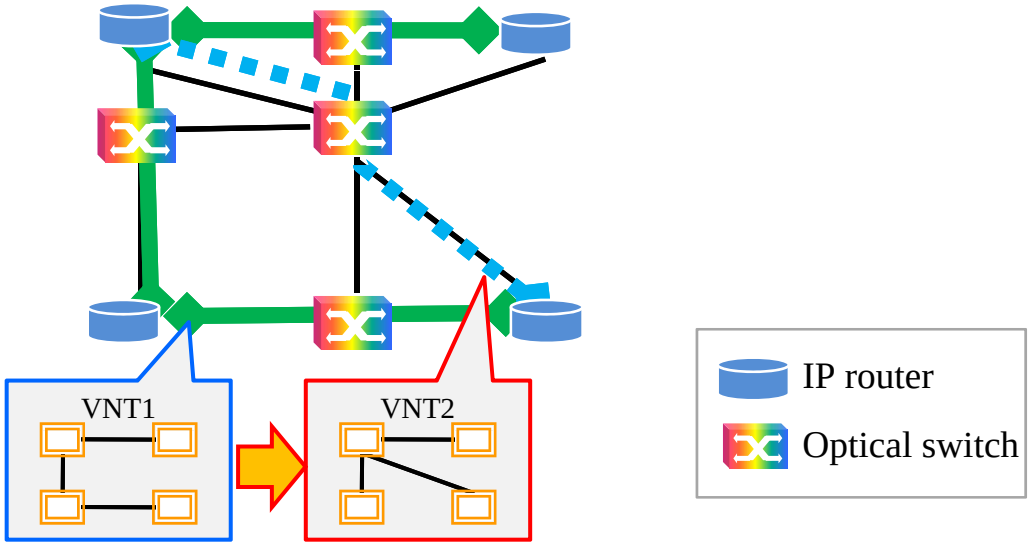
Network stratum

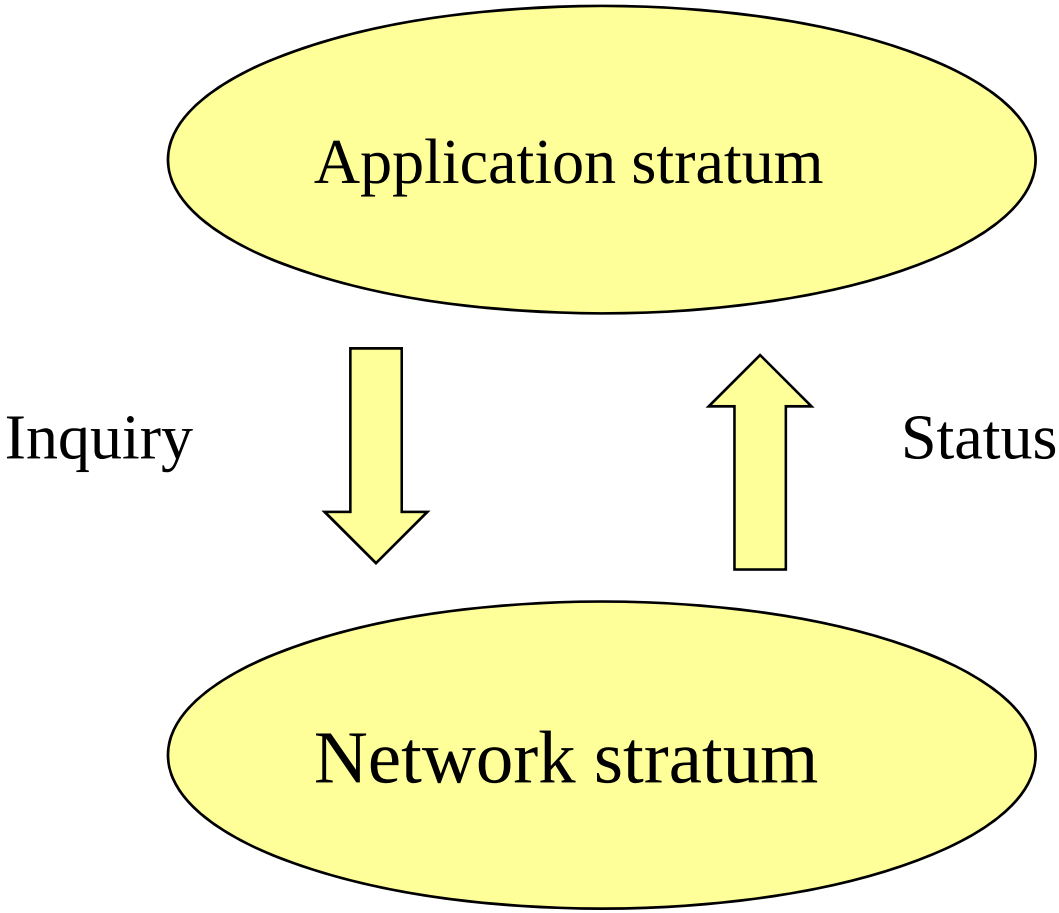
- Sub-IP layer: Multi-layer network (MLN)
  - MPLS, SDH, OTN, WDM
  - Lower layer provides Virtual Network Topology (VNT) to upper layer.
- Optimization
  - Route optimization / Topology optimization
  - Global optimization / Local optimization



Application stratum

- Inter-DC communications
- Bulk data transfer
  - Data backup, disaster recovery, etc.
- Emerging high bandwidth image applications
  - Sporting events, live converts, 3D video applications, remote medical surgery, etc.
- Research & education network applications
  - E-VLBI, e-Learning, scientific computing, etc.

Cross stratum interface



Optimization if needed…

Cross stratum optimization

- Resource optimization (application and network)
- Responsiveness to quickly changing demands
- Enhanced service resilience (via cooperative recovery techniques between application and network)
- Quality of application experience (QoE) enhancement

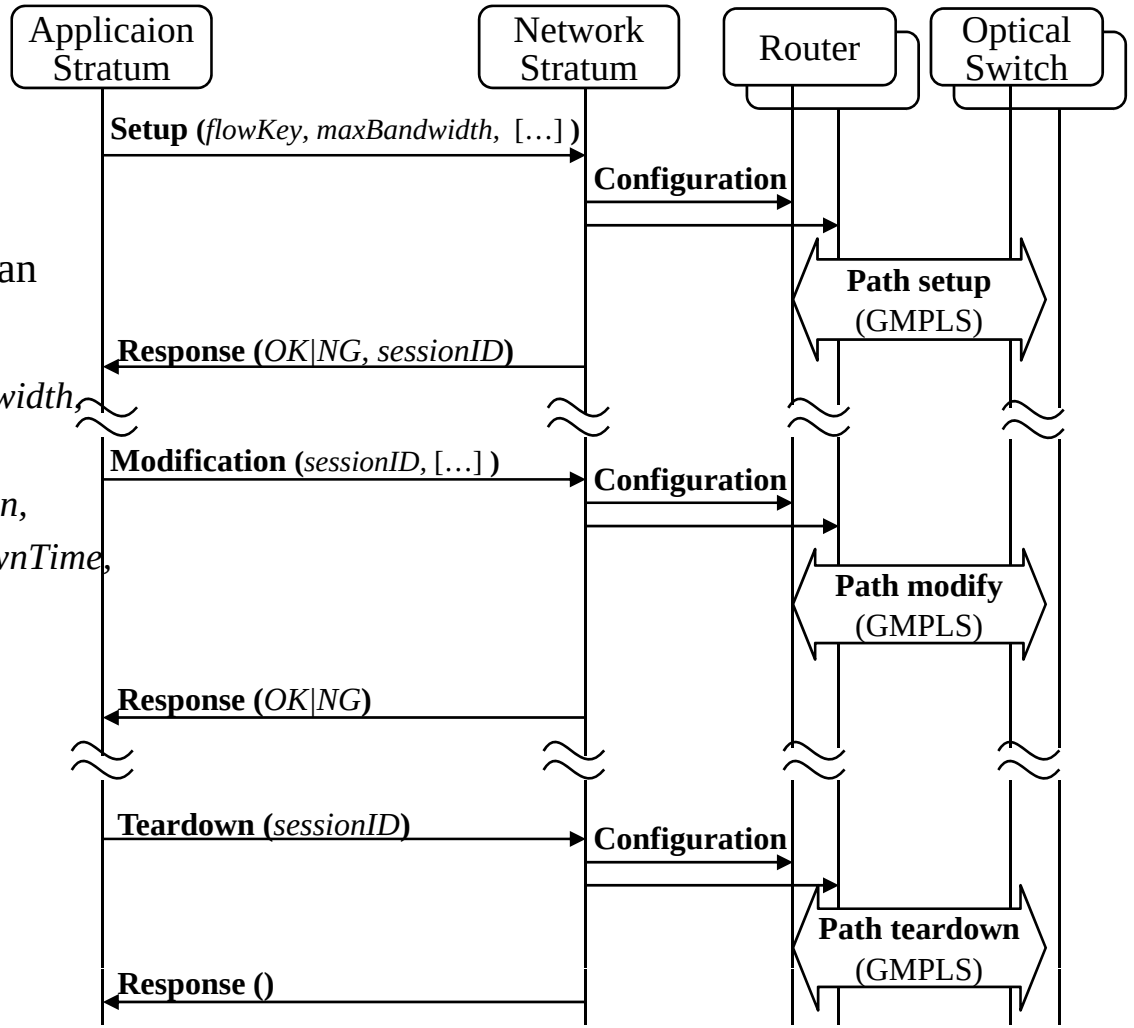
Expected research items

- Baseline network/application model
- Trust relationships model
- Data center/cloud based applications
- Key interfaces and their functionality
- Role of TE based network infrastructure, (G)MPLS
- Resiliency mechanisms
- Responsiveness to application/network interaction.

Cross-stratum interface between application and network

- Interface commands
  - **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



Prototype implementation

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

Setup(

flowKey,

applicationType,

maxBandwidth,
minBandwidth,

maxDelay,
maxDelayVariation Range,
protection,
setupTime,

setupTimeRange,

teardownTime,
teardownTimeRange,
fileSize,

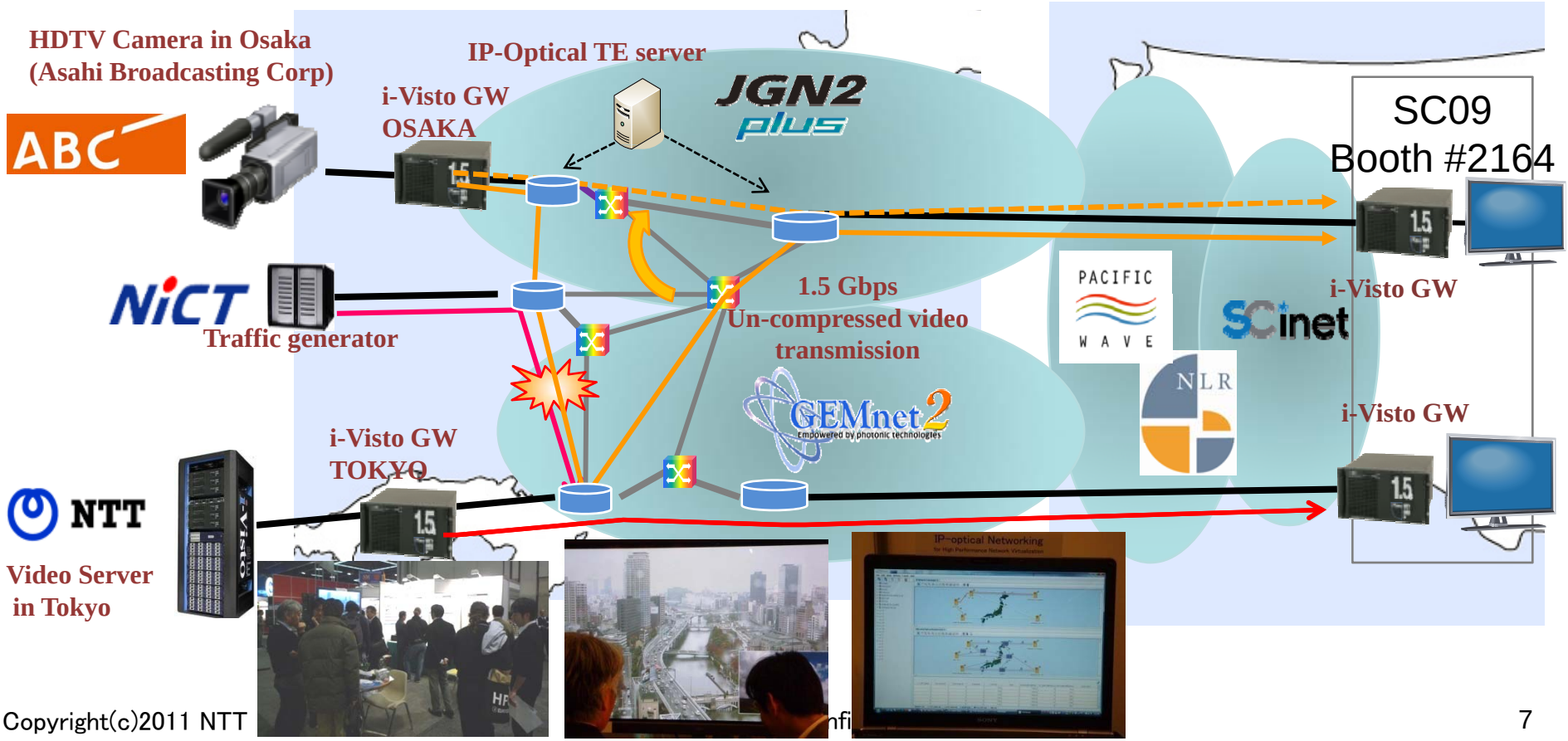
deadline,

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>
```

Demonstration of dynamic topology reconfiguration (at Super Computing 2009)

- We have implemented and successfully verified our on-demand video transmission and dynamic topology reconfiguration with a GMPLS-controlled experimental network constructed upon R&D testbeds: JGN2plus (NiCT) and GEMnet2 (NTT)
- Demo shown at SC09 booth #2164, through international connections supported by JGN2plus, GEMnet2, and Pacific Wave



Thank you!