MPSoC 2015

# Programmable Network

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NTT Network Innovation Laboratories
July 17th, 2015

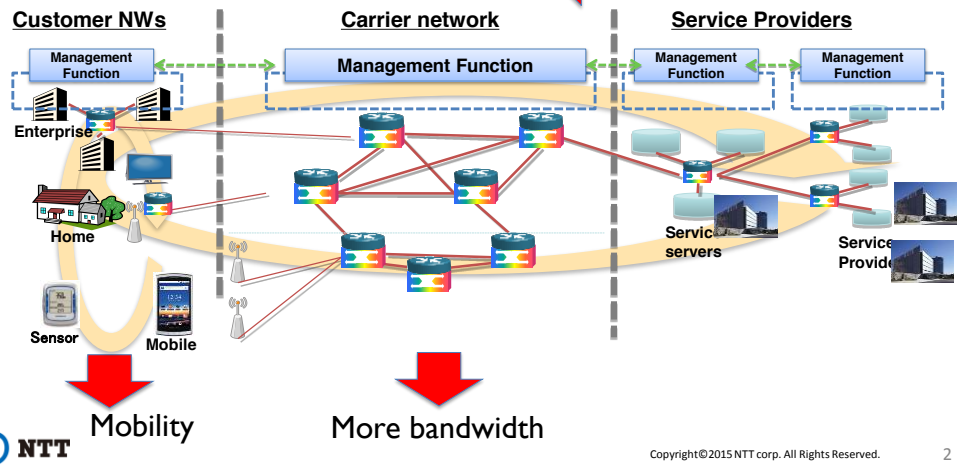


## Common style of networking

## Requirements for network

Application specific networking
(Contents delivery, BCP (back up), SNS, …)

On-Demand




Mobility

More bandwidth




## Current trend

- SDN, NFV
  - Network virtualization and programmability in network becomes common.
  - 2011-2012 was the turning point.
- CAPX/OPEX reduction

  is the first and comprehensive benefit of network virtualization.
- Programmability in Network
  - Providing fast, collaborative and safe platform for business/social activities
  - DPN (Deeply Programmable Network)

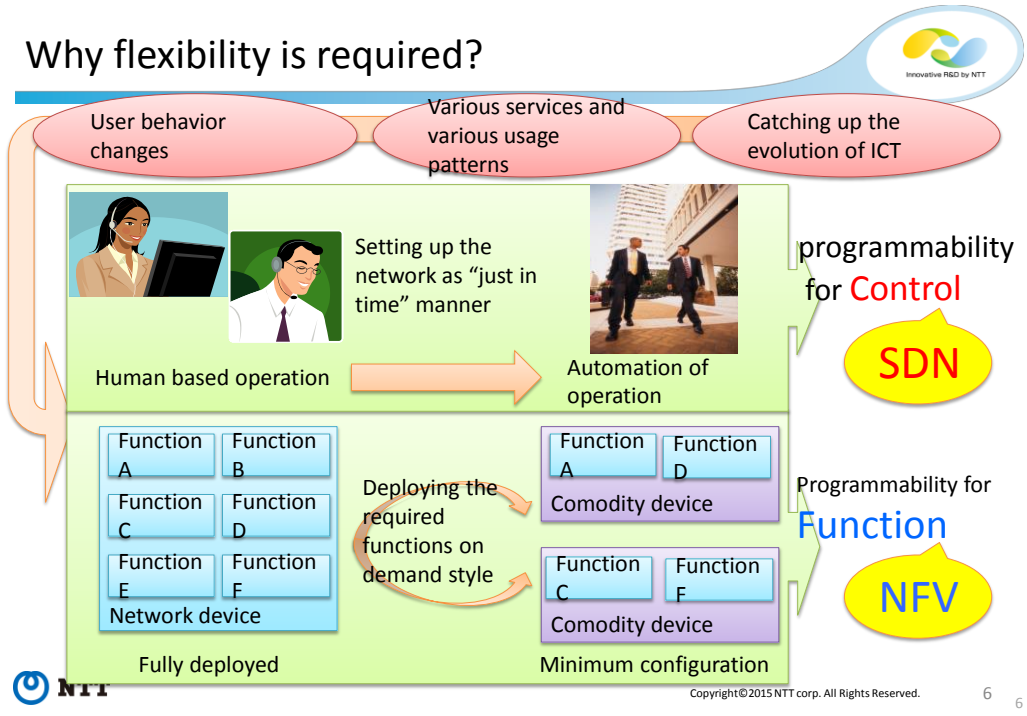
## Outline

- Network Infrastructure
  - Network Virtualization
  - Transport technologies
- Network in Application
  - Media
  - Resiliency
  - Personalization
- Network in Future

## Network Virtualization : SDN and NFV

## Why flexibility is required?

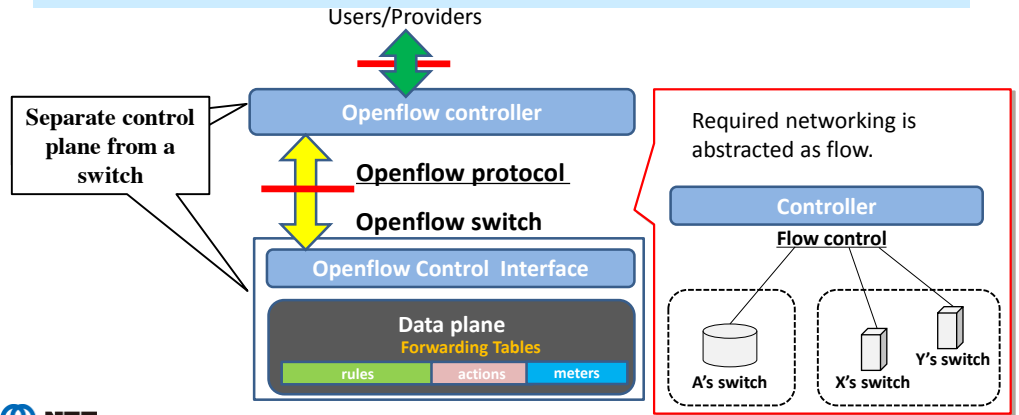






## Openflow/SDN

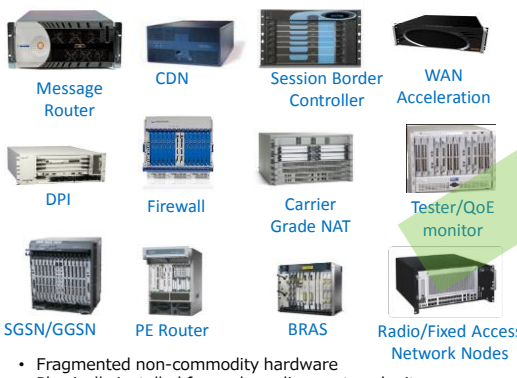
- Open API of control plane
- Centralized control for the entire L2/L3 switches : Openflow protocol
- Flow base control rather than routing table
  - Flexibilities for different applications/demands without affecting other applications



# NFV（Network Functions Virtualisation）

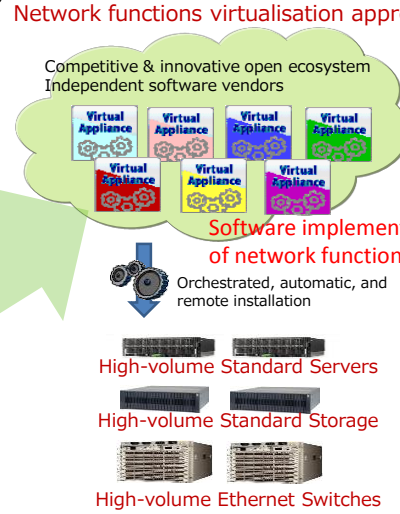
Design concept in which network functions are implemented as software on commodity hardware

## Conventional network appliance approach




- Fragmented non-commodity hardware
- Physically installed for each appliance at each site
- Hardware development is large barrier to entry for new vendors, constraining innovation & competition.

## Network functions virtualisation approach

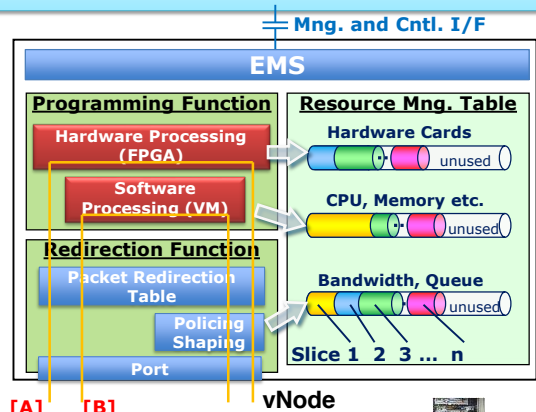






# NW Virtualization Project (VNode project)

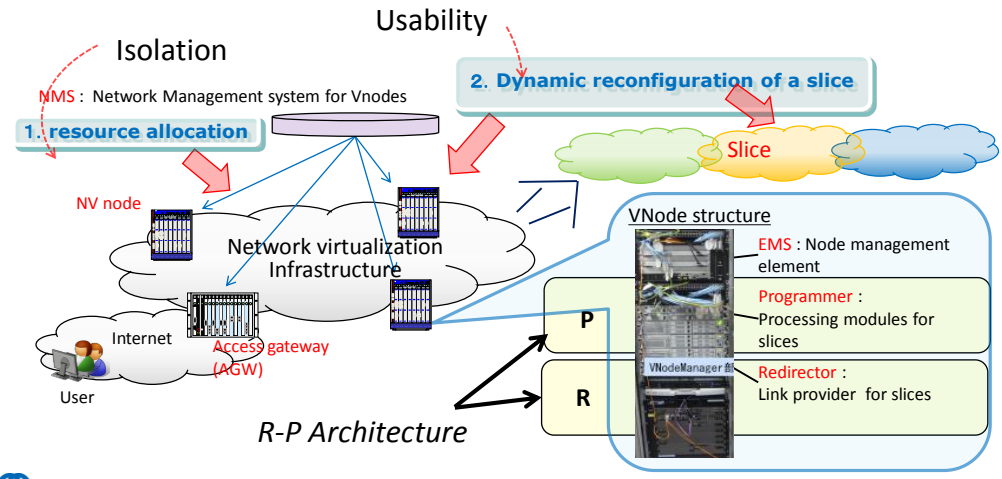
**Joint project with NEC, Fujitsu, Hitachi, U. of Tokyo and NICT from 2008. Now is the second phase funded by NICT.**




*11 VNodes are working on JGN-X testbed.*

## VNode Architecture

Exploiting optimal architecture for Network Virtualization

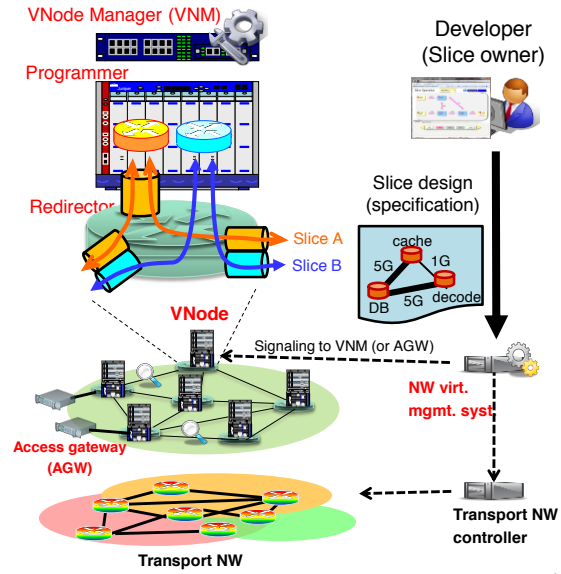






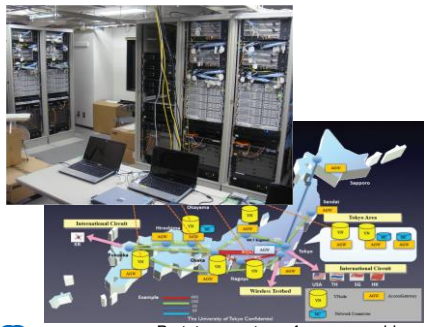
## Vnode system : early stage trial

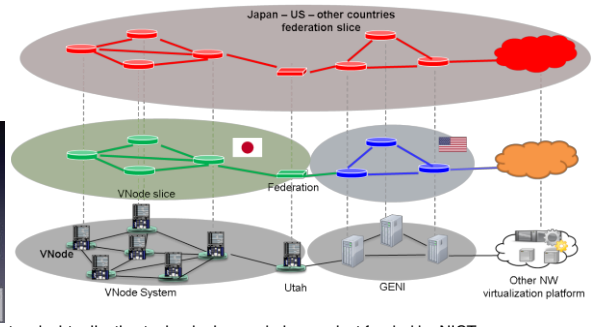
- VNode (NE)
  - VNode Manager (EMS)
    - Integration of Programmer(s) and Redirector(s).
    - Negotiation of neighbor VNodes.
  - Programmer (Router)
    - Programmable processing units for routing/forwarding engine (VM, NPU, etc…).
  - Redirector (Transmission)
    - Tunnel creation for virtual link.
- Access gateway (Gateway)
  - Programmable gateway units for connecting user terminals and slices.
- NW virt. mgmt. syst. (NMS)
  - Integrated slice management in a domain.
- Transport NW
  - Provides the underlay connectivity or reachability between VNodes.



# Prototype system (extended to U.S.)

- We are promoting constructing a testbed to install our technologies and services in future networks.
  - The testbed has been deployed on JGN-X of NICT. The 2nd version works from Nov. 2013.
  - It is publicly in service (7 VNodes, 2 Network Connectors, 11 Access Gateways)
- Slice-Around-The-World Project (A VNode in University of Utah connected to ProtoGENI)






Prototype system of programmable network virtualization technologies made in a project funded by NICT




# O3 Project Concept, Approach, & Goal

## *Open, Organic, Optima*

***Anyone, Anything, Anywhere***

***Neutrality & Efficiency for Resource, Performance, Reliability, ….***

***Multi-Layer, Multi-Provider, Multi-Service***

## *User-oriented SDN for WAN*

***Softwarization: Unified Tools and Libraries***

***On-demand, Dynamic, Scalable, High-performance***

## *Features*

***Object-defined Network Framework***

***SDN WAN Open Source Software***

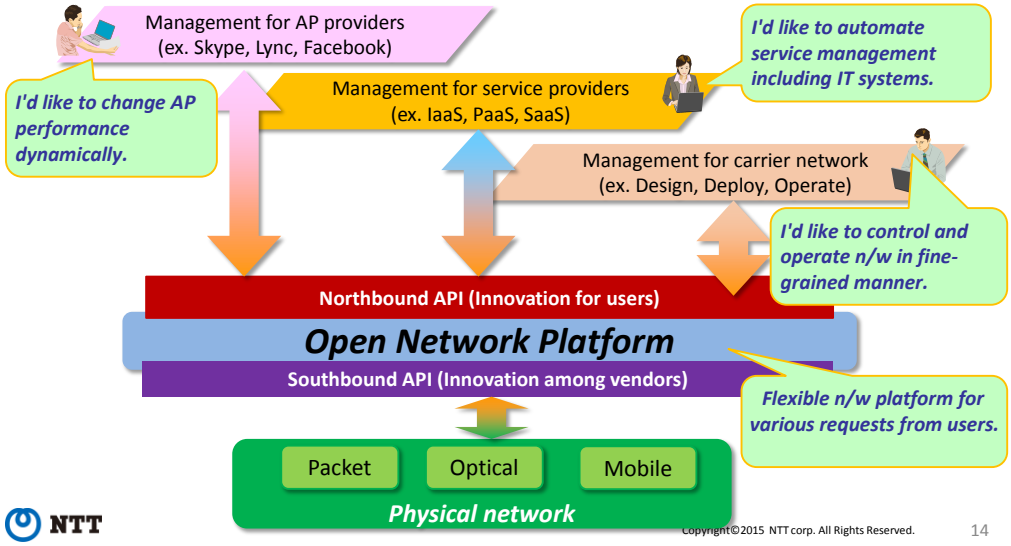
***SDN Design & Operations Guideline***

## *Accelerates*

***Service Innovation, Re-engineering, Business Eco-System***

# O3 Deliverables: User-oriented SDN

■ ***Provides Orchestration for different user requirements***



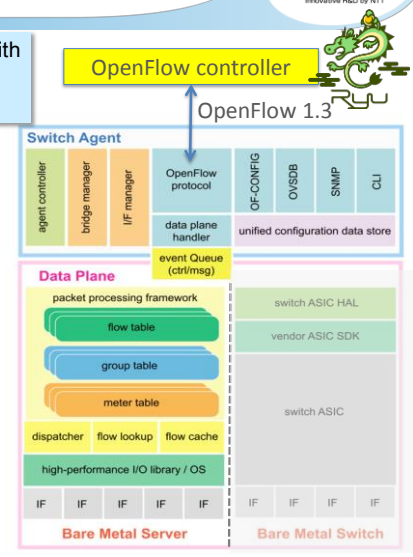




# Lagopus: SDN/OpenFlow Software Switch

■ The world's highest performance SDN software switch with 1M flow entries.
■ To be released as OSS in Y2014 Q2.

- **Best OpenFlow 1.3 compliant software-based switch**
  - Ryu certification score: 920/928 (http://osrg.github.io/ryu/certification.html)
  - Multi tables, Group tables support
  - MPLS, PBB, QinQ, support
- **ONF standard specification support**
  - OpenFlow Switch Specification 1.3.3
  - OF-CONFIG 1.1
- **Multiple data-plane configuration**
  - High performance software data-plane on Intel x86 bare-metal server
    - Intel DPDK, Raw socket
  - Bare metal switch
- **Various management/configuration interfaces**
  - OF-CONFIG, OVSDB, CLI
  - SNMP, Ethernet-OAM functionality
- **Modular architecture**
- **To be released as OSS in Y2014 Q2**
  - Apache v2 license




This research has been executed under the Commissioned Research of Ministry of Internal Affairs and Communications

## Implementation strategy for vSwitch

- Massive RX interrupts handling for NIC device

=> Polling-based packet receiving

- Heavy overhead of task switch

=> Thread assignment
(one thread/one physical CPU)

- Lower performance of PCI-Express I/O and memory bandwidth compared with CPU

=> Reduction of # of access in I/O and memory

- Shared data access is bottleneck between threads

=> Lockless-queue, RCU, batch processing

- Huge amount of $ miss/update in data translation lookaside buffer (TLB) (4KB)

=> Huge DTLB (2MB - 1GB)

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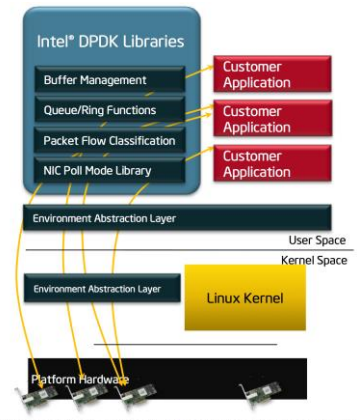
## Intel Data Plane Development Kit

- x86 architecture-optimized data-plane library and NIC driver
  - Memory structure-aware queue, buffer management
  - packet flow classification
  - polling mode-based NIC driver
- Low-overhead & high-speed runtime optimized with data-plane processing
- Abstraction layer for hetero server environments
- BSD-license :)
  - Good for commercial use

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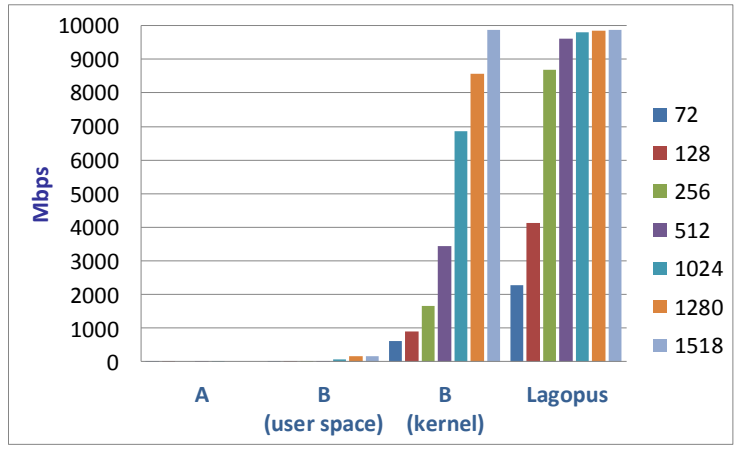
# Performance Comparison

- Performance compared in terms of layer-2 switching capacity (forwarded bits per second), using a standard benchmarking method, RFC2544.
  - Comparison with B (kernel implementation, widely used): over 4 times performance
  - Comparison with B (user-space implementation, as in Lagopus): over 100 times performance







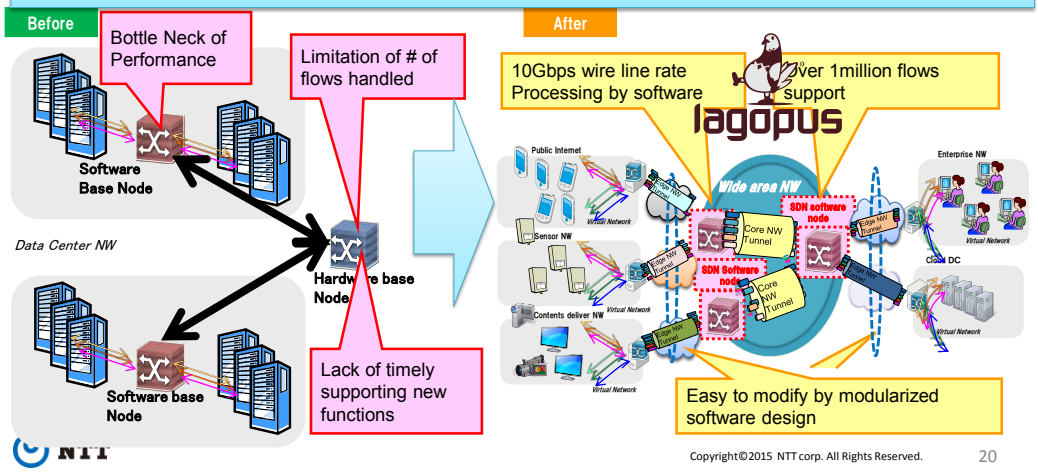
# Information

・website and source code
lagopus.github.io
・Twitter
@lagopusvswitch
・E-mail
lagopus-support@lab.ntt.co.jp
・Organization
NTT Network Innovation Labs.
http://www.ntt.co.jp/mirai/

lagopus.github.io

## Lagopas: Software based packet processing

- O3 (Open, Organic, Optimal) project for realizing wide area SDN platform
  - How can we implement carrier grade SDN by software?
  - 10Million Flows and 10Gbps wire rate in a software processing switch

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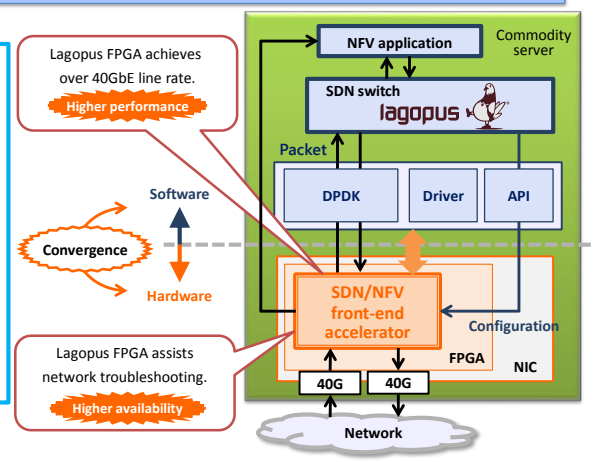
## Accelerator of Lagopus

- Lagopus FPGA : enhancing Lagopus SW 10GbE line rate to 40GbE
- First target is to assist in network with less than 10% x86 CPU power dissipation.

Lagopus FPGA NIC
- Assist high-intensity data plane operations
  - Packet classification/editing
  - Packet dispatching/searching
  - Load balancing
  - Over multiple bit rates (10/40/100 GbE)
- Reliable virtualized network
  - Real-time packet monitoring
  - Just-in-time deployment of new features

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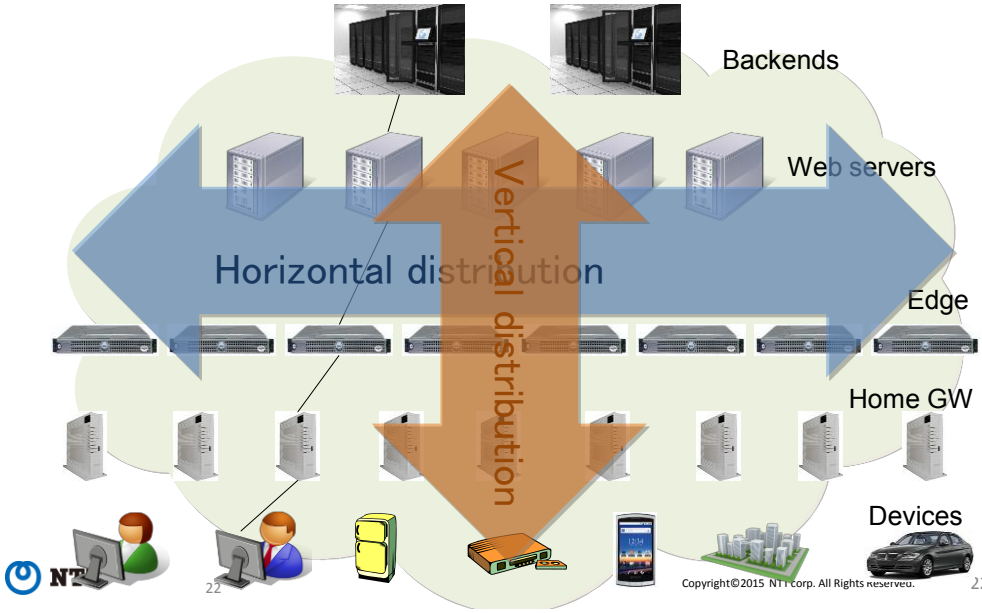
## Distributed processing : two directions

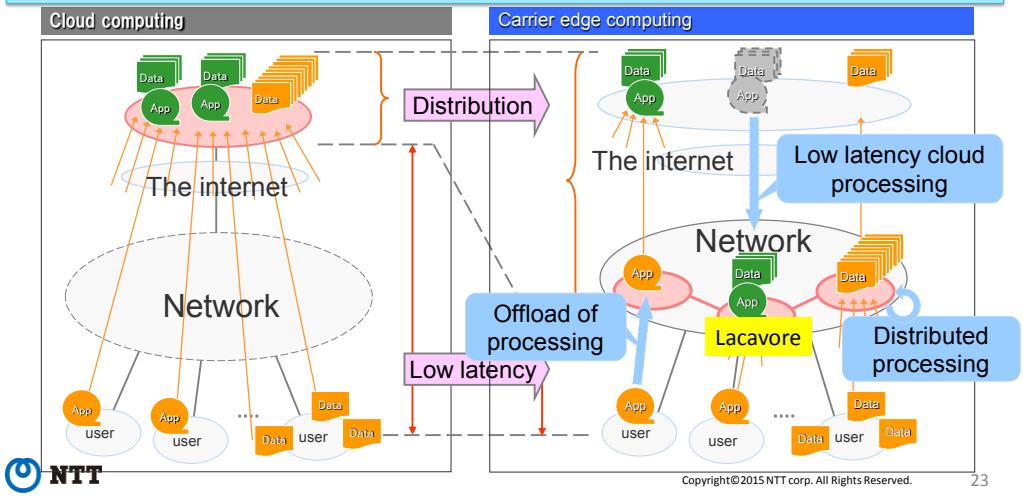






## Carrier Edge Computing

- Acceleration of cloud computing
  - Free to provide computation facilities in network
  - More benefit from network: Latency, off-loading of processing in terminal



## Edge Computing - Applications -





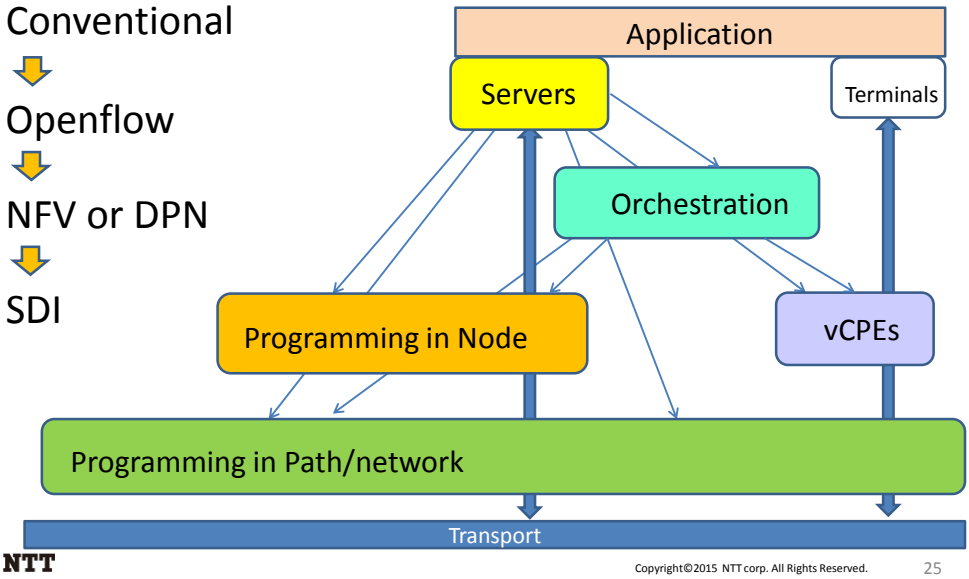
## Network Virtualization overview

Conventional

Openflow

NFV or DPN

SDI



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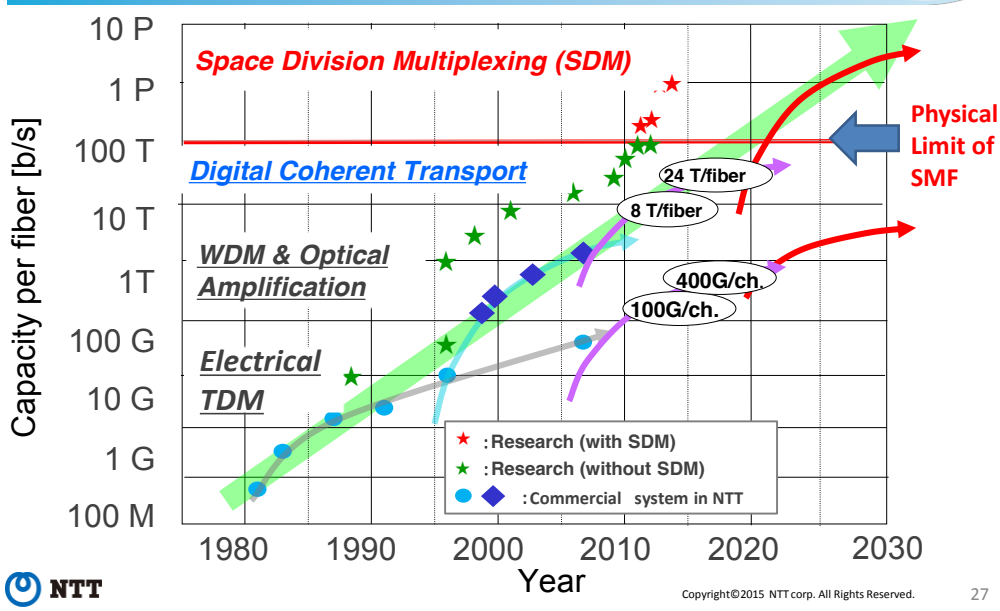
# Transport layer technologies



## Capacity Trend in Optical Transport Systems

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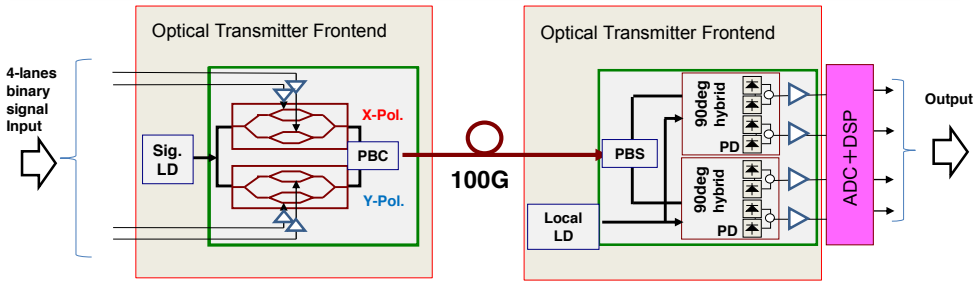
## 100Gbit/s Digital Coherent Transport System

- High capacity:
  - 100Gbps/λ, 8 Tbps per fiber by enhancement of spectral efficiency
- Long-haul:
  - >1000km transmission by high-sensitivity coherent detection




<40nm
100M Gates
Commercially available

Presented in ISSCC2014 by Miyamoto, NTT

Open collaboration of Fujitsu, Mitsubishi, NEC, NTT
A part of this work is supported by MITI.

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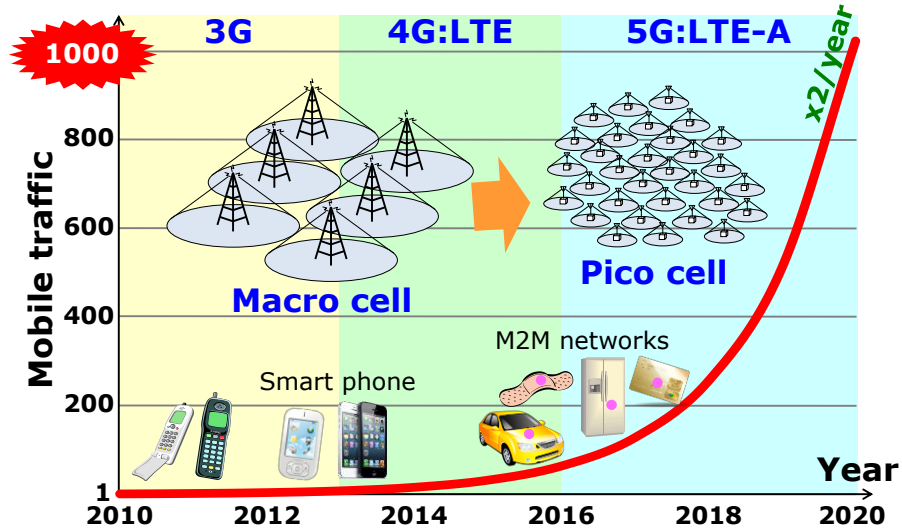
## Traffic Growth and Network Evolution



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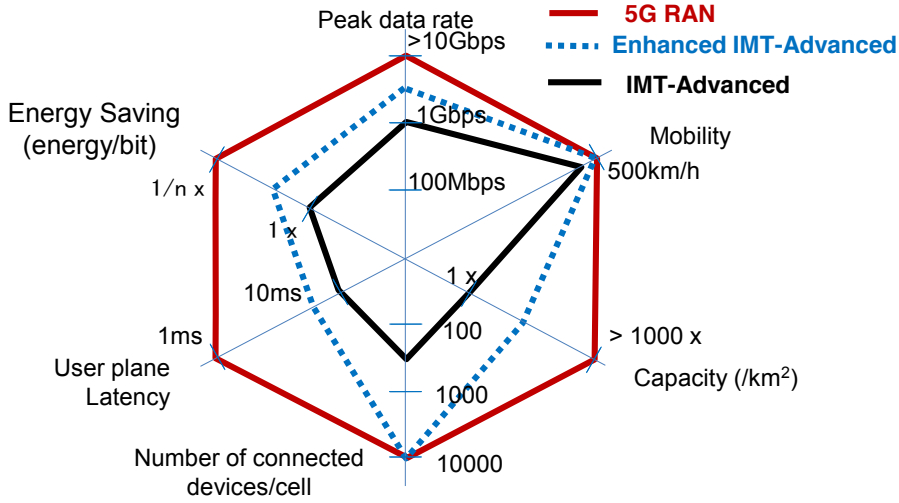
# Maximum system capabilities




"Mobile Communications Systems for 2020 and beyond", ARIB 2020 and Beyond Ad Hoc Group White Paper, October 2014.

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# The Fifth Generation Mobile Communication Promotion Forum

The Fifth Generation Mobile Communications Promotion Forum

Launching the forum for discussing 5G and beyond in September, 2014

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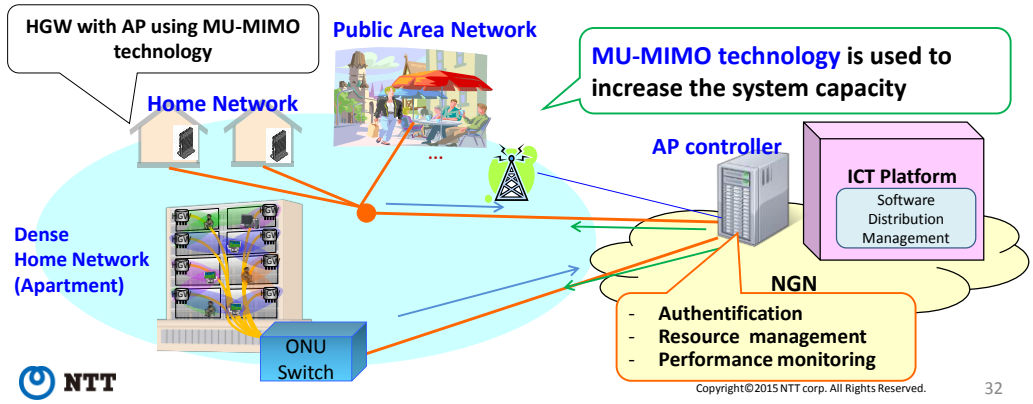
# R&D Activities in **WLAN**

- Interference among Access Points are major problem in WLAN.
  - How can we utilize the limited frequency space efficiently?
- Standardization in IEEE
  - May, 2013 : New Study Group (HEW-SG) is launched to discuss for High Efficiency WLAN







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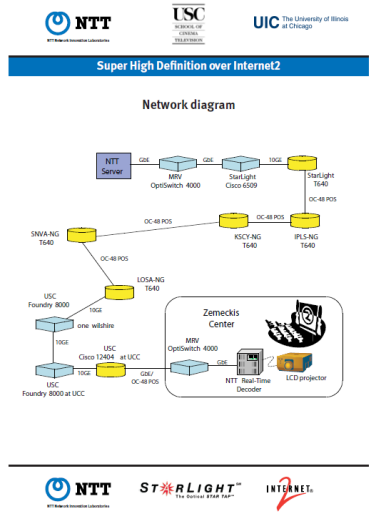
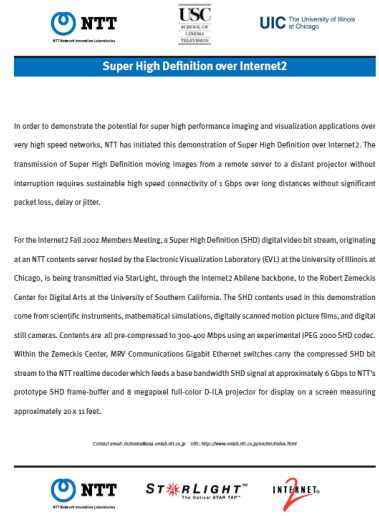
# Media Application and SDN

# First trail of 4K distribution over Internet2

October, 2002

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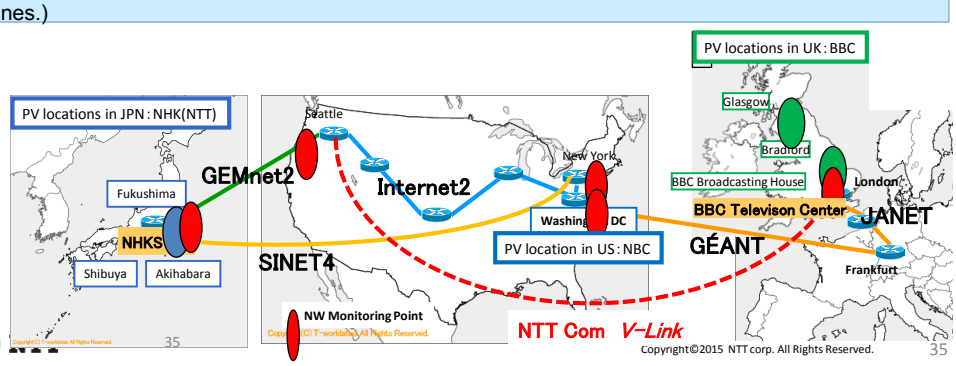
# 8K Live streaming from London to Tokyo

- Multi-hop shared R&E networks over EU/US/Japan
  1. BBC-JANET-GEANT(IP)-Internet2(IP)-GEMnet2(L3)-NHK
  2. BBC-JANET-GEANT(IP)- SINET4 -GEMnet2(L3)-NHK
- On-demand networking by DCN (Dynamic Circuit network)
  3. BBC-JANET-GEANT(BoD)-Internet2(ION)-GEMnet2(L2)-NHK
- Commercial service network (NTT Communications' V-Link)
  4. BBC-VLink-GEMnet2-NHK

(In Japan, SHV streams are distributed by IP multicasting over NTT Communications' dedicated lines.)



# World Cup 8K Public Viewing

NHK presenting : 6/13～7/14 (JST)

- ◆ 4 places in Japan (3 places in Brazil)
- ◆ 9 matches

＜8K Live Public Viewing Schedule＞

6/15(Sun)10:00 Japan vs Côte d'Ivoire
6/17(Tue) 7:00 Ghana vs USA
6/20(Fri) 7:00 Japan vs Greece
6/24(Tue) 5:00 Cameroon vs Brazil
6/29(Sun) 1:00 Round of 16(Brazil vs Chili)
7/ 1(Tue) 1:00 Round of 6(France vs Nigeria)
7/ 6(Sun) 1:00 Quarter Final (Argentina vs Belgium)
7/ 9(Wed) 5:00 Semi Final(Brazil vs Germany)
7/ 14(Mon) 4:00 Final(Germany vs República Argentina)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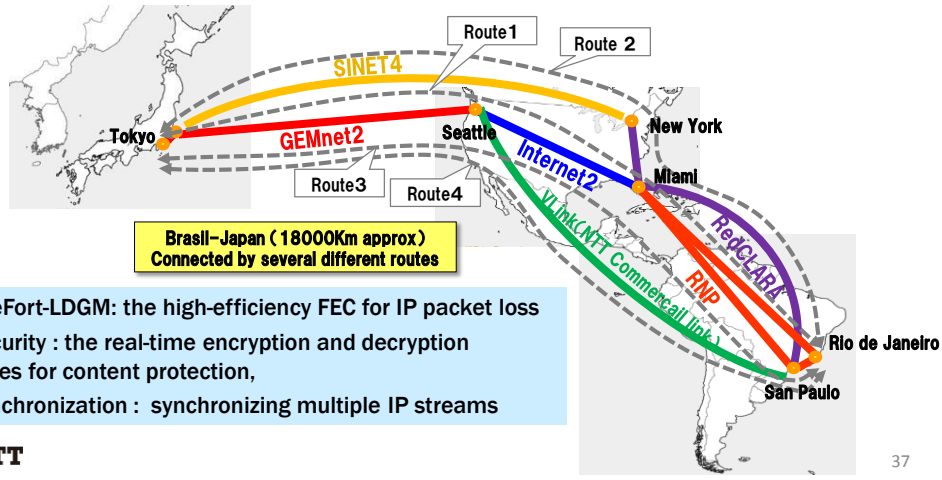
# 8K Live streaming from Brazil to Tokyo

- ➢ SHV streaming processed by the software implemented in PC
- ➢ Enabled highly reliable and high-speed IP transmission




1) FireFort-LDGM: the high-efficiency FEC for IP packet loss
2) Security : the real-time encryption and decryption features for content protection,
3) Synchronization : synchronizing multiple IP streams

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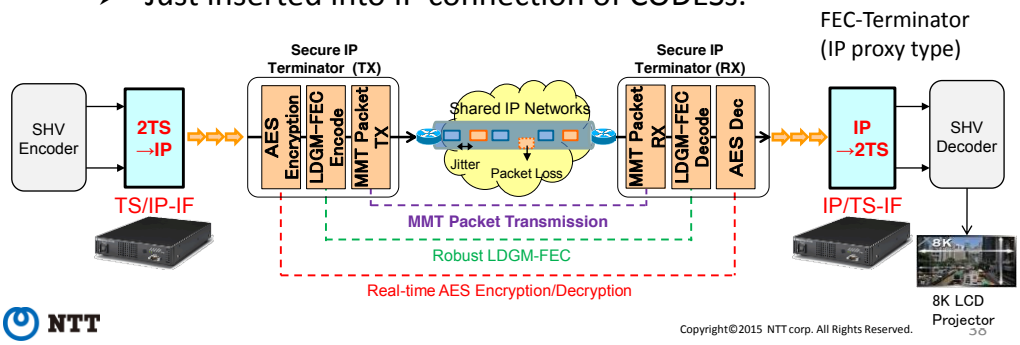
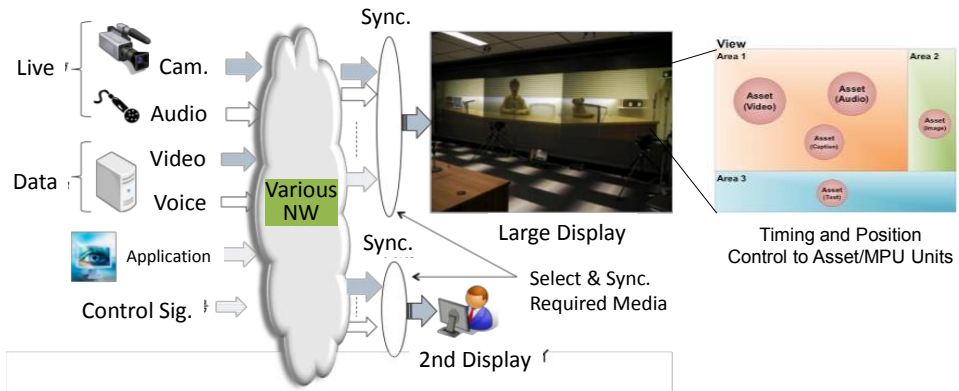
## Software Implementation of FireFort LDGM-FEC

- PC/Linux box for 8K-PV
  - Large block size against long burst loss.
    - e.g. 150000 blocks, 20% redundancy.
  - Tolerance for loss of >20000 packet long.
  - AES128 encryption, MMT packet format.
- Proxy-type implementation
  - Just inserted into IP connection of CODESs.






## MMT (MPEG Media Transport) Functions




**[Application level FEC]**
- Super high speed
- Low computation cost
- High recovery rate

**[Flexible distribution with global time]**
- Free combination of A/V/Data to form single/multiple streams

**[CI : Composition Information]**
- Presentation control of multi-source media.

## SDN for Media application

- What do they need?
- Production
  - Project basis budget
  - Virtual studio (Resource sharing platform)
  - Huge size of Data Storage
  - Processing power
    - E.x. Transcoding for Chinema, TV, streamaing, DVD, airlines, …
- Collaboration
  - More resolution for understanding deeply
    - Seeing micro behavior of people
    - Getting more than the real view with virtual view
    - Helping deeper understanding
    - Managed meeting (discussion)

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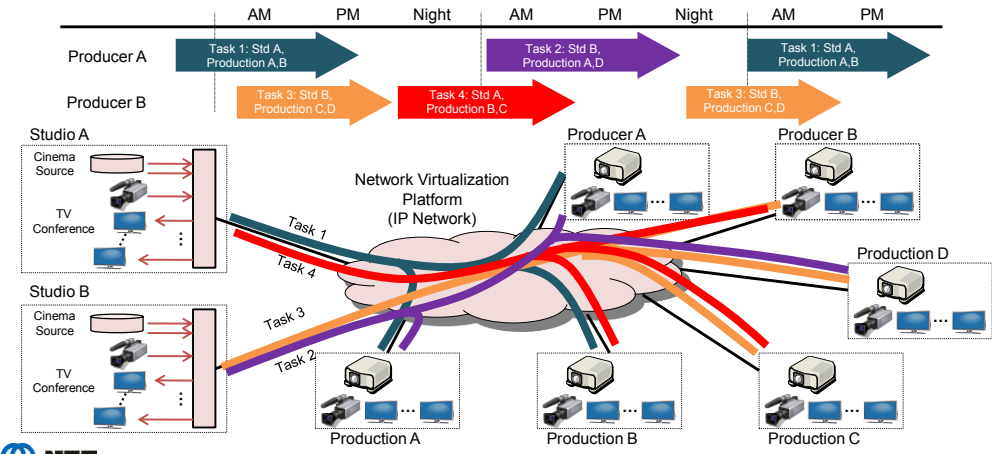
## Benefit : On-demand task NW switching service

- For each task, a 'task network' is configured in advance using a virtual network technology.
- At each location, users can switch their project NWs swiftly on-demand basis (No need to contact NTT).
  - 'Short-term' NW configuration.

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# Summary of NTT Group Video Service

Innovative R&D by NTT

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## High-end Encoders by NEL

XVE9310: 4K 1080p 4K/3D Encoder
HVE9230: H.264 Embedded Audio 16ch Encoder
HVE9210: 1 Frame Super Low Latency Encoder
HVE9110: High Quality Video and Super Low Latency Encoder

## Super High Speed IP Video System by NTT-IT

viaPlatz: Video-based Information and Knowledge Sharing System
SHS-XMS: Super high speed video server with IP interface
SHS-4KGW: Conversion between for HD-SDI and 10G Ether

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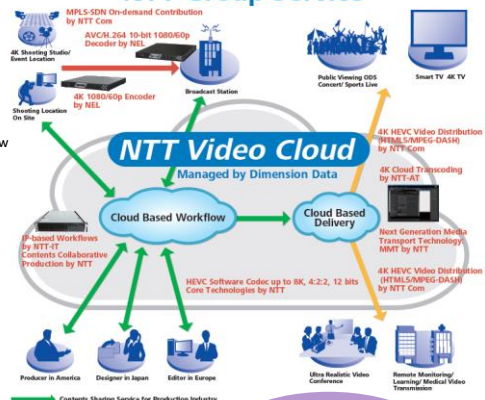
## NTT Group Service




## Near-real-time HEVC Transcoder by NTT Data Italy

Hyper: adaptive VoD transcoder
NRT 2.0: Distributed live encoder
iCE: Intelligent Cloud Encoding

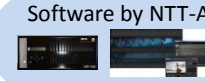
## High-end Decoders by NEL

HVD9130: H.264 10bit 1080p Decoder -option 4:2:2:10bit IRD

## Compact IP Encoder/ Decoders , ASI-IP converter by NEL

MVE5000/MVD5000: 1U Half Rack size Encoder/Decoder
NA8000: ASI-IP protocol converter

## HEVC Decoder and Software by NTT-AT



UHD-1000: HEVC Decoder
HEVC-1000 SDK: HEVC Codec SDK

## File-based HEVC Transcoder by NTT-AT

Grid Computing Transcode System: 4:2:2 10bit 4K HEVC Converter powered by Dimension Data

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Innovative R&D by NTT

# Resiliency and SDN

## Motivation

- 3.11 Great East Japan Earthquake
  - Broader area has been damaged.
  - There remained no resources but mobile phones.
  - The redundant physical resources might not be effective.
  - Networking and local communication is very important.
- Policy change:
  - It was impossible to provide sufficient ICT service soon after the disaster until rehabilitation was completed.
  - Minimizing physical redundancy
  - Maximizing logical redundancy
- Movable and Deployable ICT Resource Unit (MDRU)
  - Local communication recovery first
  - flexible configurations for adapting the demand changes

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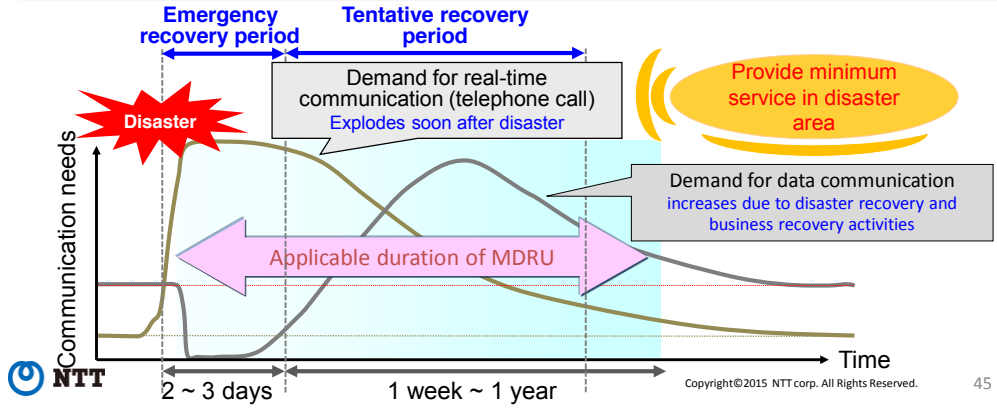
## Application concept of MDRU

- MDRU provides minimum ICT services to meet communication demand in a disaster area soon after a disaster.
  - **Emergency recovery period** : Real time communication demand explodes through confirming status of relatives, near neighbors, etc.
  - **Tentative recovery period** : Data communication demand increases because of information gathering by local governments and enterprises.

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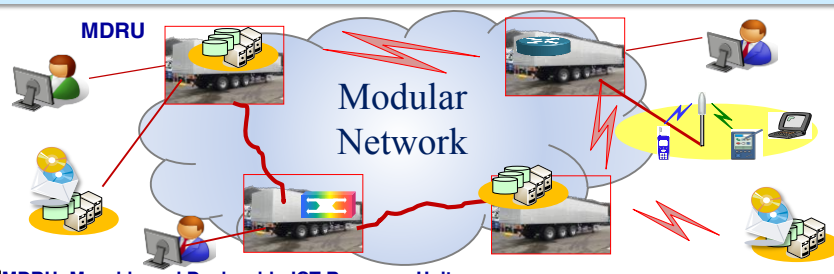
## R&D project of MDRU

- An R&D project was launched in March 2012 with a support of the Ministry of Internal Affairs and Communications of Japan.
  - NTT Network Innovation Labs., NTT Communications, Fujitsu and Tohoku University funded by MIC
- The goal of the project
  - Prototyping of a movable and deployable ICT resource unit (MDRU)and modular network of MDRUs to cover wide area
  - Use cases for providing communication methods fast and flexible by MDRU
  - Proof of concept trials




NTT MDRU :Movable and Deployable ICT Resource Unit

## Inside of MDRU

MDRU accommodates equipments needed both to supply ICT services locally and to act as a remote station of the remained ICT infrastructure.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# Inside of MDRU

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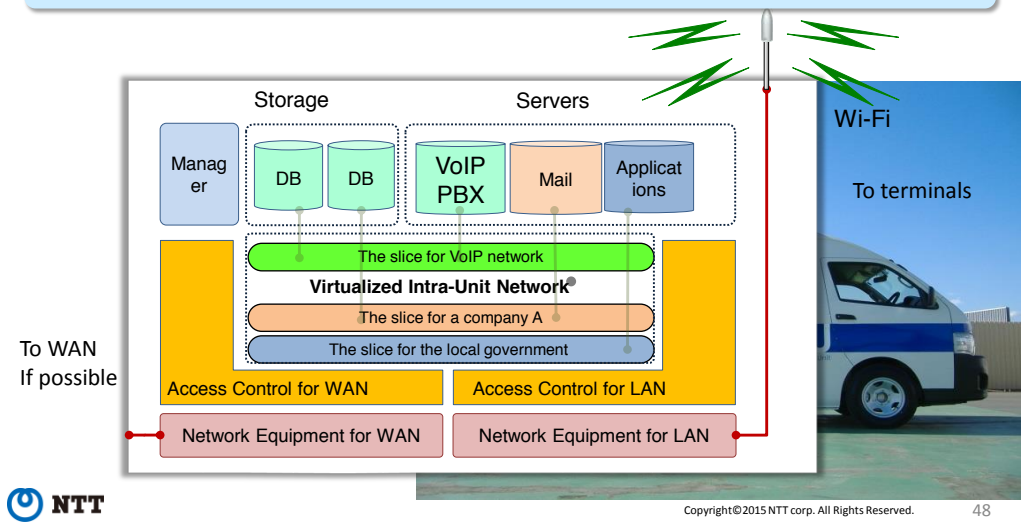
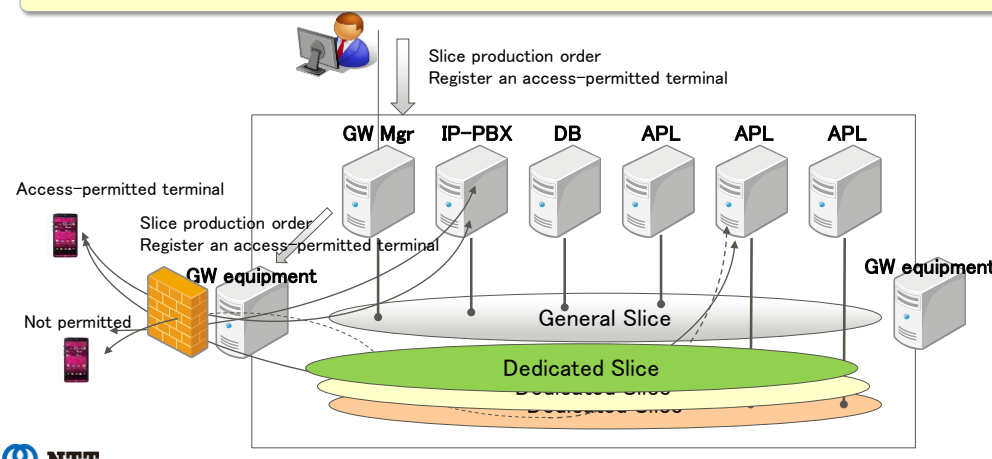






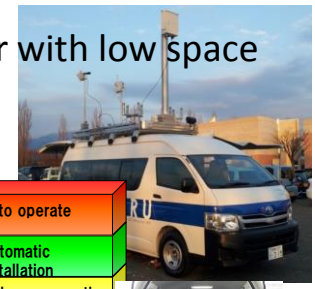
# Operation concept of MDRU

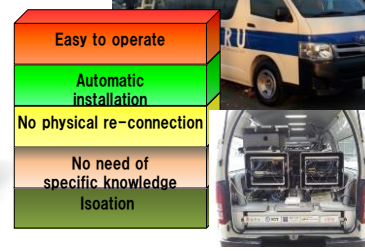
- SDN and Virtual networking of virtual machines
  - easy to deploy and operate various application according to the demand.
  - Isolating traffic for proper controlling in usage



## The benefit of Virtualization

- To minimize physical resources
- To provide the appropriate functions according to the demand (timely manner) and
- To prepare the APPs before the disaster with low space cost



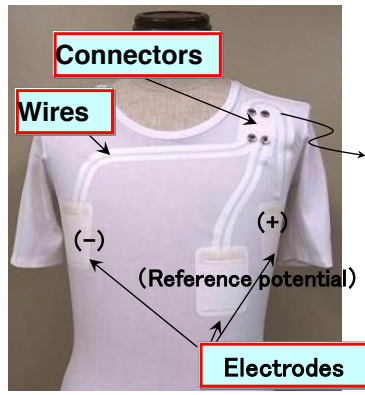






## Personalization and SDN

## Network connected wearable sensors

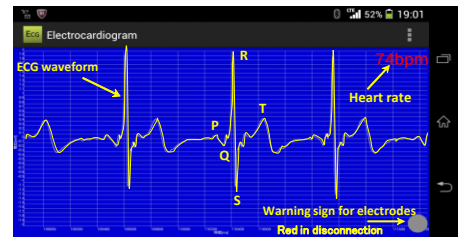



**Design T-shirt type heart rate/electrocardiogram (ECG) sensor as an electrical circuit**

**Transmitter**

Bluetooth

**Screenshot on smart phone**

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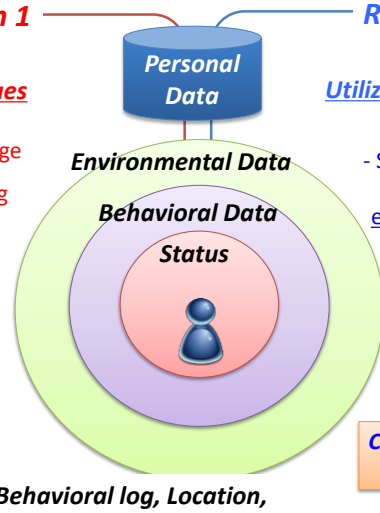
## Personal ICT -- Research Topics

***Research Item 1***

***Privacy Protection Issues***

- Safe Personal Data Storage
- Information anonymizing
- Personal Data management agent
- Personal Data distribution platform
- Opt-in system




***Behavioral log, Location, Information from circumstances***

***Research Item 2***

***Utilization of Personal Data***

- Services and Applications for enhancing individuals' 'Quality of Life'

ex. Assist daily life …

solving social problems

⇓

***Crowd Behavior Control and Optimization***

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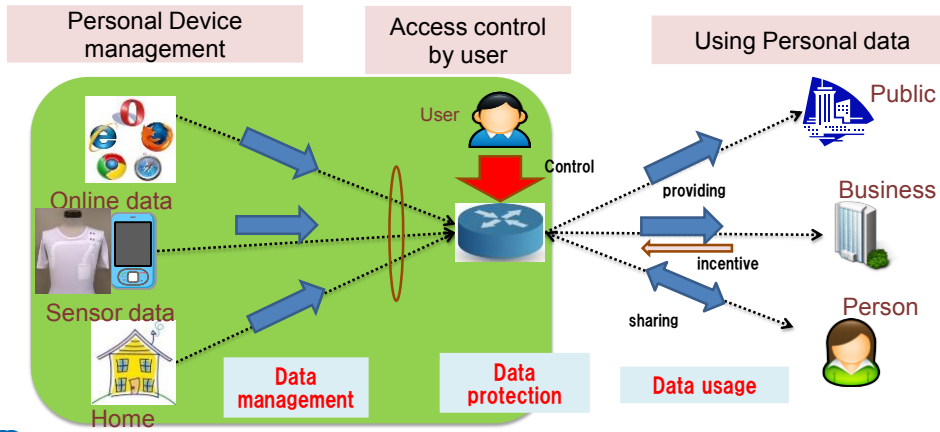
## Personalized ICT concept

- How to protect your data?
  - Can we control the access to our own remote data by yourself?
- Control other access requests remotely by your personal devices.



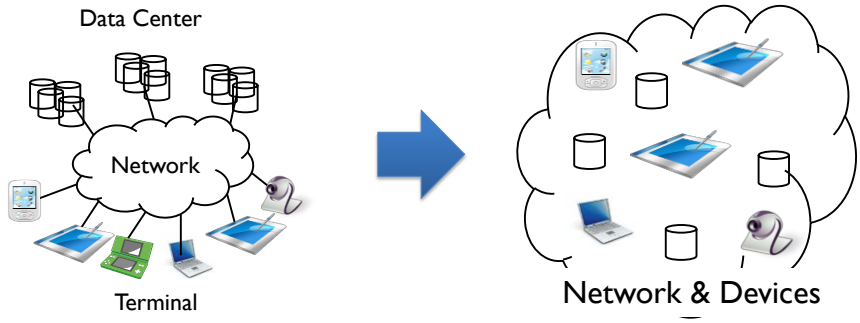




## Network in Future

## Next consideration

- Functions implemented in Cloud, Smart phone, Wearable devices
  - 5G and 5G beyond
- A huge number of devices are connected.
- How can we manage and operate these connected things?

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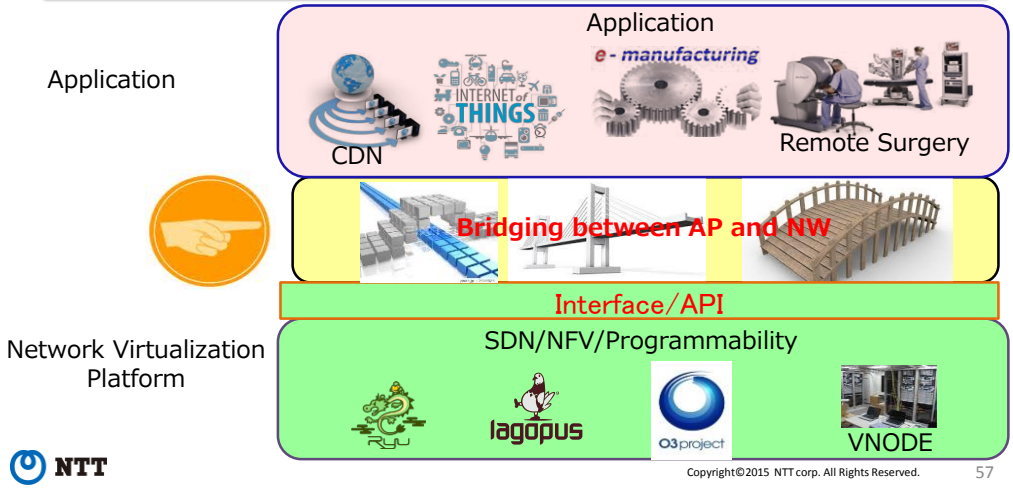
## Next step in Network virtualization

- SDN provides the interface to networking for APPs.
- There are still gaps between APP designers and network providers.

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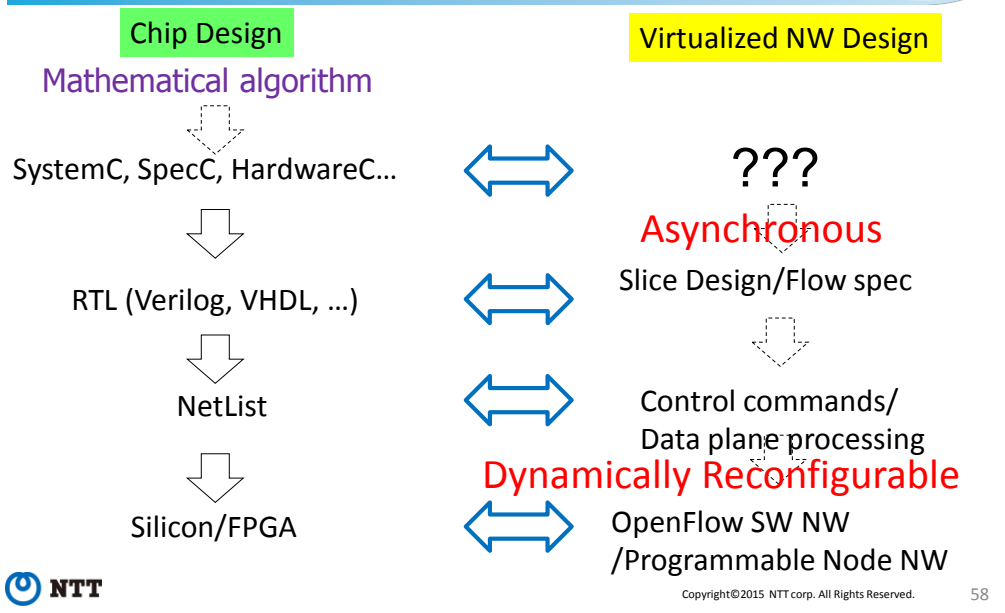
## Analogy

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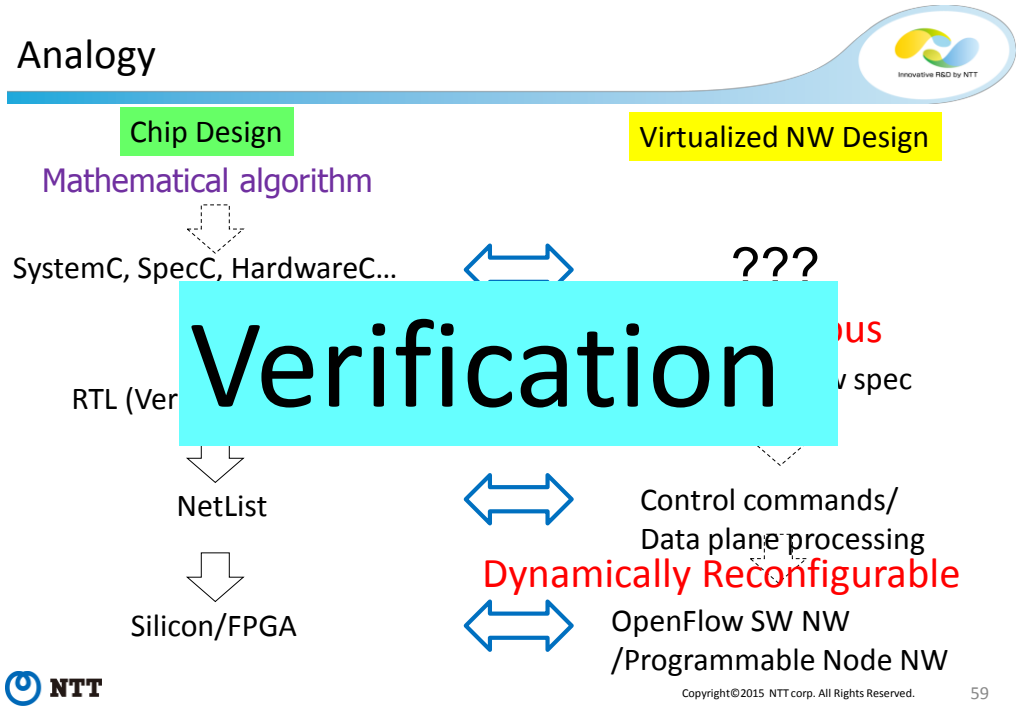
## Analogy

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## New view for connecting

Connecting Human and Society

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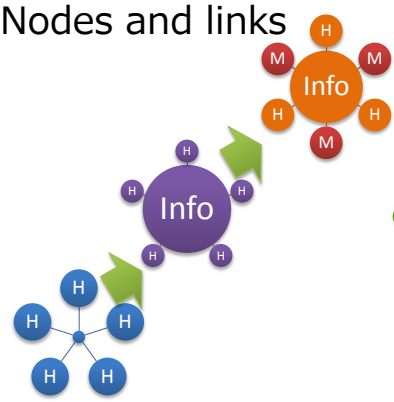
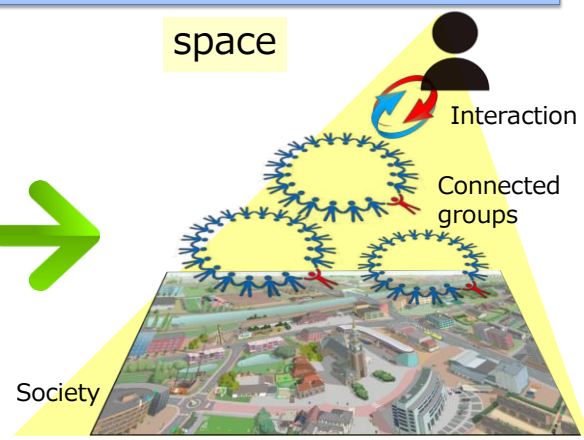
Connecting Activities in Society and Human

Nodes and links




space

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Innovative R&D by NTT

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Thank you very much for your kind attention.

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