

Application-network Collaborative Bandwidth On-Demand for Uncompressed HDTV Transmission in IP-optical Networks

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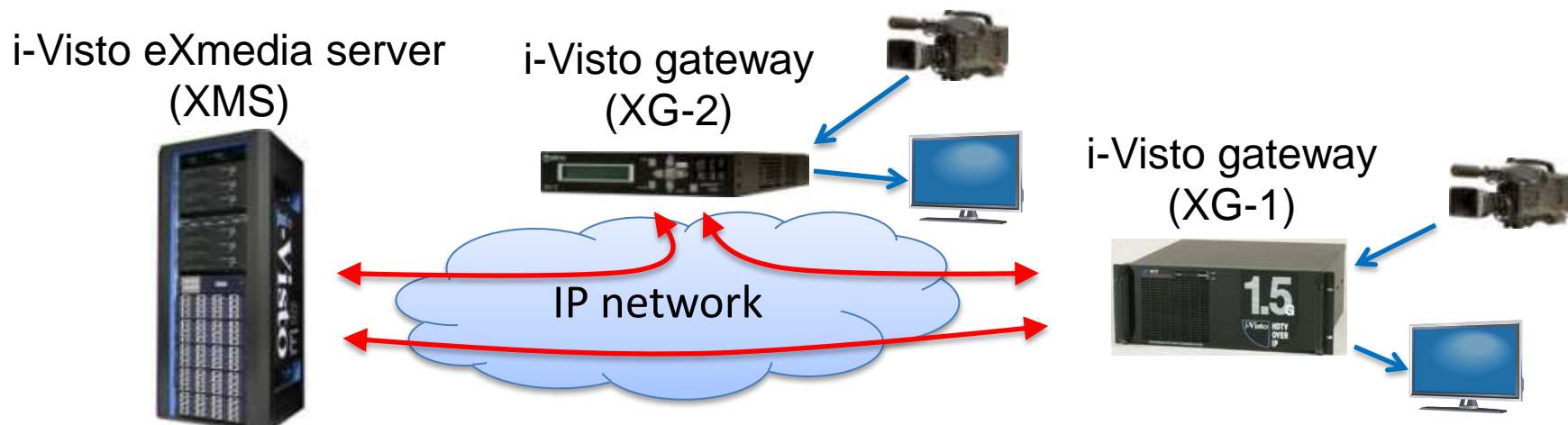
NTT Labs, Japan

- Uncompressed HDTV Transmission in IP Networks
- Difficulties
- Solution
 - Application-network Collaboration in IP-optical Networks
- Prototype implementation and Experiment
- Conclusion

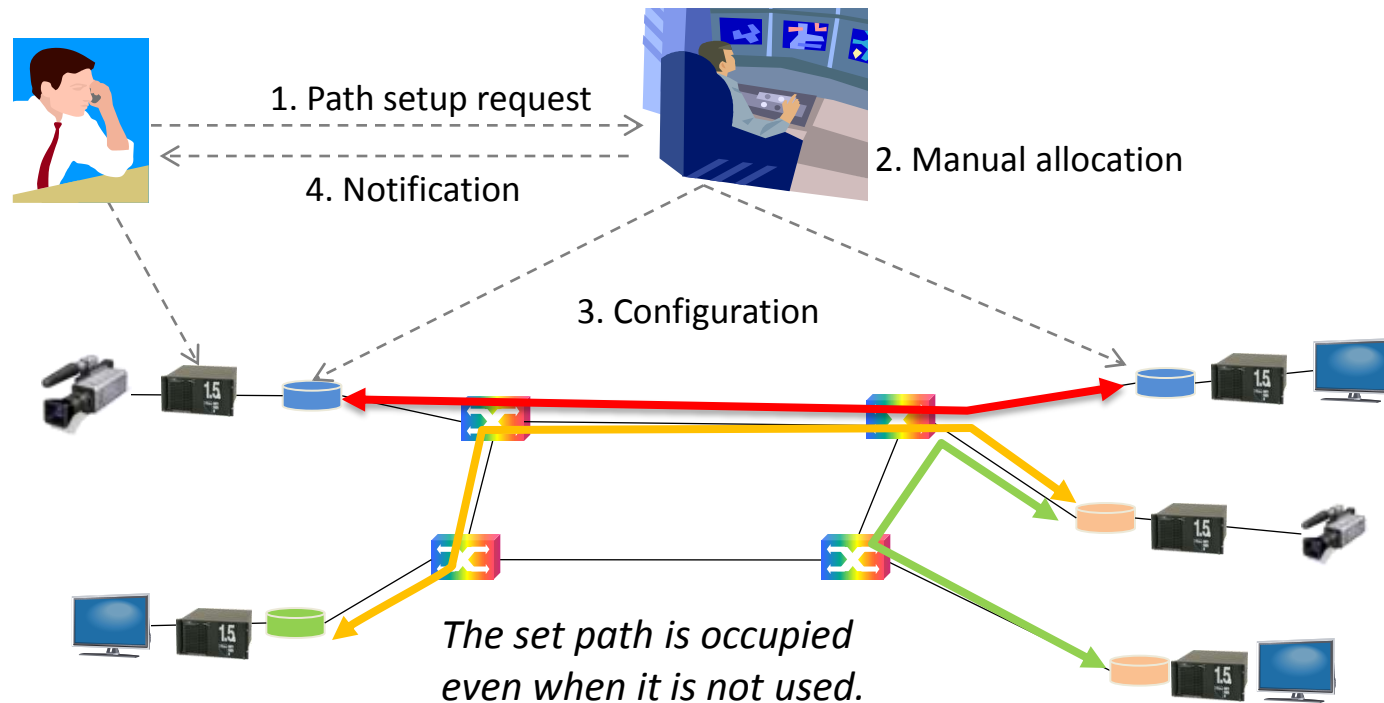
- Videos are usually **compressed** before transmitting over networks
 - Compression causes **encoding /decoding delays** and **Loss of information**
- **Uncompressed** HDTV video transmission offers significant values
 - **Low Delay** enables high-presence, bi-directional visual communication
 - Broadcasting studios can share **original materials** to edit programs
 - Future advanced use of high-definition video in **telemedicine, e-learning**, etc

i-Visto: Internet Video Studio System for High-resolution Video Production

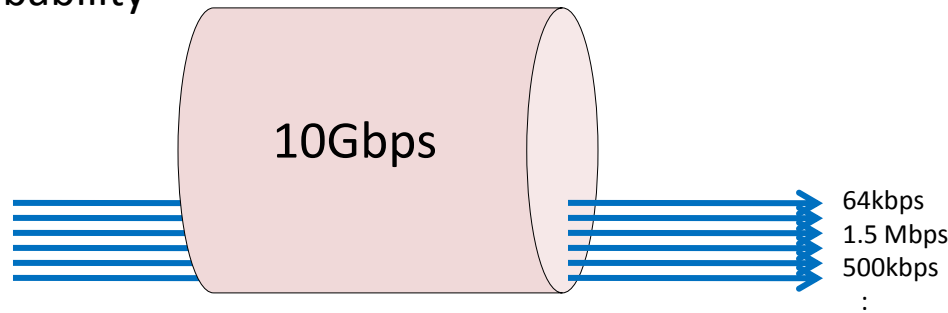
Transfers, stores and delivers high-quality uncompressed video over IP network



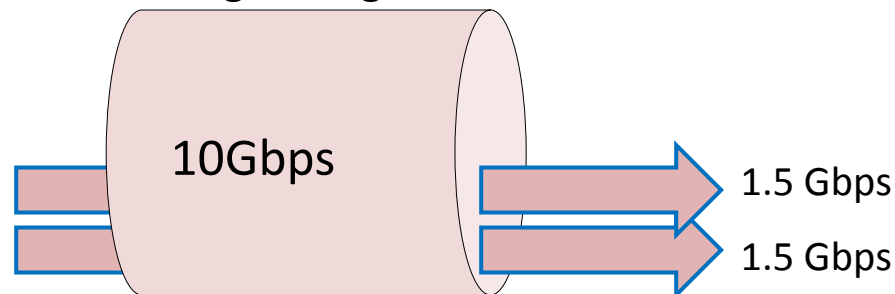
- It requires a dedicated circuit with huge bandwidth (Uncompressed HDTV-Class video = 1.5Gbps)
- ⇒ Cannot be used immediately
 - It usually takes several weeks or even months to subscribe a circuit
- ⇒ Availability information is important
 - Users want to know when and how much is the bandwidth is available



- Legacy: large number of small flows are accommodated in a large capacity circuit
 - Expect a large group effect, capacity design is done based on the target call blocking probability



- Uncompressed HDTV transmission: a flow occupies large part of the link capacity
 - Call blocking probability is high
 - Legacy TE technologies might not work well



- Network Virtualization
- Application-network Collaboration

Problem

Immediate use



Solution

Network provides an interface to let applications **setup optical circuit dynamically**

Network availability info.



Network provides a Interface to **make inquiry of the network status** (ex. available bandwidth and time, delay)

Network capacity design



Network **optimizes its topology** by switching the optical path

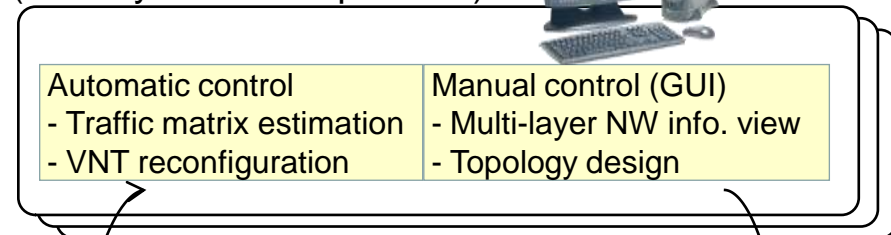
Network provides not only immediate but also **future reservation** of the circuit

Key components – High performance network virtualization

- Virtualization and path setup control is conducted by the **IP-optical TE server** developed based on the PCE/VNTM architecture [RFC 5212, 5623]

Application

(Overlay Network Operation)



Network status

- Allocated resources
- Measured traffic

Topology control

- Optical/MPLS path setup request

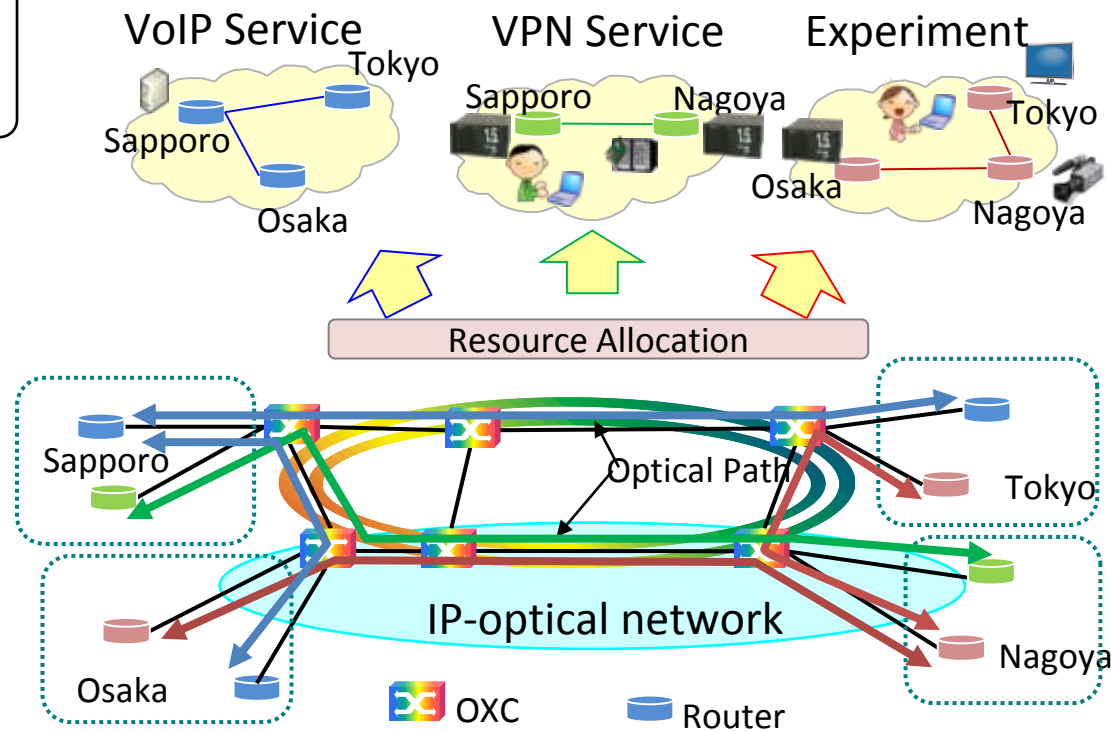
Open interface (XML/CORBA)

- Resource management
- Resource allocation
 - Resource optimization

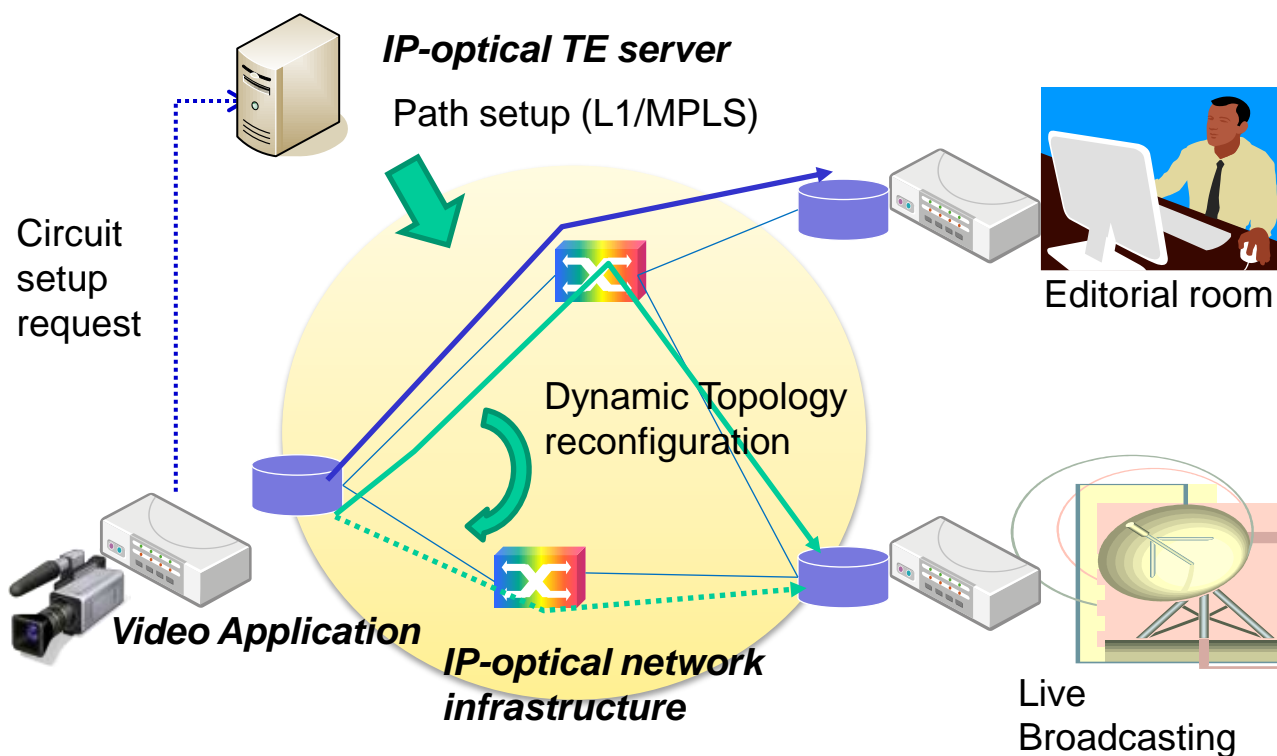
- Network Control
- Optical/MPLS path setup
 - Topology info. collection
 - Traffic info. collection

Platform server

(Underlay Network virtualization and control)



- On-demand circuit setup
 - MPLS-LSP route that can accommodate the required bandwidth is calculated
 - If no route is found, it calculates to set up a new optical path (L1-LSP)
- Reconfigure virtual network topology dynamically
 - IP-optical TE Server optimizes the virtual network topology based on estimated traffic matrix

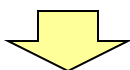


- IP-optical TE Server provides four commands to the applications

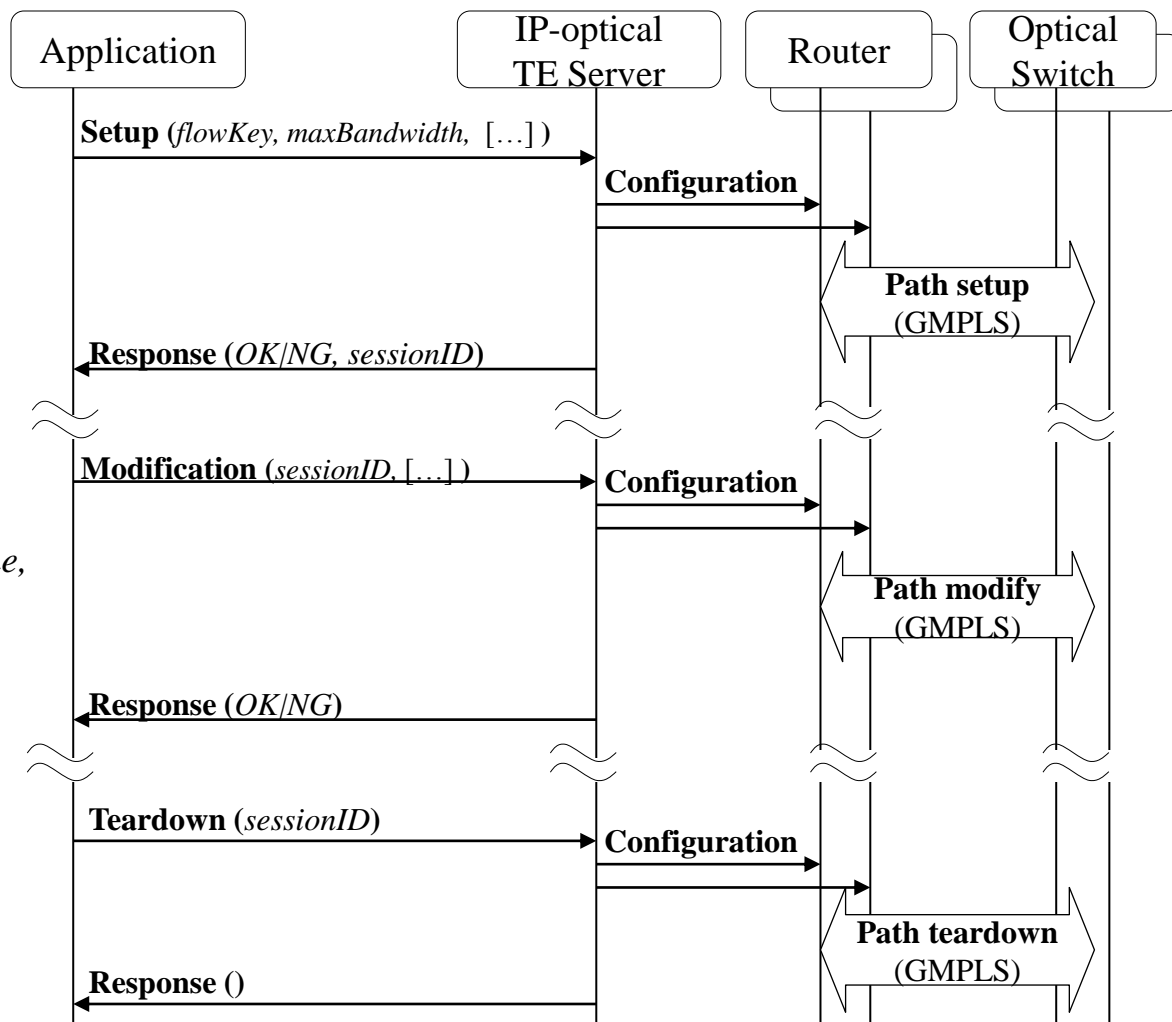
- **Setup**
- **Modification**
- **Teardown**
- **Inquiry**

- By adding parameters, applications can use the functions such as 1.-5.

- *flowKey, applicationType, maxBandwidth, minBandwidth, maxDelay, maxDelayVariation Range, protection, setupTime, setupTimeRange, teardownTime, teardownTimeRange, fileSize, deadline, deadlineRange*



1. Circuit setup (immediate)
2. Circuit setup (future reservation)
3. Modification
4. Bandwidth reservation for file transfer
5. Network availability inquiry



1. Circuit setup (immediate)
 - MPLS/L1 LSP is set according to the constraints notified by the parameters
 - *maxDelayVariationTime*: constraint to avoid route changes that cause large difference of the delay that the video stream cannot tolerate

2. Circuit setup (future reservation)
 - Applications can specify time range (T_s to $T_s + \Delta T_s$)

3. Modification
 - Applications can modify the condition of the existing or the reserved circuit (ex. bandwidth, time ...)

4. Bandwidth reservation for file transfer

- Broadcasting studios want to transmit video materials before a deadline to start the editorial
- ⇒ Network plans a circuit to transfer the *filesize* before the *deadline*.
 - The path/bandwidth may not be consistent through the reserved time.
 - *maxBandwidth*
 - User site may have limitation in transmission capacity

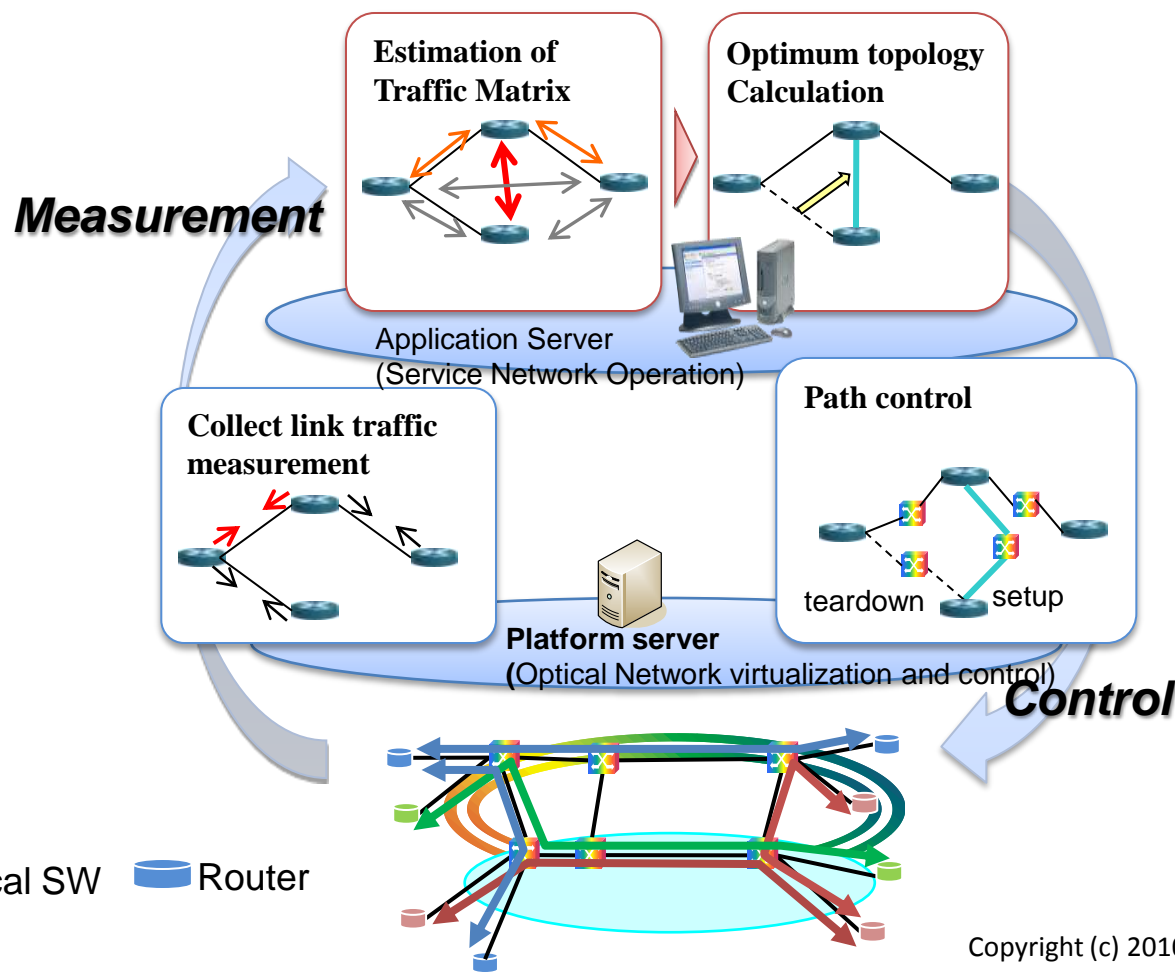
5. Network availability inquiry

- Users want to know when and how the network is available
- Users can adapt the video steaming according to the network availability (rescheduling, transcoding, ...)

⇒ Network answers to the question

- How much bandwidth is available between A and B?
- When does the bandwidth become available?
- How is the packet delay between A and B?
- What is the price?
 - Bandwidth in a less available time can be sold at high price

- VNT can be dynamically reconfigured by setting up and/or tearing down the optical paths between any pair of IP routers.
- The VNT reconfiguration is done in response to the change in the traffic condition



- Implementation of basic commands (Setup and Teardown)
- XML format

Setup(

flowKey,

applicationType,

maxBandwidth,

minBandwidth,

maxDelay,

maxDelayVariation Range,

protection,

setupTime,

setupTimeRange,

teardownTime,

teardownTimeRange,

fileSize,

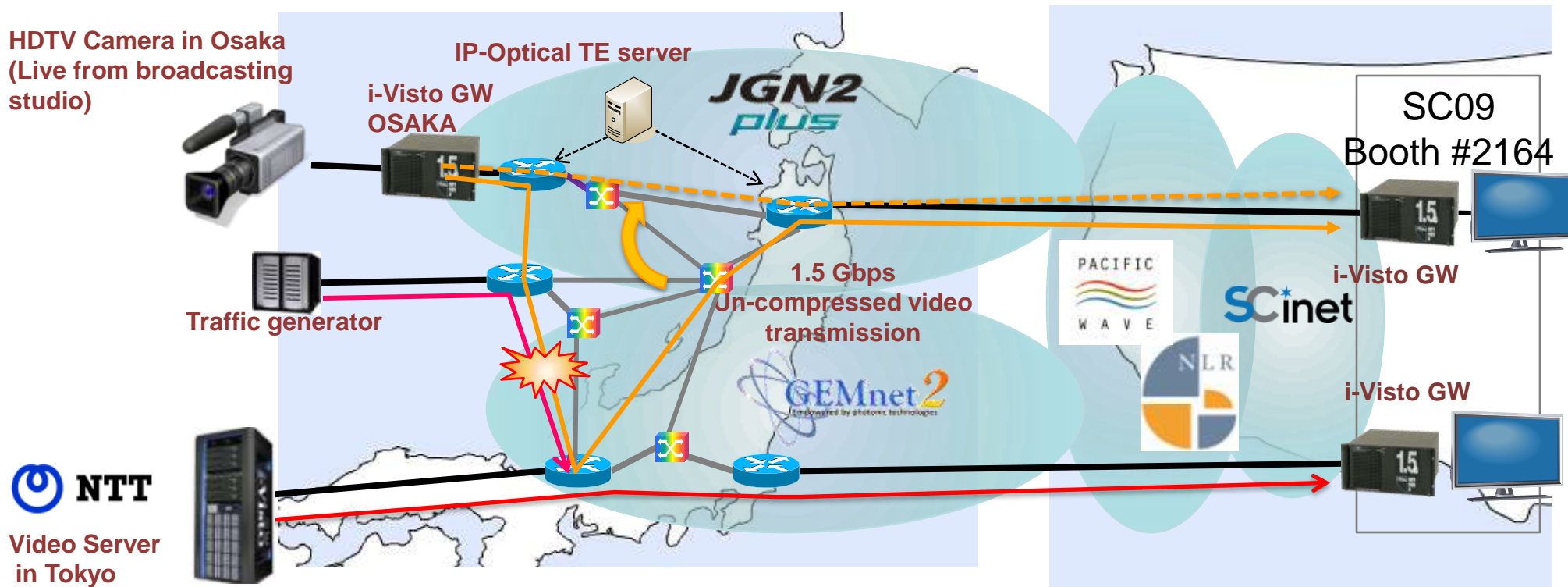
deadline,

deadlineRange)

```
<?xml version="1.0" encoding="UTF-8"?>
<pce>
  <command>setup</command>
  <request>
    <layer>multilayer</layer>
    <src>
      <id>2</id>
      <ip>1.0.0.201</ip>
    </src>
    <dst>
      <id>2</id>
      <ip>1.0.0.202</ip>
    </dst>
    <fixed>1</fixed>
  </request>
  <restriction>
    <band>1.000000E+08</band>
  </restriction>
  <request-id></request-id>
  <path-deletetime>
    <date>2009/02/02</date>
    <time>12:59</time>
  </path-deletetime>
</pce>
```

Wide area experiment

- Experimental network using testbeds
- Demo in SC09 (Portland, OR) using international connection
- Dynamic optimization of the VNT successfully worked without packet drop.
- On-demand path setup time = 28 seconds



- Application-network collaboration functions and interface is designed assuming use of uncompressed video transmission in broadcasting studios
 - On-demand path setup and future reservation
 - Inquiry of network availability
 - Dynamic optimization of the virtual network topology
- Prototype implementation and experiment
 - (Legacy) several weeks or months -> (proposal) 28 seconds
- Future work
 - Algorithm to let immediate and future reservation to coexist
 - Algorithm to calculate max available bandwidth at a certain time
 - Further implementation and experiments