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MPSoC2017 for Software Defined Hardware

From Software Defined Network (SDN) to Software Defined Infrastructure (SDI)

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NEC Corp.

Agenda

Introduction to SDN/NFV

High-performance NFV platform

Software Defined Hardware meets MPSoC

Towards “Software-Defined Infrastructure”

Introduction to SDN/NFV

Software-Defined Networking and Network Functions Virtualization

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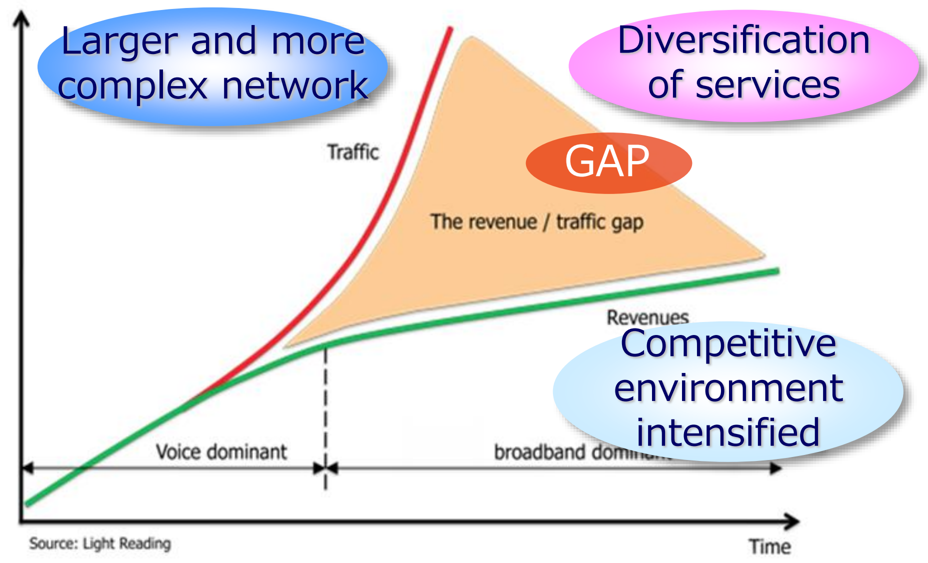
Problem of telecom carriers – traffic trend

Capital expenses tend to increase, while revenue ceasing

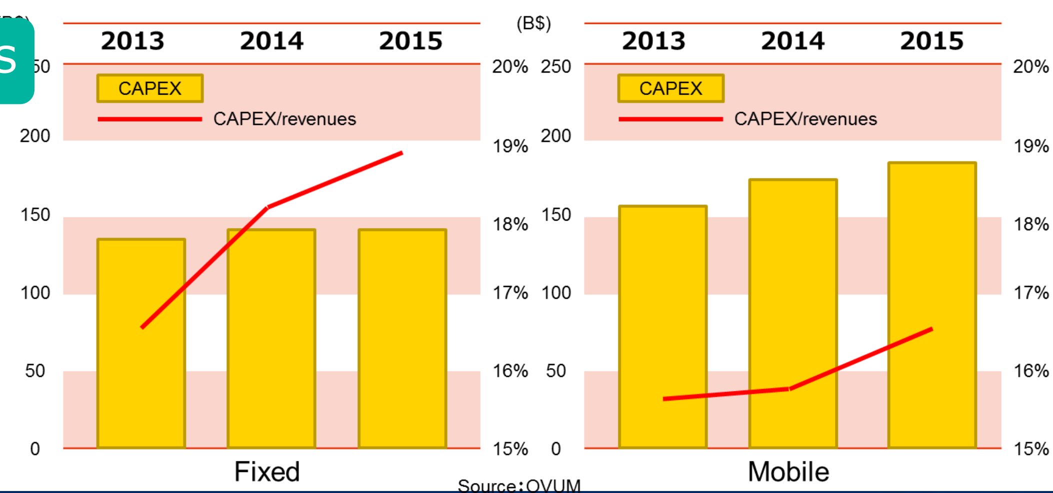
Gap between traffic demand and service revenue

- Network traffic continues to increase while telecom revenue will peak
- The gap between traffic and revenue will expand



Capital expense of telecom carriers

- The ratio of capital expense to revenue tend to increase, for both fixed and mobile communications



Problem of telecom carriers – business issues

Make network business economic, efficient, and providing value-added services, in order to adapt to the environmental changes

Environmental changes

Competitive environment intensified
(Subscriber reduction, revenue ceasing)

Large scale and complicated infrastructure
(Various devices types and configurations)

Diversification of services
(Rise of OTT)

More efficient and economical network infrastructure
➡ Reduction of CAPEX and OPEX

Value-added services
➡ Advanced network infrastructure towards expanding revenue

OTT: Over The Top

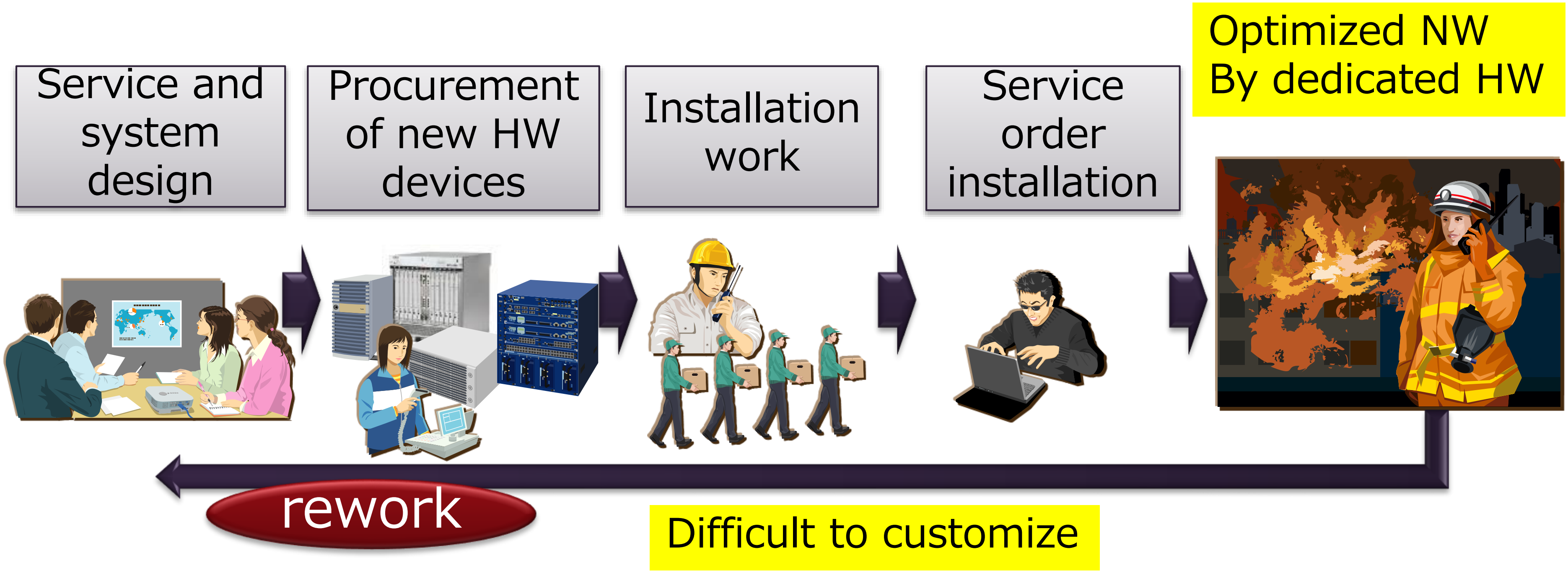
Conventional carrier infrastructure without SDN/NFV

Diverse dedicated hardware devices required for different services

- Need to secure a place and power supply for introducing new hardware devices for new services
- Expanding difficulty for design and operation, and securing experts

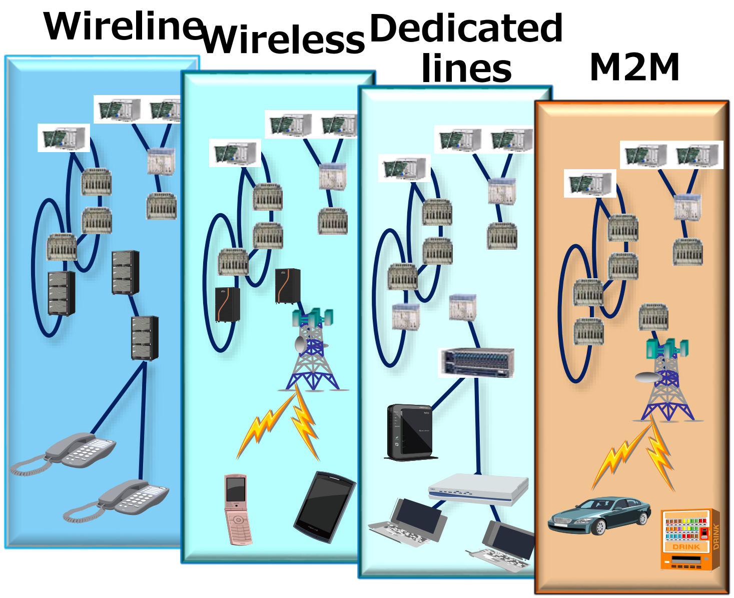
···result in:

- Increasing CAPEX and OPEX
- Time and difficulty for starting new value-added services

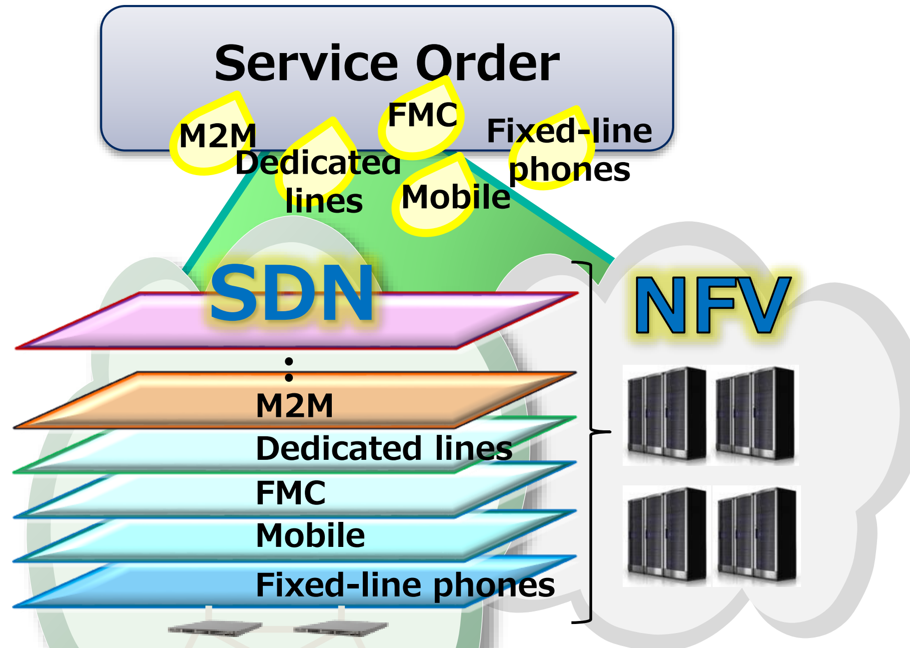


Expectations to SDN and NFV

BEFORE:
Vertical network silos with dedicated hardware



AFTER:
Diversification of services on one common network infrastructure



SDN (Software-Defined Networking):

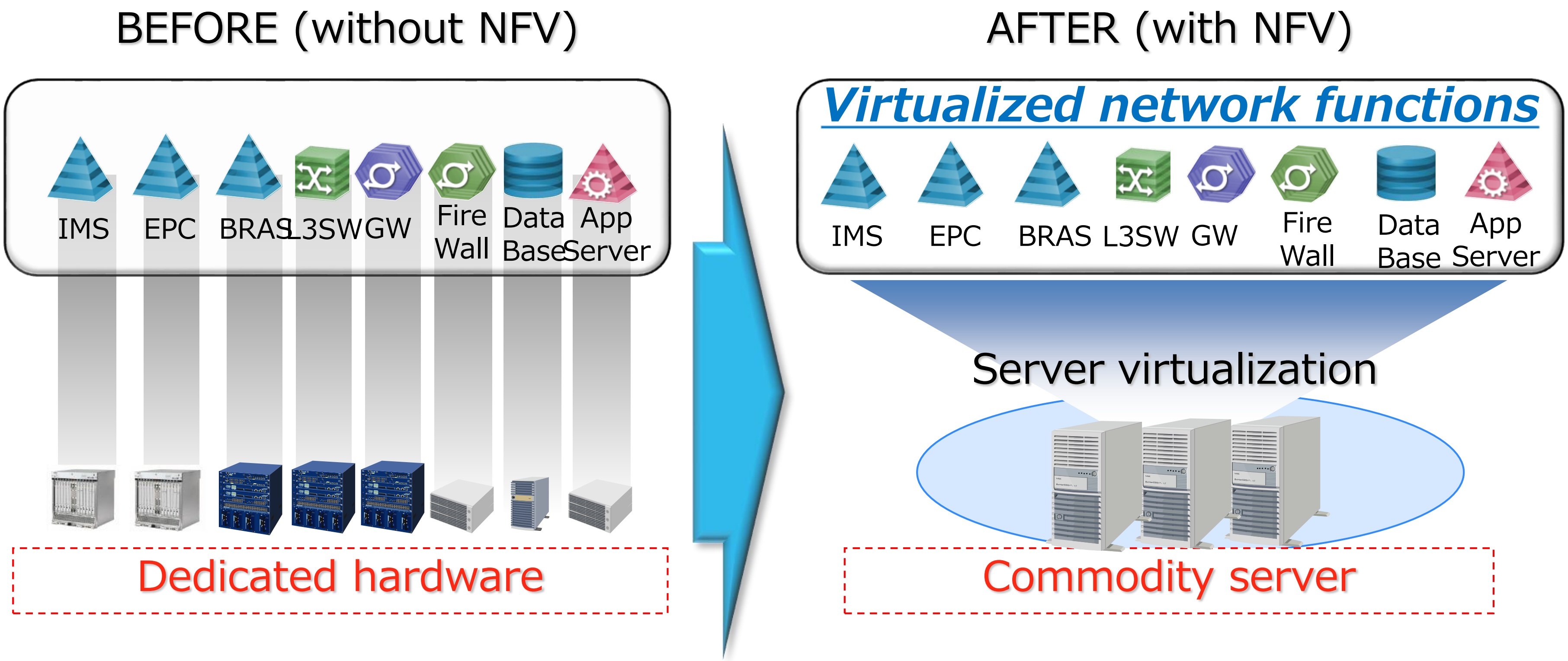
- Separation of control-plane and data-plane
- Tailored control mechanisms for various services

NFV (Network Functions Virtualization):

- Dedicated network functions running on commodity servers

Concept of NFV

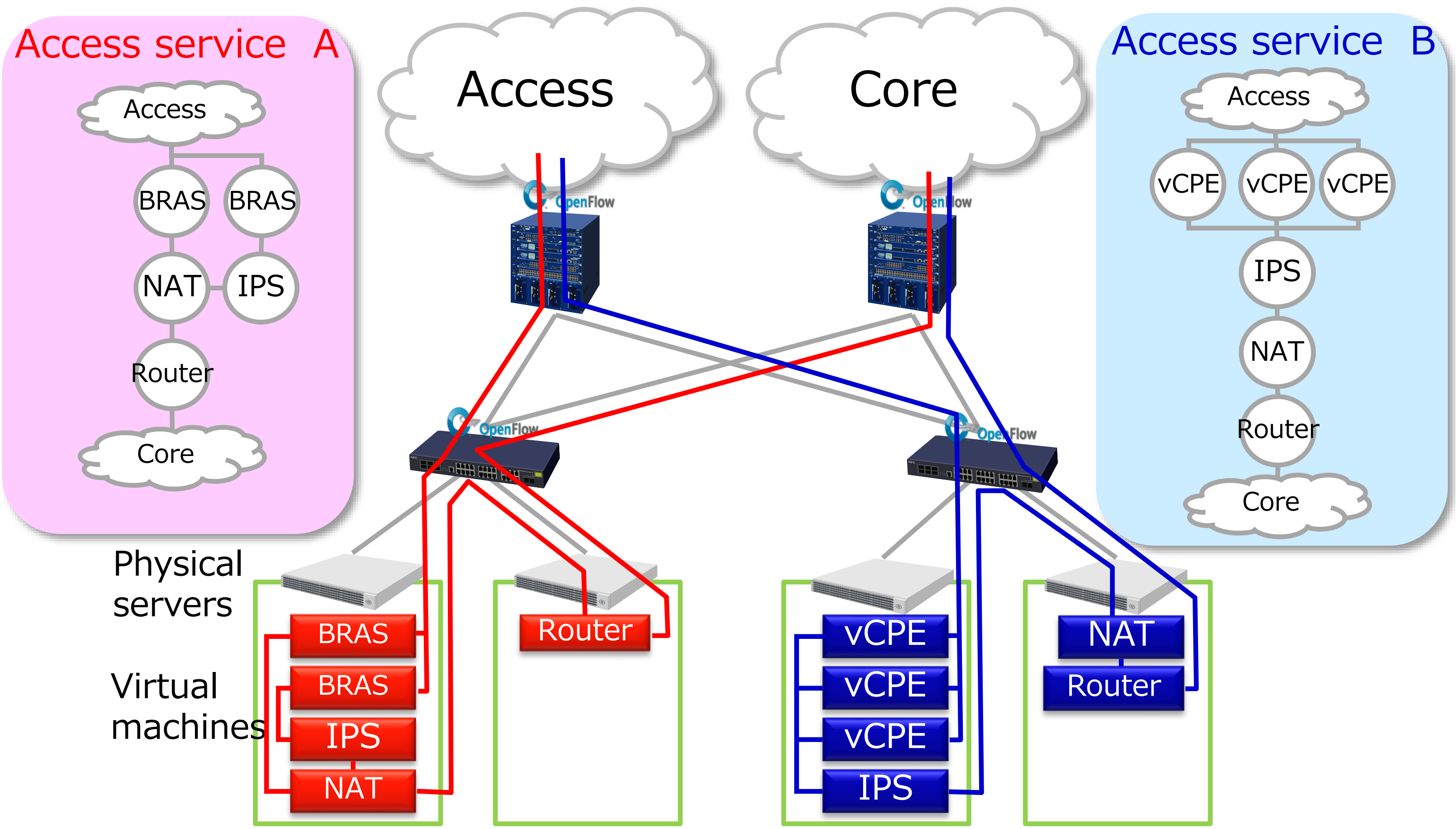
Commodity servers host network functions, which have been provided by dedicated hardware



IMS,EPC: network equipment used in mobile core network
BRAS: network equipment used in fixed access network

System virtualization with SDN/NFV

Agile service deployment over carrier cloud infrastructure



Benefit of SDN/NFV

Reduce resources by sharing infrastructure

- Various services share common infrastructure to reduce the amount of necessary resources
- Automated operation and management help flexible system sizing according to demand changes

Provide new services quickly and flexibly

- Small start on the cloud and scalable as required
- Multiple versions of service instances can coexist at the same time, allowing for smooth migration

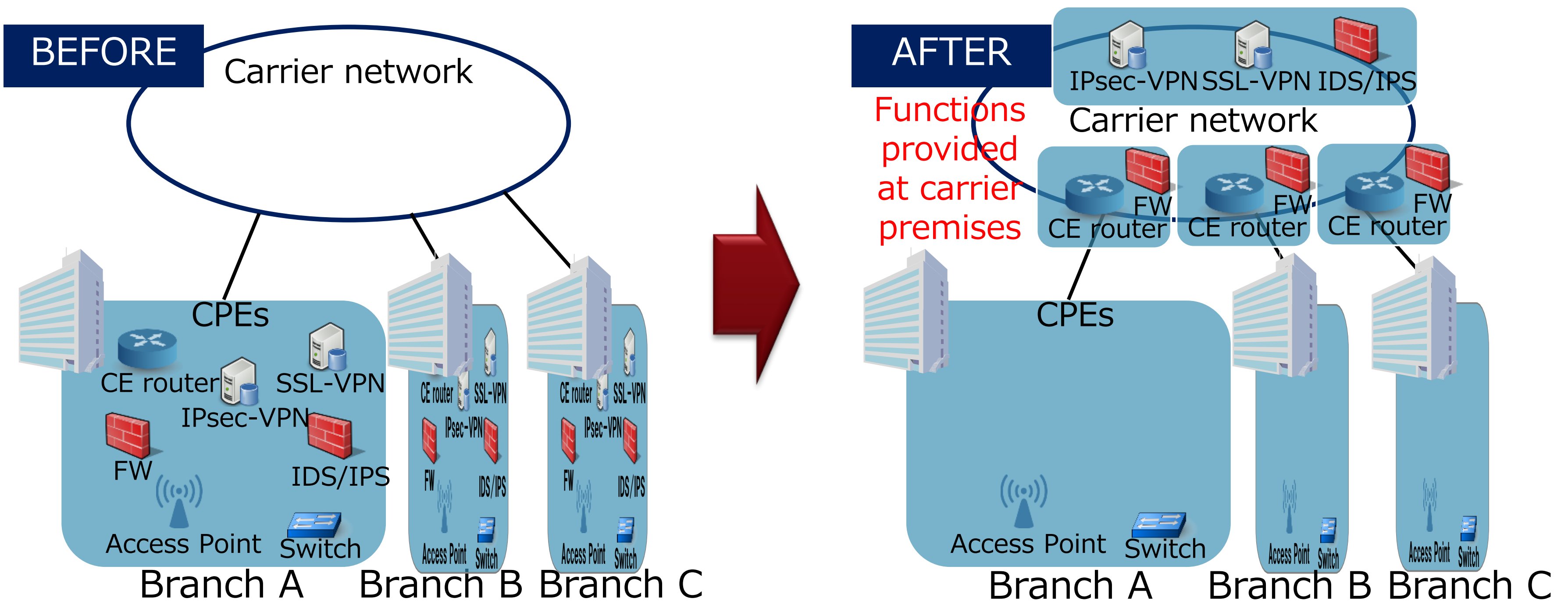
Simplified operation against disasters and congestion

- Decouple logical and physical installations
- Local disaster or congestions can be mitigated by remote resources

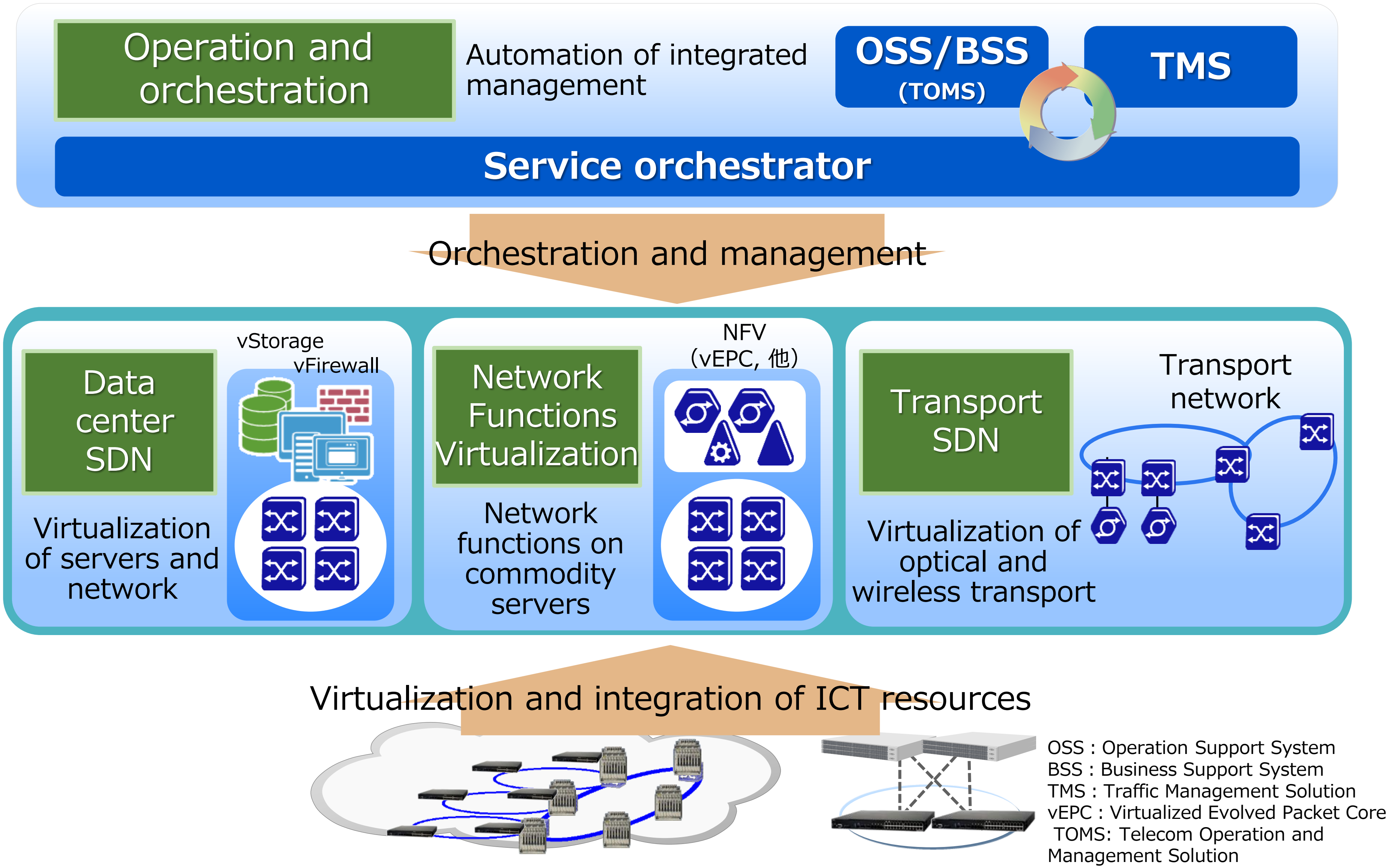
Use case: enterprise virtualized CPE(Customer Premises Equipment)

- Provide WAN service functions, installed at each site of user company premises, move to carrier premise (SD-WAN)

CAPEX	OPEX
Small start on the cloud with cheaper access lines (up to 90% cost reduction)	Reduce maintenance time and cost (weeks to hours)



Overview of NEC's SDN/NFV solution

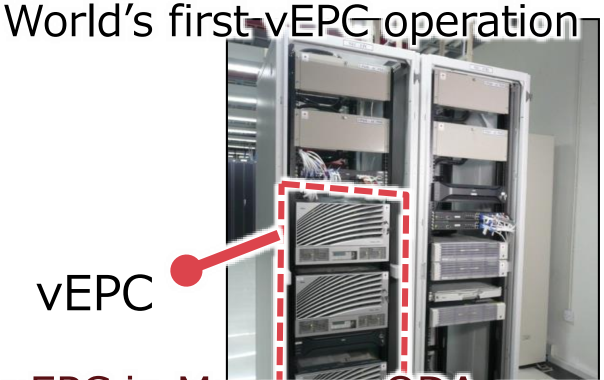


NEC's SDN/NFV products and PoCs

World's first commercial SDN switch (2011)

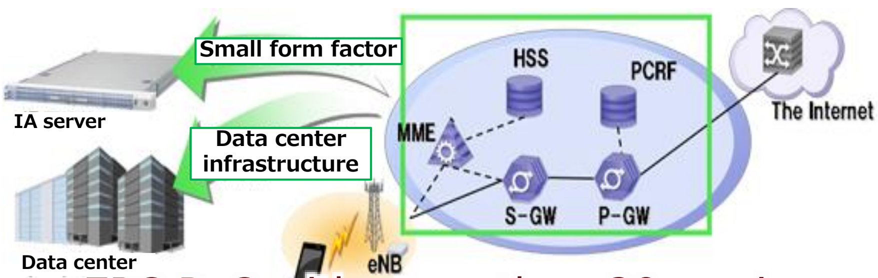
OpenFlow enabled SDN switch
"UNIVERGE PF series"

World's first vEPC operation (2013)



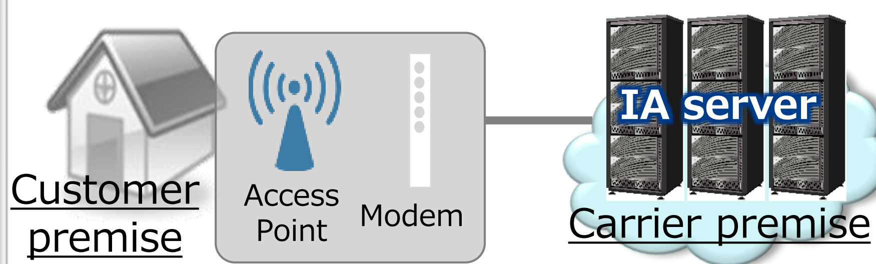
vEPC in Myanmar ODA communication backbone network
30-40% CAPEX saving

Successful demonstration of vEPC inter-operability test



vEPC PoC with more than 20 carriers
Respond quickly to changes in usage and failures

Joint demonstration experiment of vCPE with ViVo/Telefonica



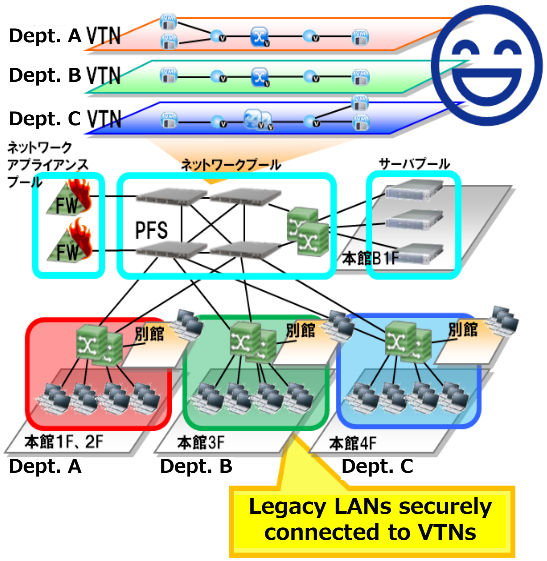
CPE functions move to carrier premise
No need for on-site maintenance

vCPE : Virtualized Customer Premises Equipment

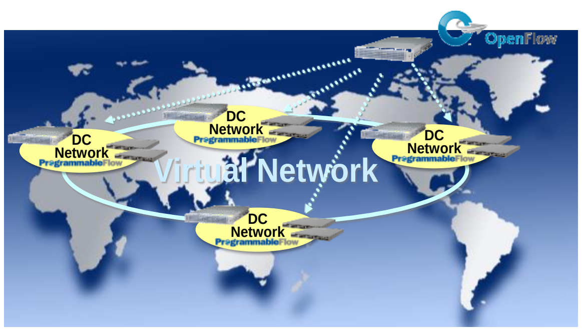
Expansion of SDN use cases

SDN commercialization extends from private to public networks

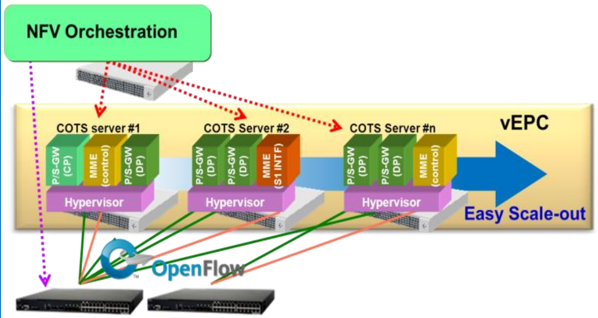
Enterprise



Data Center



Mobile core



Construct secure VTNs (Virtual Tenant Networks) over integrated infrastructure

Remote maintenance of globally distributed data centers

Flexible resource allocation according to load changes

NEC's SDN/NFV case studies

More than 250 systems are in operation at enterprises, governments, and telecom carriers

Common network infrastructure at railroad station (JR-East)

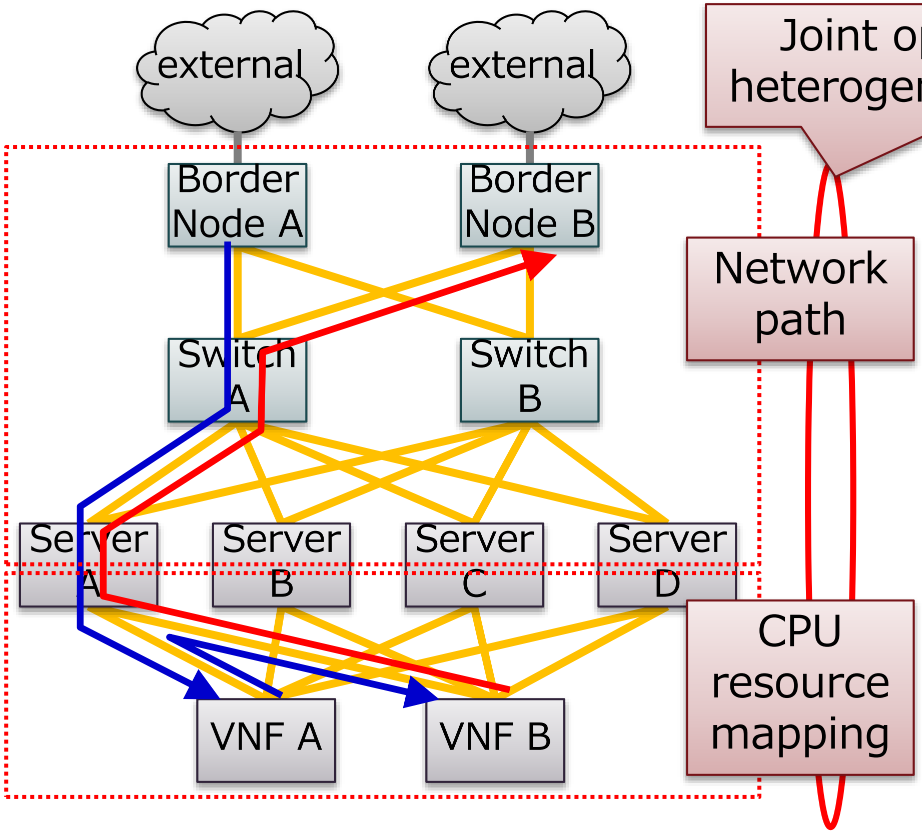
SDN wide area backbone network for high-way maintenance (NEXCO)

Integrated network infrastructure for banking system (Bank)

Network update for private cloud in city hall infrastructure

SDN/NFV resource allocation mechanism

- Modeling IT and NW resources using unified graph representation
- Solves the graph embedding problem using ILP



IT and NW resource modeling

Example of solution using ILP

Objective

Minimize physical links used by service chain $\sum_i \sum_j utopology_{ij}$

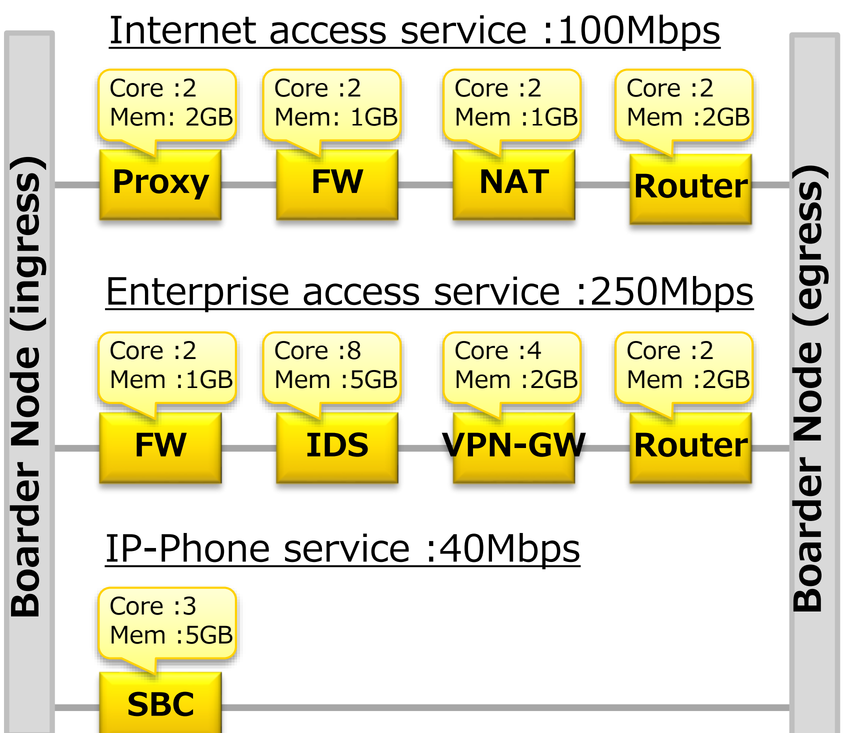
Subjections

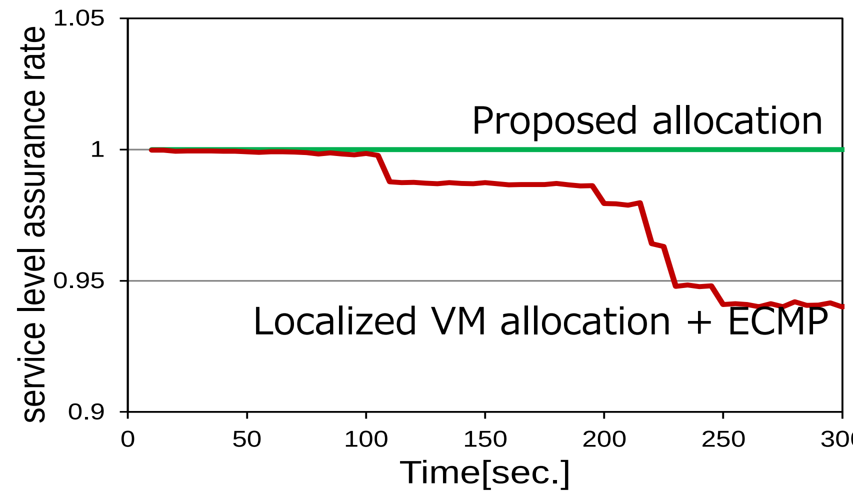
- Flow Conservation Rules
- Bandwidth Limitation
- Computing Limitation
- VNF Link Limitation
- Virtual Topology Limitation
- Loop Avoidance

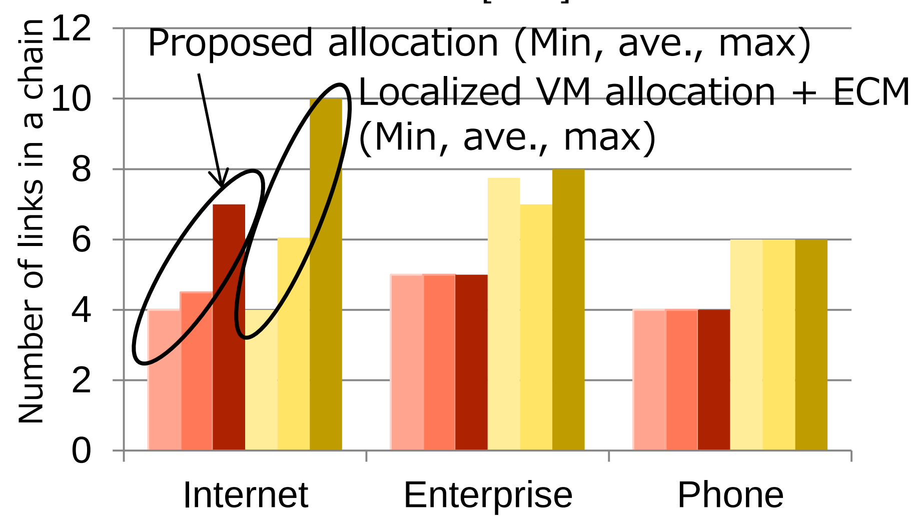
SDN/NFV resource allocation mechanism – numerical examples

Proposed VM and network path allocation mechanism achieves service level guarantee and minimum link usage

Three different services embedded into a shared infrastructure





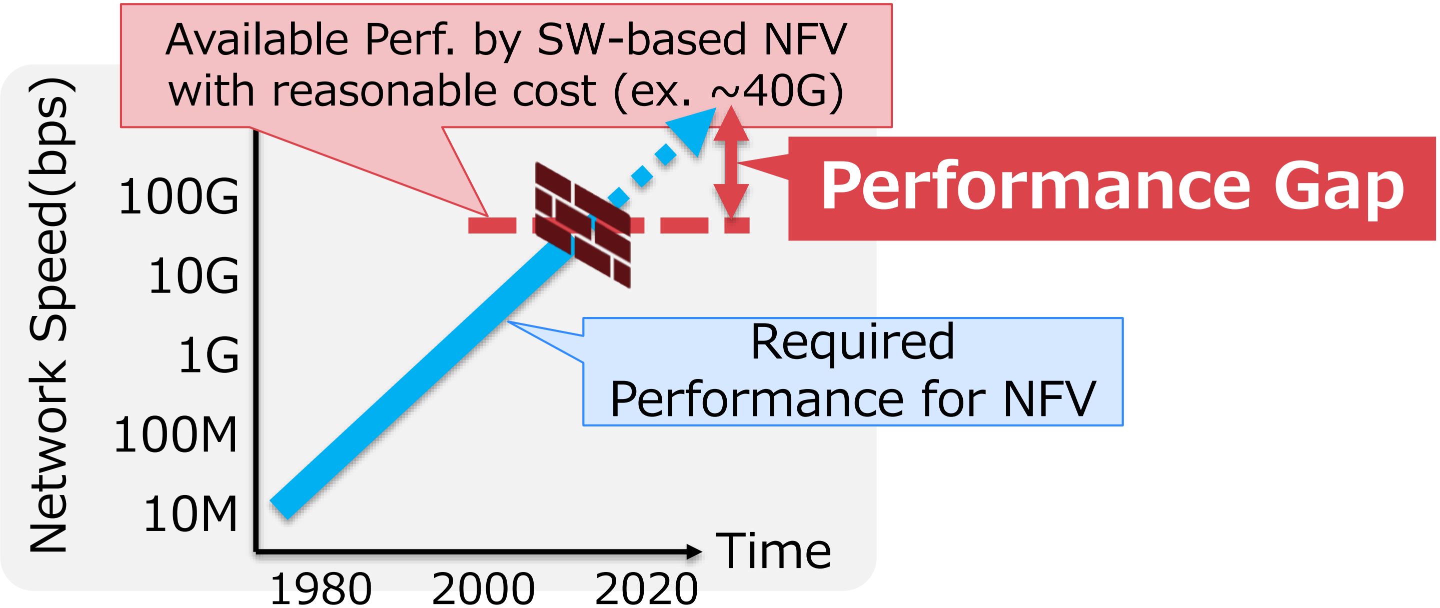


High-performance NFV platform

Needs for Accelerating NFV Application

SW-based NFV will not be able to sustain the future network performance (80G, 100G, 200G, ···) with reasonable cost

- ETSI* reported the performance bottleneck on pure software implementation -> investigating HW acceleration of NFV[1]
  - To allow further optimization and efficiency
  - Example of Accelerator: FPGA, GPU, Many-core



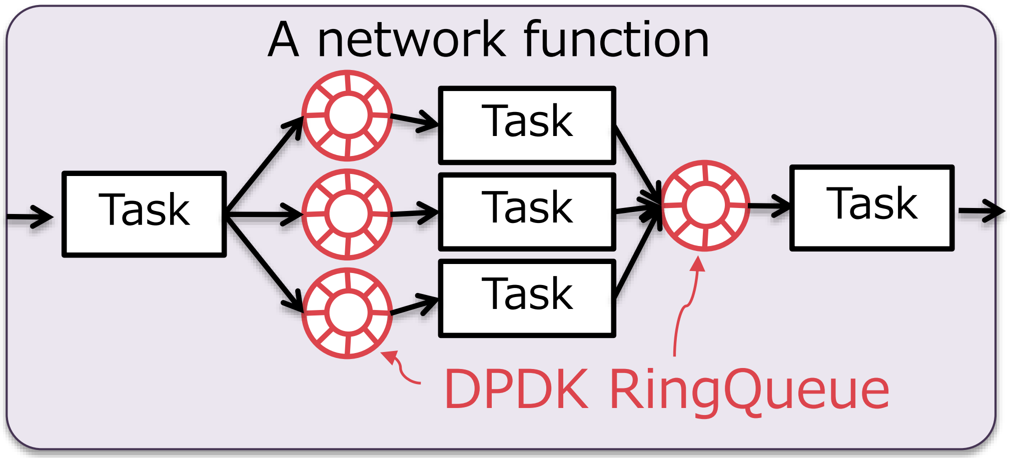
*ETSI: European Telecommunications Standards

[1] "NFV; acceleration technologies; report on acceleration technologies & use cases," ETSI GS NFV-IFA 001 V1.1.1 (2015-12).

Requirement for Acceleration: SW Compatibility

SW compatibility with existing NFV Application is crucial for the market -> supporting DPDK framework

- DPDK[2] framework is widely used in NFV applications
  - Low overhead communication between tasks/NICs
- HW Acceleration should not introduce extra SW development cost
- A key technology is an easy migration to HW accelerator while keeping the DPDK interface of the application as it is

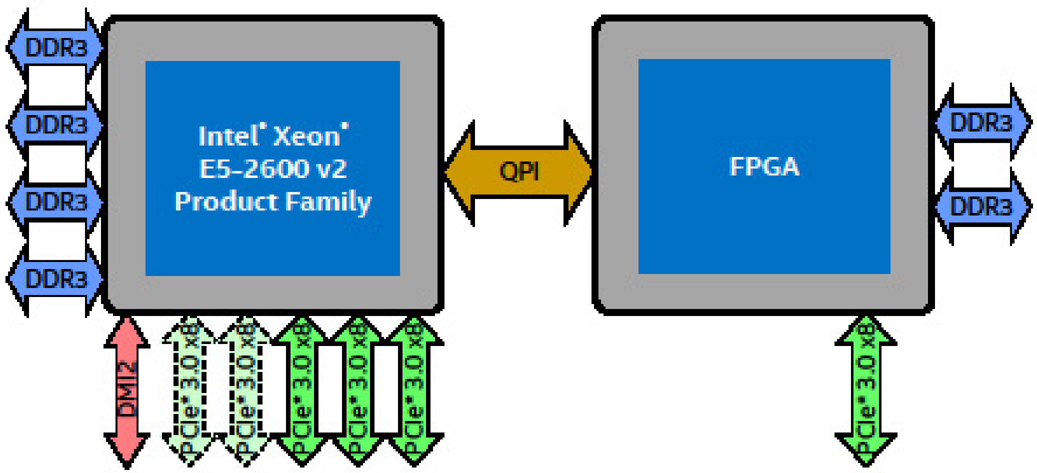


[2] DPDK: Data Plane Development Kit, http://dpdk.org/

CPU-FPGA Tightly Coupled Processor

IVB+FPGA Software Development Platform

Software Development for Accelerating Workloads using Xeon and coherently attached FPGA in-socket



Processor	Intel® Xeon® E5-26xx v2 Processor
FPGA Module	Altera Stratix V
QPI Speed	6.4 GT/s full width (target 8.0 GT/s at full width)
Memory to FPGA Module	2 channels of DDR3 (up to 64 GB)
Expansion connector to FPGA Module	PCIe 3.0 x8 lanes - maybe used for direct I/O e.g. Ethernet
Features	Configuration Agent, Caching Agent,, (optional) Memory Controller
Software	Accelerator Abstraction Layer (AAL) runtime, drivers, sample applications

Heterogeneous architecture with homogenous platform support

intel | 14

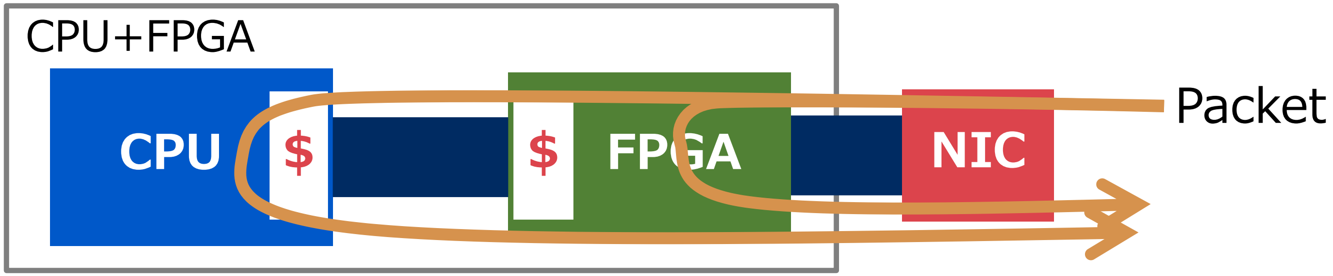
[3] IBM: Coherent Accelerator Processor Interface (CAPI).
[4] Xilinx: Zynq-7000 All Programmable SoC Technical Reference Manual, 2014.
[5] PK Gupta: “Using a Field Programmable Gate Array to Accelerate Application Performance,” IDF’15, DCWS008, 2015.

Use Cases: Software defined hardware meets MPSoC

Accelerating tasks of NFV application benefits to the increase of the number of subscribers supported by a server

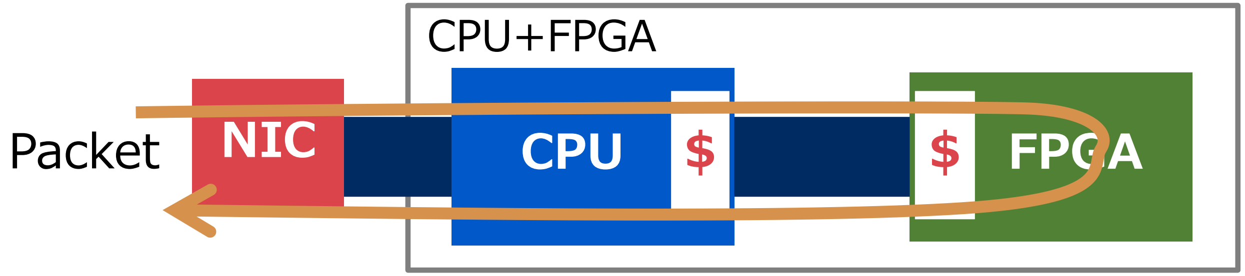
Type1: RX and TX are accelerated by FPGA

- CPU can focus on complicated & flexible tasks
- E.g. vCPE, Intelligent packet processing



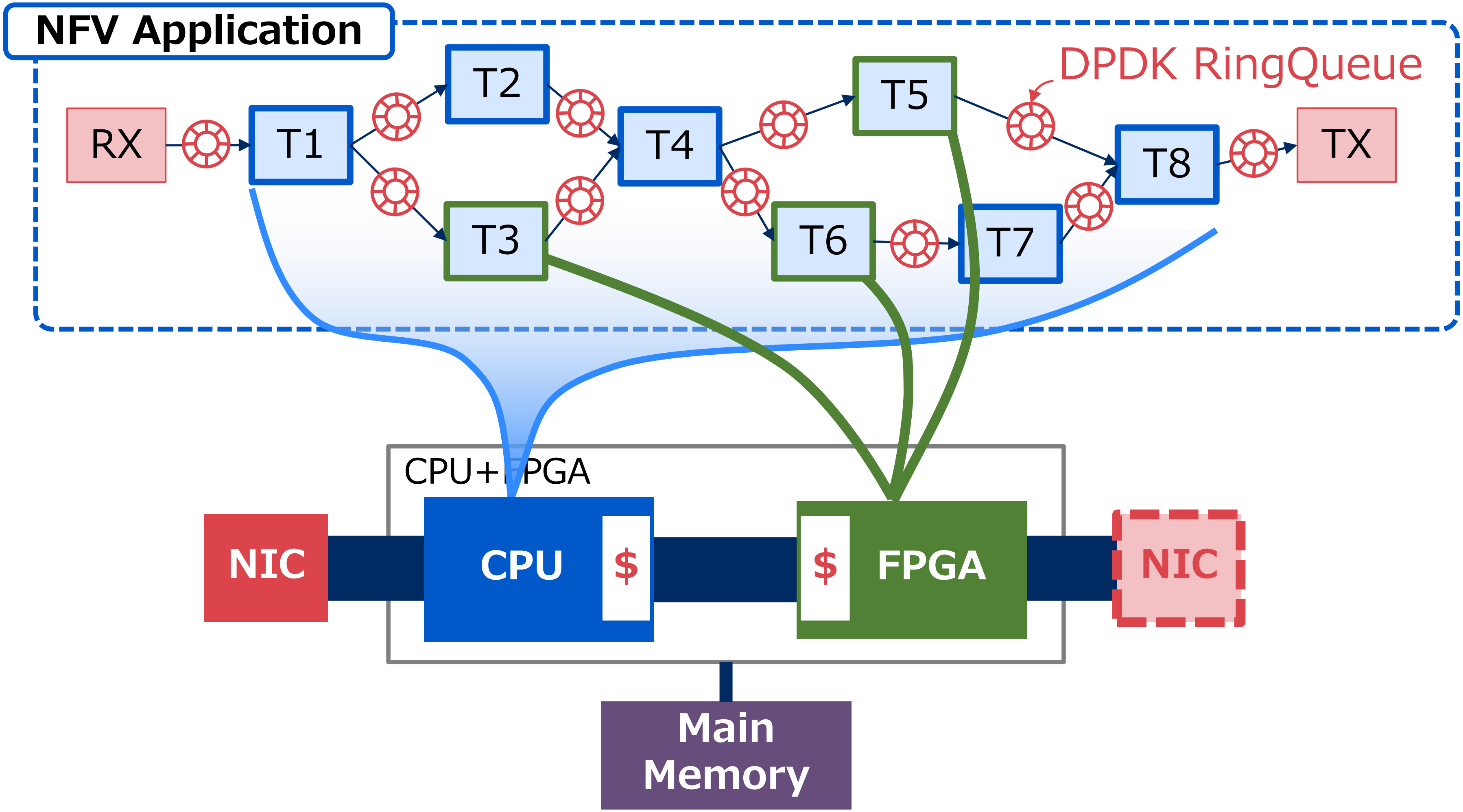
Type2: Heavy computation is accelerated by FPGA

- FPGA can accelerate a heavy task -> A single node can treat more subscribers
- E.g. audio codec transcoder



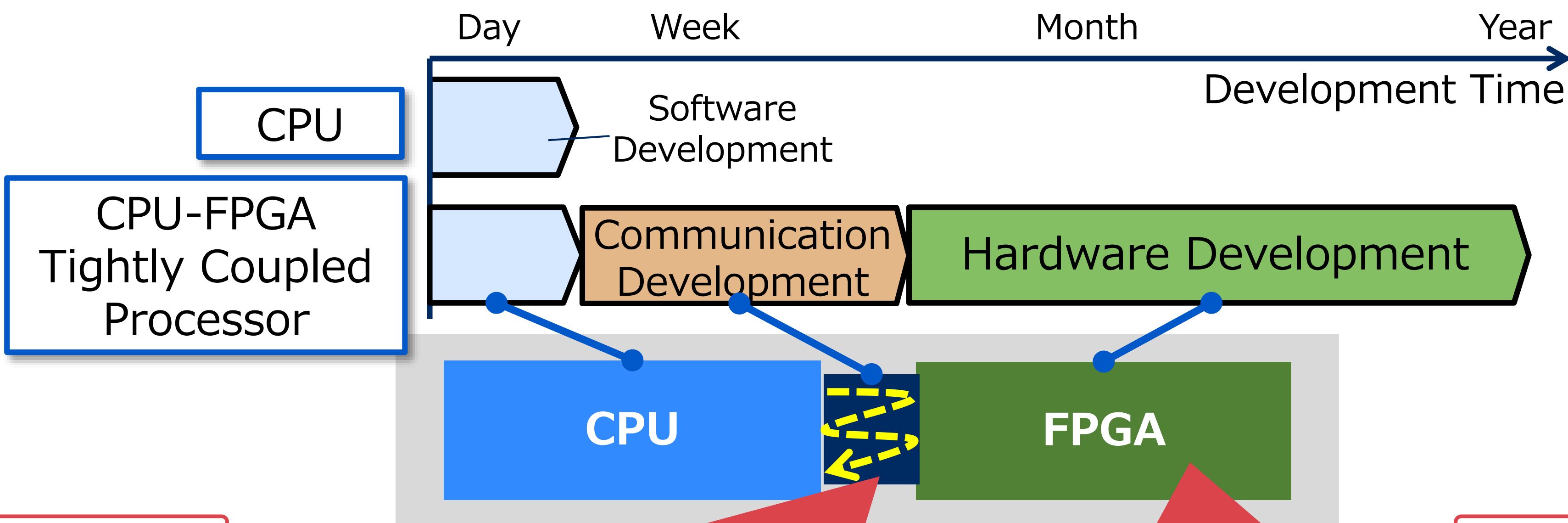
NFV on CPU-FPGA Tightly Coupled Processor

NFV application can be accelerated by applying CPU-FPGA Tightly Coupled Processor



Challenges for Tightly Coupled Processor: Development Time

Challenge 1: It needs long time for a HW expert to make design which exploits the FPGA's potential performance
Challenge 2: It requires to develop both SW and HW to utilize the broad bandwidth between CPU and FPGA



Challenge 2
Both HW & SW need to be developed/optimized to exploit the potential broad bandwidth

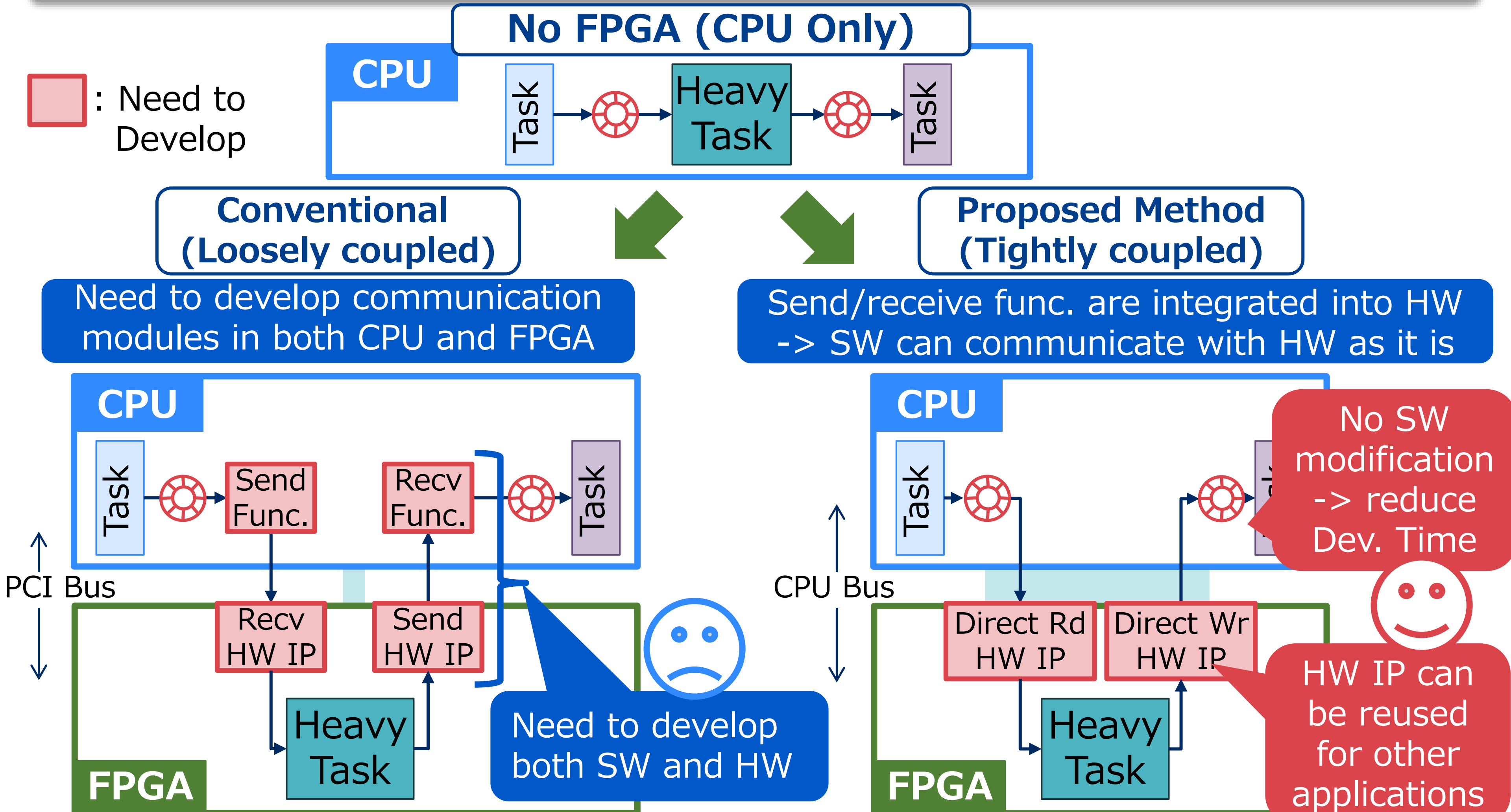
Challenge 1
Large effort for developing High performance HW

NEC's Tech 2
High performance and flexible framework to utilize the unique features of CPU+FPGA

NEC's Tech 1
High Level Synthesis by CyberWorkBench(R)

Proposed Framework for CPU-FPGA Tightly Coupled Processor

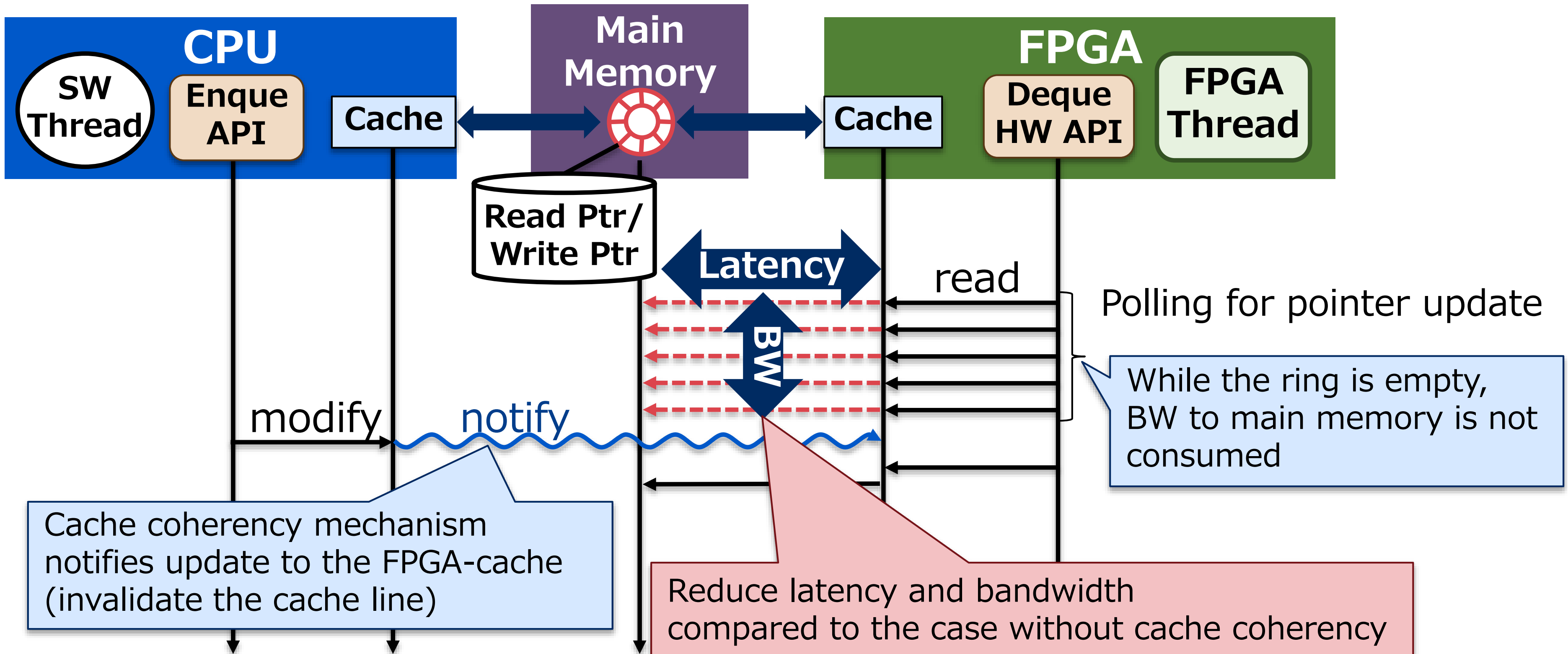
SW can communicate with HW (FPGA) in a software manner (i.e. DPDK Ring-queue) -> reducing SW development effort



Framework Detail 1/2: Reduce waste of bandwidth by coherent cache

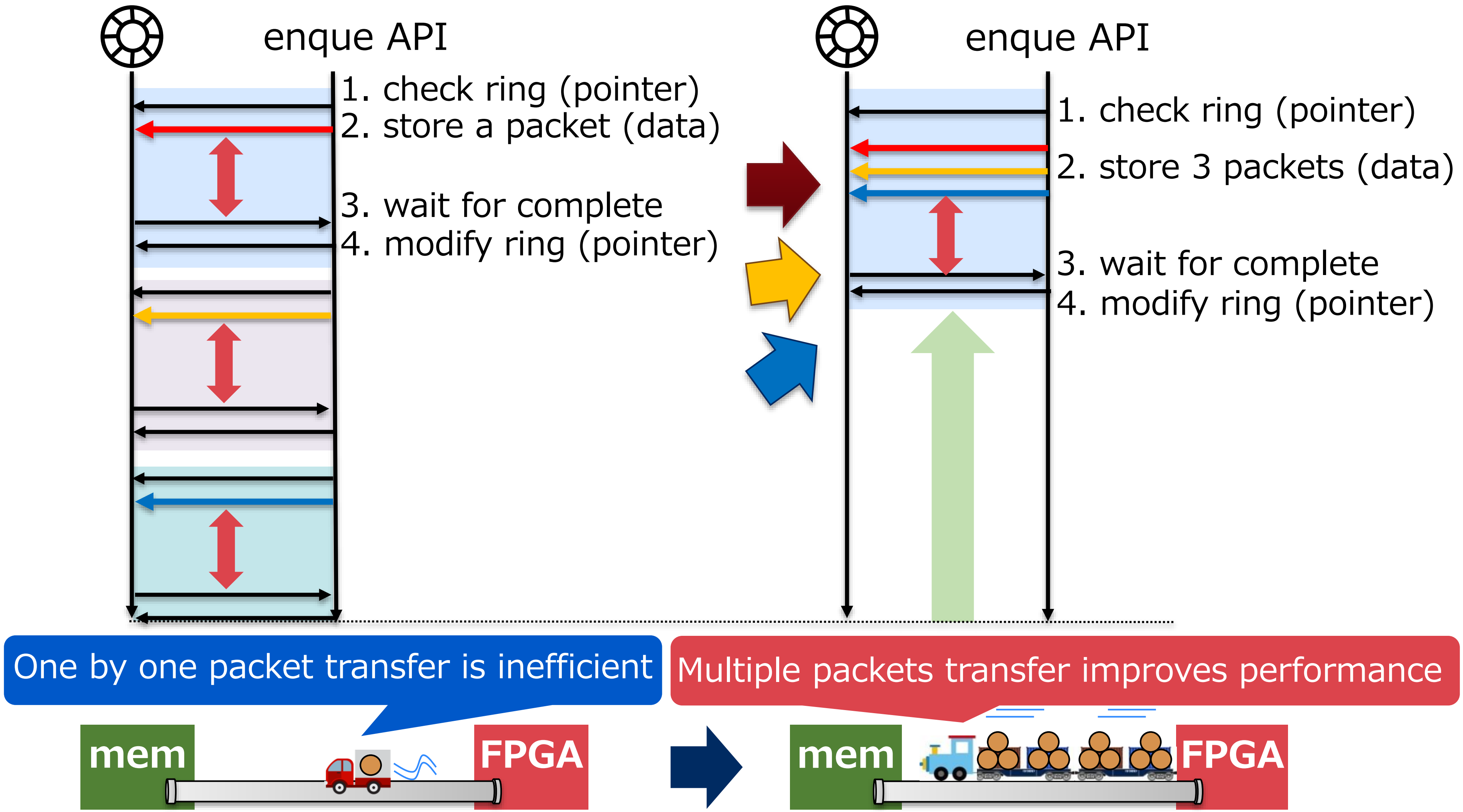
- Our approach enables **efficient polling from FPGA** utilizing cache coherency
- FPGA can poll the state of RingQueue with low latency and less waste of memory bandwidth (BW).

Ex. Case of FPGA waiting for CPU to enqueue data to the ring-queue



Framework Detail 2/2: Batch transfer support

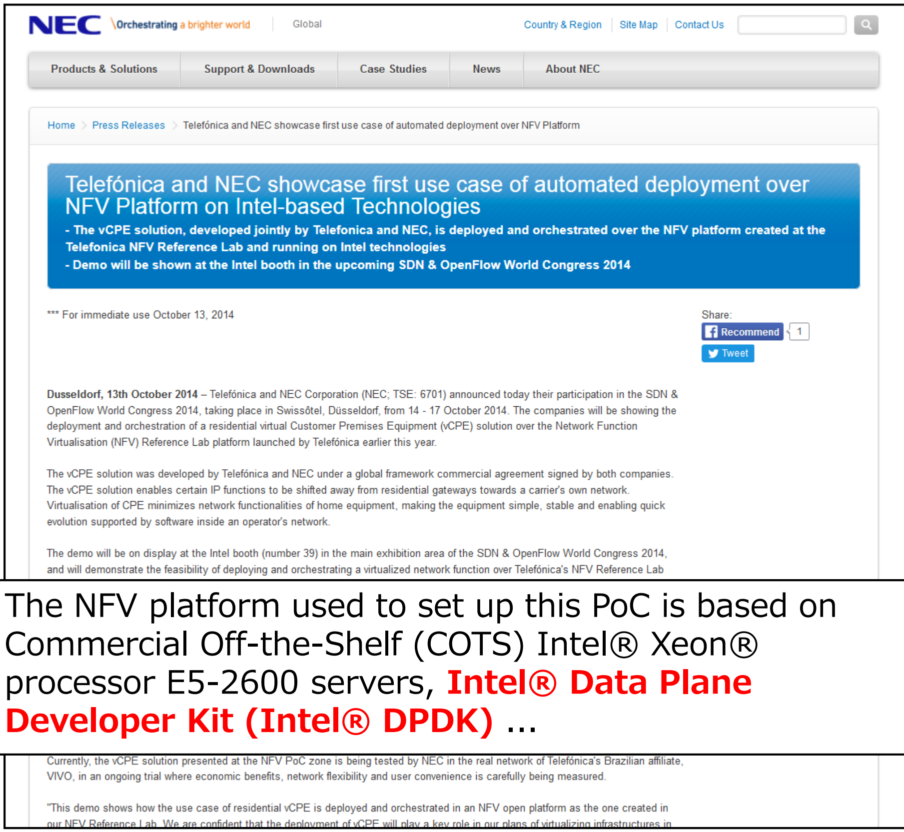
Batch transfer achieves full-bandwidth utilization



Evaluation: on Current Xeon FPGA evaluation board.

NEC developed NFV applications such as vCPE on Xeon and DPDK.

ex) Our vCPE achieved 40Gbps performance thanks to DPDK on Xeon.



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Home > Press Releases > Telefónica and NEC showcase first use case of automated deployment over NFV Platform

Telefónica and NEC showcase first use case of automated deployment over NFV Platform on Intel-based Technologies

- The vCPE solution, developed jointly by Telefonica and NEC, is deployed and orchestrated over the NFV platform created at the Telefonica NFV Reference Lab and running on Intel technologies

- Demo will be shown at the Intel booth in the upcoming SDN & OpenFlow World Congress 2014

*** For immediate use October 13, 2014

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Dusseldorf, 13th October 2014 – Telefónica and NEC Corporation (NEC; TSE: 6701) announced today their participation in the SDN & OpenFlow World Congress 2014, taking place in Swissôtel, Düsseldorf, from 14 - 17 October 2014. The companies will be showing the deployment and orchestration of a residential virtual Customer Premises Equipment (vCPE) solution over the Network Function Virtualisation (NFV) Reference Lab platform launched by Telefónica earlier this year.

The vCPE solution was developed by Telefónica and NEC under a global framework commercial agreement signed by both companies. The vCPE solution enables certain IP functions to be shifted away from residential gateways towards a carrier's own network. Virtualisation of CPE minimizes network functionalities of home equipment, making the equipment simple, stable and enabling quick evolution supported by software inside an operator's network.

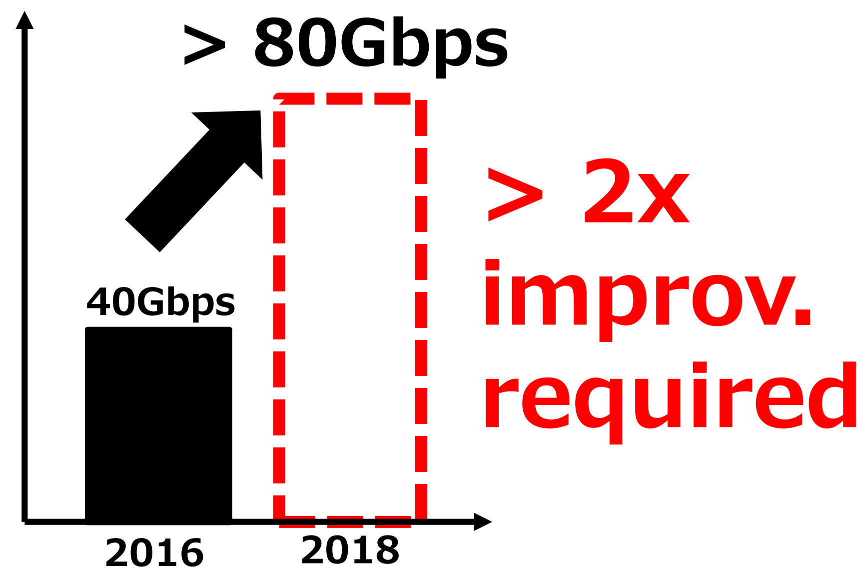
The demo will be on display at the Intel booth (number 39) in the main exhibition area of the SDN & OpenFlow World Congress 2014, and will demonstrate the feasibility of deploying and orchestrating a virtualized network function over Telefónica's NFV Reference Lab

Currently, the vCPE solution presented at the NFV PoC zone is being tested by NEC in the real network of Telefónica's Brazilian affiliate, VIVO, in an ongoing trial where economic benefits, network flexibility and user convenience is carefully being measured.

"This demo shows how the use case of residential vCPE is deployed and orchestrated in an NFV open platform as the one created in our NFV Reference Lab. We are confident that the deployment of vCPE will play a key role in our plans of virtualizing infrastructures in

The NFV platform used to set up this PoC is based on Commercial Off-the-Shelf (COTS) Intel® Xeon® processor E5-2600 servers, **Intel® Data Plane Developer Kit (Intel® DPDK)** …

Subscribers' bandwidth is increasing by 1.5x / year. It is expected to require 80G-100Gbps in 2018.



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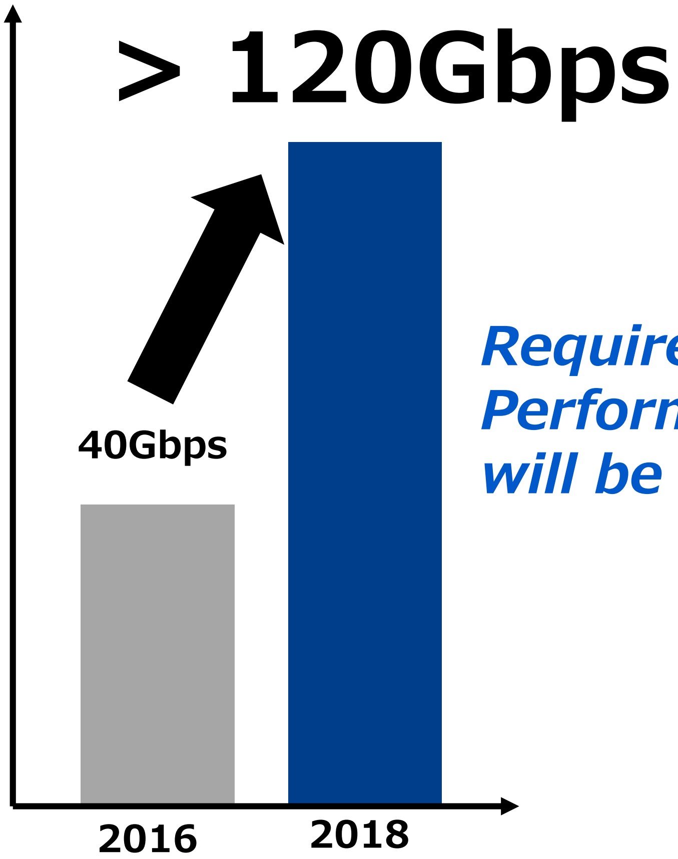
Perf. estimation of vCPE on Xeon+FPGA SKX

Expected that the commercial version of Xeon+FPGA will achieve required performance

By using the commercial version of Xeon+FPGA
We can have:

- **Larger FPGA**
  (Arria 10: > 2x than IVB SDP)
- **Wider effective bandwidth**
  (UPI+PCIe : > 3x than IVB SDP)
- **Increasing cores**
  (> 3x than IVB)
- **Direct attached NIC with 100Gbps**
  (currently 10Gbpx * 2)



Required Performance will be achieved

Towards “Software-Defined Infrastructure”

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Evolution of SDN/NFV to Software-Defined Infrastructure

SDN/NFV started from telecom carrier

- CAPEC/OPEX reduction and agile service creation
- Manage IT and NW resources jointly

SDN/NFV platform evolves to scale

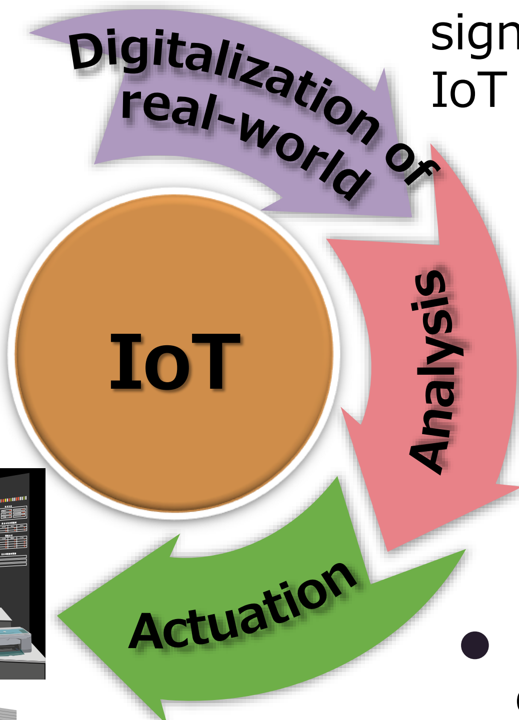
- CPU-FPGA combination scales performance in a cost effective way

SDN/NFV expands to social infrastructure

- "Software-Defined" Infrastructure empowers social IoT/ICT system, e.g. traffic management and smart city

Example; real-time traffic management

V2V/V2I communications and edge computing are required future ITS system to reduce accident and mitigate congestion

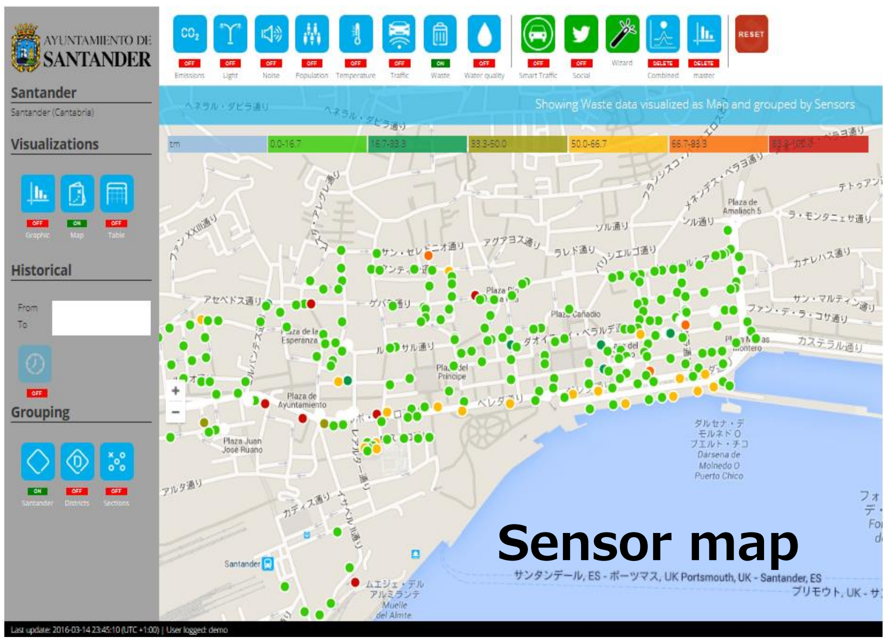


- Collecting Big Data (sensor signals or video) from massive IoT devices on the road
  - Dynamic map (precise digital map for autonomous driving)
  - Real-time prediction of collisions or congestions through big data analysis
- Low latency and reliable communication for remote control or actuations

Example; smart city

12,000 sensors placed in the city to optimize the route of the garbage collection
NEC has introduced IoT platform (CCOC)

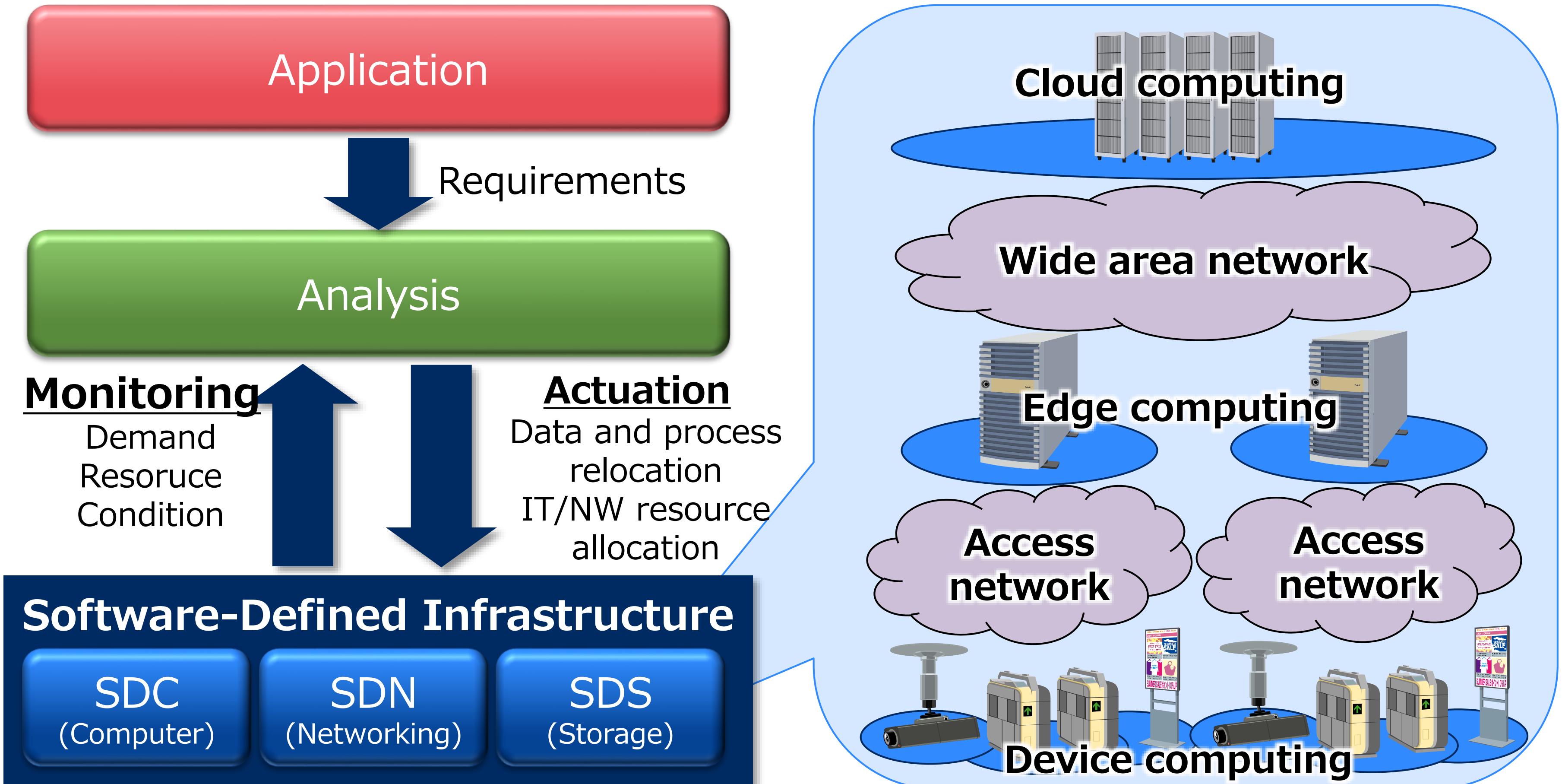
CCOC: Cloud City Operation Center



In addition to visualization of air temperature, traffic condition, and environmental noise, advanced garbage collection management is provided using IoT technologies

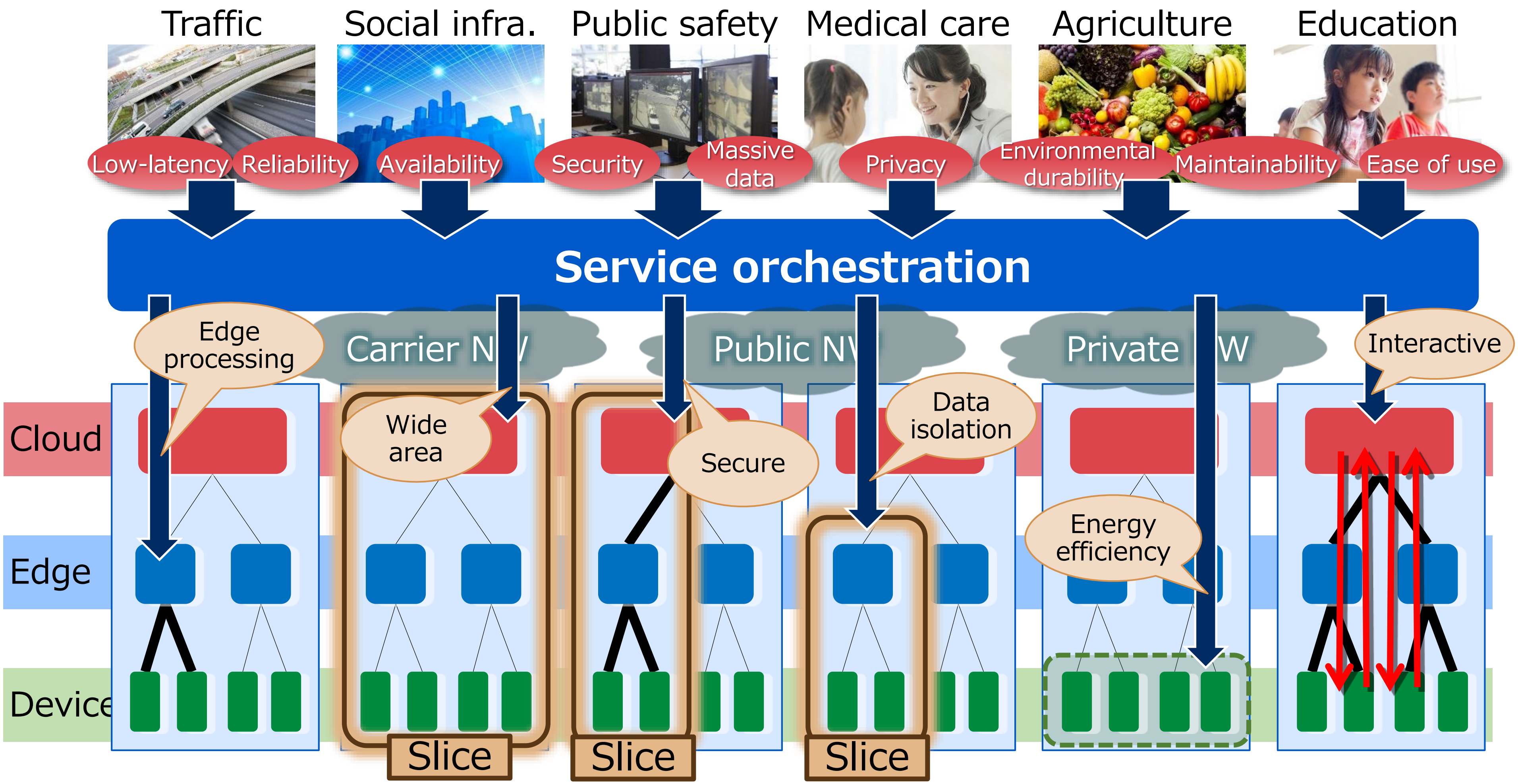
SDI: Software-Defined Infrastructure

SDI enables dynamic control loop between applications and infrastructure, to provide customized infrastructure for various social services



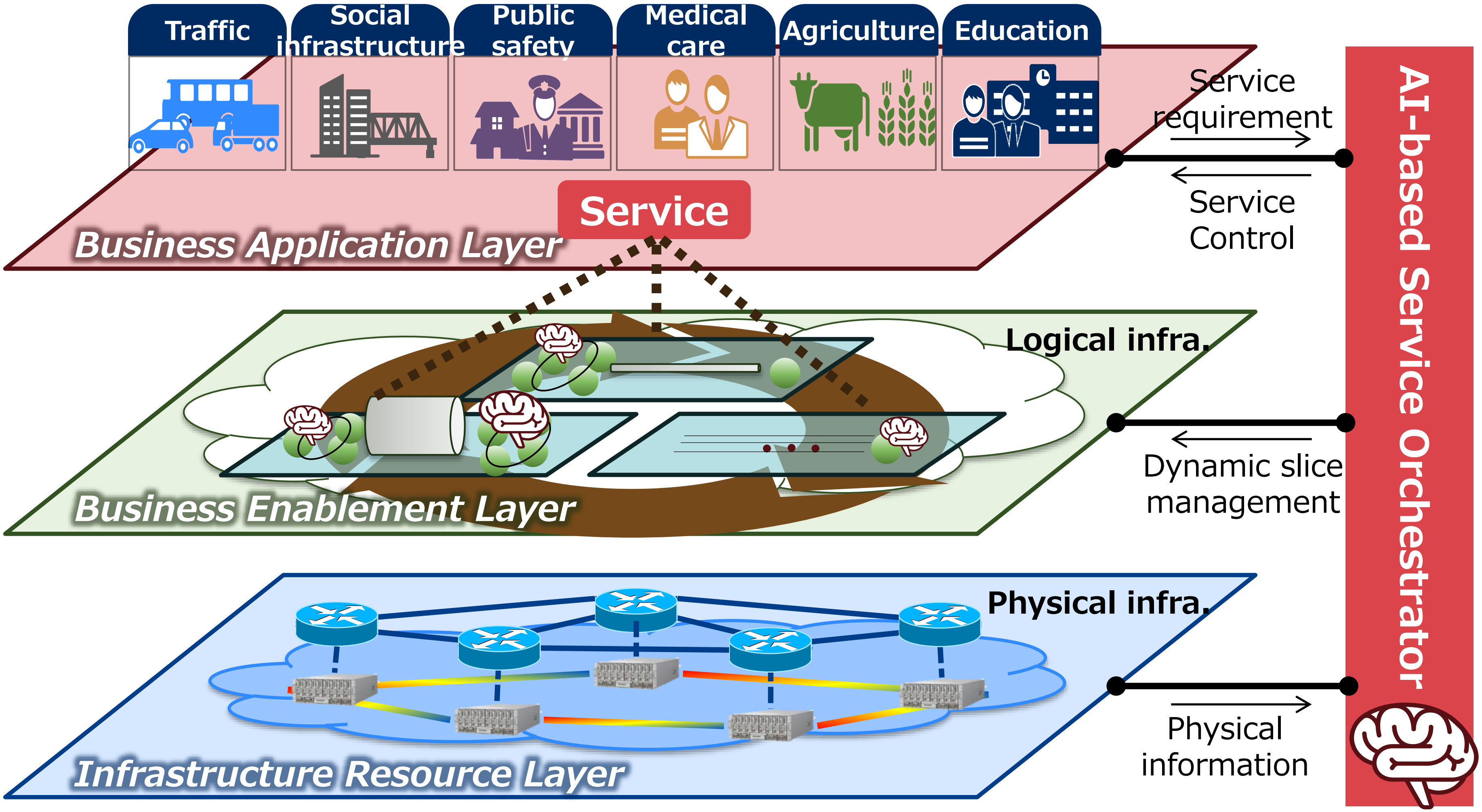
Dynamic slicing for various service creation

Social services are instantiated as a "slice"; virtualized set of resources from cloud/edge/devices



Service orchestration

Service orchestrator takes care of management of logical and physical infrastructure to satisfy requirements of individual services



Research targets

5G infrastructure

- CPU/GPU/FPGA platform for SDN/NFV/Cloud-RAN environment
- End-to-end (RAN and core) slicing and resource orchestration

Telemetry and analysis

- Traffic bottleneck measurement and analysis
- Extremely rare event (node failures or congestion) prediction

Design and operation

- Operator intent recognition and automated system design
- Cognitive system reconfiguration for unexpected failures

User data analysis

- Social data analysis, encrypted data analysis, and traffic data analysis for public safety, city traffic optimization, customer behavior analysis, etc

Possible use of "AI" technologies for high-dimension data analysis and huge state-space exploration for complex system design

Summary

Introduction to SDN/NFV

- SDN/NFV solves network operator's problem –CAPEC/OPEX reduction and agile service creation
- SDN/NFV use cases expand to enterprise, data centers, and telecom carriers

High-performance NFV platform

- Software defined HW meets MPSoC
- CPU-FPGA combination scales performance in a cost effective way
- Optimum joint resource allocation guarantees SLA

Towards "Software-Defined Infrastructure"

- SDI to provide customized infrastructure for various social services

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