Deep programmable network architecture having URLLC-link for highly secure and manageable network

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18:00 JST

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Andrea fumagalli
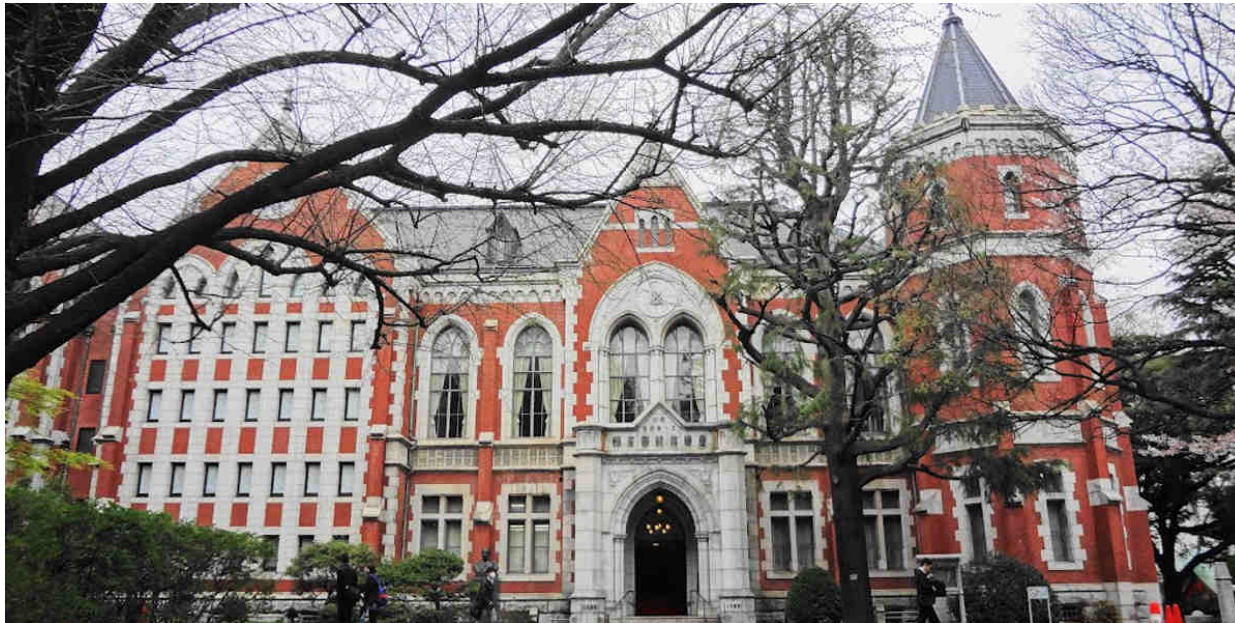Keio univ. Alaksala NW(Japan) and UTD(USA)

Keio University
1858
CALAMVS GLADIO FORTIOR

AlaxalA

What's Keio University

Keio University

Establish in 1858, Oldest and best private University in Japan

What's ALAXALA ?

AlaxalA

The Guaranteed Network

Closer to you, Further into the future.

ALAXALA Networks is one of Japan's leading vendors of Routers/Switches.

◆ Establishment   October, 2004

◆ Location   Kawasaki, Kanagawa, Japan

◆ Business   Development, manufacturing, sales, maintenance

   of Routers/Switches for mission critical network

*Layer 2 switches
(AX2130S,AX2530S)*

*Layer 3 switches
(AX4630S,AX3660S)*
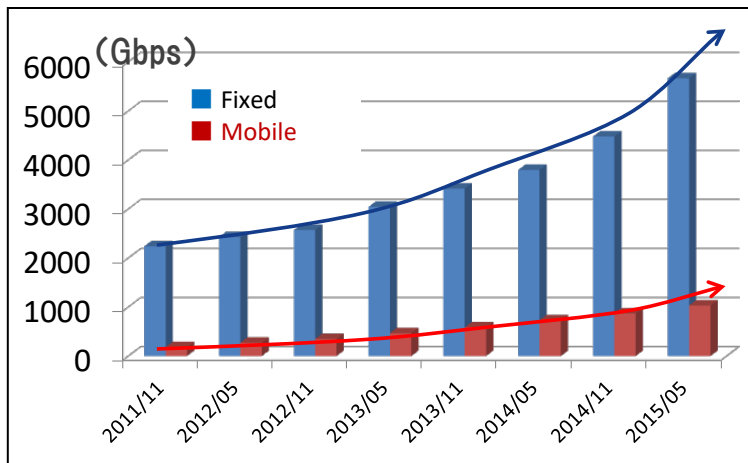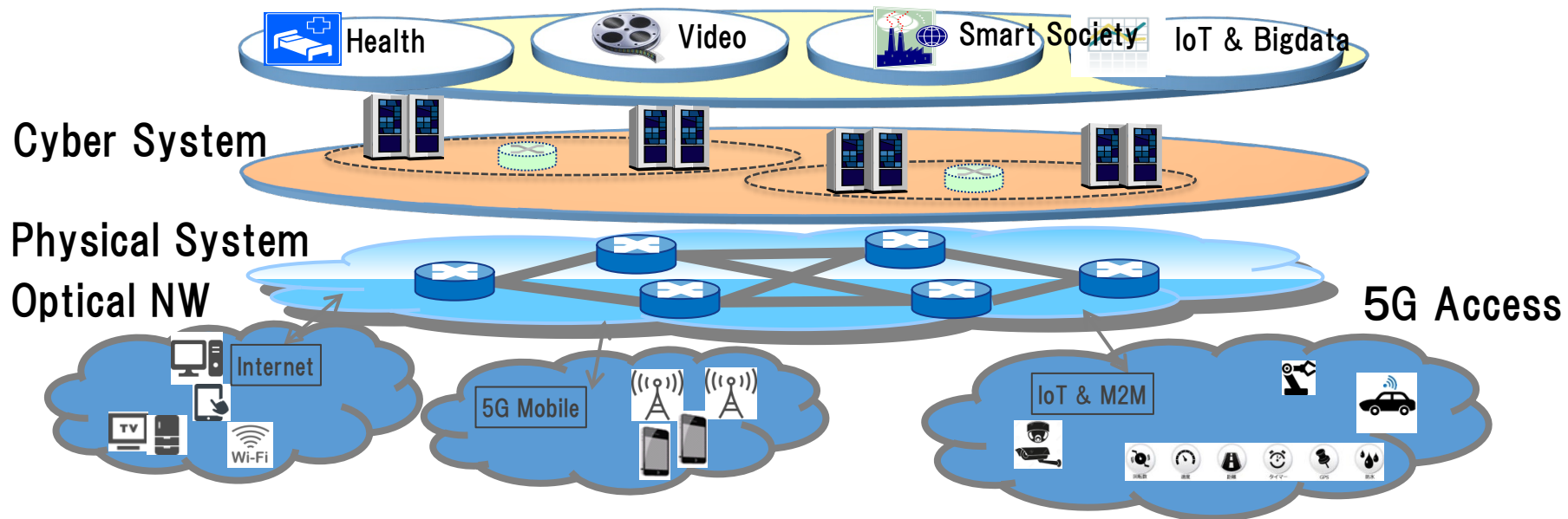
*Core and edge routers
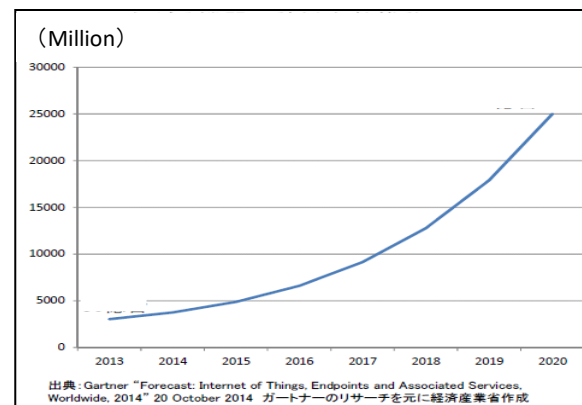(AX8600R)*

2. Background

Smart & Connected Community

Multi-service and huge traffic demand by smart & Connected Community

Health

Video

Smart Society

IoT & Bigdata

Cyber System

Physical System
Optical NW

5G Access

Internet

Wi-Fi

5G Mobile

IoT & M2M

Traffic Demand

(Gbps)

- Fixed
- Mobile

2011/11 2012/05 2012/11 2013/05 2013/11 2014/05 2014/11 2015/05

Connected IoT device

（Million）

2013 2014 2015 2016 2017 2018 2019 2020

出典：Gartner "Forecast: Internet of Things, Endpoints and Associated Services, Worldwide, 2014" 20 October 2014　ガートナーのリサーチを元に経済産業省作成

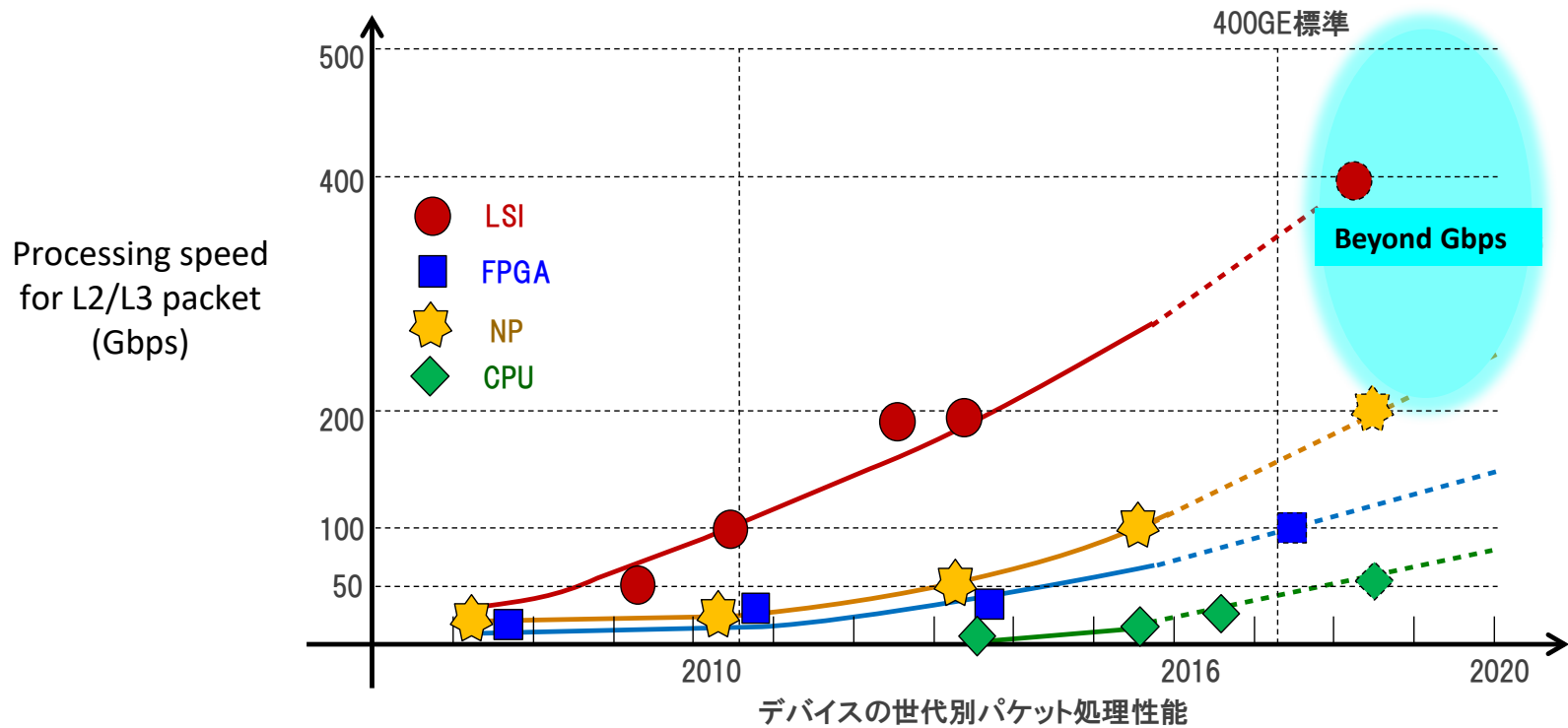# Background for Smart & Connected Community

- Heavy traffic demand
  - Video traffic (4K, 8K) requires more than 100Gbps interface

- Service diversity
  - From over 100Gbps video and several bit/hr IoT sensors are connected

- Dynamic and Mobility
  - Autonomous Driving Vehicle and M2M is new demand

Full-flexible and Programable NW

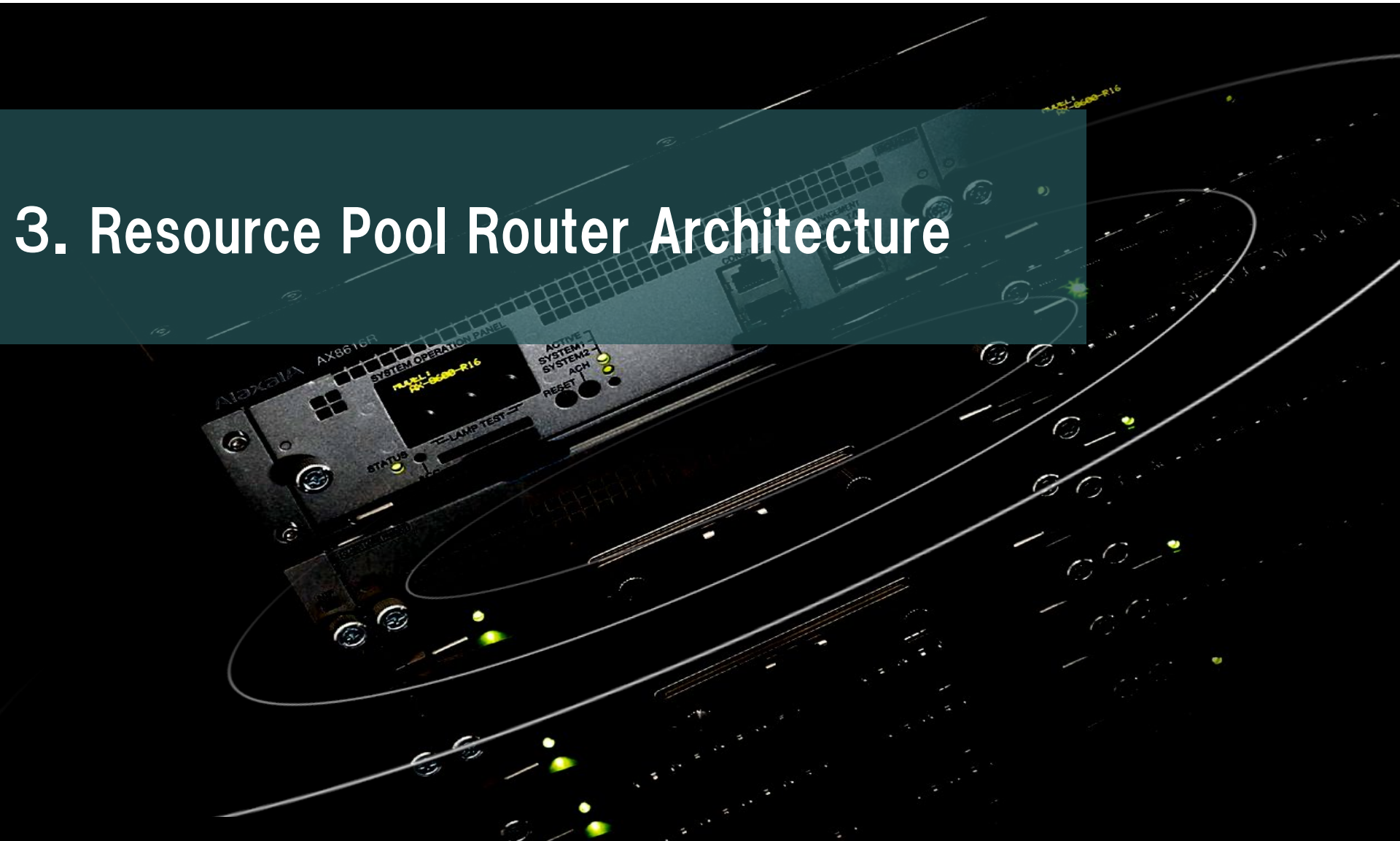Node and Network architecture have to meet those requirements

The state-of-the art Device

Next target is Beyond 100G full-flexible NW

Processing speed for L2/L3 packet (Gbps)

- ● LSI
- ■ FPGA
- ★ NP
- ◆ CPU

400GE標準

Beyond Gbps

デバイスの世代別パケット処理性能

LSI/FPGA/NP/CPU (Software) Co-design is needed
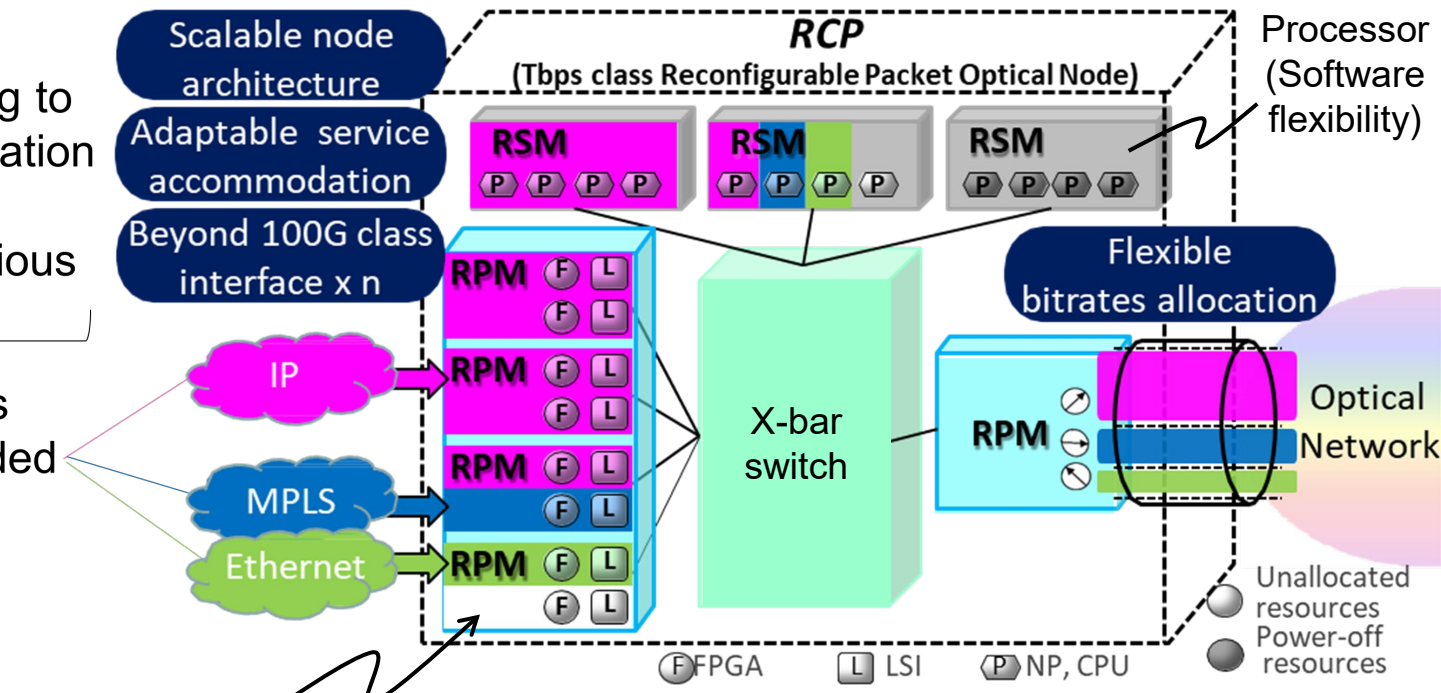
3. Resource Pool Router Architecture

Our newly developed reconfigurable Communication Processor (NODE)

RCP consists of a Reconfigurable Processing Module(RPM)※1, Reconfigurable Service Module (RSM)※2, and a Tbps class switch module interconnecting them.

- RPM corresponding to multiple communication protocols
- RSM providing various functions

Multiple services
Slice can be provided

FPGA + LSI
(High-speed hardware)

Scalable node architecture

Adaptable service accommodation

Beyond 100G class interface x n

RCP
(Tbps class Reconfigurable Packet Optical Node)

RSM

RSM

RSM

Processor (Software flexibility)

Flexible bitrates allocation

RPM

IP

MPLS

Ethernet

X-bar switch

RPM

Optical Network

Unallocated resources
Power-off resources
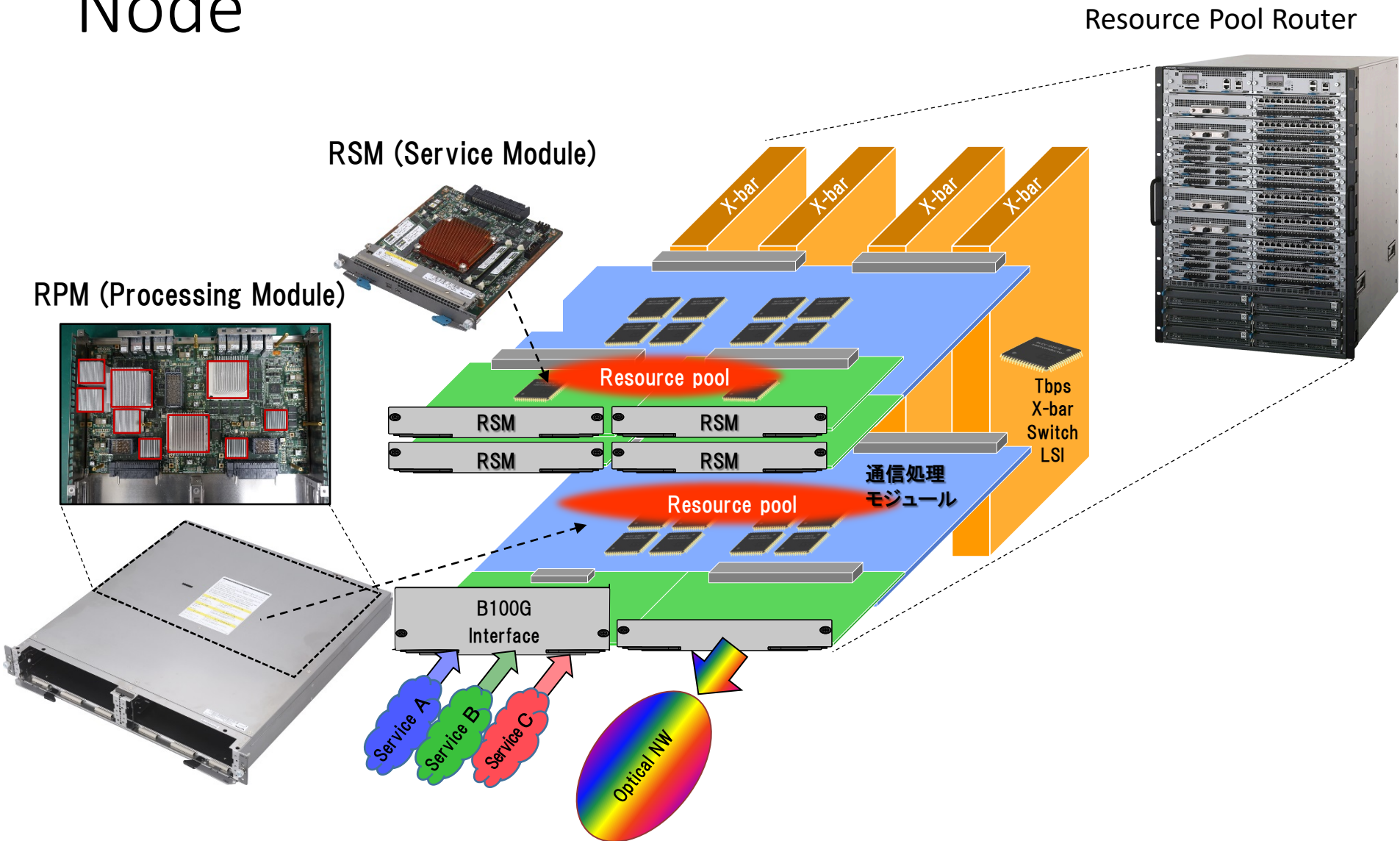
F FPGA   L LSI   P NP, CPU

Basic Concept
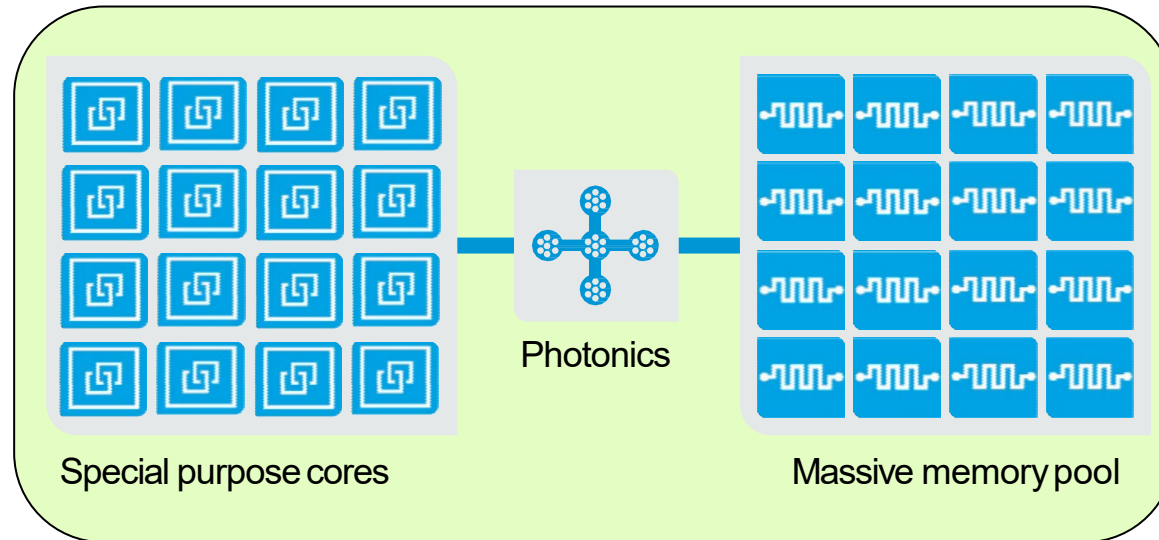
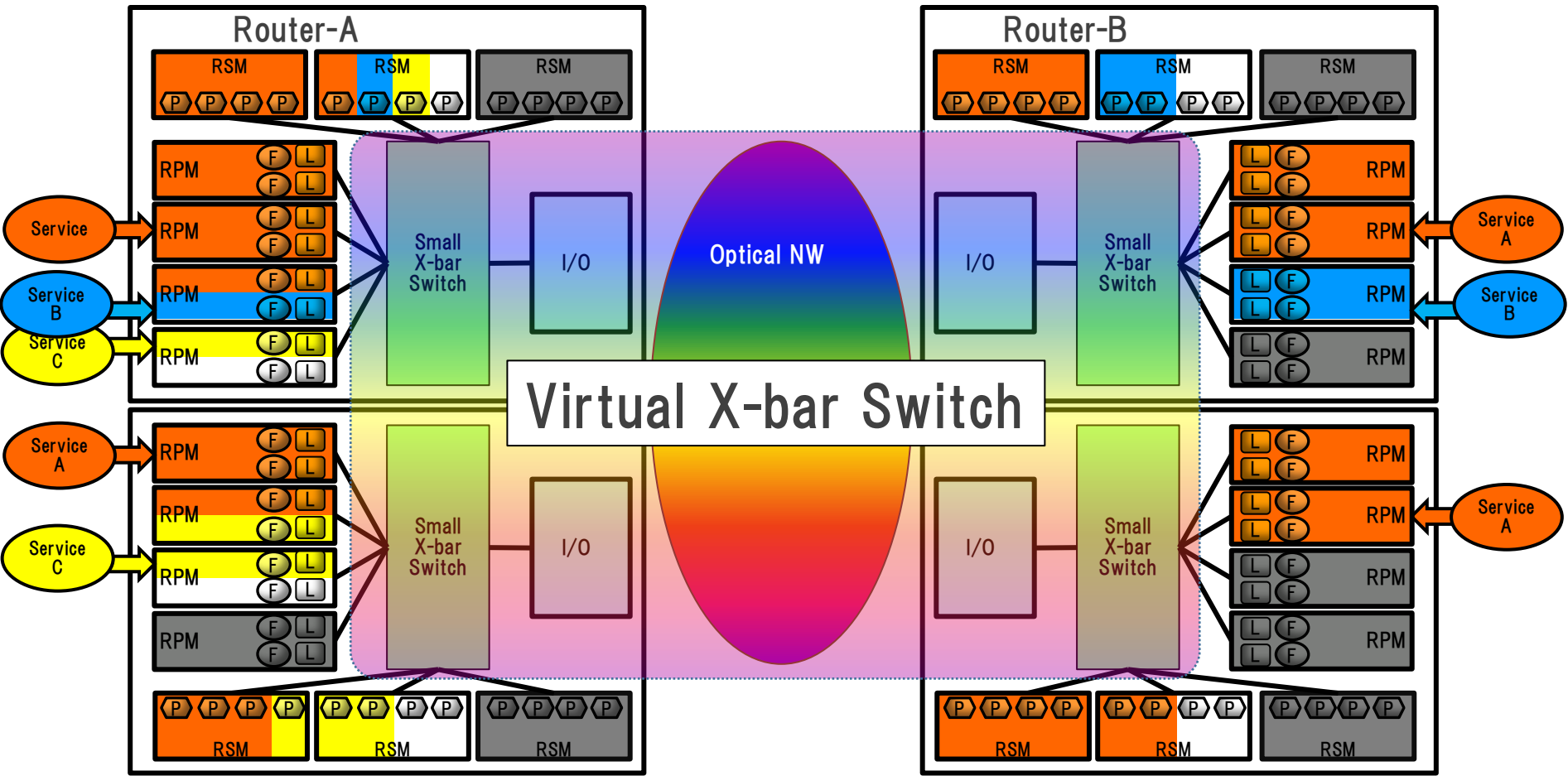Optically interconnect massive resource in NW
→ Optical Interconnection
⇒ Restriction free from bandwidth from distance
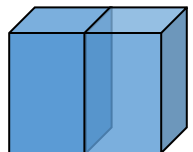
Resource pool architecture

Structure resource Pool Architecture Node

Resource Pool Router

RSM（Service Module）

RPM（Processing Module）

X-bar

X-bar

X-bar

X-bar

Resource pool

RSM

RSM

RSM

RSM

Resource pool

通信処理
モジュール

Tbps
X-bar
Switch
LSI

B100G
Interface

Service A

Service B

Service C

Optical NW

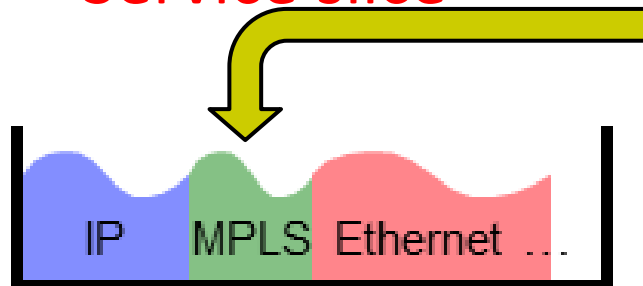# How to scale out by Optical Interconnection

Resources are tightly connected by optical wire
Distance and bandwidth restriction free

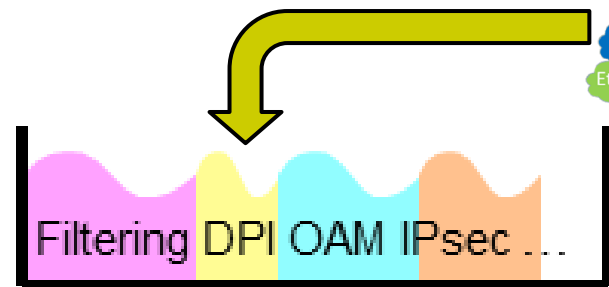Multi-shelf Architecture

Design of resource pool architecture for flexible network service accommodation

Service slice

IP MPLS Ethernet ...

Resource pool of
Processing Module

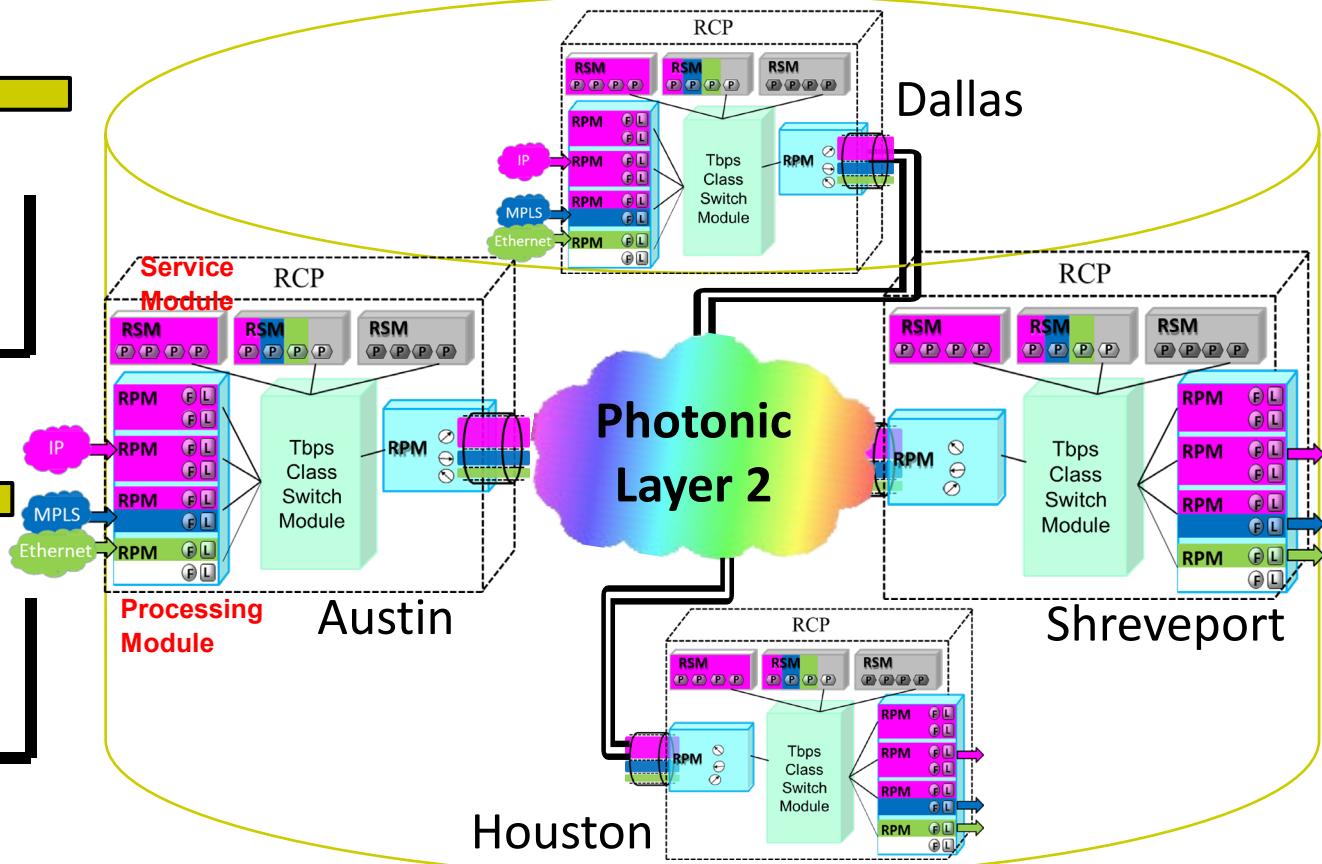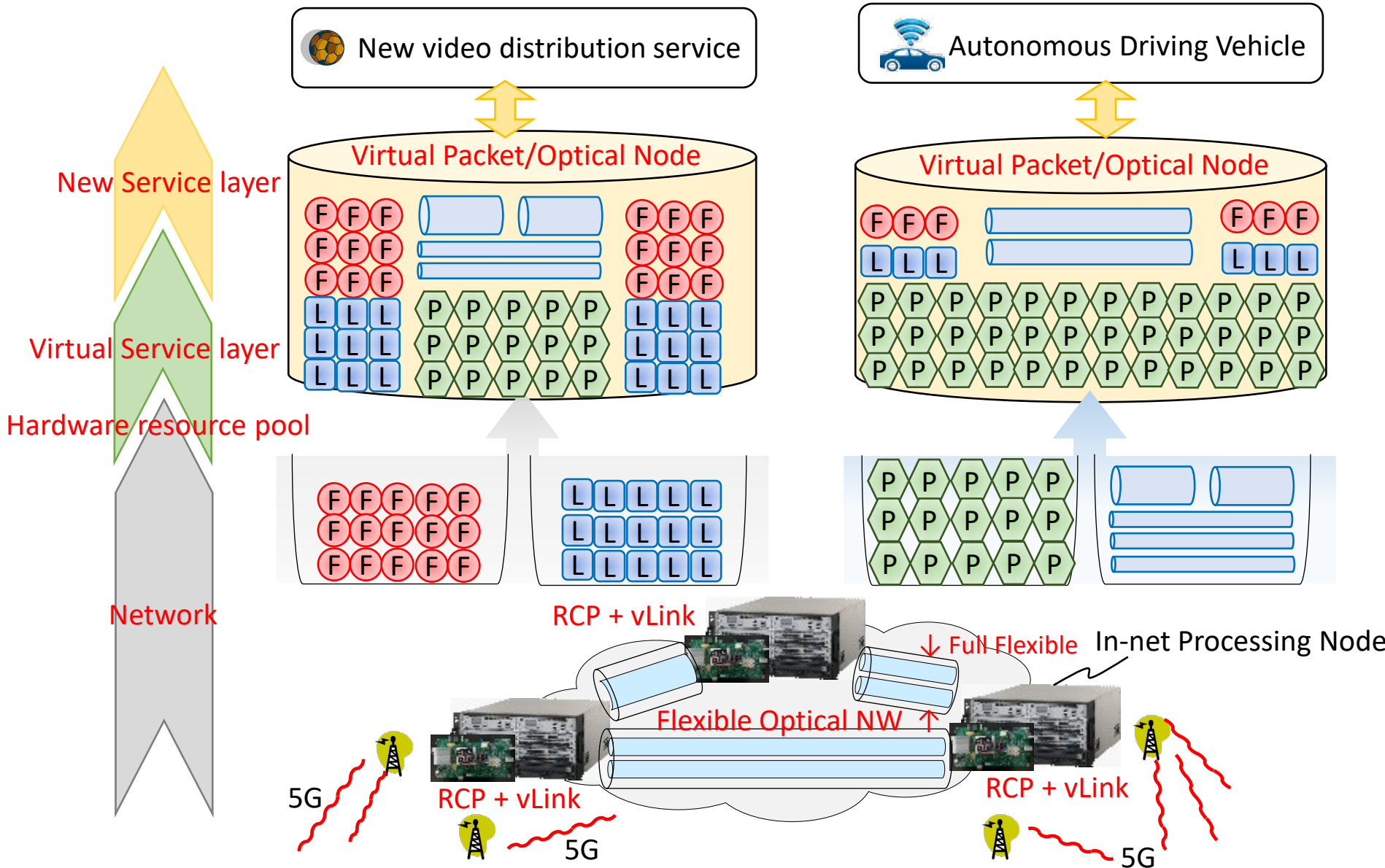Filtering DPI OAM IPsec ...

Resource pool of
Service Module

Fig.3 Conceptual diagram of Resource pool architecture

Resource pool architecture is realized by flexible reconfigurable nodes in the photonic network
It accommodates flexible network services and enables flexible network construction

Virtual network cloud router architecture

New video distribution service

Autonomous Driving Vehicle

New Service layer

Virtual Service layer

Hardware resource pool

Network

Virtual Packet/Optical Node

Virtual Packet/Optical Node

RCP + vLink

↓ Full Flexible

In-net Processing Node

Flexible Optical NW ↑

RCP + vLink

RCP + vLink

5G

5G

5G

4. Flexible Network using Resource Pool

Photonic Layer 2

A new layer 2 specialized for transport and corresponding to wide area and multi domain
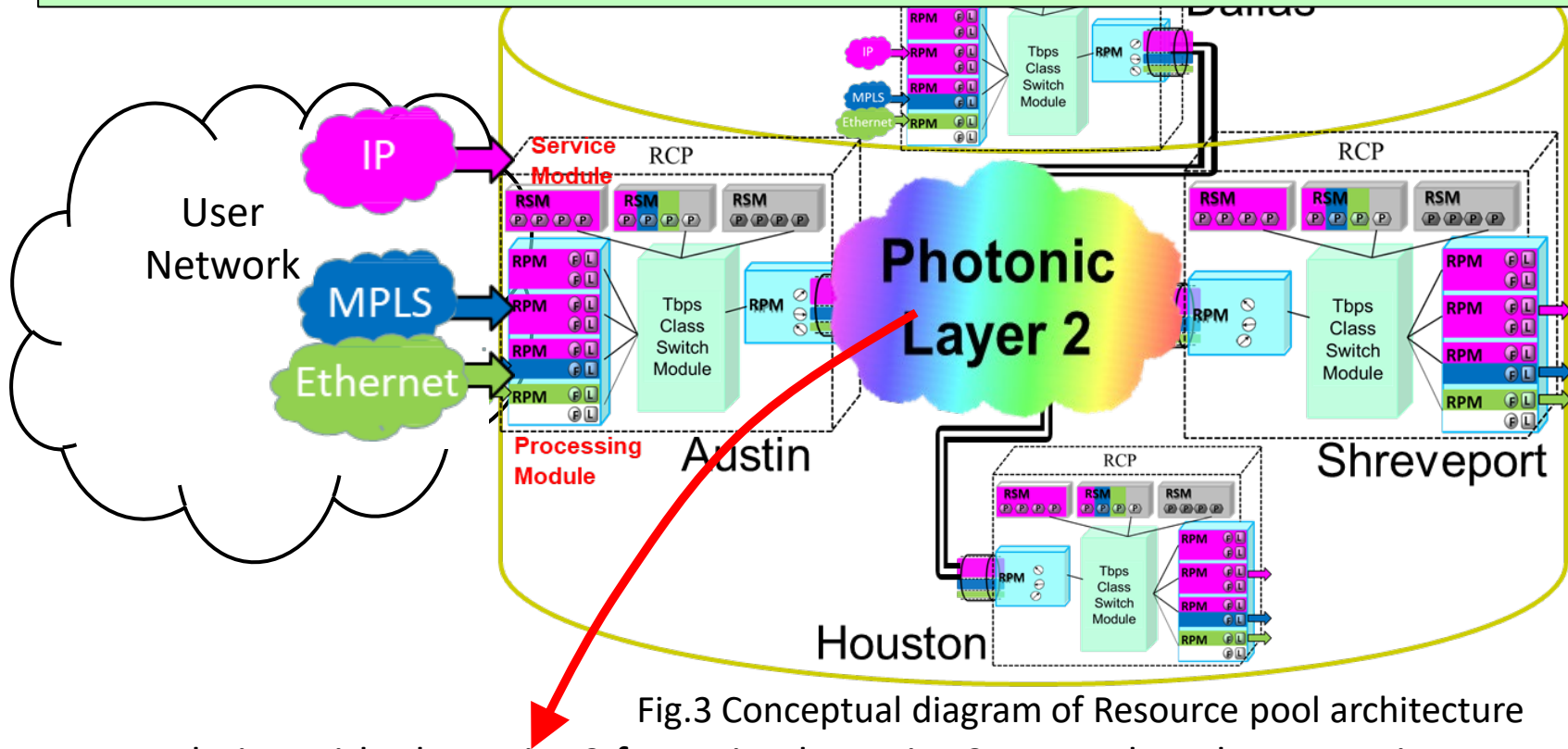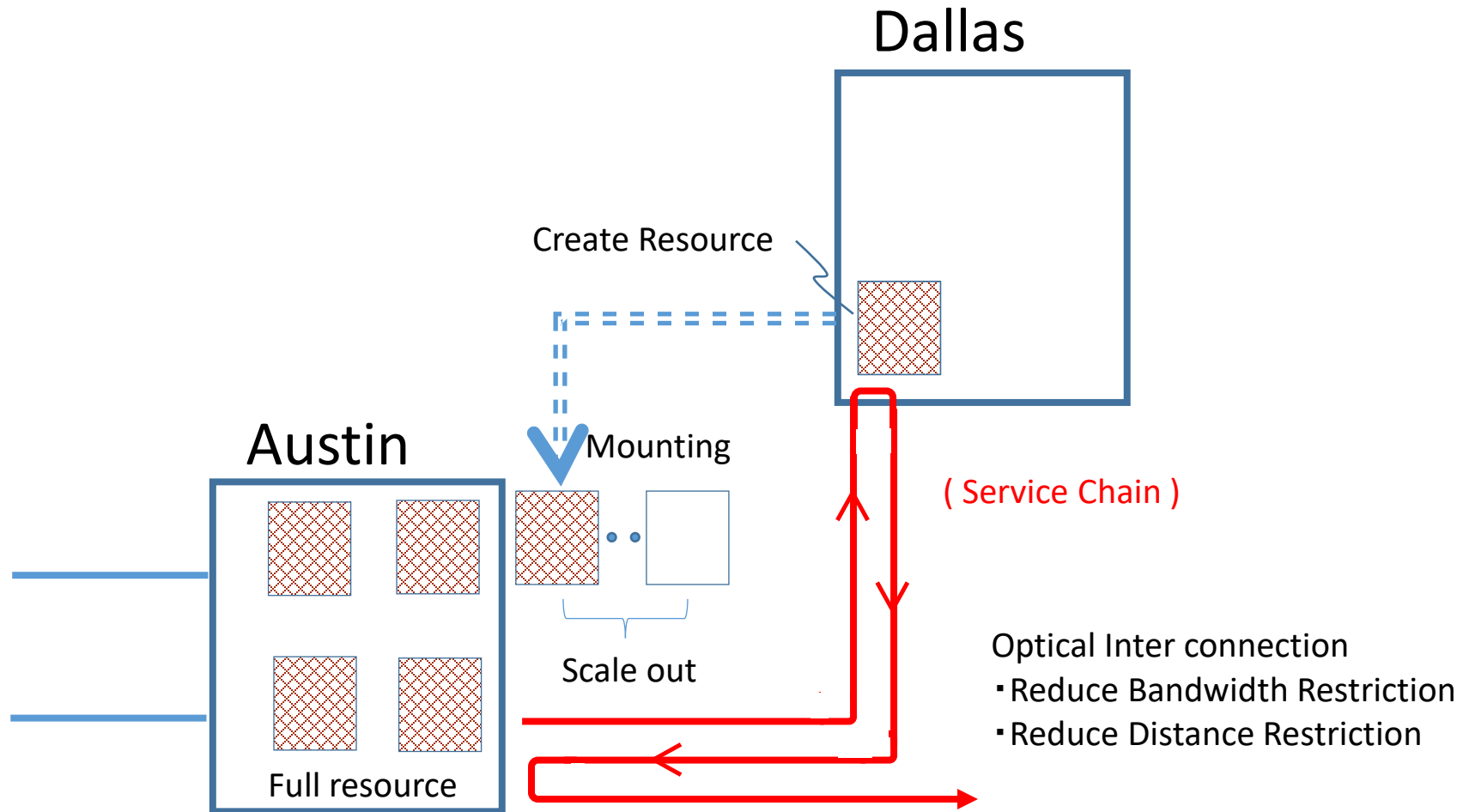

Fig.3 Conceptual diagram of Resource pool architecture

Encapsulating with Photonic L2 frame in Photonic L2 network and communicate high-speed transmission network service is realized by optical communication

To accommodate upper services from the user (IP, MPLS, Ethernet, etc.), the frame structure of Photonic L2 is corresponding to Ethernet

Function Mounting for scale out service

Dallas

Create Resource

Austin

Mounting

Scale out

Full resource

(Service Chain)

Optical Inter connection
・Reduce Bandwidth Restriction
・Reduce Distance Restriction

It's like Dropbox services.
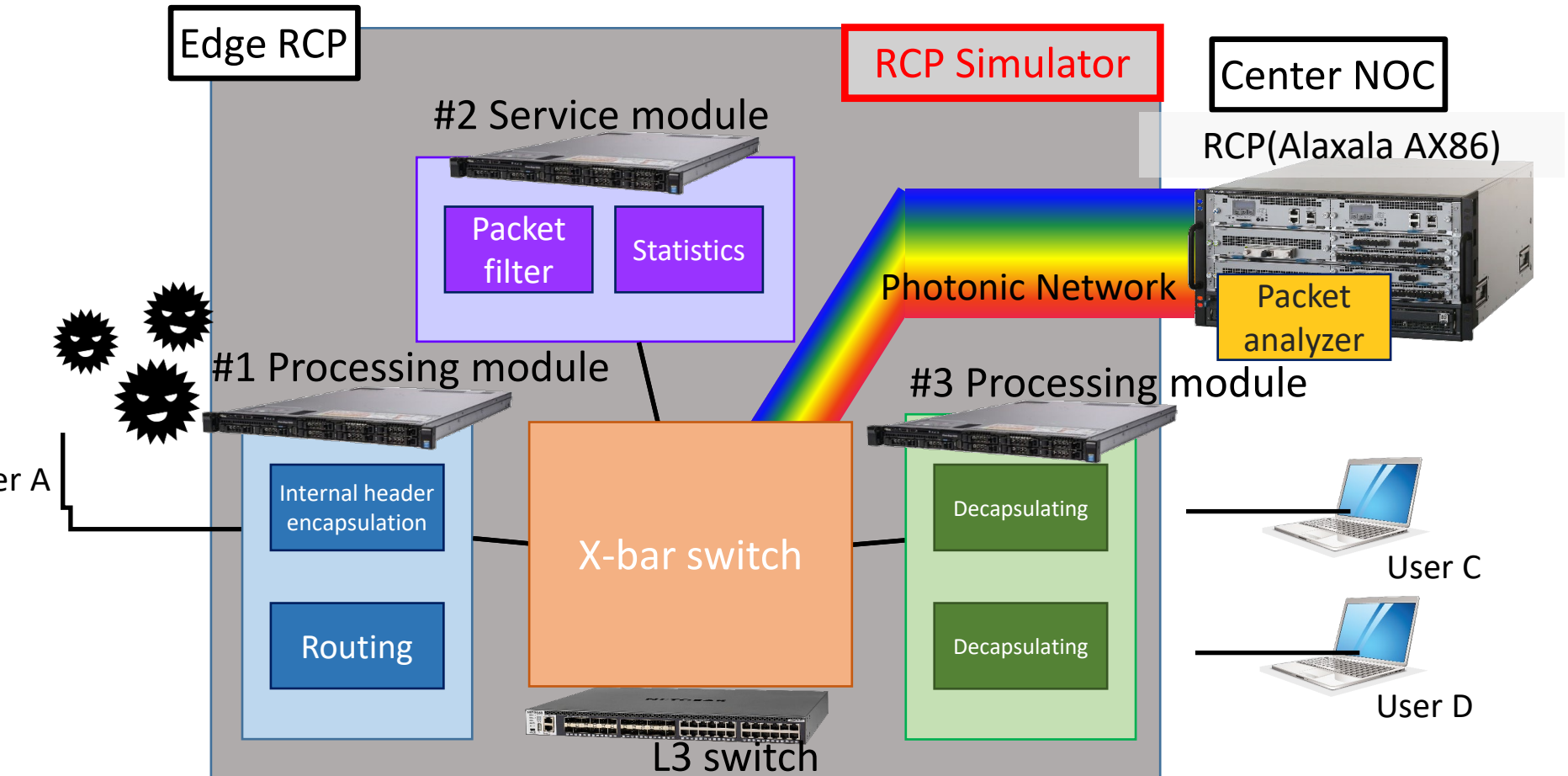
Test equipment insert at Edge device

Fig.6 Constitution of RCP simulator

Splitting router (L3) function using Click (software router) and place it in each vm inside each server.

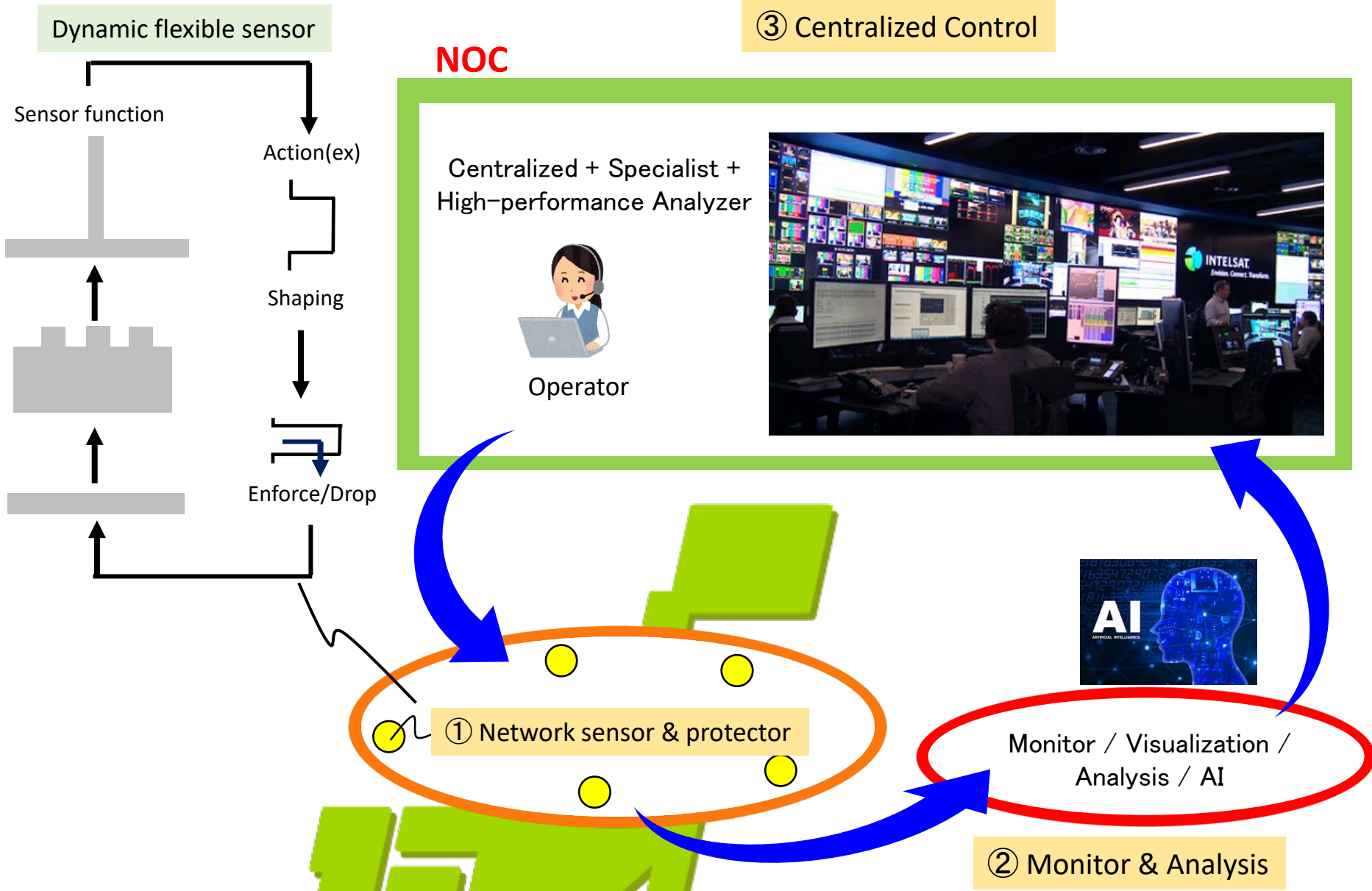# High-performance Network Monitoring from Centralized NOC

Dynamic flexible sensor

Sensor function

Action(ex)

Shaping

Enforce/Drop

③ Centralized Control

NOC

Centralized + Specialist + High-performance Analyzer

Operator

AI

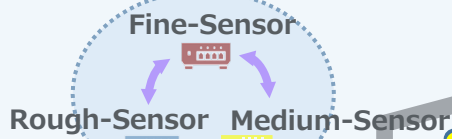① Network sensor & protector

Monitor / Visualization / Analysis / AI

② Monitor & Analysis

図3．全体のループシーケンス

Digital Twin Architecture by Specialist from Centralized NOC

（Tokyo Centralized Operation Center）

NOC

Decision & Control

Digital-twin Operation

Osaka ★Tokyo

Shizuoka
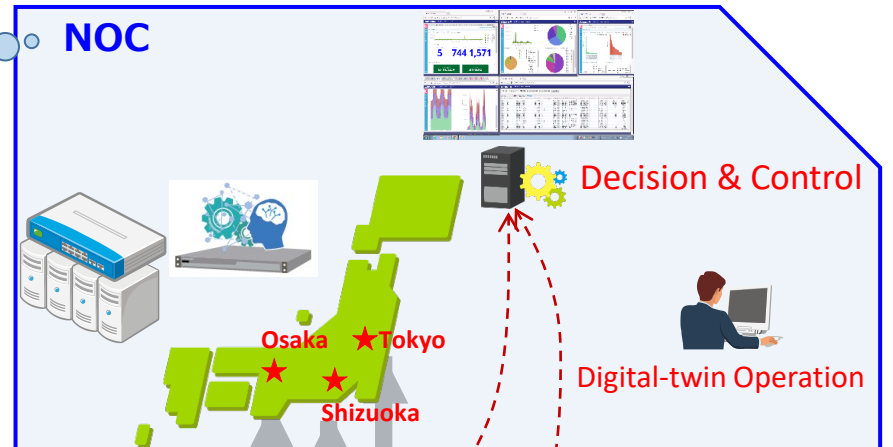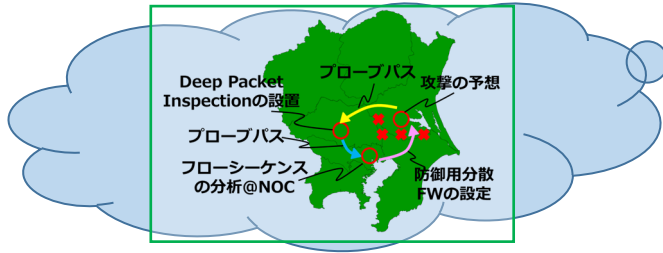
URLLC-DN: Ultra Reliable Low Latency Communications – Deterministic Networking

Hyper – Probing Layer

Fine-Sensor

Rough-Sensor   Medium-Sensor

URLLC-DN tunnel

Reconfigurable Transport Layer

Metro

Core

Metro

Network Sensor

Network Sensor

Access

5G Mobile

FTTH

Access

5G Mobile URLLC Service
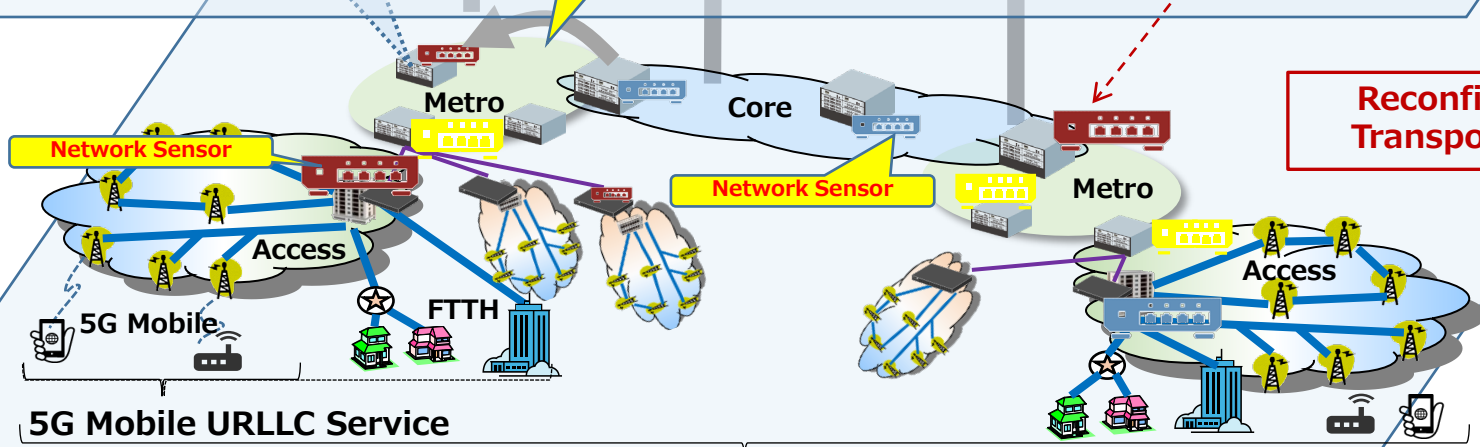
B5G End-to-End URLLC-DN capable network

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History of Full-flexible network

•S&CC stands for Smart and Connected Community, invoking the use of Full-flexible Network based on Software Defined Networking (SDN) principles applied to the optical network physical layer

•The concept of implementing and deploying S&CC as *both research and test-bed* originated during a number of meetings held by the PIs of a former JUNO project titled "ACTION" in June of 2014 (NSF-NICT JUNO workshop at UC Davis)

•Malathi Veeraraghavan (UVA) (She died in May 12, 2020, My deepest sympathies.)

•Naoaki Yamanaka (Keio University)

•Eiji Oki (Kyoto University)

•Andrea Fumagalli (UT Dallas)

•The application triggered flexible NW concept was driven by the PIs' interest in experimentally testing technologies and expected advantages to the applications that may result from automatically reconfiguring the optical network on-demand and through well-defined APIs

Conclusions

- Resource Pool Architecture for Flexible Service has been proposed

- LSI/FPGA/NP/CPU Co-design method is describe

- Optical wire interconnects "Resource" as function chaining

- It creates flexible and scalable network node

- We proposed Network Sensor and Centralized / Digital Twin NOC architecture

Acknowledgment