e-VLBI activity in NICT

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New Generation Network Research Center

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and Communications Technology

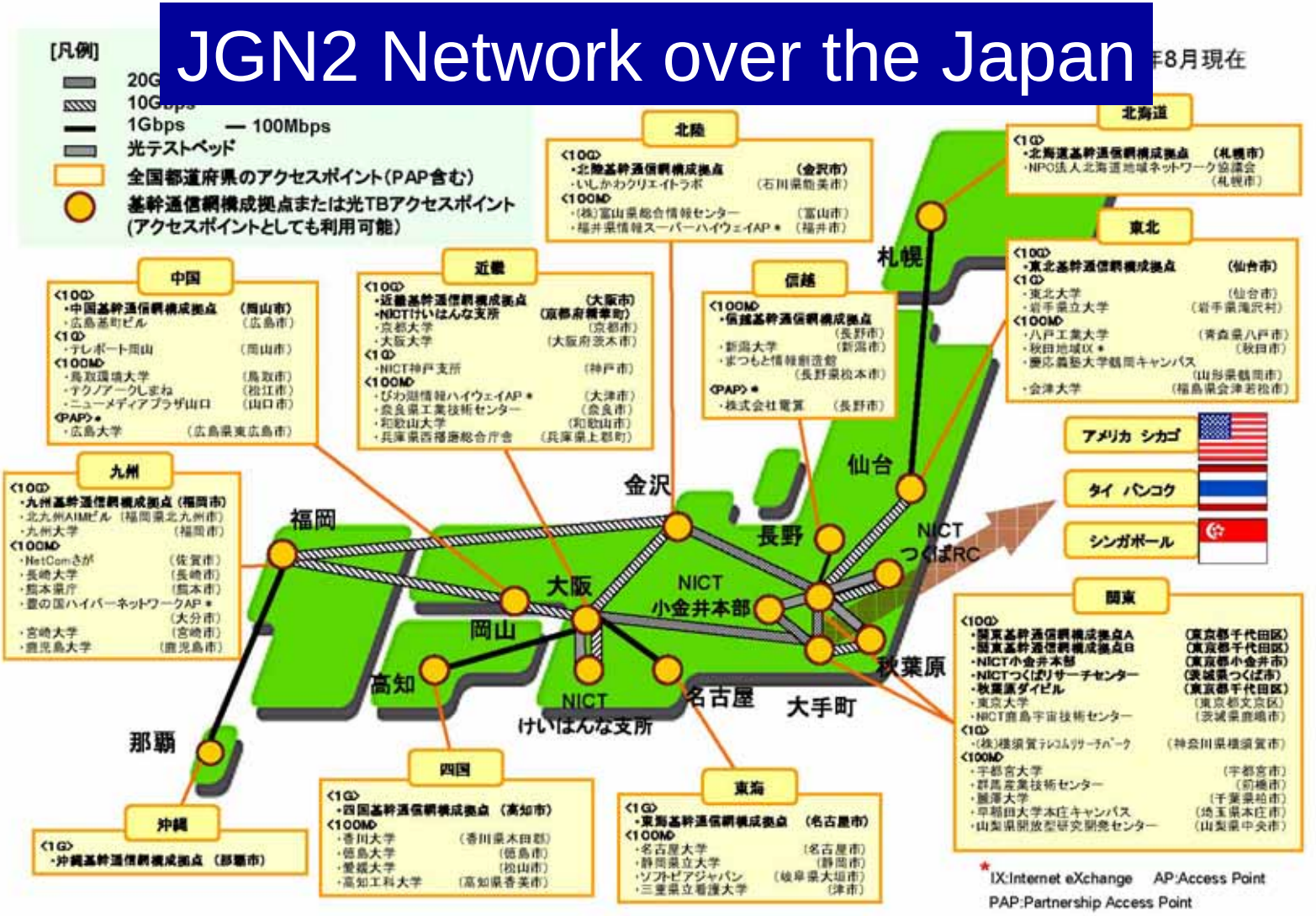
Introduction of NICT

- Technical Development Center of IVS
  - Data acquisition system: K5/VSSP, K5/VSI
  - K5 Software Correlator
    - EVN Fringe Finding
    - Geodetic VLBI observation by GSI Japan, Ultra-rapid UT1 measurement
    - Backup correlator for VERA Project
    - VLBI application for Spacecraft Navigation
- NICT: Institute of Information Technology
  - VLBI-Group＋JGN2＋Network Architecture Group Collaboration

Contents of Presentation

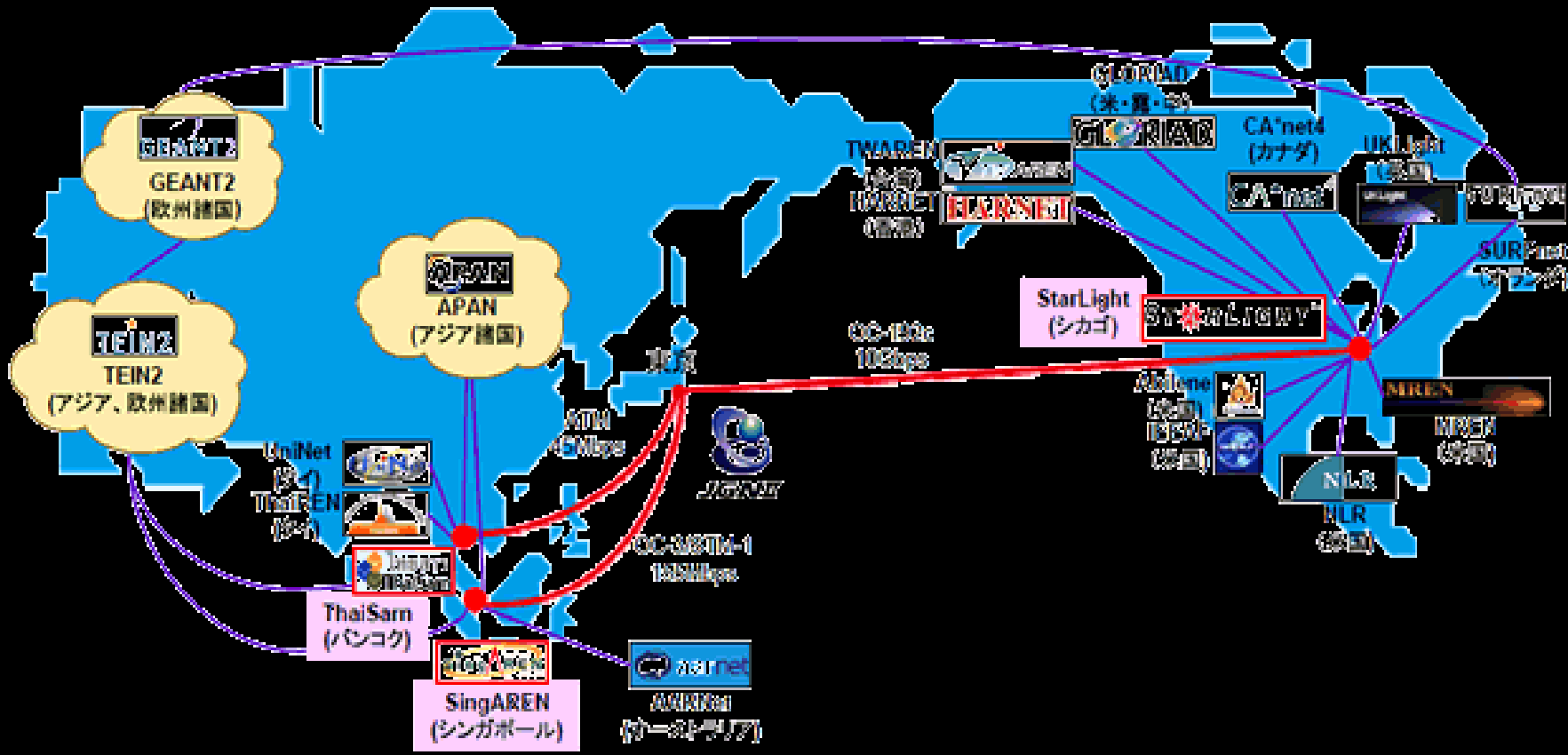
- E-VLBI activity in NICT
  - Ultra-rapid UT1 measurement with Onsala,Metsähovi
  - 8Gbps e-VLBI demonstration Kashima34-Koganei11 baseline by collaboration with NAOJ and JGN2 News
- Benefit of e-VLBI
- Prospect for future e-VLBI protocol
  - Optimal VLBI data transport protocol
  - Conflict of benefit for VLBI and Network
  - One of the Solution: Bandwidth on demand

JGN2 Network conducted by NICT



International Network connection of JGN2

◆米国回線　　：東京～シカゴ間、10Gbps×1回線
◆タイ回線　　：東京～バンコク間、45Mbps（ATM）×1回線
◆シンガポール回線：東京～シンガポール間、155Mbps×１回線

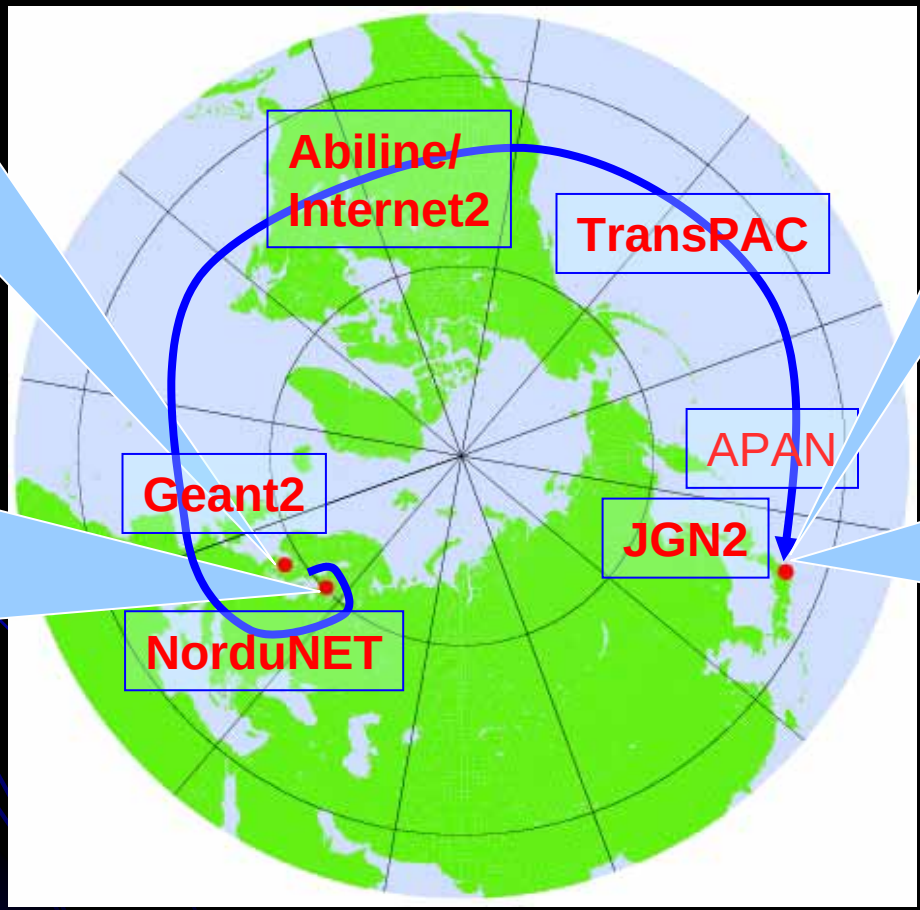


Ultra-rapid UT1 Experiment

NiCT

Onsala20m
(Sweden)

After 5 min. of VLBI observation, UT1 is derived.

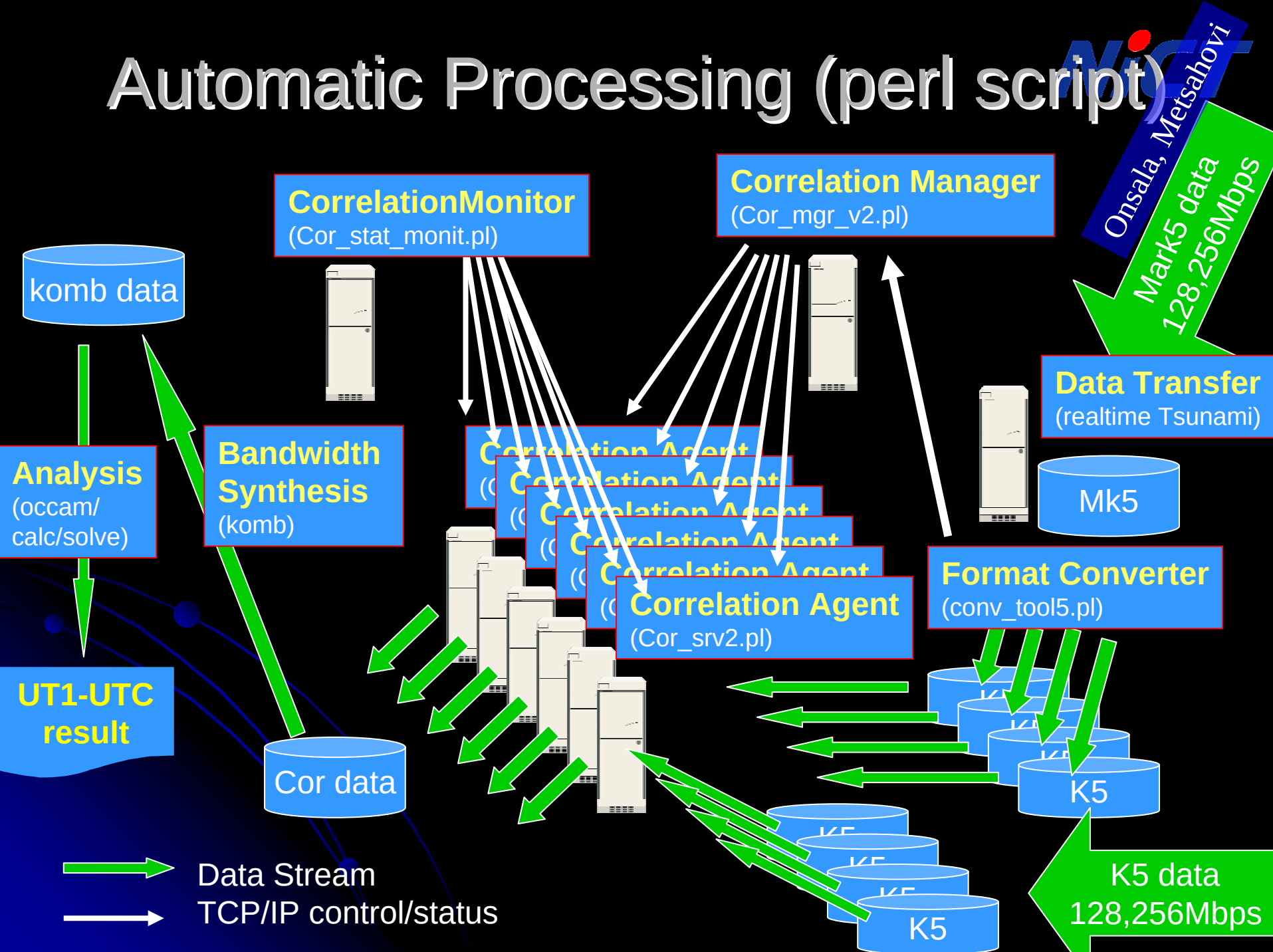


Tsukuba32m
(GSI)

Metsahovi14m
(Finland)

Kashima34m
(NICT)

Automatic Processing (perl script)



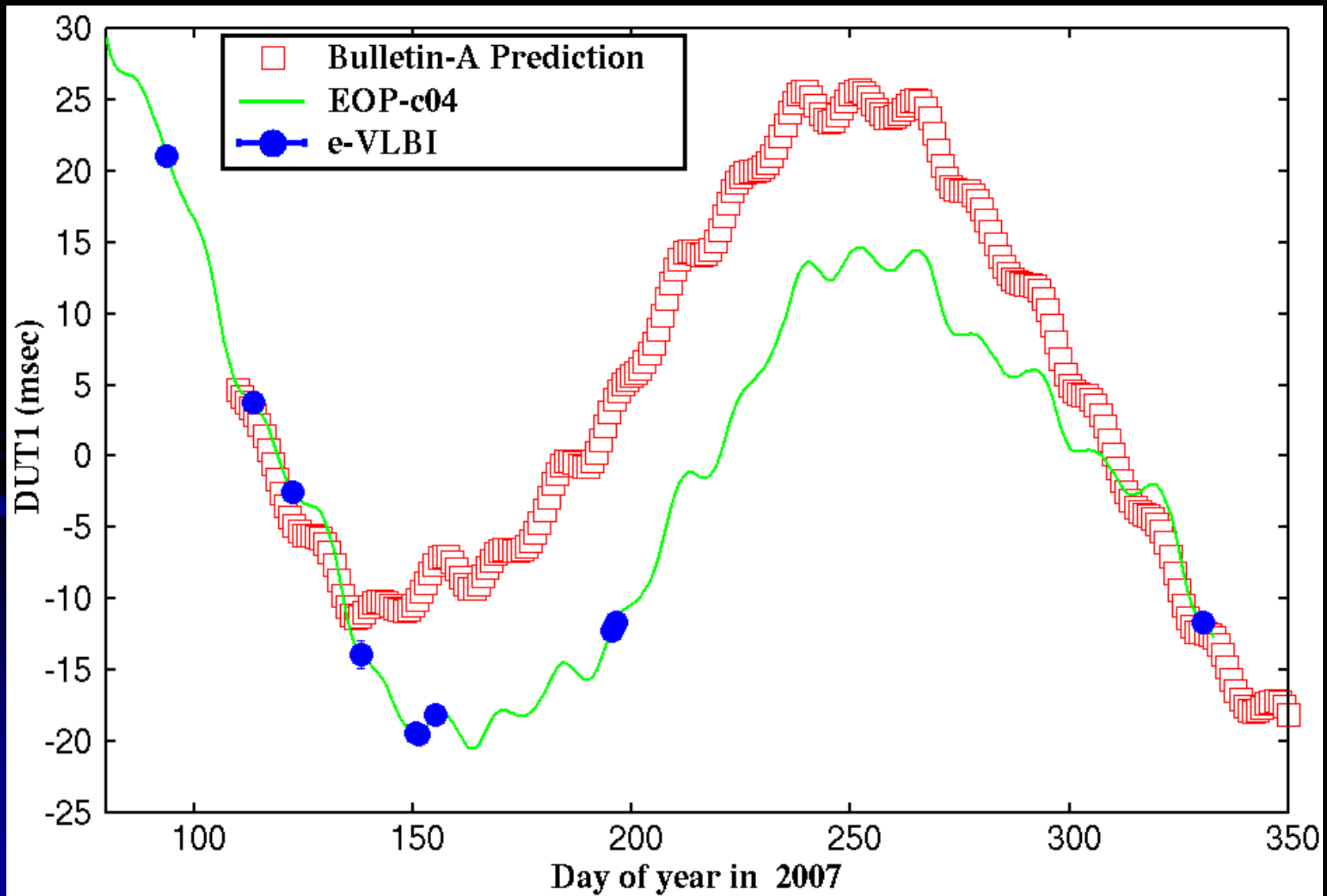
Ultra-Rapid UT1 since 2007

Date	Baseline	Data Rate	UT1-UTC (msec)	UT1-c04 (μsec)	Formal Error (μsec)	Latency
Apr.3	Ks-On	128	-69.6044	-38	8	--
Apr.23	Ks-On	128	-98.4422	15	41	1h35m
May 2	Ks-On	128	-110.0189	-30	16	--
May 18	Ks-Mh	128	-130.5832	68	98	2h38m
May 30	Ks-On	128	-143.2703	-15	9	28m
May 31	Ks-On	128	-143.7011	-84	8	--
Jun. 4	Ks-On	256	-144.6447	13	6	31m
Jul. 14	Ks-On	256	-162.102	9	10	offline
	Ts-Wz	256	-162.0585	52	5	--
Jul.15	Ks-On	256	-162.0186	-32	6	Offline
	Ts-Wz	256	-162.0017	-8	8	Offline

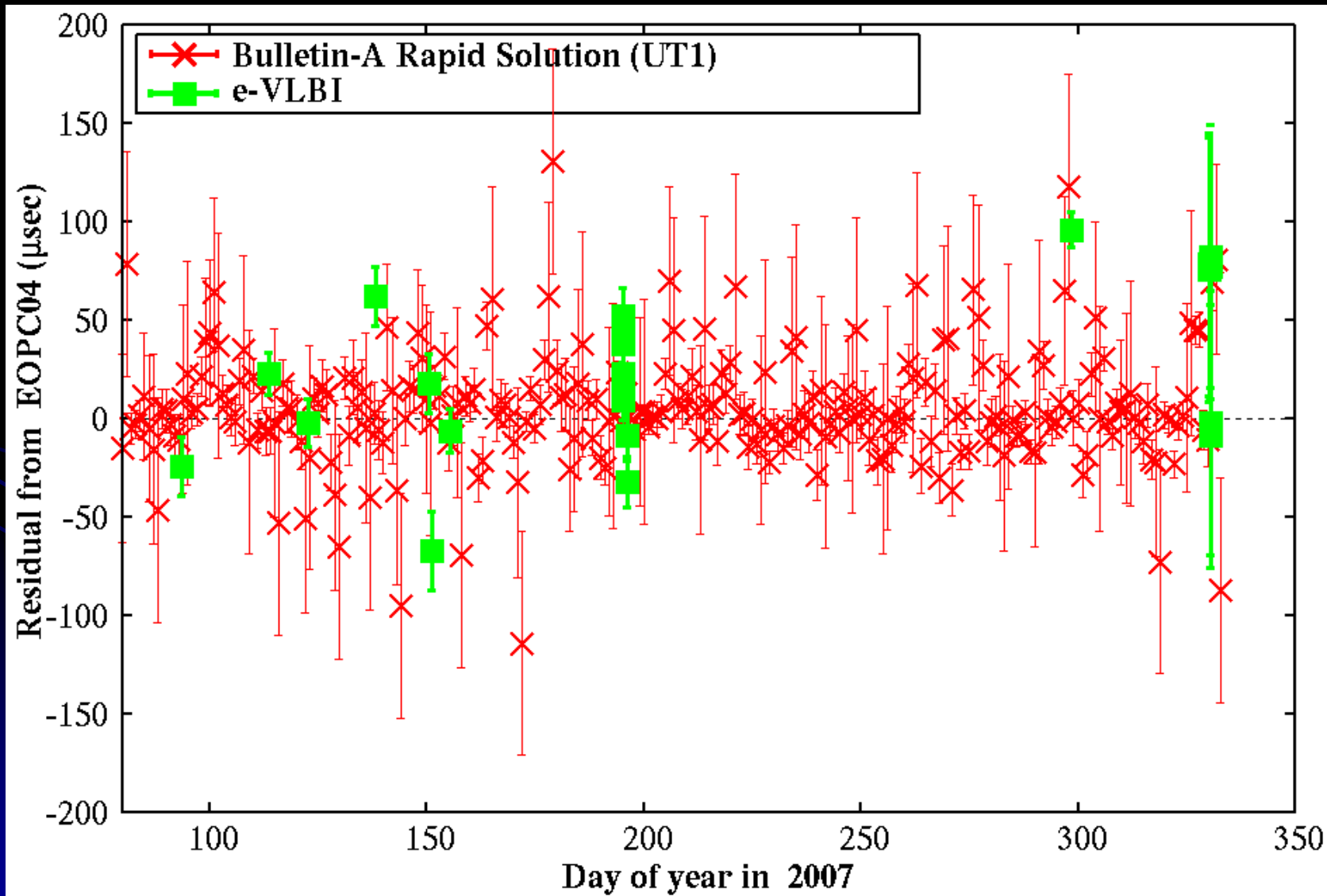
Ultra-Rapid UT1 since 2007

Date	Baseline	Data Rate	UT1-UTC (msec)	UT1-c04 (μsec)	Formal Error (μsec)	Latency
Nov.26	Ks-On	128	-240.0078	76	8	--
	Ks-On	256	-240.1118	78	16	--
	Ks-On	512	-240.1134	83	29	Offline
	Ks-On	128	-240.1621	77	8	25m
	Ks-On	256	-240.2628	-2	14	27m
	Ks-On	512	-240.3020	-9	30	Offline

Prediction(BulletinA),EOPc04, and e-VLBI



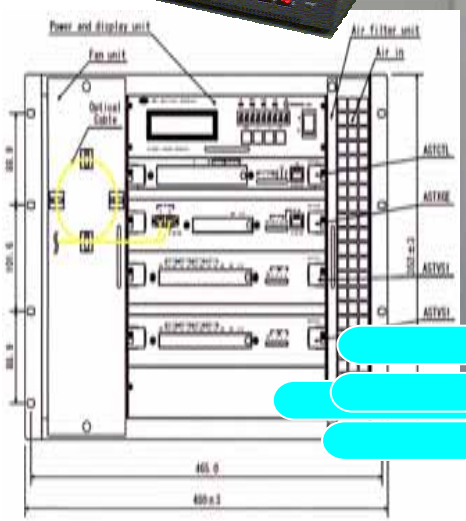
Rapid Solution (Bulletin-A) and e-VLBI – EOPc04



News

The First 10Gbps VLBI

8Gbps realtime VLBI has successfully performed on March 18 under the collaboration among **NICT ,NAOJ, and JGN2.** Demonstration will be given APEC-TEL Conf. 25-27 March.



10Gbit Ether

VOA-200

e-VLBI

- E-VLBI: Definition
  - VLBI by using High-speed Network and Computer Technology
- Benefits
  1. Media independent data⇒Compatibility
  2. Rapid turn around, and Wide bandwidth(10G)
  3. Automatic observation/data reduction
     - Ex.) Ultra-Rapid UT1 measurement.

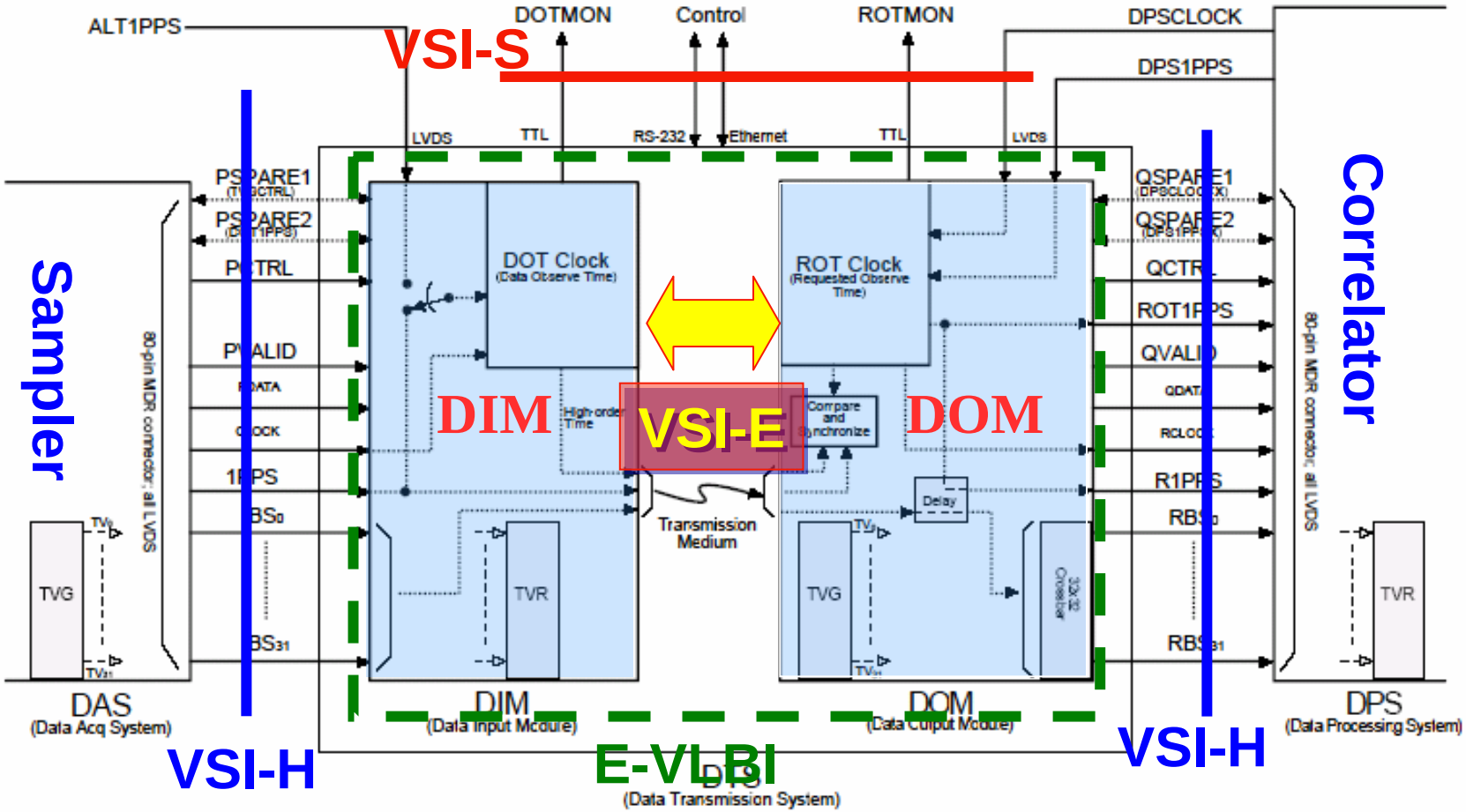
E-VLBI, The Most Important Feature is

- **Compatibility**
  - Mark5,K5,S2,VSIB,…
- Network/Data handling by software drastically reduced the difficulty for interconnection.
- VLBI is enabled by International/domestic collaboration between institute.
- Compatibility enhance
  - Variety of combination of collaboration among institutes/telescopes/people.
  - Ad hoc network observation for variety of targets in the field of Geodesy/Astronomy/Space Navigation

VLBI Standard Interface (VSI)

- VLBI Data acquisition systems
  - Mak5, K5
- VLBI Standard Interface (VSI-H,S,E;1999～)
  - VSI-H　Hardware ⇒Interface (Sampler,DAS)
  - VSI-S　Software ⇒DAS system control
  - VSI-E　Network　Protocol ⇒Data Transport

VSI-H, VSI-S, VSI-E

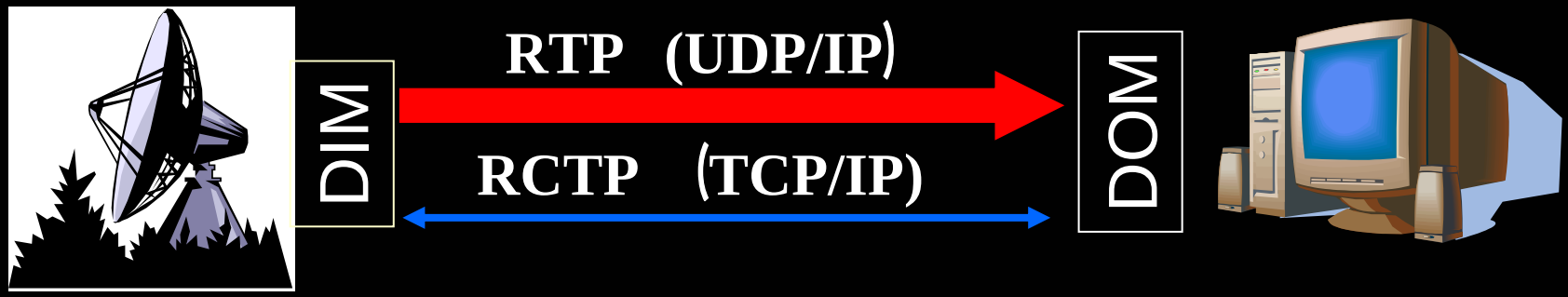


Examples of successes of VSI-H

- Sampler
  - Mark5 sampler –<VSI-H>
  - K5(ADS-1000,2000,3000)-<VSI-H>
- DAS
  - <VSI-H>-K5/VSI (NICT)
  - <VSI-H>-Mark5 (Haystack)
  - <VSI-H>-VSIB (Metsahovi)
  - <VSI-H>-VOA-100/200 (NAOJ)

VSI-E

Real-time Transport Protocol (RTP)
Real-time Transport Control Protocol (RTCP)



- RTP/RTCP has been proposed by,D.Lapsley, A.Whitney, Y.Koyama
- Tsunami (UDP) protocol used for UT1 experiment, EVN
- TCP used in EVN(?)

What will happen when global e-VLBI is operated routinely?

- At present, No problem for one stream Europe-Japan with shared network. Because of no congestion.
- What about multiple streams?
- In case of congestion, data rate drastically decreases, especially in TCP/IP.
- Even Tsunami(UDP) tries to send complete data set by re-transmission mechanism, and … finally fails.

What is the Optimal transport protocol for real-time VLBI?

- Features of Realtime VLBI are
  - Fixed Data Rate or slightly adjustable.
  - Relatively large error rate(<0.1) is acceptable, if padding and flagging is done. Only Header must be preserved.
- "Optimal protocol for realtime e-VLBI" may looks like
  - Sending data in fixed rate regardless congestion
  - Just sending out by UDP (without re-transmission)
  - VLBI data may win the resource race, because it accept largest error rate than any other application.
- This may be good for VLBI, but….

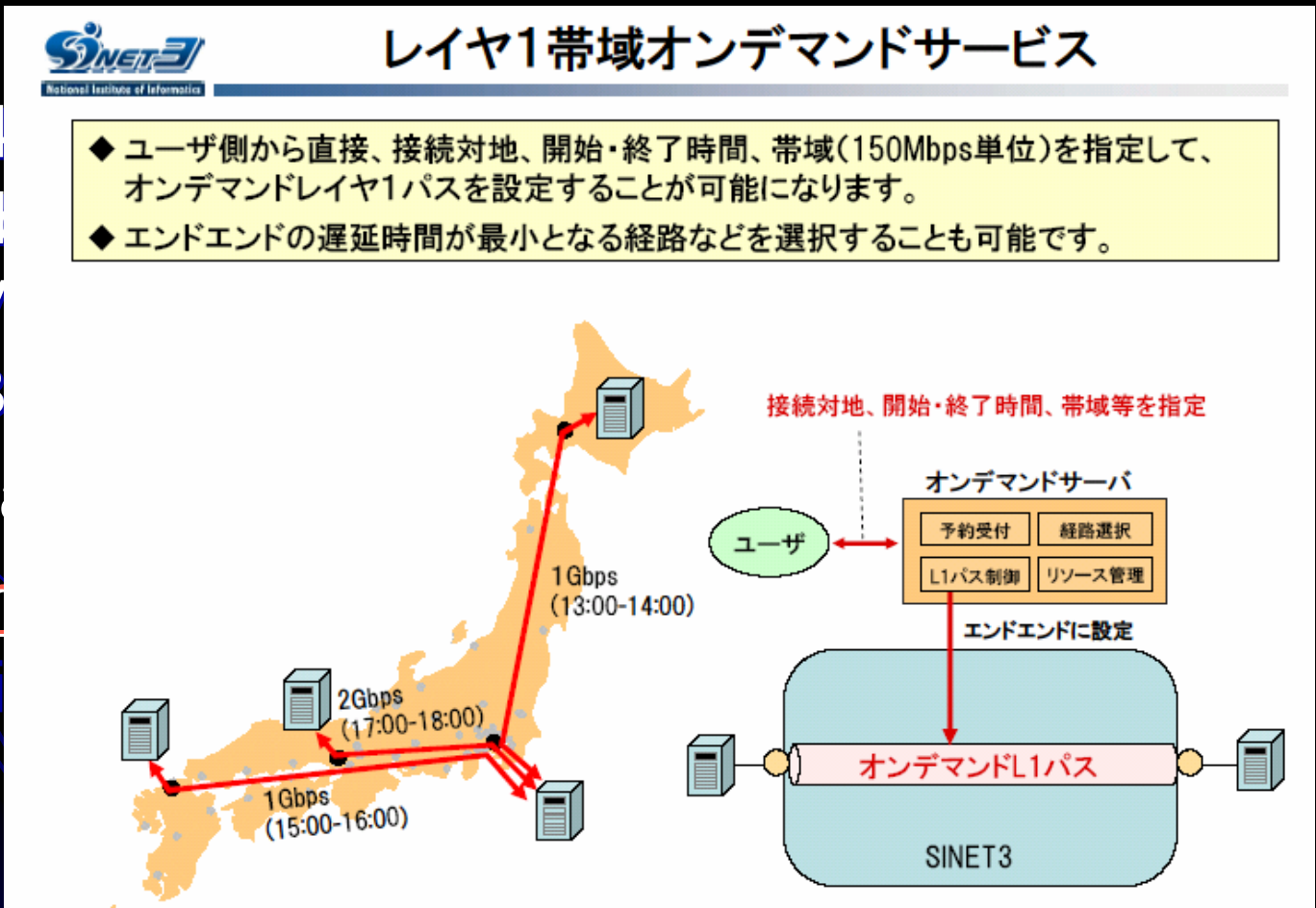
Conflict between Network and VLBI

- Network is assuming Faire users, who shares network bandwidth equally. ex).TCP reduces transmitting rate in congestion condition. Video stream may adjust the rate by changing the compression or resolution of image. Rate control is expected.
- But VLBI cannot change the rate in case of real-time VLBI. “Optimal protocol for VLBI” may defeat other data streams, but it may be criticized and kicked out from network.

⇒Not good for VLBI

Possible Solutions are

- Bandwidth on demand connection
  - Realized by GMPLS and started in operation in SINET3.
- Using Dis
  control…
  realtime V
  basis VLB
  ⇒This m
- Bandwidth
  available i



Thank you for Attention!