributed LED Display Wall**
- **IP-based Voice Command System**
- **Power and Cooling**
  - UPS: backup support > 2hours

Mark5/6 System@Center

- **Mark5/6**
  - **4 Mark5A, 8 Mark5B, 3 Mark5B+, 1 Mark5C, 1 Mark6**
  - **Disk Modules: 180**
  - **Firmware/Software upgrade, all Mark5@stations and center**

		SN	Type	Card Type	Kernel	Mark5	Streamstor SDK	Firmware	Driver
1	CLEP	Mark5-818	Mark5B+	PCI-816VXF2	2.6.18-6-686 4.0	2.2.3	9.2.1	16.31	1031
2		Mark5-811	Mark5B+	AMAZON-VP	2.6.18-6-686 4.0	2.2.2	9.2.1	16.31	1031
3		Mark5-814	Mark5B+	AMAZON-VP	2.6.18-6-686 4.0	2.2.1	9.2.1	16.31	1031
4		Mark5-653	Mark5B	AMAZON-VP	2.6.18-6-686 4.0	2.2.1	9.2.1	16.31	1031
5		Mark5-687	Mark5B	AMAZON-VP	2.6.18-6-686 4.0	2.2.1	9.2.1	16.31	1031
6		Mark5-697	Mark5B	AMAZON-VP	2.6.18-6-686 4.0	2.2.1	9.2.1	16.31	1031
7		Mark5-785	Mark5B	AMAZON-VP	2.6.18-6-686 4.0	2.2.1	9.2.1	16.31	1031
8		Mark5-636	Mark5B	AMAZON-VP	2.6.18-6-686 4.0	2.2.1	9.2.1	16.31	1031
9		Mark5-739	Mark5B	PCI-816VXF2	2.6.18-6-686 4.0	2.2.1	9.2.1	16.31	1031
10	DiFX	Mark5-643	Mark5B	PCI-816VXF2	2.6.18-6-686 4.0	2.2.1	9.2.1	16.31	1031
11		Mark5-685	Mark5A	PCI-816VXF2	2.6.18-6-686 4.0	2.2.1	9.2.1	13.04	1031
12		Mark5-635	Mark5A	PCI-816VXF2	2.6.18-6-686 4.0	2.2.1	9.2.1	13.04	1031
13		Mark5-738	Mark5B	AMAZON-VP	2.6.18-6-686 4.0	2.2.1	9.2.1	16.31	1031
14		BR-RS-8237	Mark5A	PCI-816VXF2	2.6.18-6-686 4.0	2.2.1	9.2.1	13.04	1031
15		Mark5-646	Mark5A	PCI-816VXF2	2.6.18-6-686 4.0	2.2.1	9.2.1	13.04	1031

Conclusion

- **Space mission continuous support**
  - CLEP Phase III, CE-5 mission
  - Deep space explorations: Mars, …
- **Shanghai Correlator Center**
  - Real time data transmission
  - e-Transfer
- **Bandwidth and Cost**
  - Win-win cooperation with CSTNET to get more support
  - IPv6 interested by anyone ?


THE CHINESE ACADEMY OF SCIENCES


Shanghai Astronomical Observatory, CAS

Thank☺