Kei-han-na interoperability demonstrations on interworking of inter-carrier ASON/GMPLS network domains

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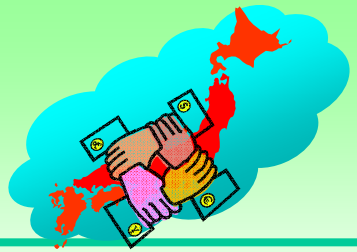
2006 iPOP IP+Optical Network



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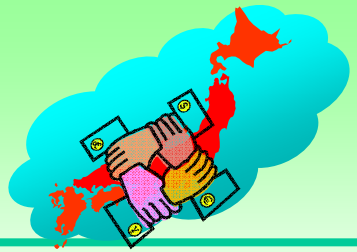
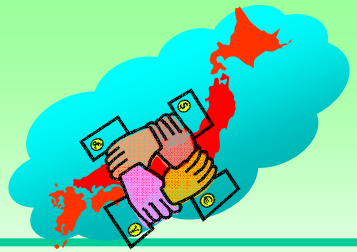
They are a member of the Interoperability WG of the Kei-han-na Info-Communication Open Laboratory

http://www.khn-openlab.jp/bunkakai-gw/kokino-net/sousetsu/index-e.html



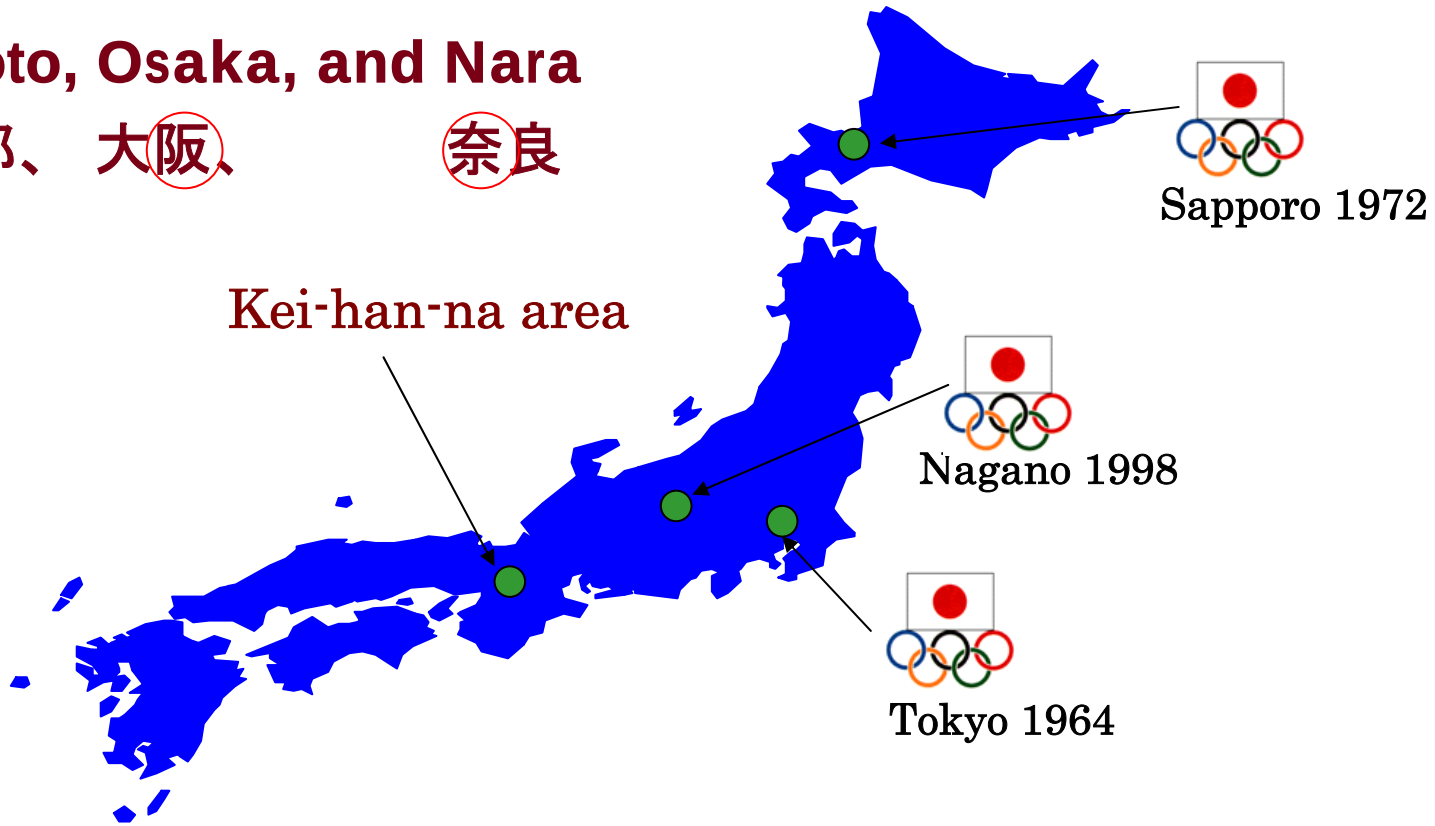
Overview

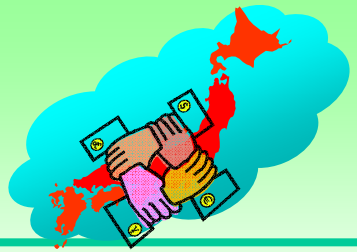
- **Kei-han-na Info-Communication Open Laboratory**
- **Motivation**
  - **Why interworking of multi-carrier ASON/GMPLS network domains is required?**
    - **ITU-T ASON overlay architecture vs. IETF GMPLS peer/overlay architecture**
- **Field Trial of Interworking of ASON/GMPLS domains**
  - **Nationwide scale**
    - **4 operators 7 ASON/GMPLS domains.**
  - **Signaling interworking with ASON E-NNI**
    - **Reachability information exchange among domains.**
    - **RSVP signaling over multiple domains.**
      - ASON to ASON
      - ASON to GMPLS
      - GMPLS to ASON
      - GMPLS to GMPLS
- **Conclusions**



Where is Kei-han-na ?

- **Kei-han-na is located over three prefectures in Japan Kansai area.**
  - **Kyoto, Osaka, and Nara**
  - **京都、 大阪、 奈良**



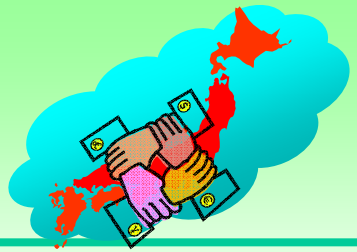


Kei-han-na Info-Communication Open Laboratory Overview

- **The open laboratory was established at 2003 with the objective of carrying out research and development based studies.**
  - **Equipped with research facilities including the high-performance network technology.**
  - **Facilities are available to universities, manufacturers, research laboratories, venture companies, the local governments, etc.**
    - **merge research and development and contribute for providing personnel training to specialists.**

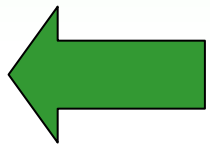
Creating new industries and services

Human resource development

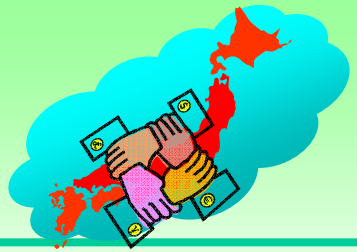


Goal of the Interoperability WG (2003-2005)

- **Verification for inter-connectivity of new inter-Carrier or inter-AS interface (E-NNI).**
  - **GMPLS E-NNI protocols.**
    - **Demonstrated at MPLS 2005.**
    - **Reported in OFC2006 PDP47.**
  - **10GbE over OTN technologies.**
- **Cooperative development from Japan, proposal for international standardize.**
  - **ITU-T, IETF, and OIF.**
- **Extended GMPLS connectivity experiment and construction of the open site.**
  - **Multi-vendor GMPLS interoperability field demonstration reported in OFC2005 PDP40.**

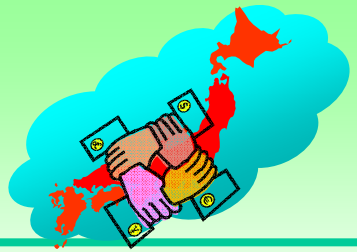


Topics in this presentation



Why interworking of ASON/GMPLS network domains is required?

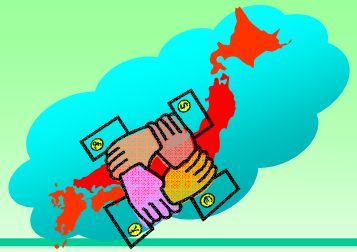
- There are two major slightly different architectures in the GMPLS network world.
  - ITU-T defines ASON architecture
    - GMPLS protocol is used to UNI/I-NNI/E-NNI
    - Heterogeneous technologies/protocols can be used
  - IETF uses GMPLS peer/overlay architectures
    - GMPLS peer: no UNI, no distinct E-NNI
    - GMPLS overlay: UNI, no distinct E-NNI
    - Homogeneous protocols; i.e. IETF GMPLS protocol suit.



Motivation (2/2)

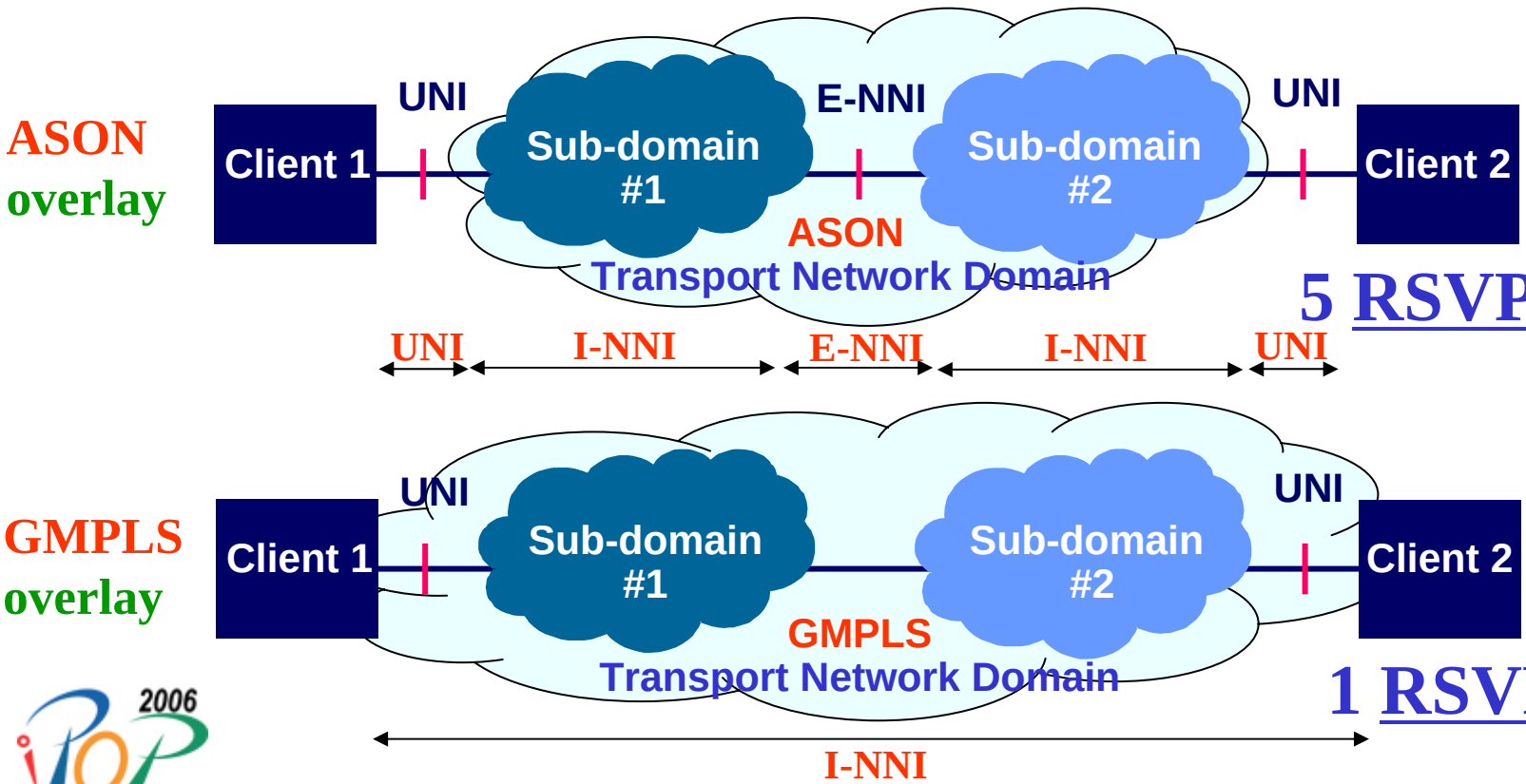
- **The architectural choice of GMPLS networks (ITU-T ASON or IETF GMPLS) differs among carriers.**
  - **Depend on operation policy, vendor selection, market trends, technology trend, …**
- **A seamless end-to-end call set up service over multi-carrier should be provided to all users.**

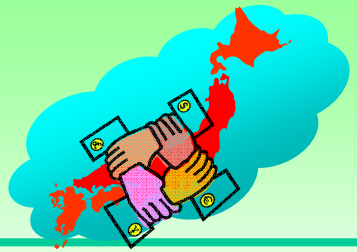
- **Interworking among ASON network domains and GMPLS network domains should be realized.**



What should we solve?

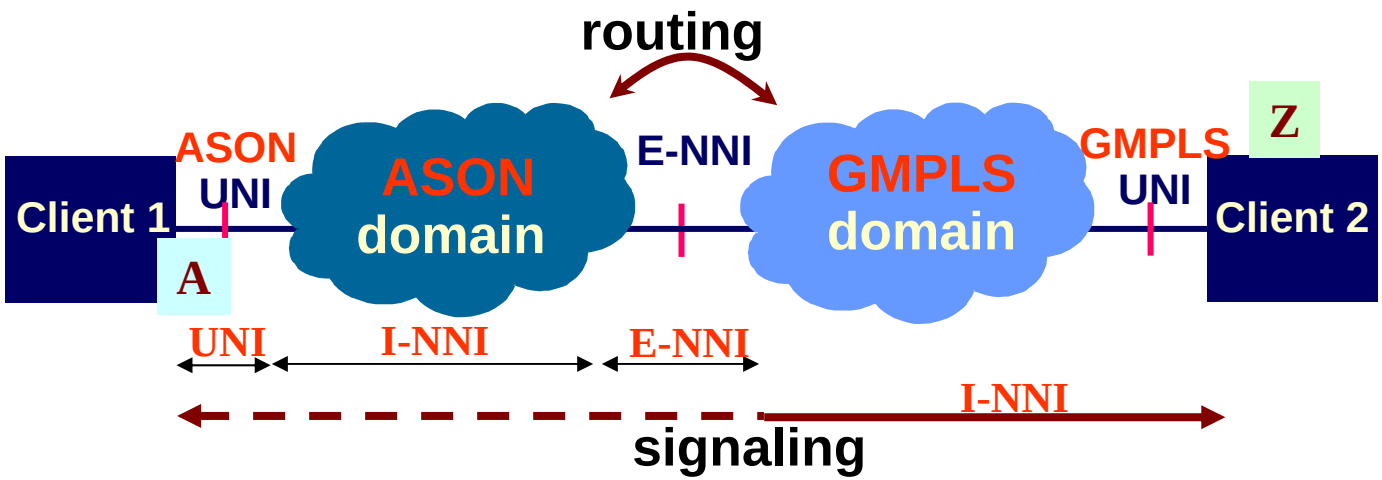
- **Signaling Session**
  - **ASON – Multi-session signaling**
  - **GMPLS – Single session signaling**

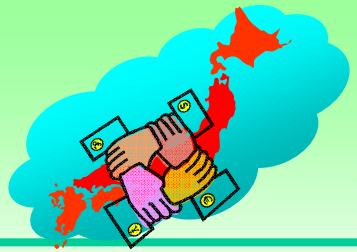




Interworking of ASON and GMPLS

- **Signaling Interworking**
  - Single session should be emulated for GMPLS peer/overlay network domains.
    - Pseudo single session mechanism was implemented to border nodes (E-NNI nodes)
- **Routing Interworking**
  - Reachable addresses should be exchanged among domains.
  - Adaptation information (Switching Capability and Encoding Type) of the end point should be also exchanged.

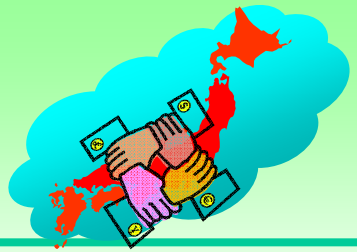




E-NNI Implementation

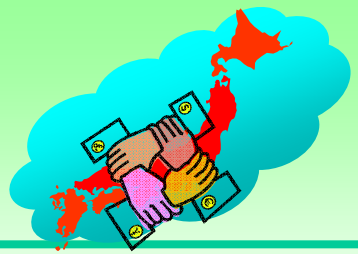
- ASON E-NNI signaling protocol (RSVP-TE)
  - TDM : OIF E-NNI 1.0
  - LSC : modified from OIF E-NNI 1.0
  - Pseudo single session was supported
- Routing protocol (BGP-4)
  - Reachability information (address and adaptation) exchange among BGP peers.
    - Proprietary BGP-4 extension
  - Local reachability information (within the domain) extract from I-NNI OSPF
    - Proprietary OSPF/BGP-4 extension
      - If not supported, manually configured.
  - Summarized reachability information (from other domains) redistribute to I-NNI OSPF.
    - Proprietary OSPF extension
    - OSPF AS-external-LSA is also used for advertising reachability addresses.

OIF OPTICAL INTERNETWORKING FORUM



Features of the field trial

- **4 operators' total 6 ASON and GMPLS network domains**
- **Interworking of PXC based Lambda Switch Capable; LSC network domains as well as TDM network domains**
- **Using ASON E-NNI signaling as an inter-carrier interface**
- **Using BGP based routing protocol as an inter-carrier interface**
- **Interworking between ASON User to Network Interface; UNI and GMPLS Internal Network to Network Interface; I-NNI**
- **Interworking between GMPLS I-NNI and ASON E-NNI**
- **Interworking between GMPLS domains via ASON E-NNI**
- **Call set up between ASON UNI and GMPLS UNI, e.g. interworking between ASON domain and GMPLS domain**



Overview of the Field Trial Network

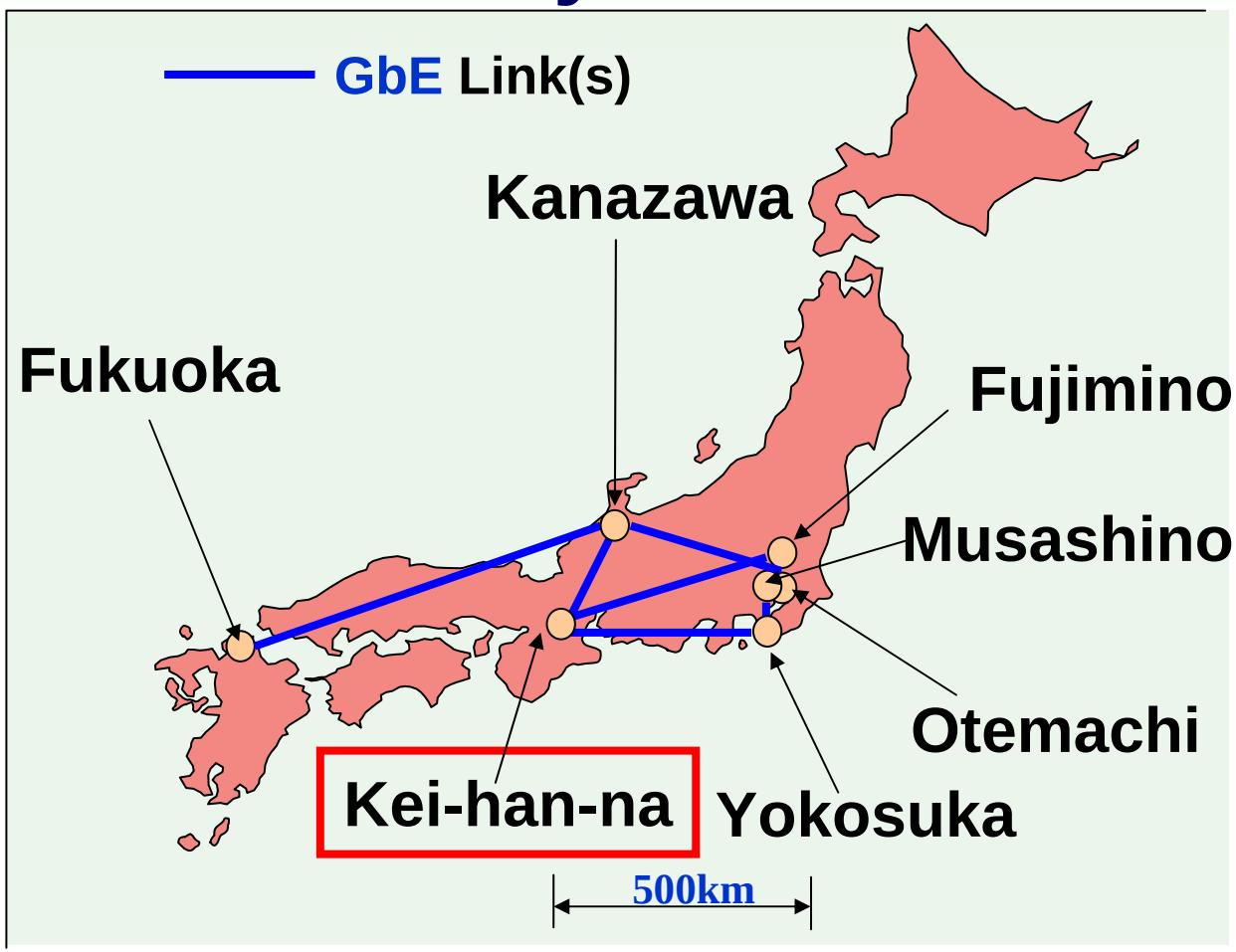
- **7 sites were connected by GbE Links**

NTT ASON
GMPLS

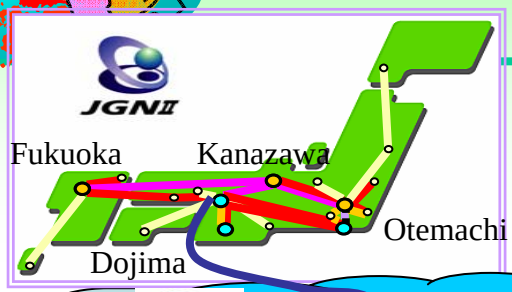
KDDI R&D LABS GMPLS

NiCT ASON
GMPLS

JGNII GMPLS



Detailed trial network configuration (Jan. – Feb. 2006)



JGNII 10G OXC service

1G
2.5G
10G

JGNII Optical testbed service

NiCT ASON
ASON UNI
ASON UNI
ASON PXC
GMPLS PXC
GMPLS PXC
ASON UNI
GMPLS UNI
GMPLS Router
NTT
ASON
GMPLS
KDDI R&D LABS
GMPLS
NiCT
GMPLS PXC
GMPLS XC
GMPLS XC
GMPLS UNI
GMPLS XC
GMPLS
Kei-han-na

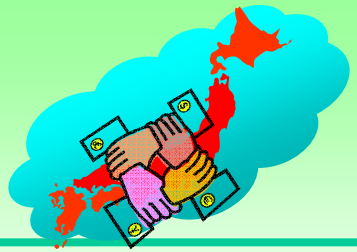
NiCT
Koganei

Otemachi

E-NNI PXC

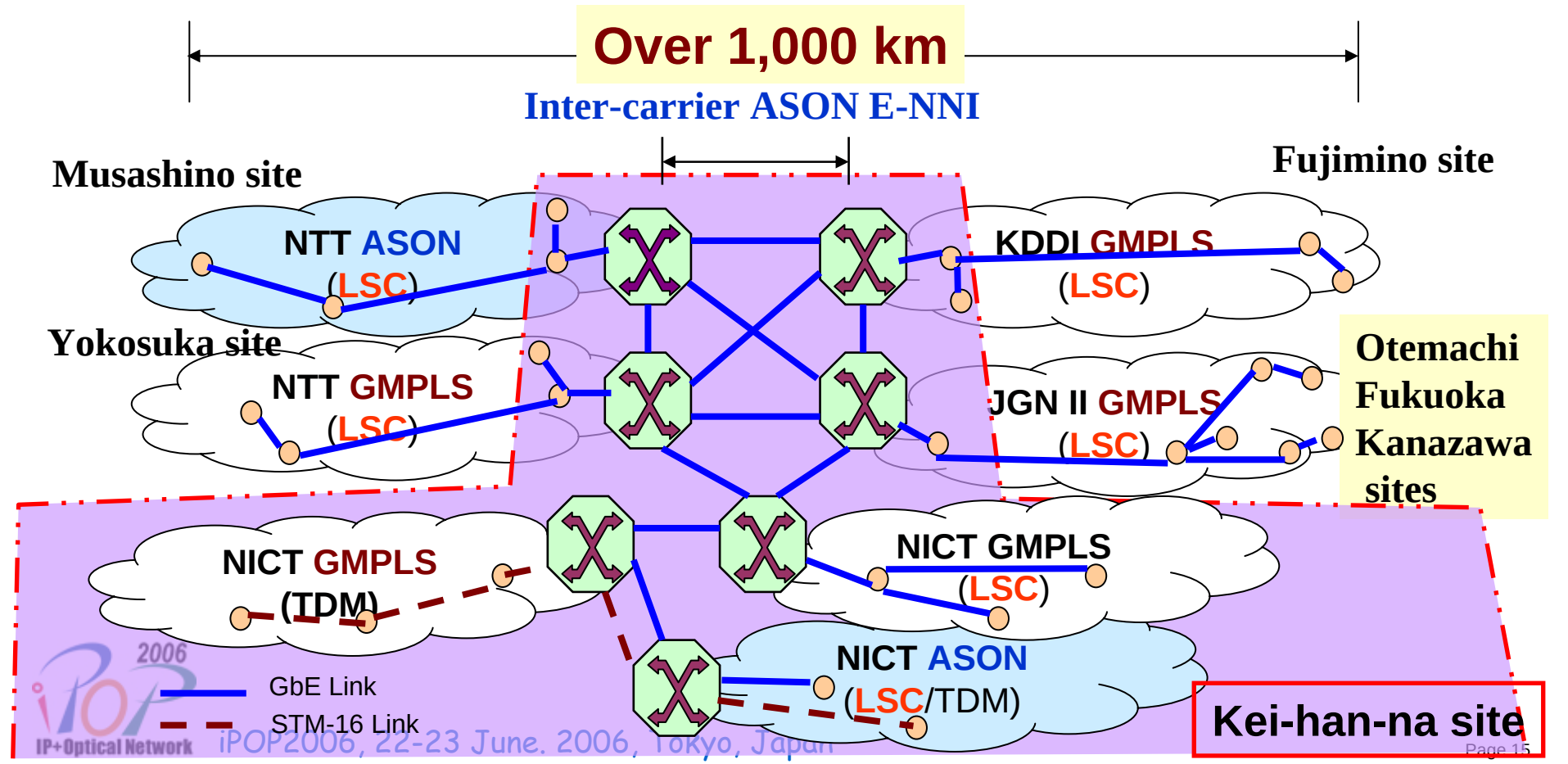
ASON PXC
ASON UNI
GMPLS PXC
GMPLS UNI
GMPLS PXC
GMPLS Router
Musashino
Yokosuka
Fujimino

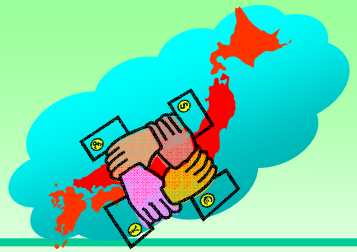
NTT
KDDI R&D LABS



Topology of the Field Trial Network

- **The inter-carrier E-NNI point was constructed at Kei-han-na site**

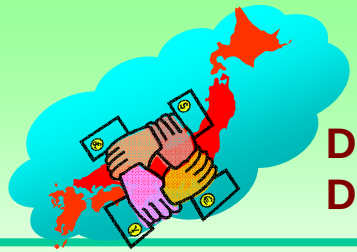




All Results (TDM)

		overlay	peer
	to / from	NICT ASON	NICT GMPLS
over-lay	NICT ASON		OK
peer	NICT GMPLS	NG	

- ASON UNI to GMPLS peer : OK
- GMPLS peer to ASON UNI: NG
  - CSPF in the ingress node could not calculate the route
    - Did not support AS-external route and proprietary extension.

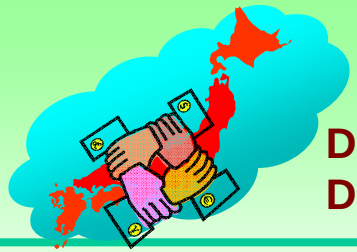


All Results (LSC)

D-P : Data-Plane

		to / from	NICT ASON	NTT ASON	NICT GMPLS	NTT GMPLS	KDDI GMPLS	JGN II GMPLS
overlay	overlay	NICT ASON		OK	OK	OK	---	---
		NTT ASON	---		---	OK With D-P	OK With D-P	NG
overlay	overlay	NICT GMPLS	NG	---		NG	---	---
		NTT GMPLS	---	OK With D-P	---		OK With D-P	NG
peer	peer	KDDI GMPLS	---	OK With D-P	---	OK With D-P		NG
		JGN II GMPLS	---	OK With D-P	---	OK With D-P	OK	

IP+Optical



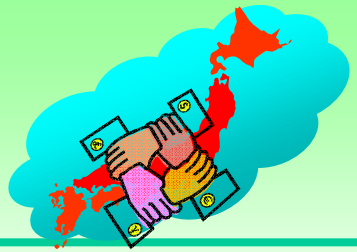
Potential Results (LSC)

D-P : Data-Plane

overlay | overlay | peer

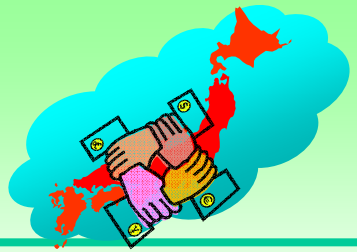
from \ to	NICT ASON	NTT ASON	NICT GMPLS	NTT GMPLS	KDDI GMPLS	JGN II GMPLS
overlay: NICT ASON		OK	OK	OK	OK	NG
overlay: NTT ASON	OK		OK	OK With D-P	OK With D-P	NG
overlay: NICT GMPLS	NG	NG		NG	NG	NG
overlay: NTT GMPLS	OK	OK With D-P	OK		OK With D-P	NG
peer: KDDI GMPLS	OK	OK With D-P	OK	OK With D-P		NG
peer: JGN II GMPLS	OK	OK With D-P	OK	OK With D-P	OK	

IP+Optical



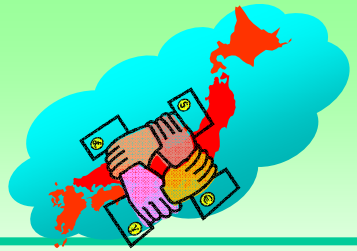
Findings from the experiments

- **Troubles were mainly occurred in the CSPF**
- **Standardization (or agreement) is required**
  - **Intra-domain**
    - **Reachability information should be advertised to E-NNI (border) node(s).**
  - **Inter-domain**
    - **Reachability information should be exchanged among E-NNI nodes.**
  - **From other domains**
    - **Reachability information should be recognized by CSPF.**



Conclusions

- **A field trial of ASON and GMPLS interworking was conducted on a nationwide scale.**
- **Seamless call set up over multi-carrier domains over the distance of 1,000 km or more was successfully achieved.**
- **Demonstrated interworking operation is expected to relax the choice of the adopted GMPLS network model for carriers.**
- **We can accelerate deployment of ASON and GMPLS networks.**



Acknowledgement

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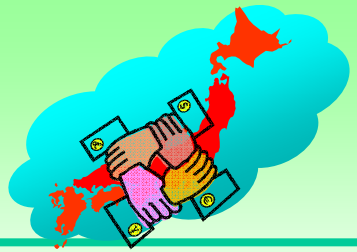
- The authors are grateful to members of the interoperability working group for their cooperation.
- Special thanks are directed to Prof. Naoaki Yamanaka (Keio University), Dr. Masatoshi Suzuki (KDDI R&D Labs.), and Dr. Fumito Kubota (NICT).



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