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Resource Allocation and Provision for Bandwidth/Networks on Demand in SINET3

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Agenda

1. **Network Service Features in SINET3**
2. Network Architecture and Networking Functions
3. Bandwidth/Networks on Demand Capabilities
4. Evaluation and Demonstration Results
5. Conclusion

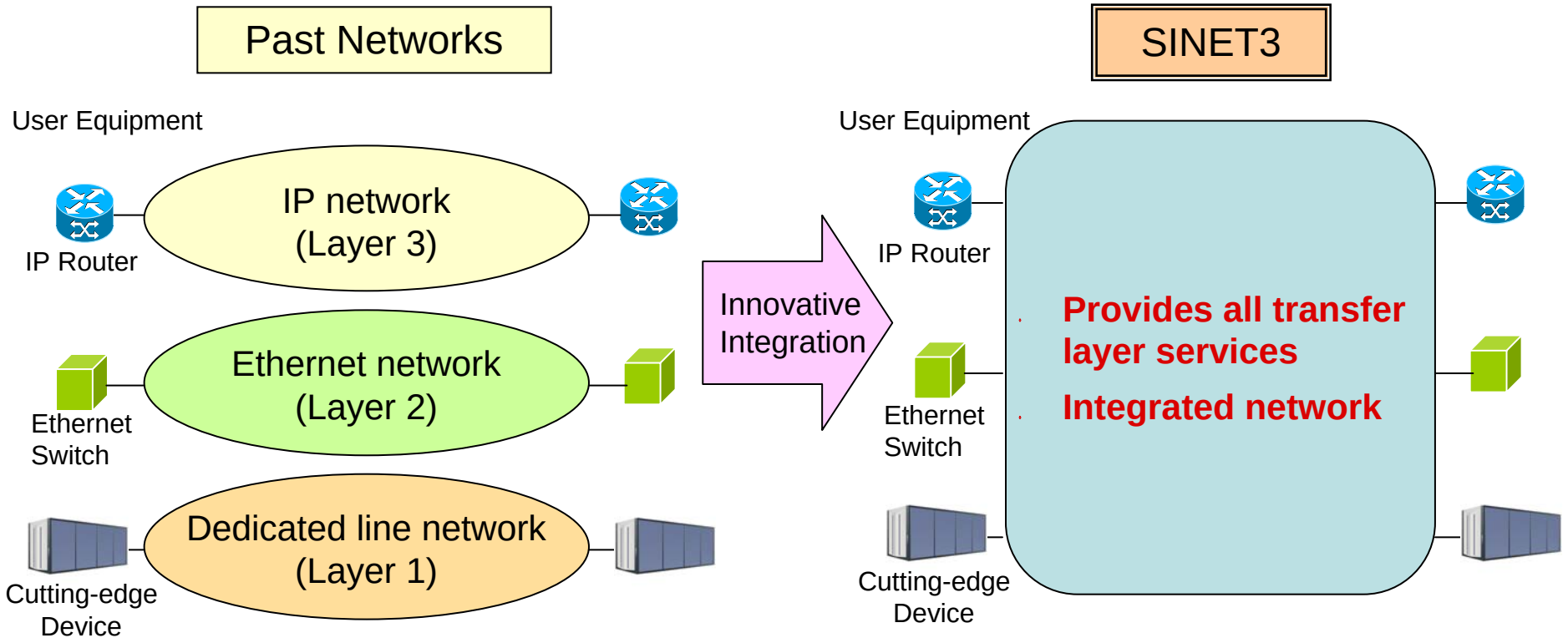
Service Features in SINET3

- SINET3 is the new Japanese academic backbone network for more than 700 universities and research institutions, providing a rich variety of services.
- SINET3 emphasizes four service aspects: transfer layer, virtual private network (VPN), quality-of-service (QoS), and bandwidth on demand.

Services	Examples
Multiple Layer Services	• L3 (IP), L2 (Ethernet), & L1 (dedicated line)
Enriched VPN Services	• Support for collaborative research among distant sites with closed user group environment
Enhanced QoS Services	• Support for performance-sensitive applications
Bandwidth-on-demand (BoD) Services	• Support for data-intensive applications

Multiple Layer Services

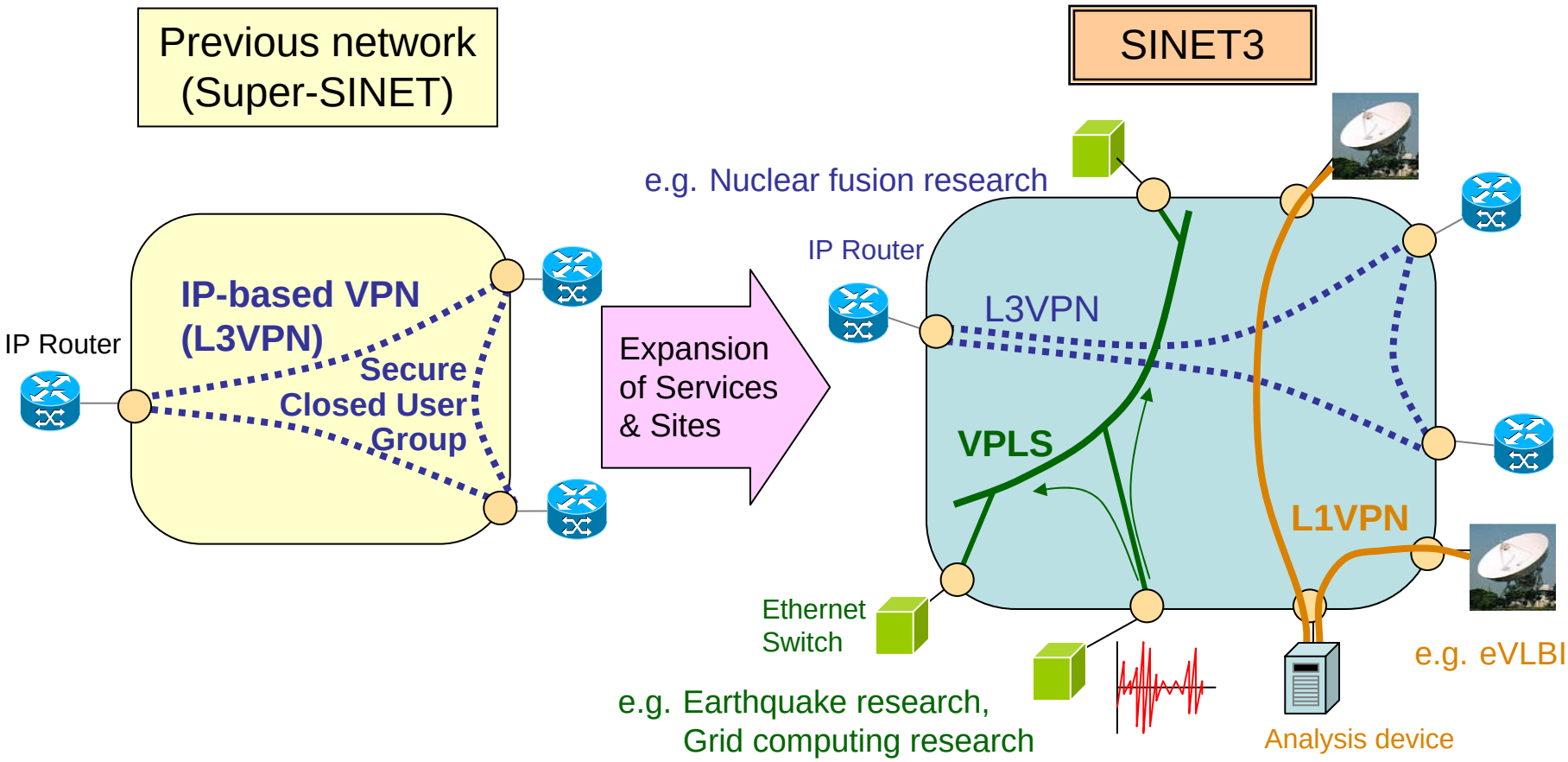
- SINET3 provides all transfer layer services on a single network platform.
- Users can freely choose the best transfer layer for their applications.
- It flexibly assigns network resource for ever-changing and unpredictable service demands.



Multiple VPN Services

- For collaborative research activity: closed user group environment (virtual private network: VPN) is essential for security reasons.
- Users can choose from L3VPN (IP), L2VPN/VPLS (Ethernet), and L1VPN services.

* Virtual Private Network (VPN); Virtual Private LAN Service (VPLS)

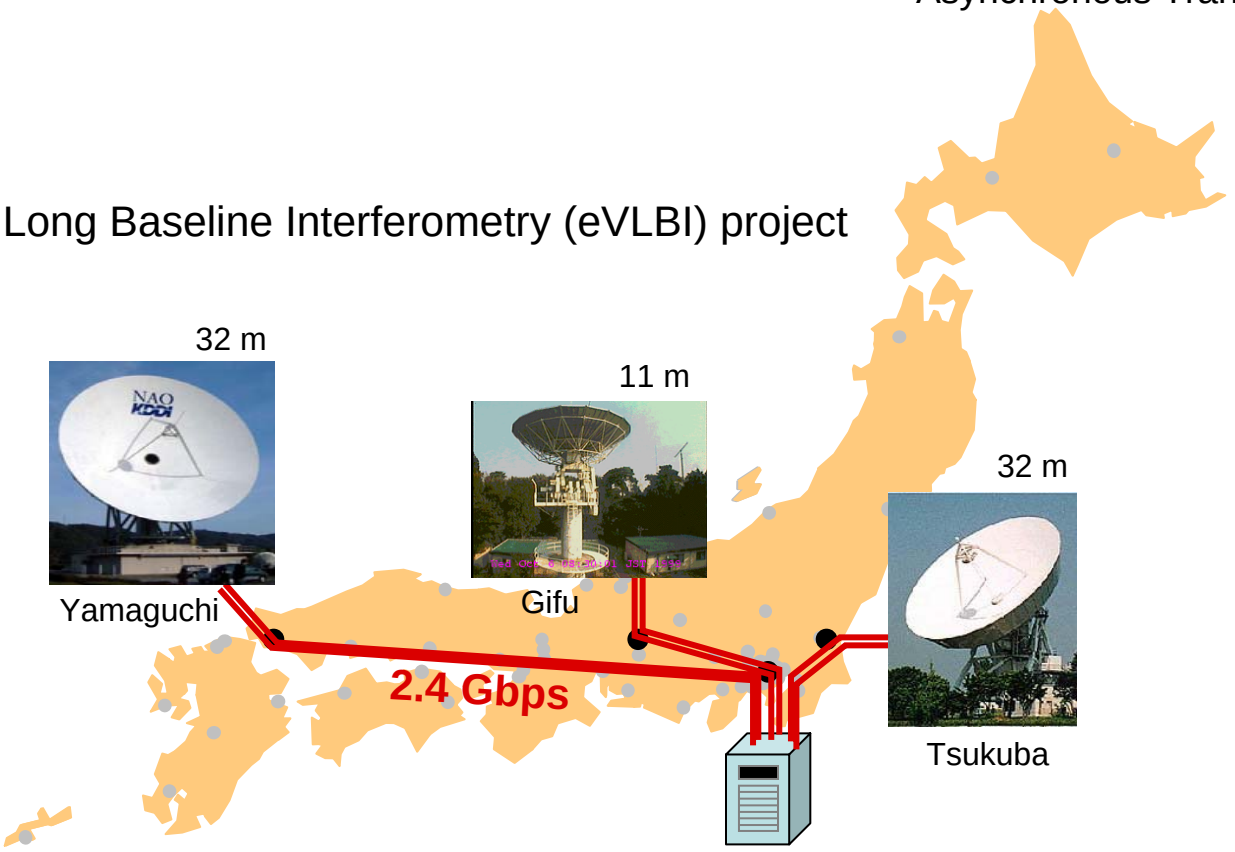


L1VPN (Layer-1 VPN)

- L1VPN is formed by dedicated lines among specified sites over shared platform.
- Users can obtain protocol-free and completely exclusive environment.
- eVLBI project utilizes this environment to form a virtual large telescope and transfer constantly-flowing ATM data through STM-16 interfaces.
- This services is provided along with on-demand capabilities.

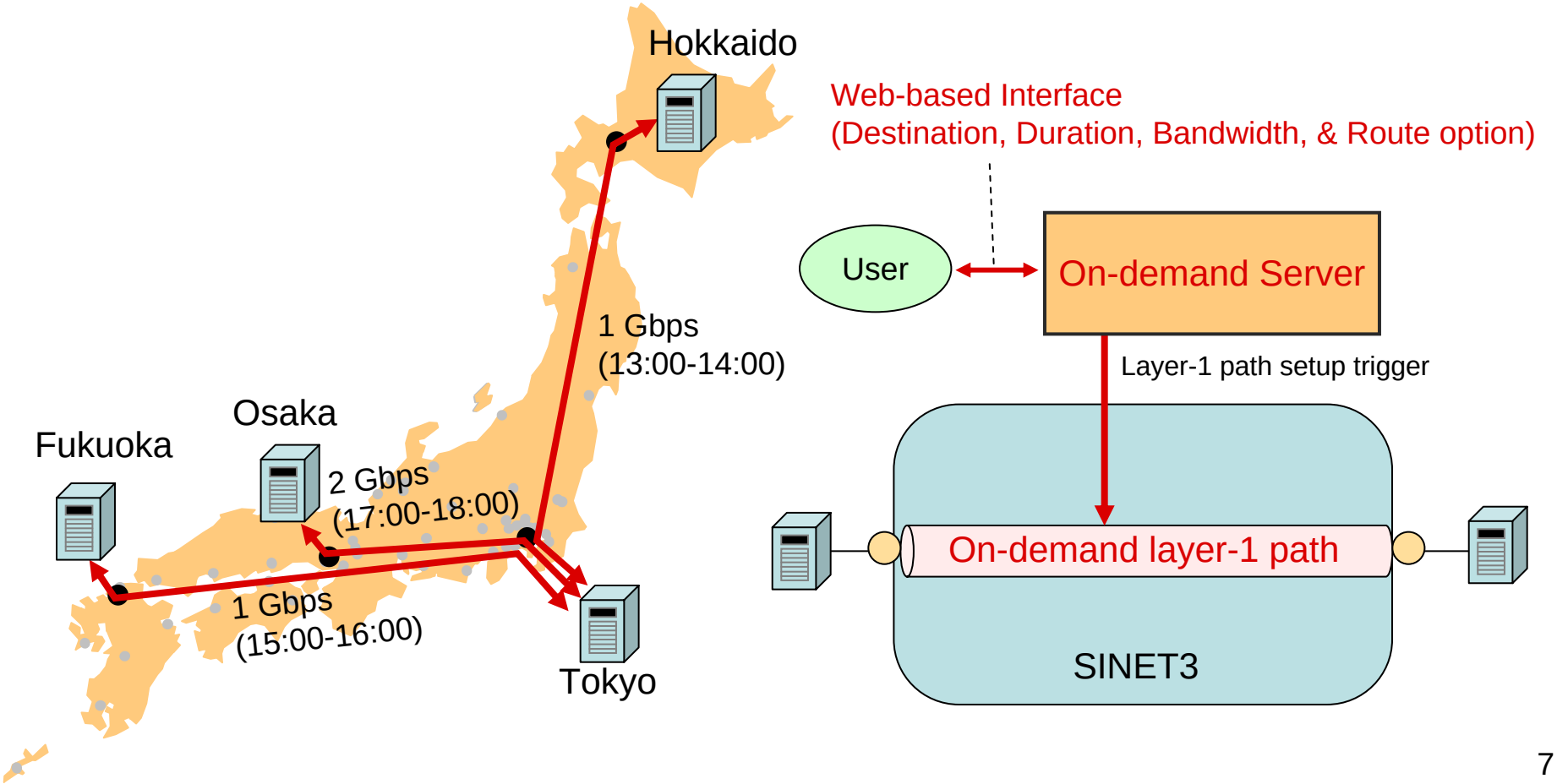
* Asynchronous Transfer Mode (ATM)

e.g. e-Very Long Baseline Interferometry (eVLBI) project



Bandwidth on Demand (BoD) Services

- SINET3 provides bandwidth-on-demand (BoD) services as part of layer-1 services.
- Users can specify the destinations, duration, bandwidth with granularity of about 150Mbps, and route option.
- BoD server receives path setup requests from users, calculates the appropriate routes, schedules accepted reservations, and triggers layer-1 path setup.



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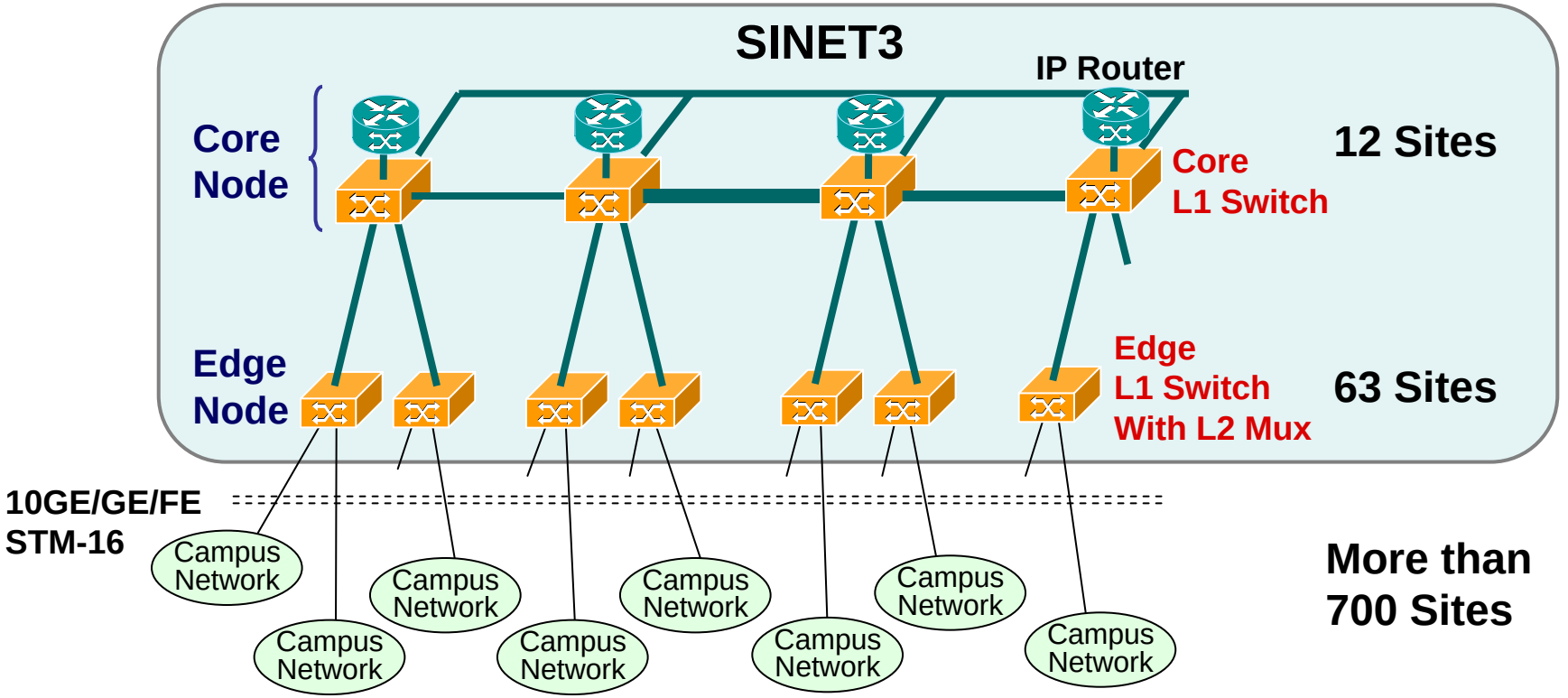
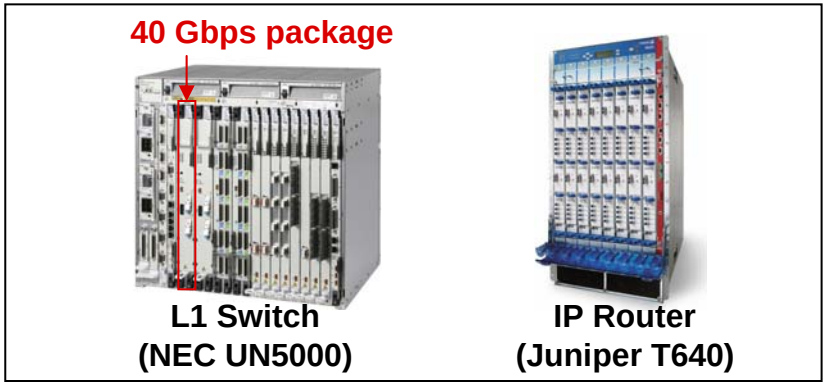
Network Structure of SINET3

- In order to accommodate more than 700 campus networks, the network has 63 edge nodes, which are located at selected universities etc. and composed of edge layer-1 switches with layer-2 multiplexing.
- The network has 12 core nodes, which are located at public data centers and are composed of high-end IP routers and core layer-1 switches.
- This architecture reduces the network cost by lessening the number of IP routers.



Network Topology of SINET3

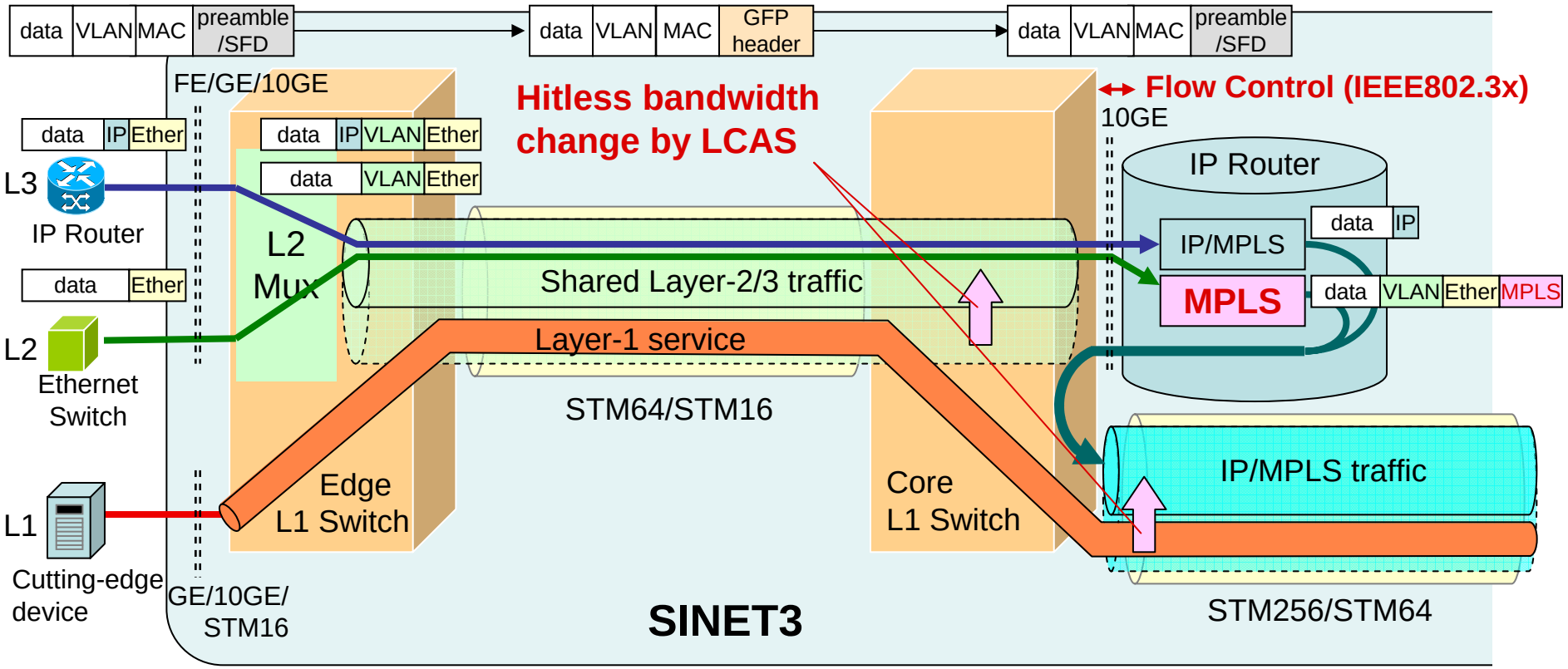
- Has 63 edge nodes and 12 core nodes (75 layer-1 switches and 12 IP routers).
- Deploys Japan's first 40 Gbps lines between Tokyo, Nagoya, and Osaka.
- Links form three loops in backbone to enable quick service recovery against link and node failures and for efficient use of network bandwidth.



Accommodation of Multi-layer Services

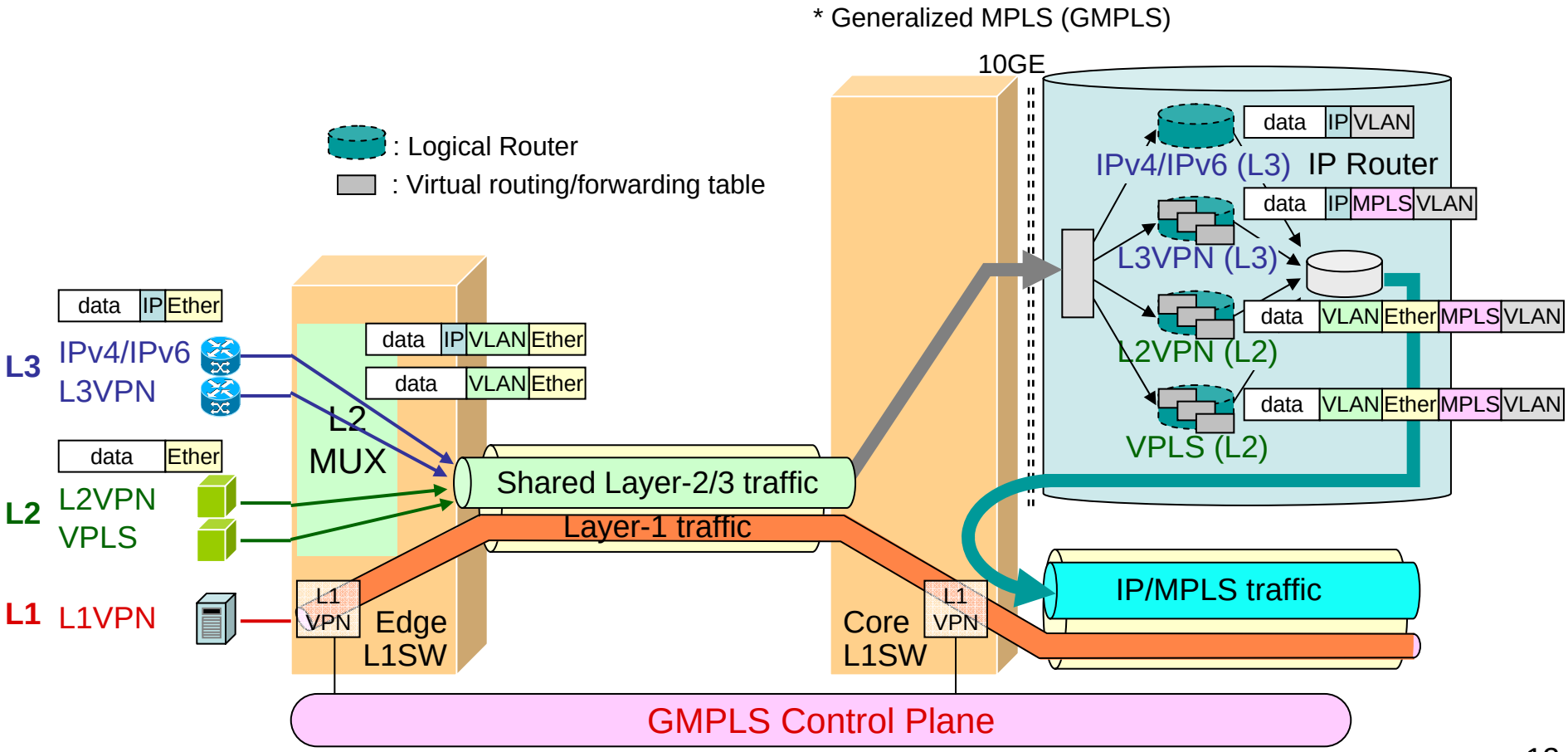
- L3 and L2 traffic are accommodated in shared bandwidth by L2 multiplexing and transferred to IP router, where each traffic is encapsulated with MPLS labels as needed.
- L1 service is assigned dedicated bandwidth and separated from L2/3 traffic.
- L2/3 traffic bandwidth can be hitlessly changed by LCAS for flexible accommodation of multi-layer services. For adjusting L2/3 traffic to assigned bandwidth, we use a flow control using PAUSE frames between layer-1 switch and IP router.

* Multi-protocol Label Switching (MPLS); Link Capacity Adjustment Scheme (LCAS)



Accommodation of Multi-VPN Services

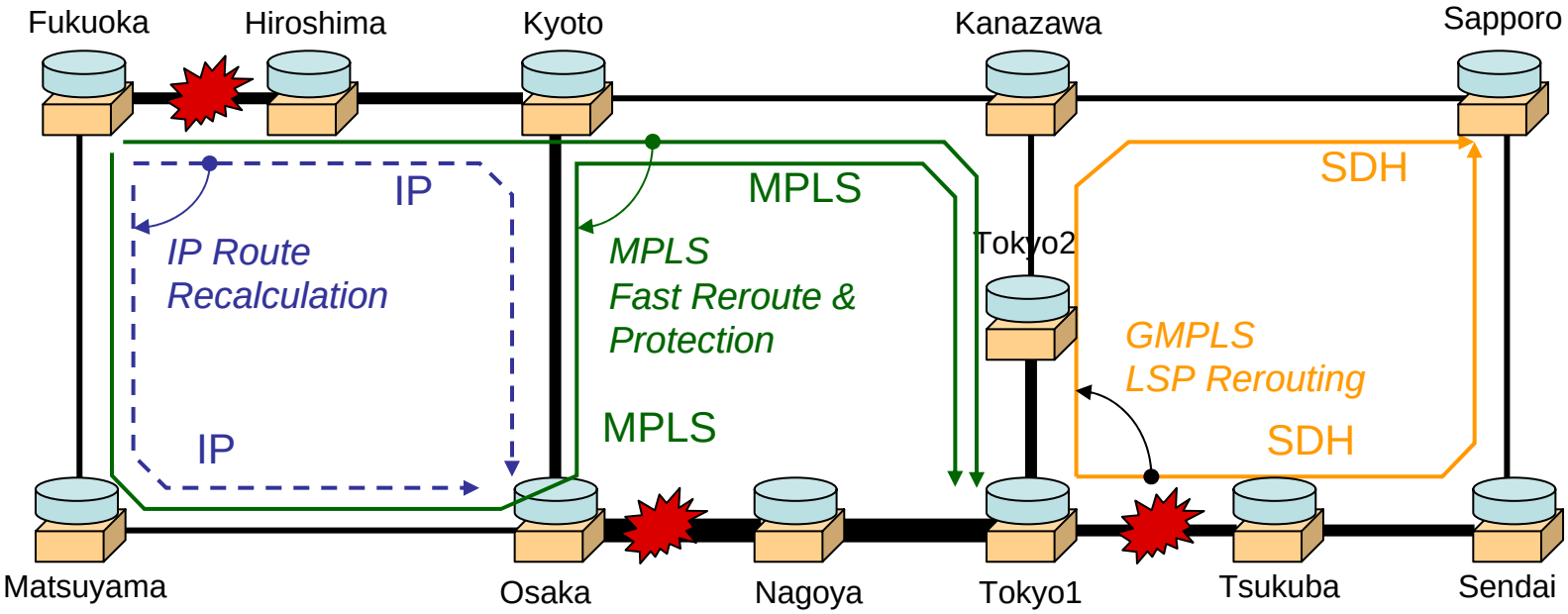
- L3VPN, L2VPN, and VPLS as well as IPv4/IPv6 dual stack are logically separated by internal VLAN tags and logical routers. Neighboring logical routers of each service are connected to each other with logical interfaces (i.e. VLANs).
- L1VPN and on-demand services need GMPLS protocols to set up layer-1 paths and have separate control planes from that of IP routers.



High-availability Networking Functions

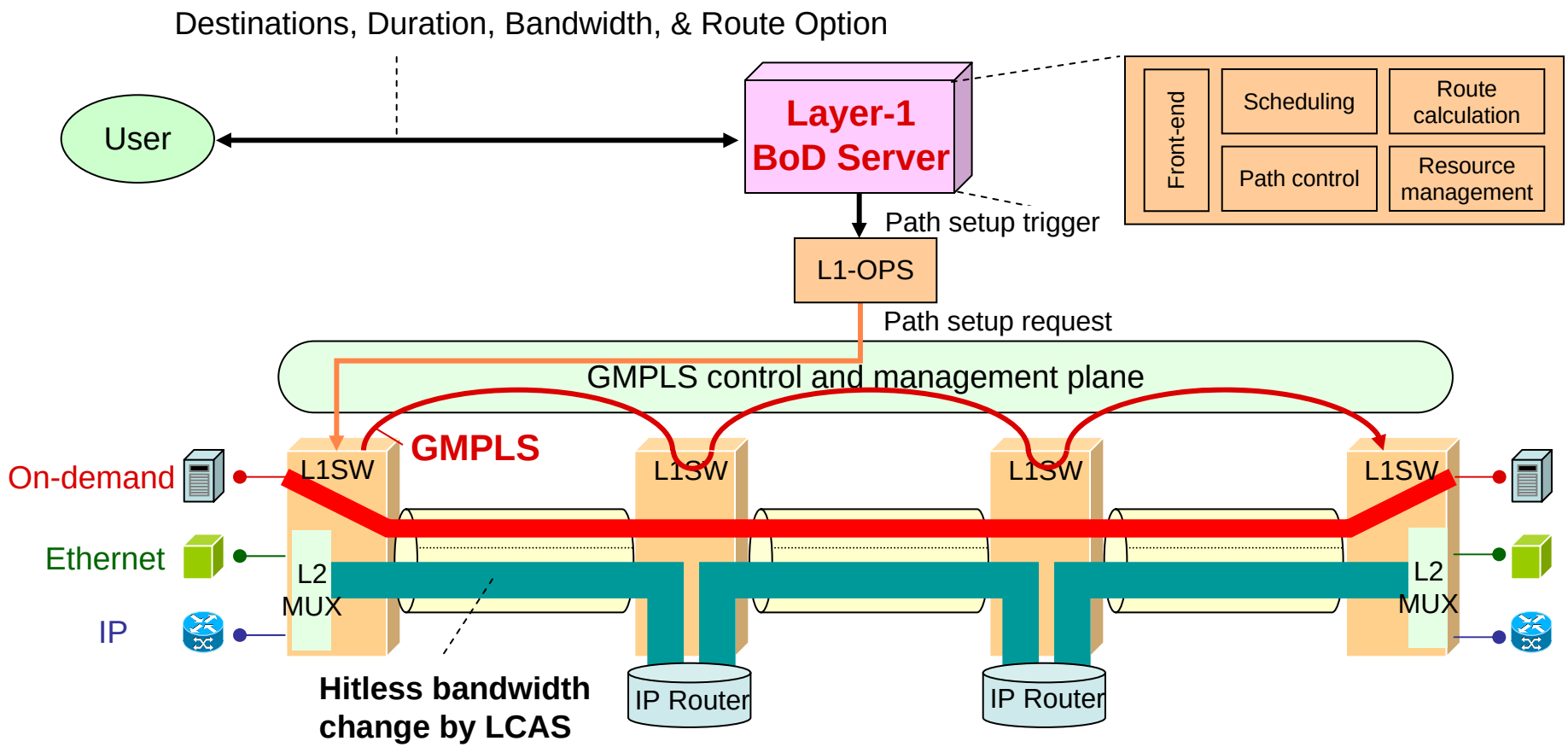
- Multiple loops easily enable multi-layer traffic to be detoured in different directions.
- Layer-1 switches detect link failures very quickly and inform them to neighboring layer-1 switches and IP routers.

Criteria \ Service	IPv4/IPv6	L3VPN, L2VPN, VPLS	L1VPN, On-demand
No. of users	Very large	Small to medium	Small
Priority of availability	Highest	High	Medium
HA function (normal)	**IP route recalculation**	**MPLS protection & Fast Reroute**	None
HA function (option)	-	-	**GMPLS LSP Rerouting**



Architecture for BoD Services

- BoD server receives reservation requests, performs path calculation, schedules accepted requests, and triggers layer-1 path setup to source layer-1 switch.
- Source layer-1 switch sets up layer-1 path toward destination using GMPLS.
- BoD server changes L2/L3 traffic bandwidth by LCAS via L1-OPS as needed.



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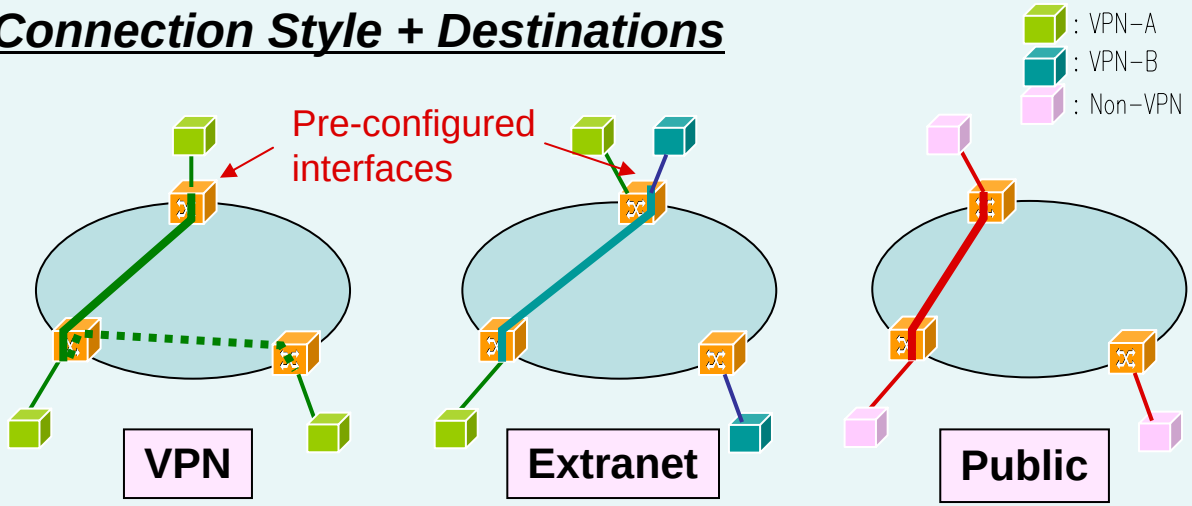
Service Parameters of L1 BoD Services

◆ BoD server allows users to specify connection style + destinations, duration, bandwidth, & route option via Web-based interface.

Connection Style + Destinations

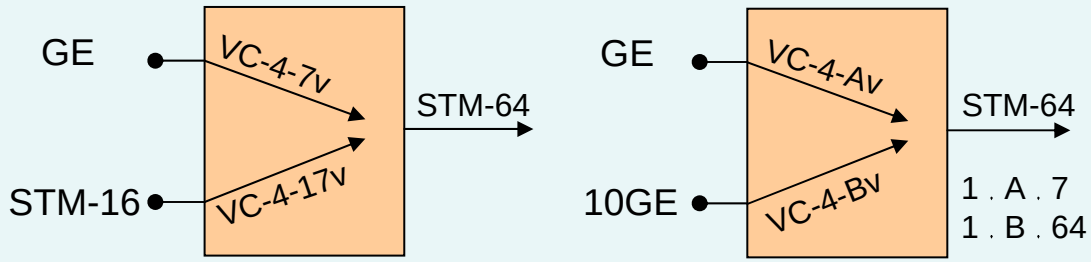


Duration

- Start Time
  &
- Finish Time
  (in 15 minute intervals)

Bandwidth

VC-4 Granularity (approx. 150 Mbps)



Lambda (Full bandwidth)

Bandwidth-specified

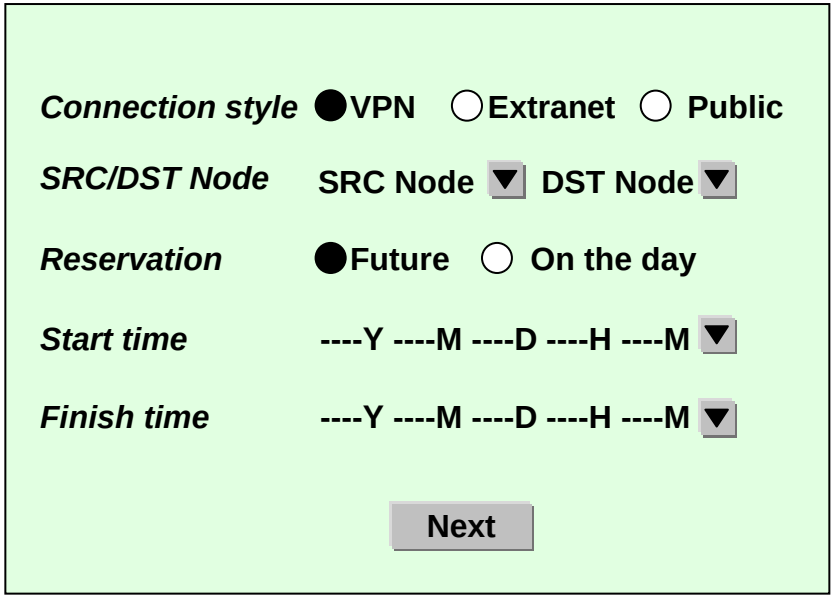
Route Option

- "Minimum Delay"
  or
- "Unspecified"

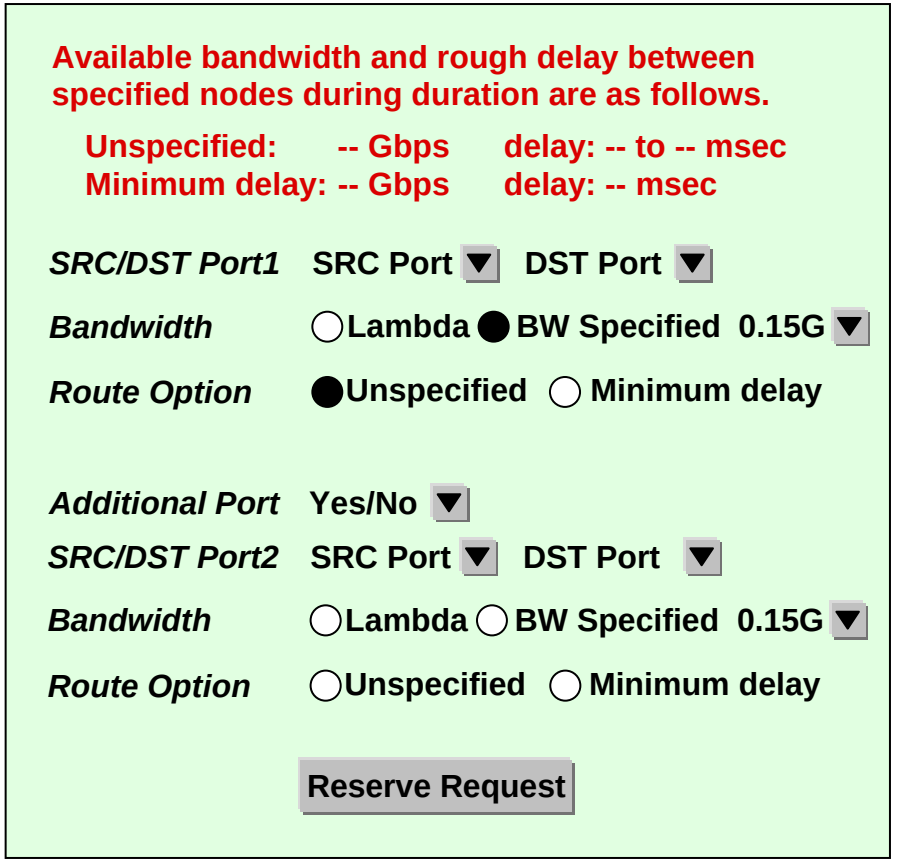
Web Screen Images for Path Reservation Request

- First, users input connection style, ingress/egress nodes, and duration.
- Next screen indicates available bandwidths and the rough delays. By referring to the availability, users input source/destination ports, bandwidth, and route options.

Web Screen Image (1)

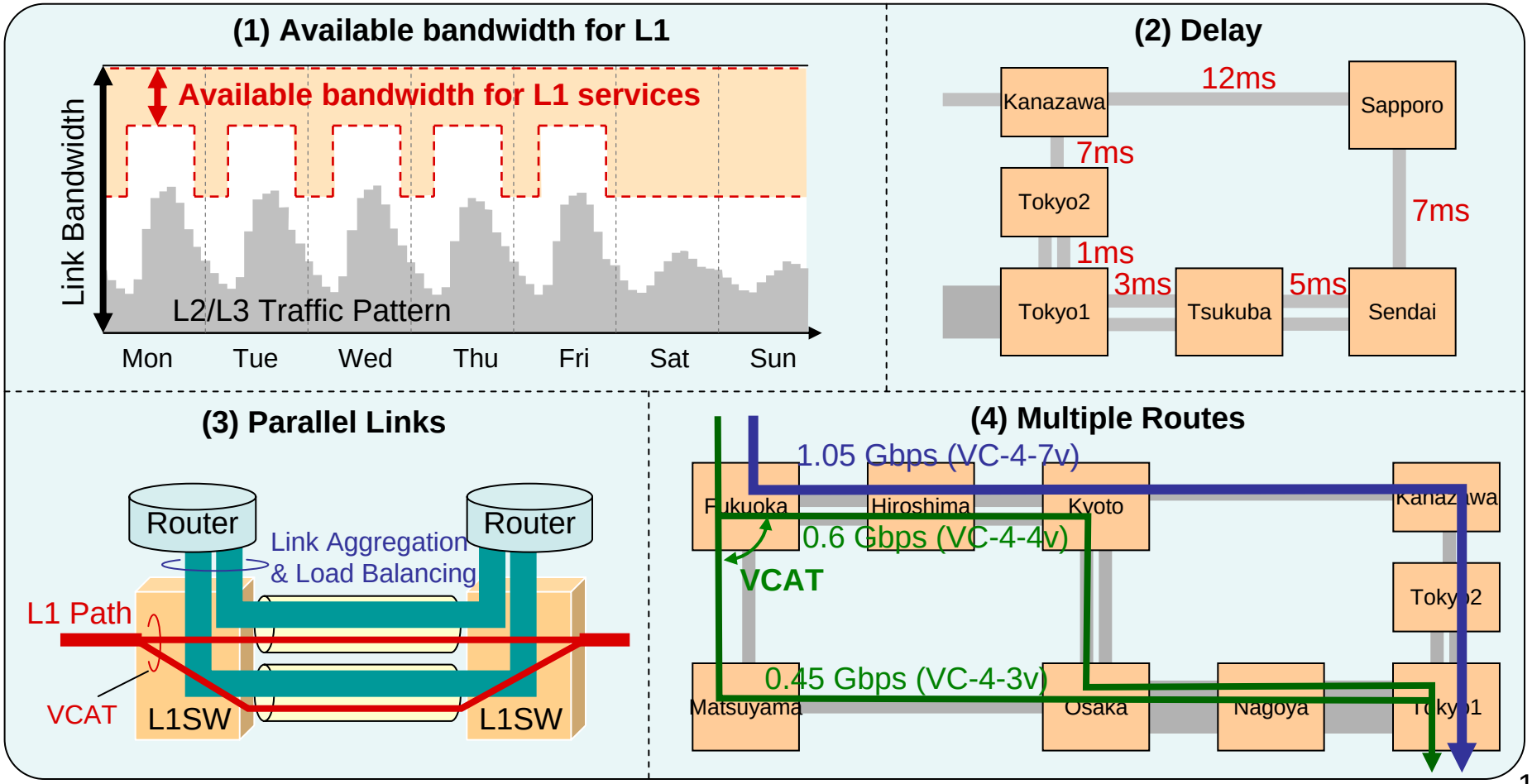


Web Screen Image (2)



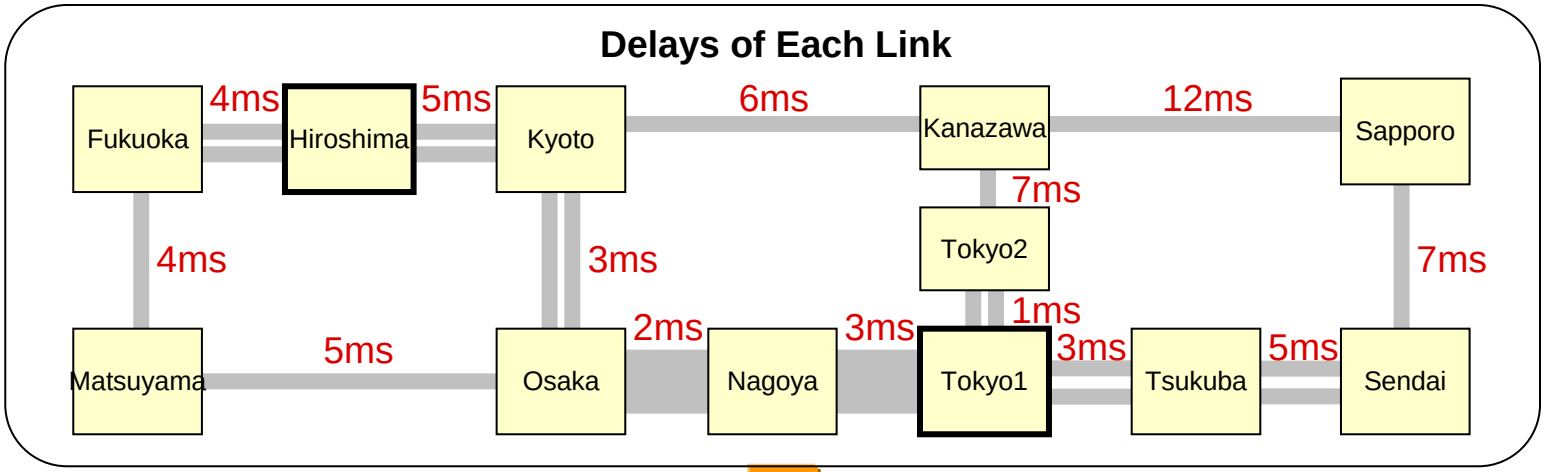
Considerations on Path Calculation

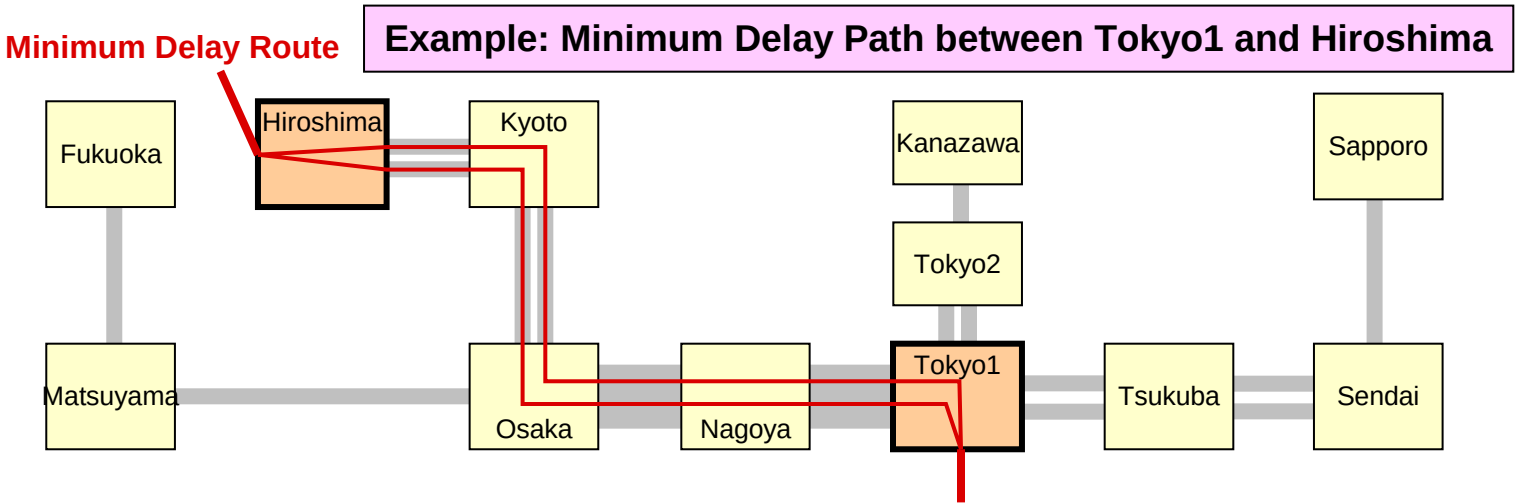
- BoD server selects path (route and links) by taking into account following conditions.
  - (1) Each link has different available bandwidth for L1 services which varies over time.
  - (2) Each link has different delay which is a fixed value.
  - (3) There are parallel links between core nodes.
  - (4) There are multiple routes between source and destination nodes



Example of Path Selection for “Minimum Delay”

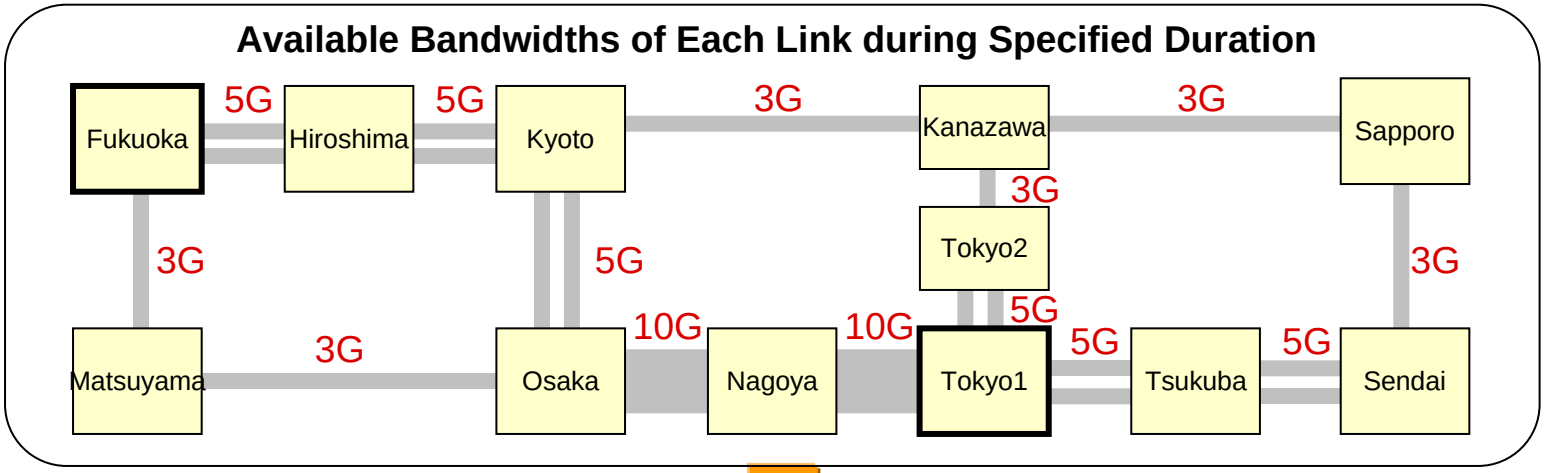
- The path for end-to-end minimum delay is calculated by using delays of each link and uniquely selected.
- Parallel links are usually used to get the total necessary bandwidth.



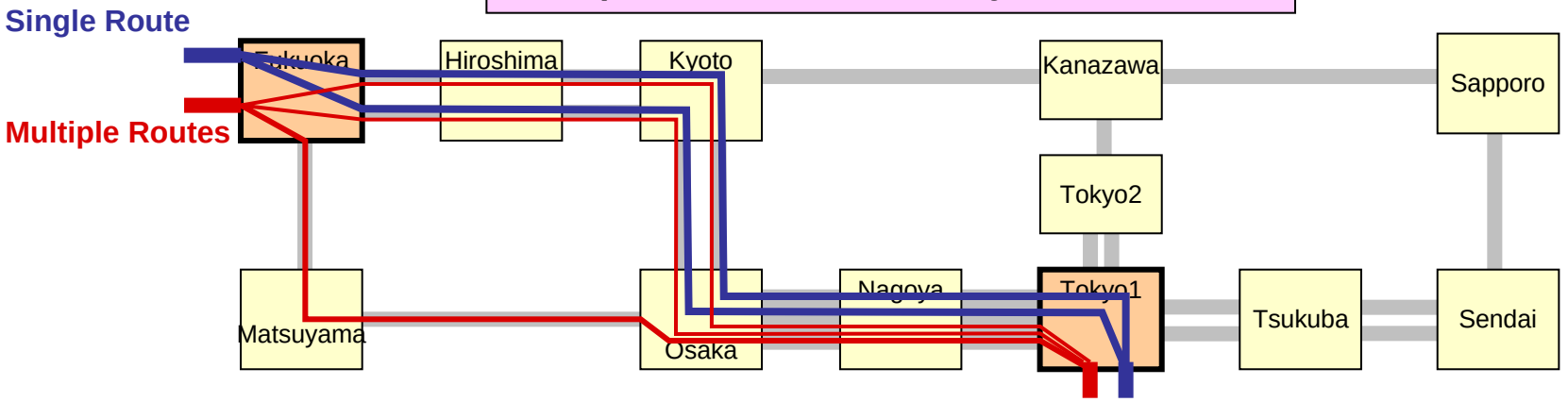


Example of Path Selection for “Unspecified”

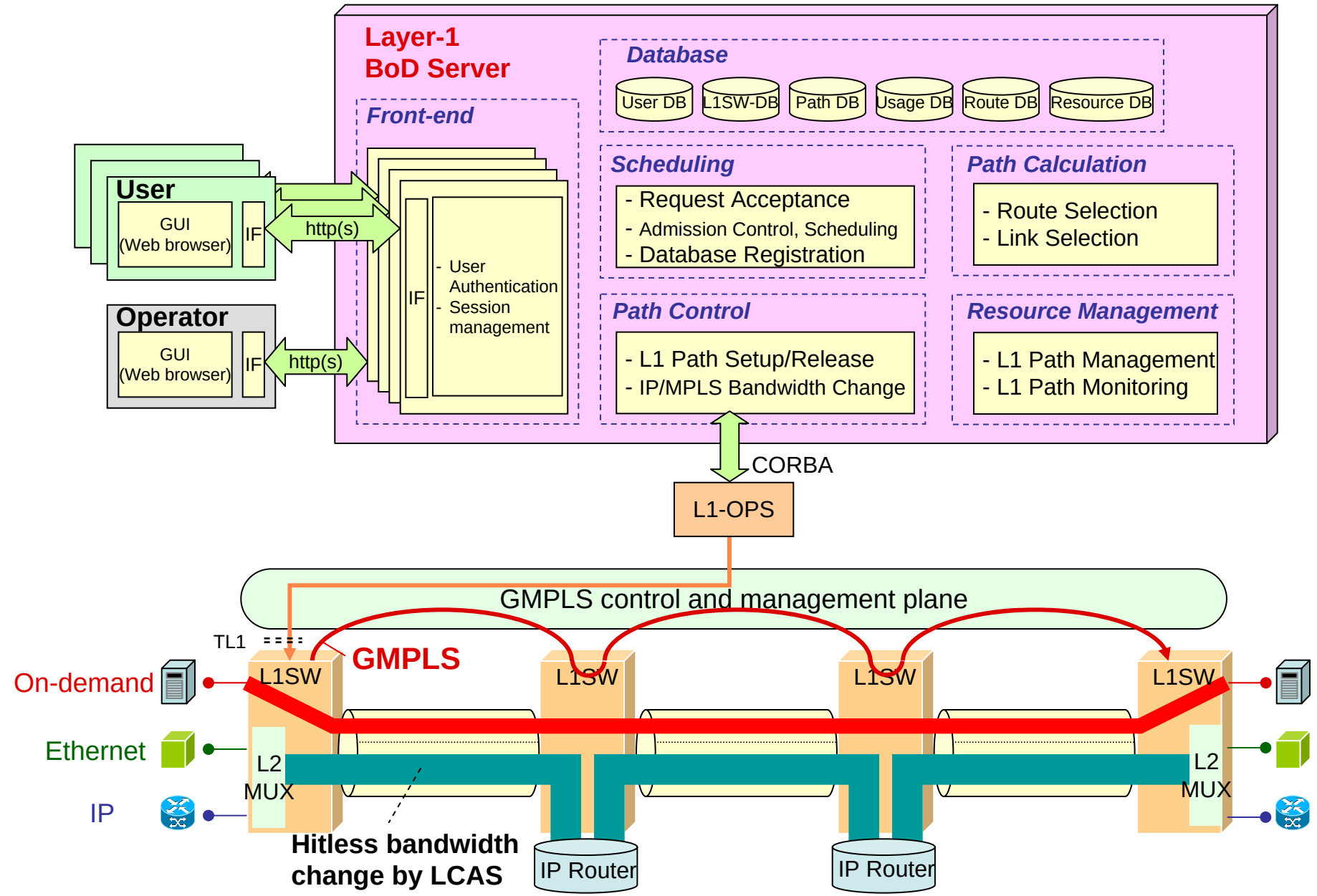
- The path for “unspecified” is calculated using available bandwidth for L1 services of each link and single route having largest available bandwidth is preferentially selected.
- If there are no appropriate single routes, multiple routes using VCAT can be selected.



Example: Paths between Tokyo1 and Fukuoka



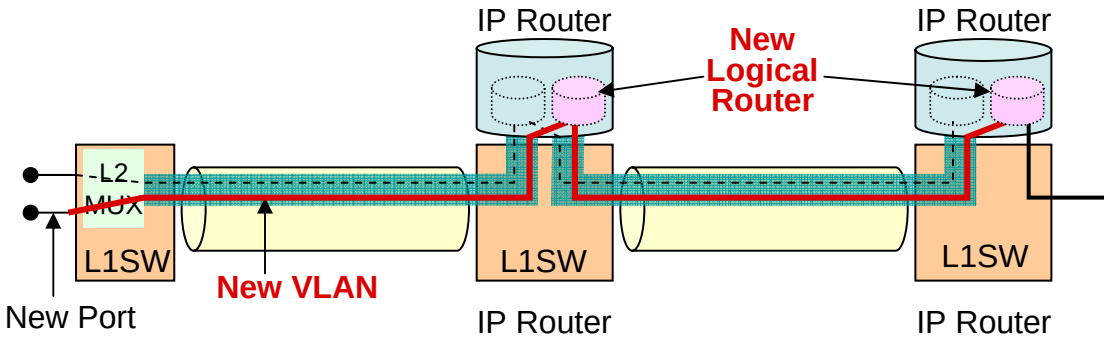
Functions of BoD Server (Summary)



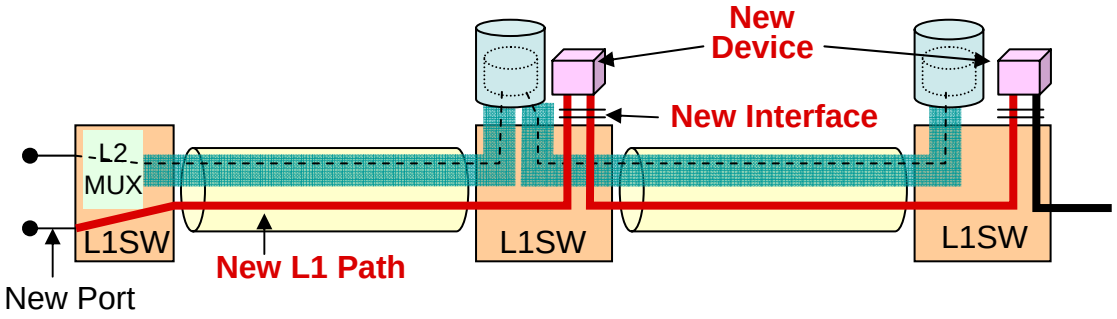
Networks on Demand in SINET3

- SINET3 flexibly provides network services by combining VLANs, logical router capabilities of IP routers, and LCAS capabilities of L1 switches.
- These capabilities can also be used to create a new logical service network for a new service or an experimental network environment.

When a new service capability can be attained by using logical routers



When we install new devices at the core sites



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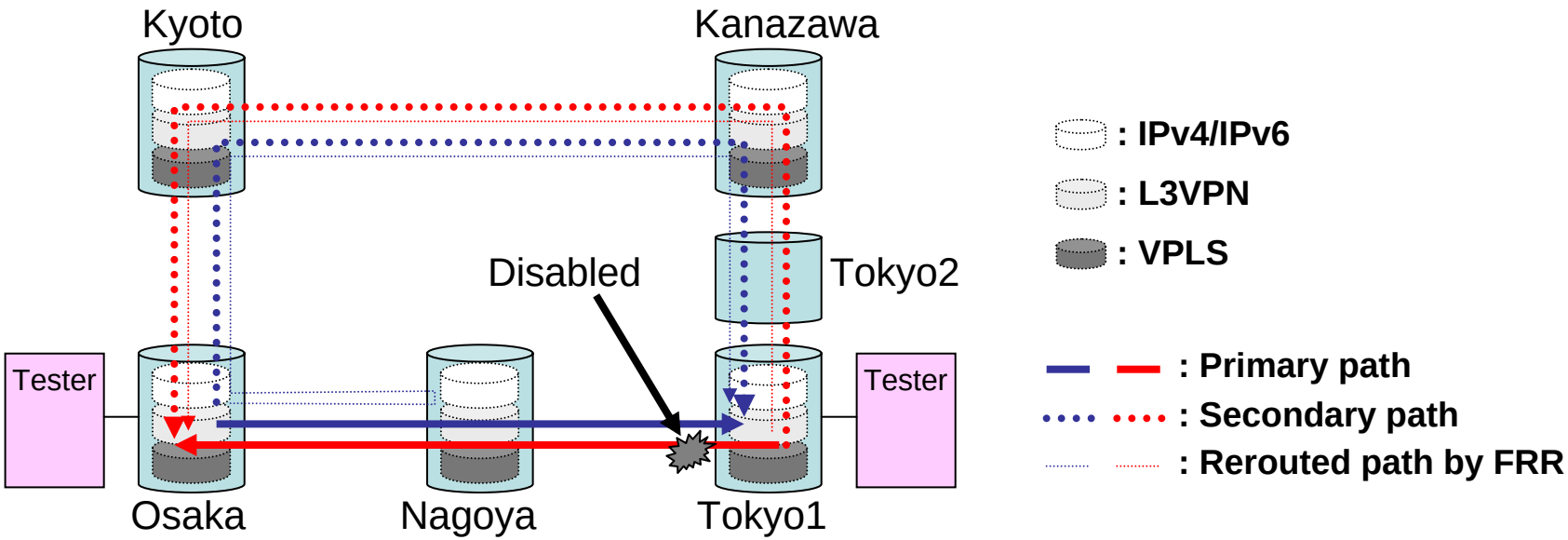
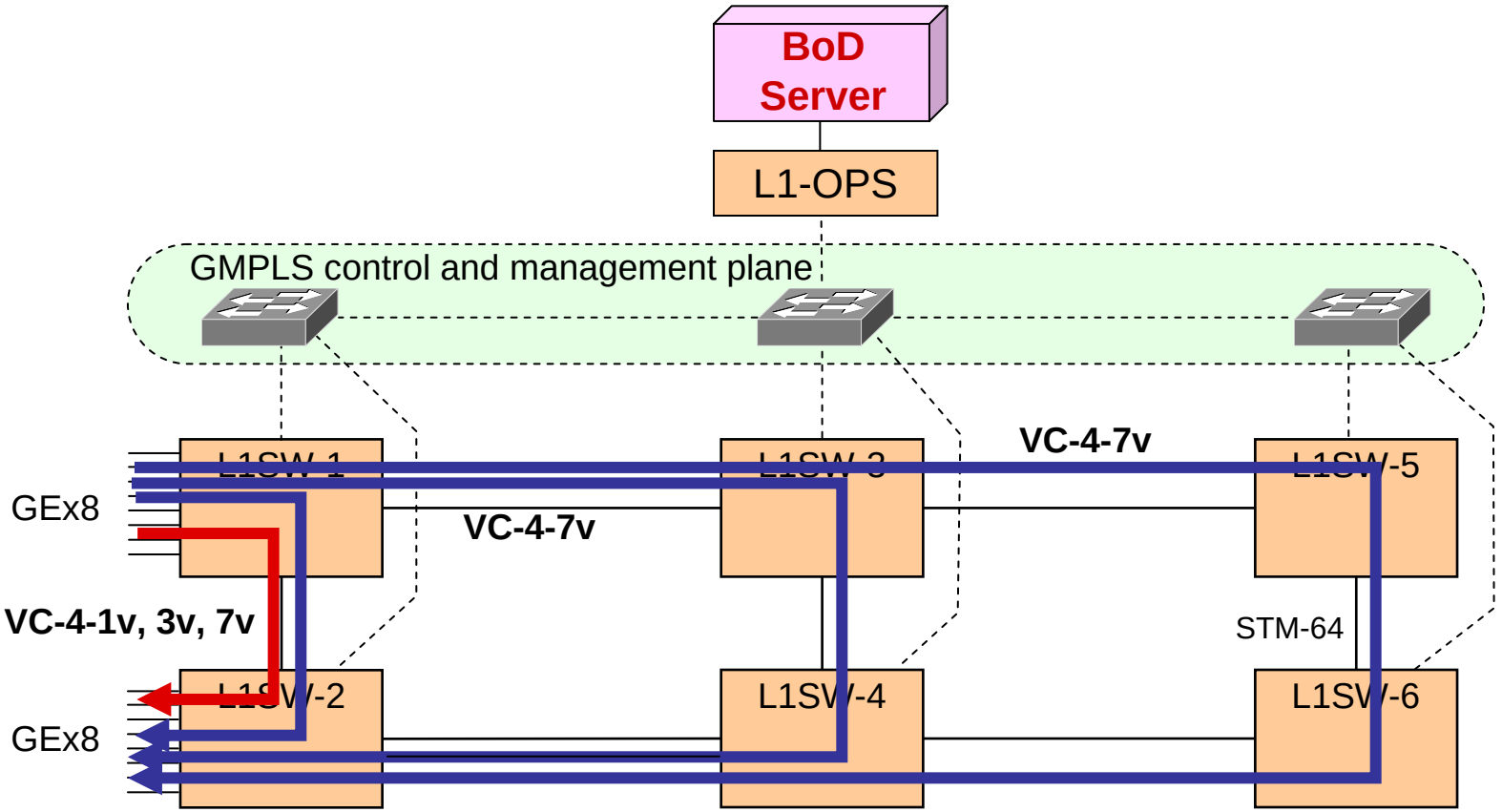
Evaluation of Logical Routers and FRR/Protection

- We evaluated switching time for FRR/protection in the case where each logical router had a large routing/forwarding table.
  - Logical router for IPv4/IPv6 : 240,000 IPv4 and 30,000 IPv6 routes
  - Logical router for L3VPN: 400 VPNs and 100,000 IP routes
  - Logical router for VPLS: 400 VPNs and 40,000 MAC addresses
- When the interface from Tokyo1 to Nagoya was disabled, the switching time was as follows.
  - For paths from Osaka to Tokyo1: 35.8 msec for L3VPN and 34.8 msec for VPLS.
  - For paths from Tokyo1 to Osaka: 79.5 msec for L3VPN and 80.8 msec for VPLS.



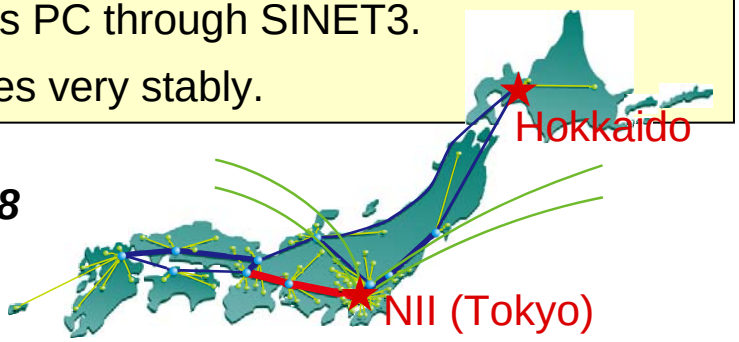
Evaluation of Path Setup Time

- Our L1 switches need a long time to establish L1 paths because they cross-connect TDM channels while carefully confirming the status per VC-4 and exchanging information with L1-OPS.
- Setup time significantly varied with the bandwidth and only slightly with the number of transit nodes, because GMPLS signals for the path setup are transferred before cross-connecting.
  - For 0.15G, 0.3G, and 1.05G paths between two L1 switches, it took about 23, 43, and 72 seconds.
  - For 1.05G path between two, four, and six L1 switches, it took about 72, 83, and 95 seconds.



Demonstration of L1 BoD Capabilities

- First, we reduced the bandwidths of each layer-2/3 path from 9.6 Gbps to 7.8 Gbps (or 19.2Gbps to 17.4Gbps) by using LCAS, which showed no negative effect on other services.
- Then, two layer-1 paths (0.9 Gbps x 2) were established on demand between two sites. A user at the Hokkaido site input the request information from his PC through SINET3.
- Non-compressed HDTV was transmitted between the sites very stably.



February 1st, 2008

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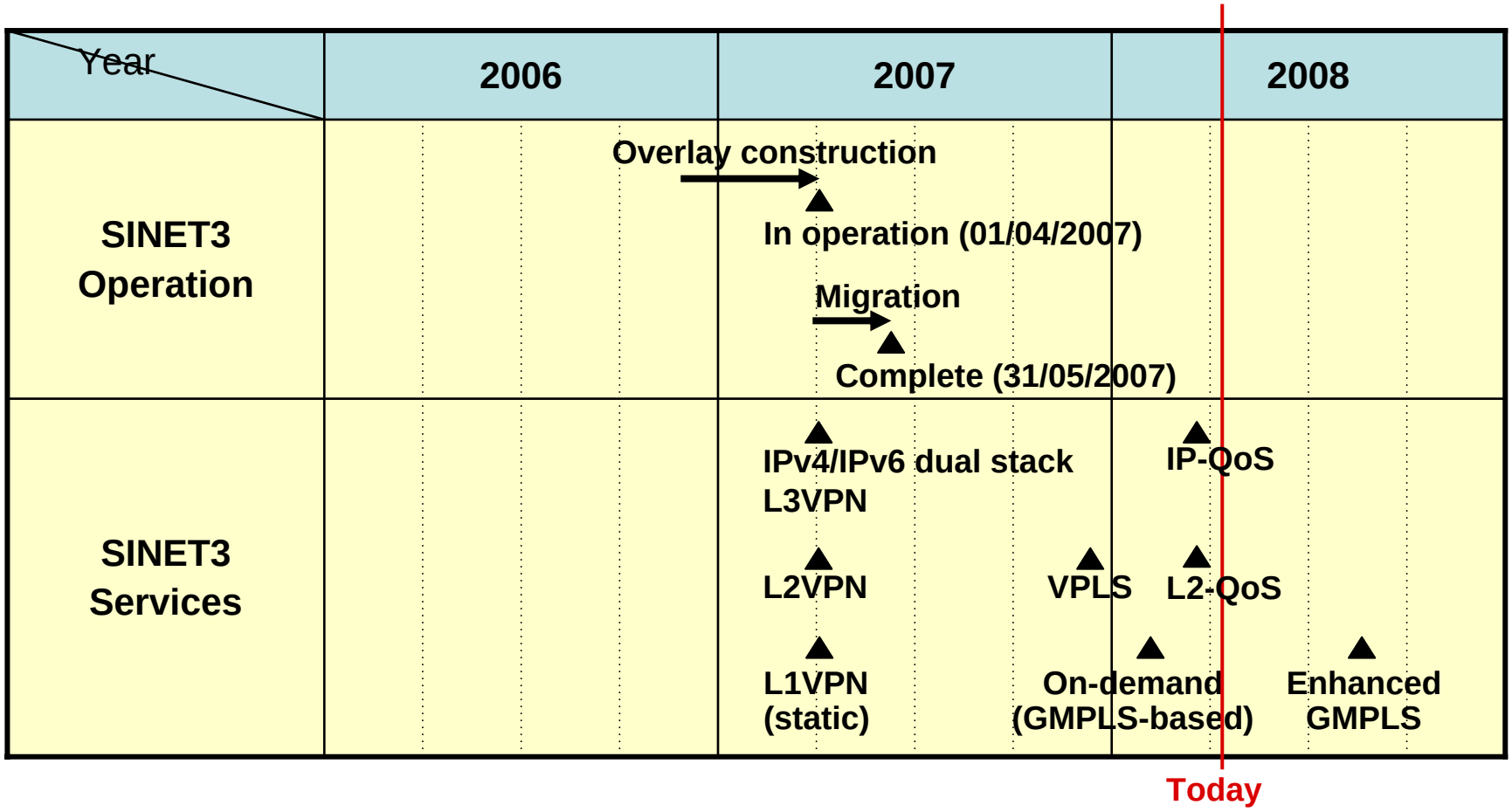
Conclusion

- We described bandwidth/networks on demand capabilities which combine several networking functions, such as VLAN, logical routers, GFP/VCAT/LCAS, and MPLS/GMPLS.
- Experimental and demonstration results were shown to confirm the stable operation.
- We started evaluating the layer-1 BoD capabilities with some monitors in the real network environment.



Thank you very much!