



NetroSphere and NetworkAnalytics

Innovation of network architecture and operation beyond SDN/
NFV evolution

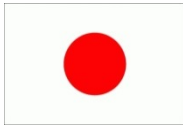
IEEE NetSoft 2016

June 2016

Kohei Shiimoto (NTT)

Creation of new values via Hikari Collaboration Model

"Hikari" = optical, fiber access

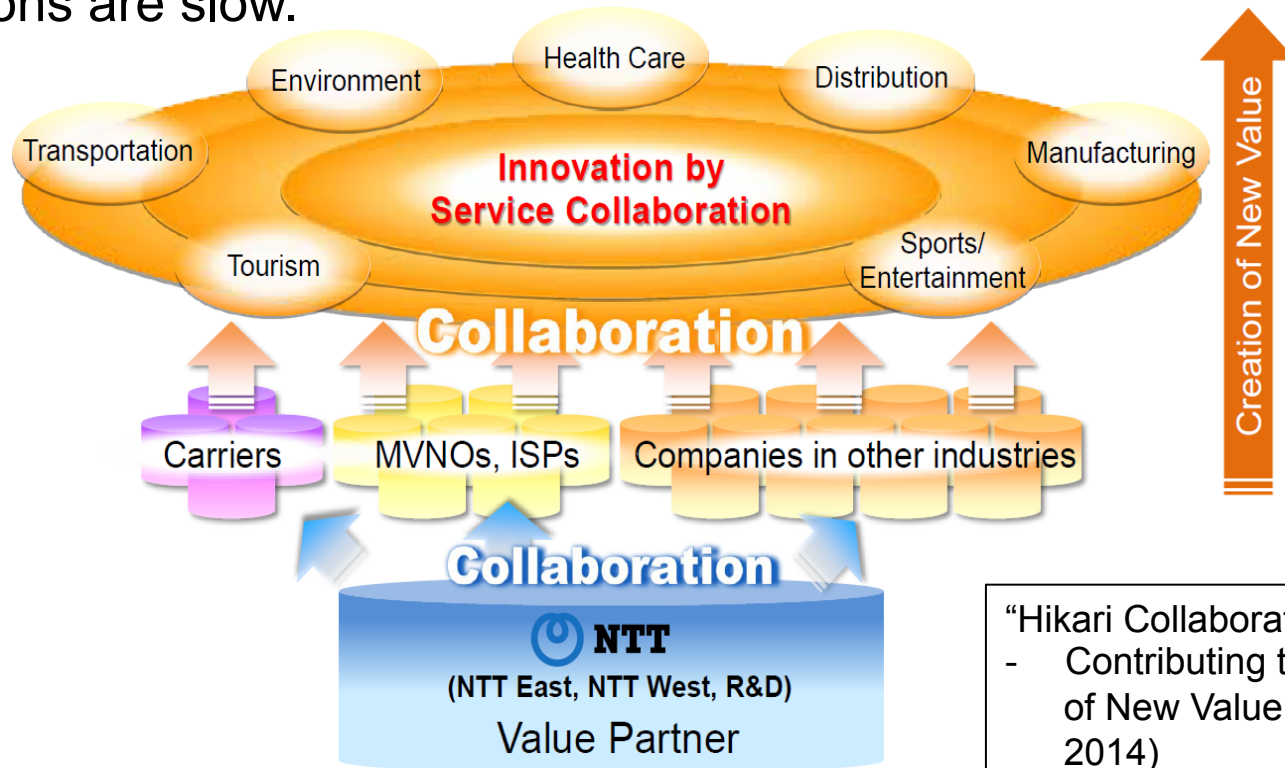


Faces a variety of issues:

- aging society
- environmental and energy issues

ICT solutions are slow.

- Wholesale of the world most advanced fiber optical access.
- Stimulates ICT market
- Contribute to resolve issues.



"Hikari Collaboration Model"

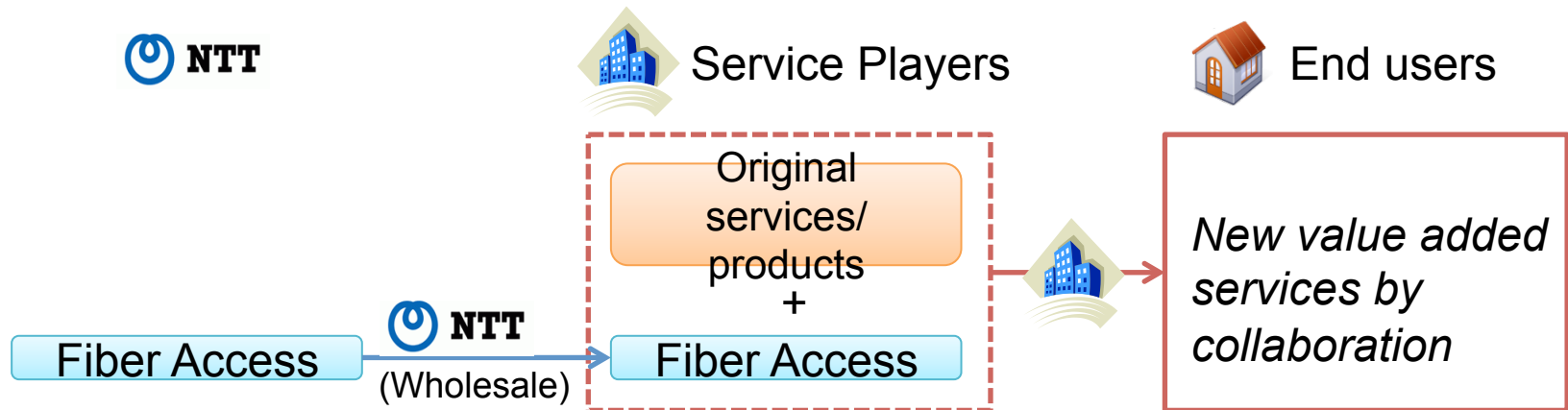
- Contributing to the Creation of New Value – (May 13th, 2014)

Hikari Collaboration model

“Hikari” = optical, fiber access



- Wholesaling fiber access services by NTT East and NTT West
 - The **world's first** full-scale wholesaling of fiber access
 - Shifting the business model to become a **“Value Partner”**

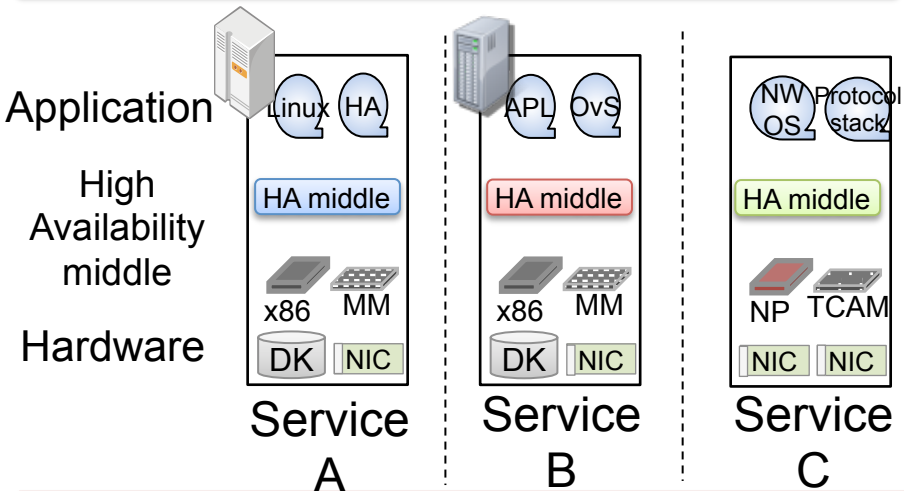


“Conditions to Provide Hikari Collaboration Model”
NTT East and NTT West, May 13th, 2014

Today's network situation

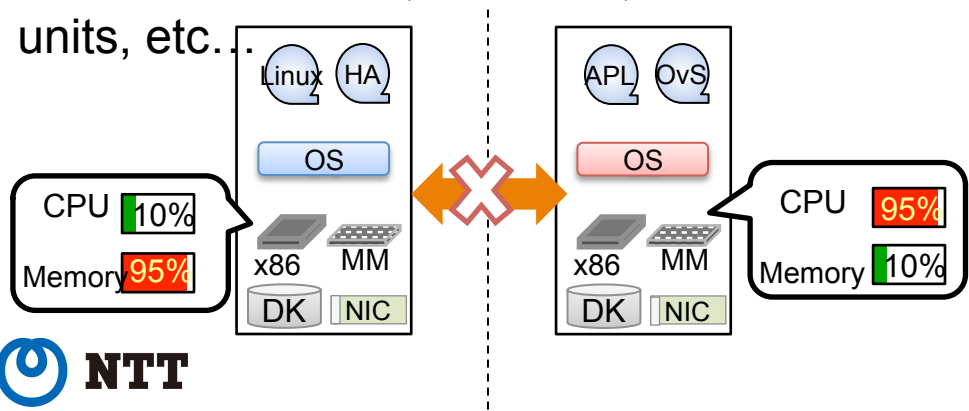


Silo-like development style



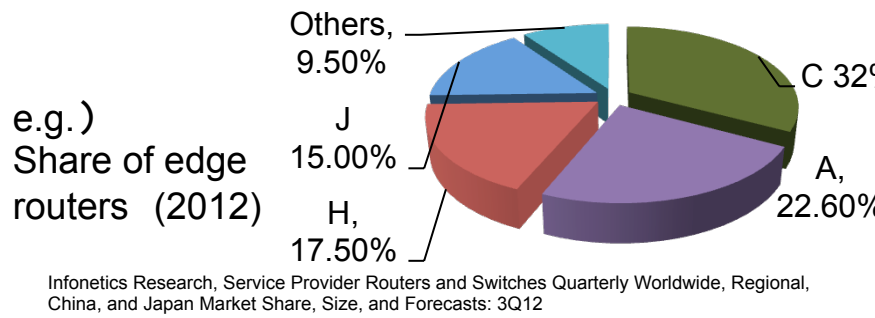
Inefficient resource usage

Unable to share unused resources between functions, locations, hardware units, etc...

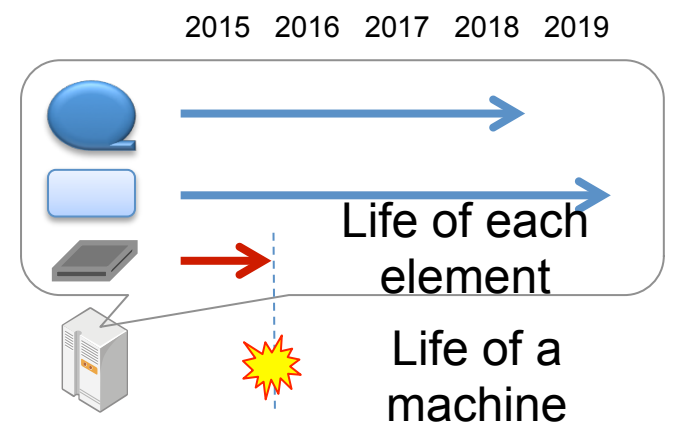


Less opportunity for new vendors

Initiative of functional enhancement is taken by vendors

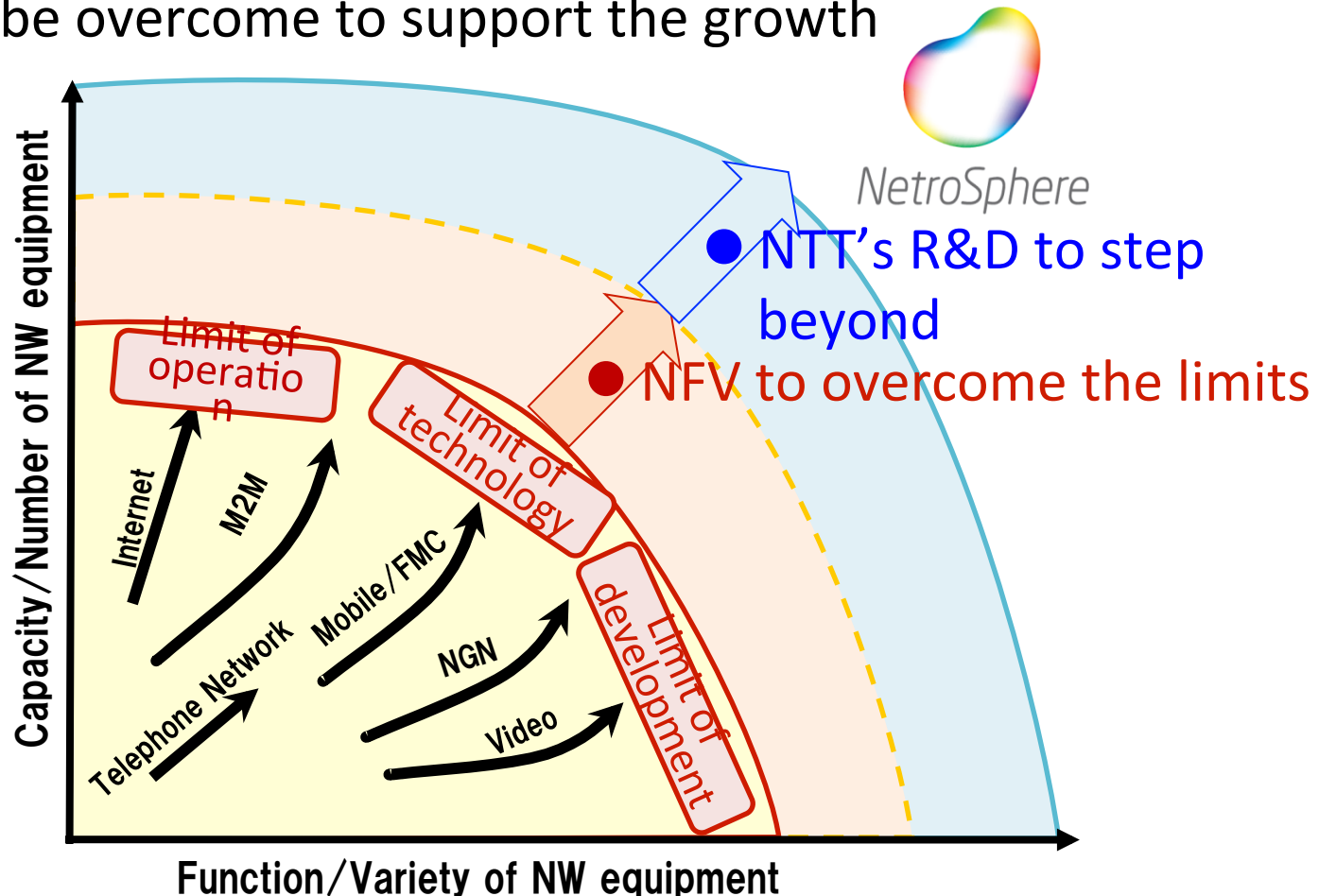


EoL of equipment becomes EoL of whole network system



Beyond the limit

- Variety/number of network equipment grows endlessly
- Limitations in terms of technology, development and operation should be overcome to support the growth



NetroSphere : Announced by NTT in Feb. 2015



NetroSphere

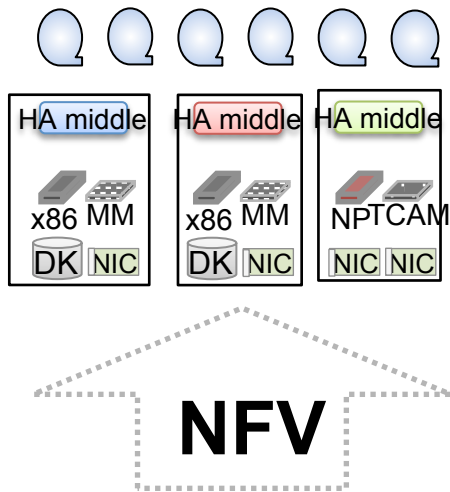
Netro: a prospect that stands upon the deep and wide knowledge of network development and operation which acquired in the past.

+

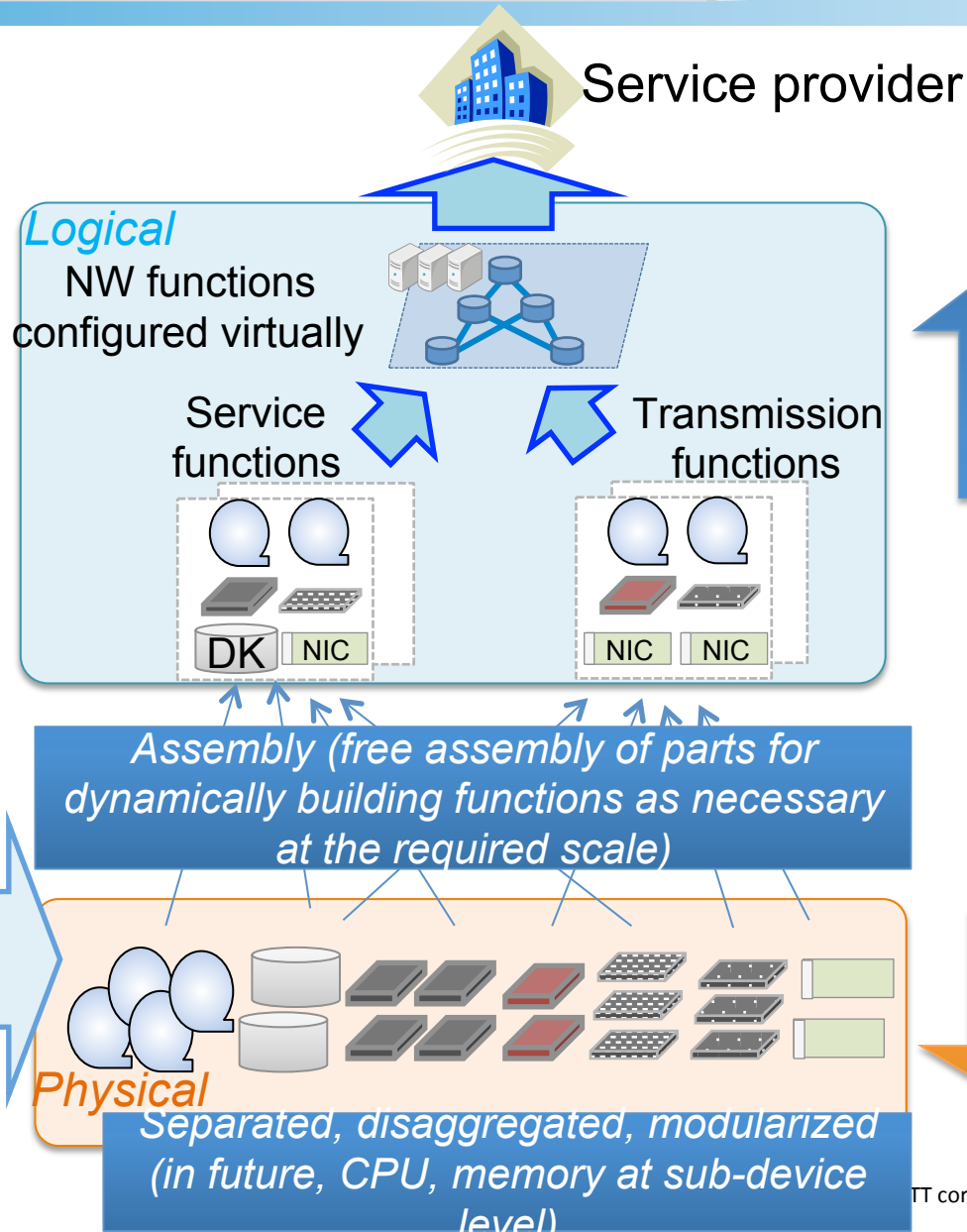
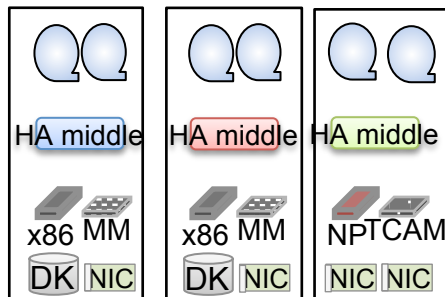
Sphere: Atmosphere

Our direction for future network

General NW function
virtualization



Old equipment
for each function



Better
Adaptability
& Agility

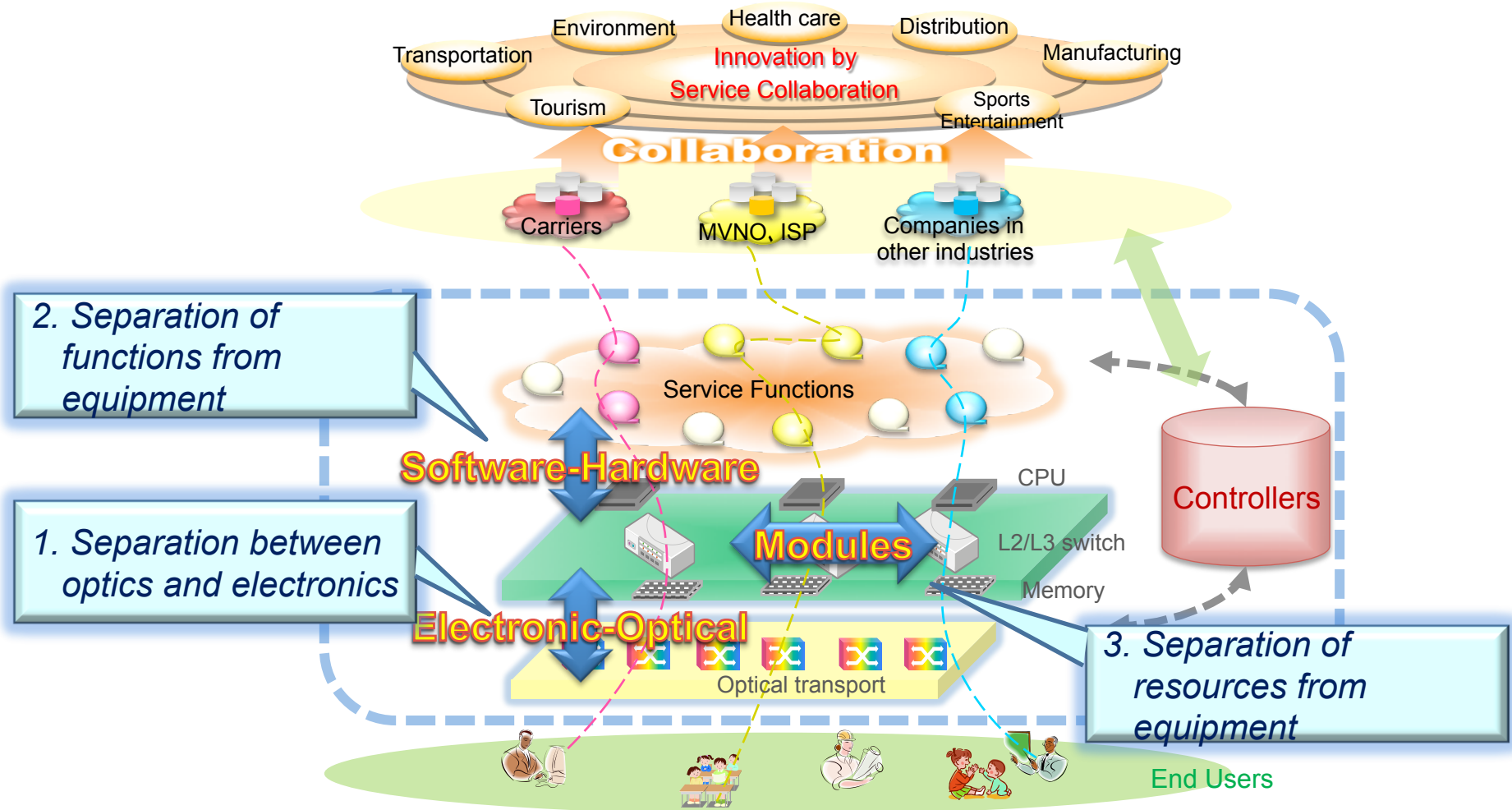
On demand
response to
service provider
demands

Drive vendor
participation,
commoditization

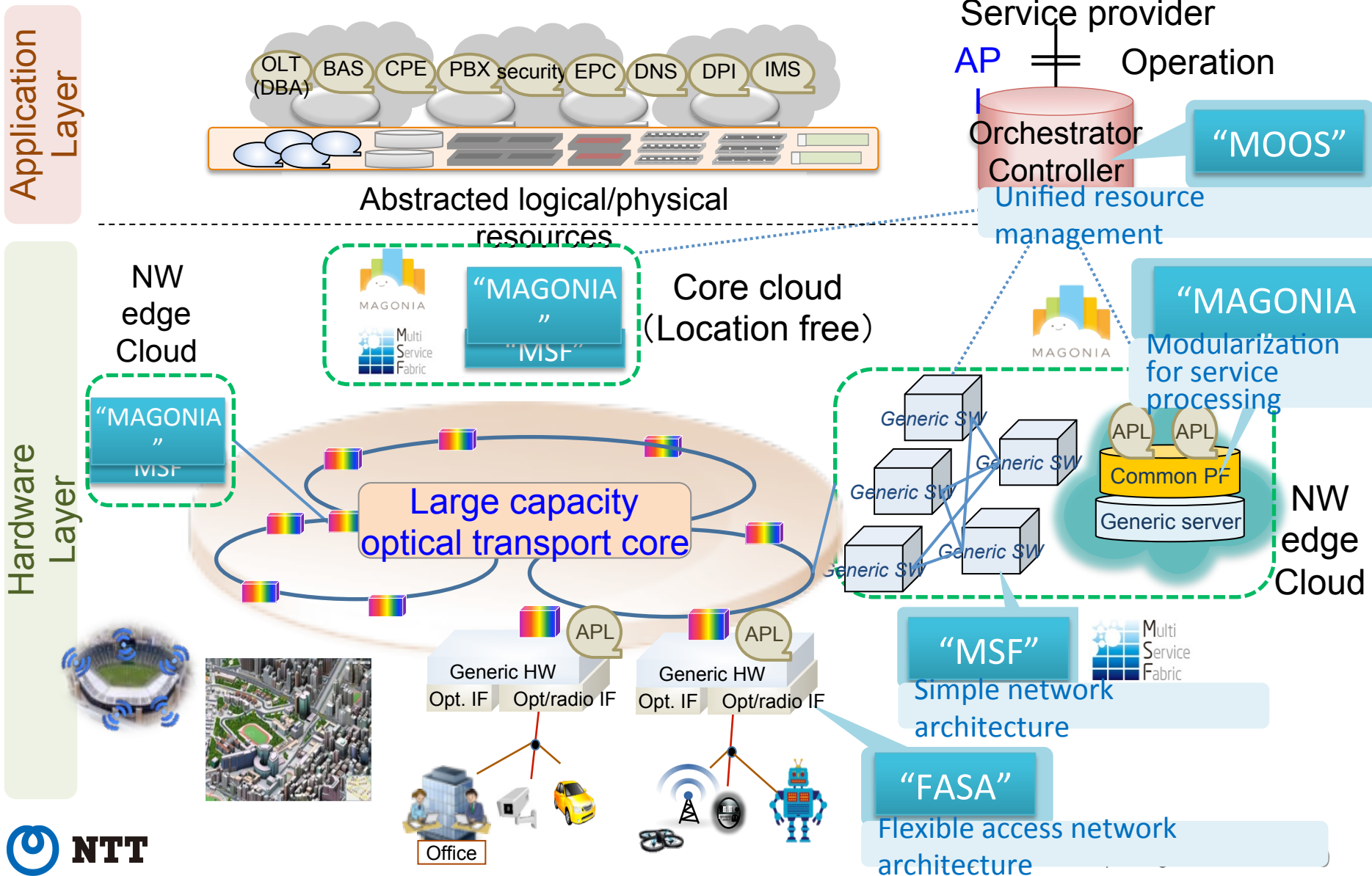
Drastic
cost
reductions

NetroSphere: technological view

- A novel concept for future network to reduce cost, support service creation, and improve resiliency and agility



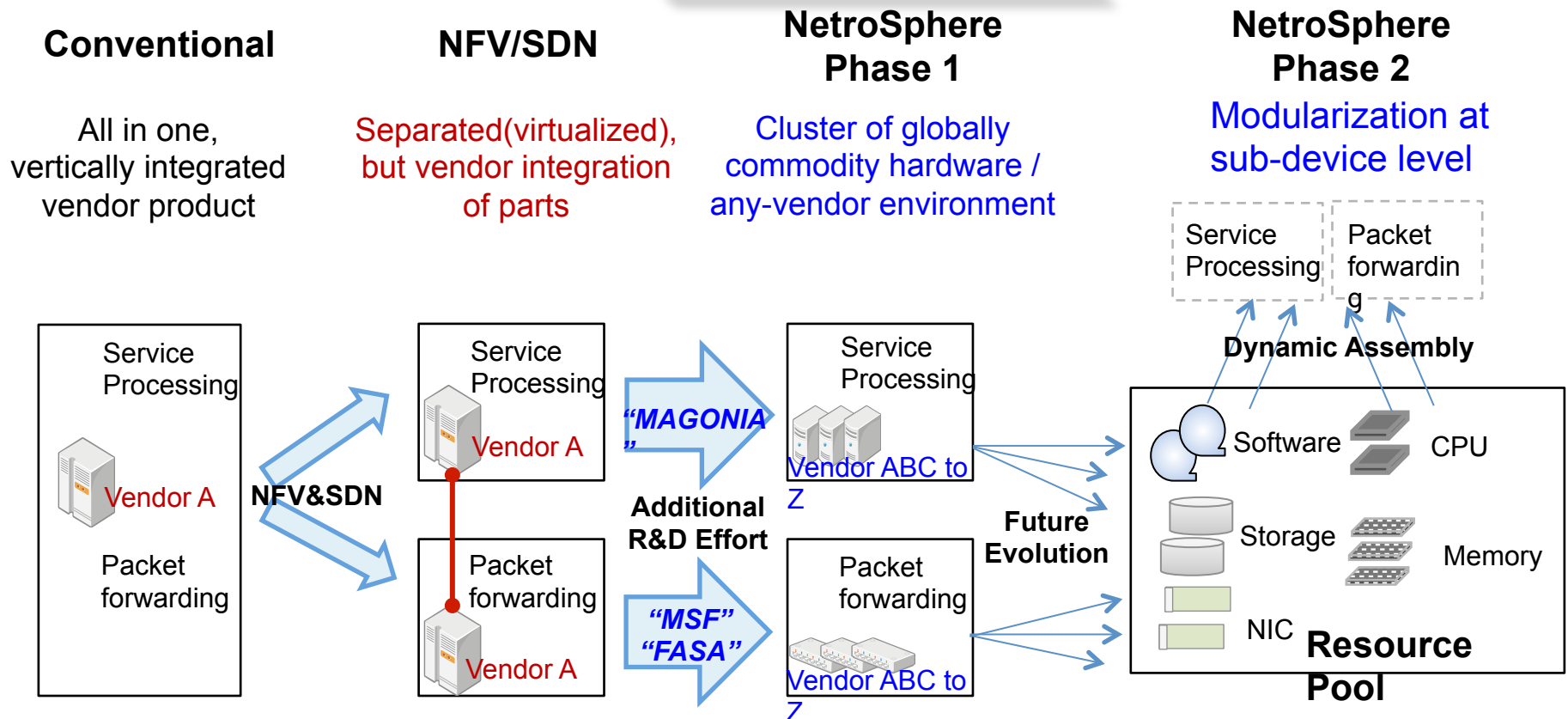
Network architecture image based on NetroSphere concept



Current Initiatives of NetroSphere concept

- NetroSphere aims at sub-device level modularization and assembly ultimately.
- We currently drive forward clustering of globally commodity hardware and any-vendor environment (NetroSphere Phase1)

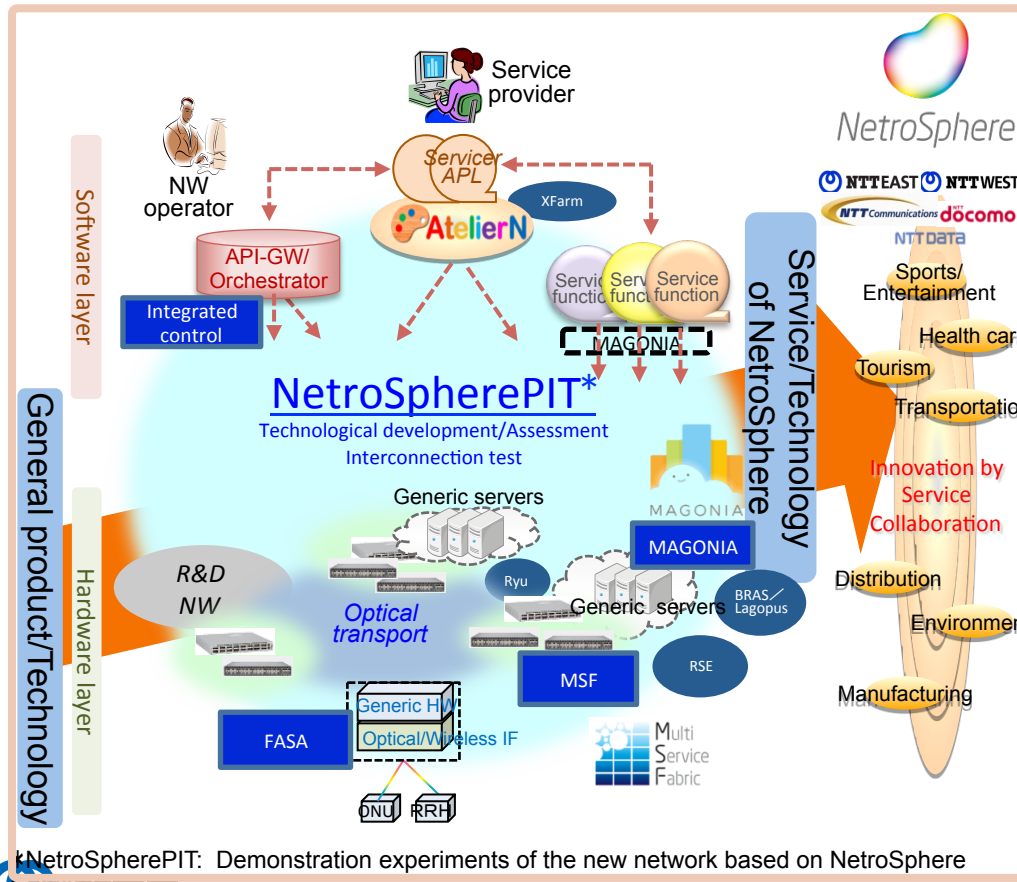
Current R&D Initiatives



NetroSpherePIT

~Demonstration and experimental environment of NetroSphere Concept~

- NetroSpherePIT is experimental environment for NetroSphere concept.
- We aims to achieve "acceleration of service co-creation for partner needs" and "economic profitability of the network", by assembling, evaluating and verifying multiple technologies and products.



Features

- Overall network environment consisting of various components of NetroSphere and used for practical assessment of technologies.
- Used for service demonstration with partners such as global carriers, service providers, and vendors.
- Used in R&D to extract issues from a user's viewpoint, examine network management policies, and examine practical use applications, etc.

Application Scenarios

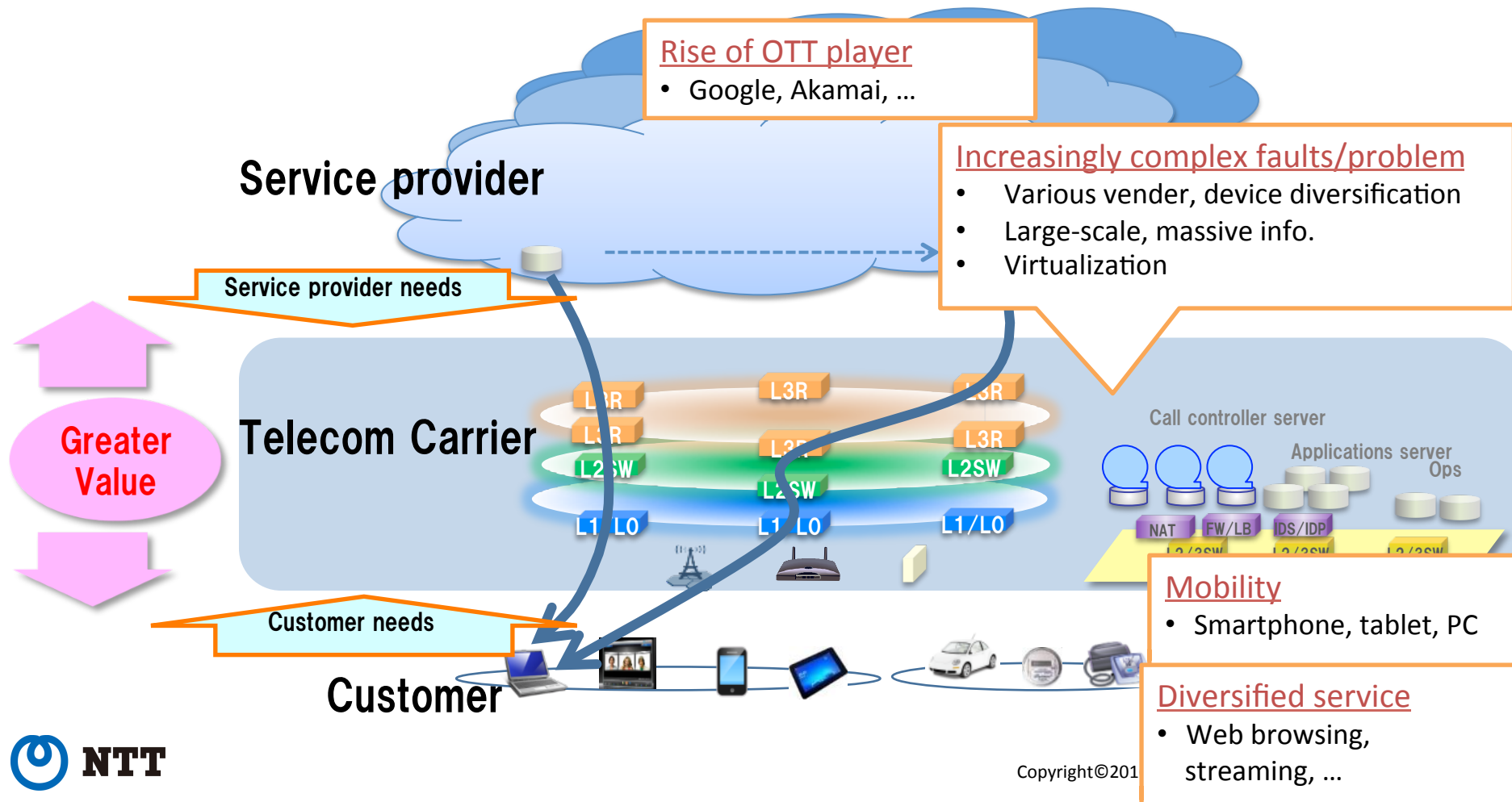
- Verifies the behavior of the network when multiple products work simultaneously in order to realize "one-network": an integrated network of mobile networks, fixed networks, and leased lines.
- Utilized as a showcase to create colorful services through cooperation with various players and to gain a sense of the effect of the services.
- Confirms the interface specifications for one-stop setting of the network being used by multiple players to promote collaboration among players.

NetroSpherePIT: Demonstration experiments of the new network based on NetroSphere concept

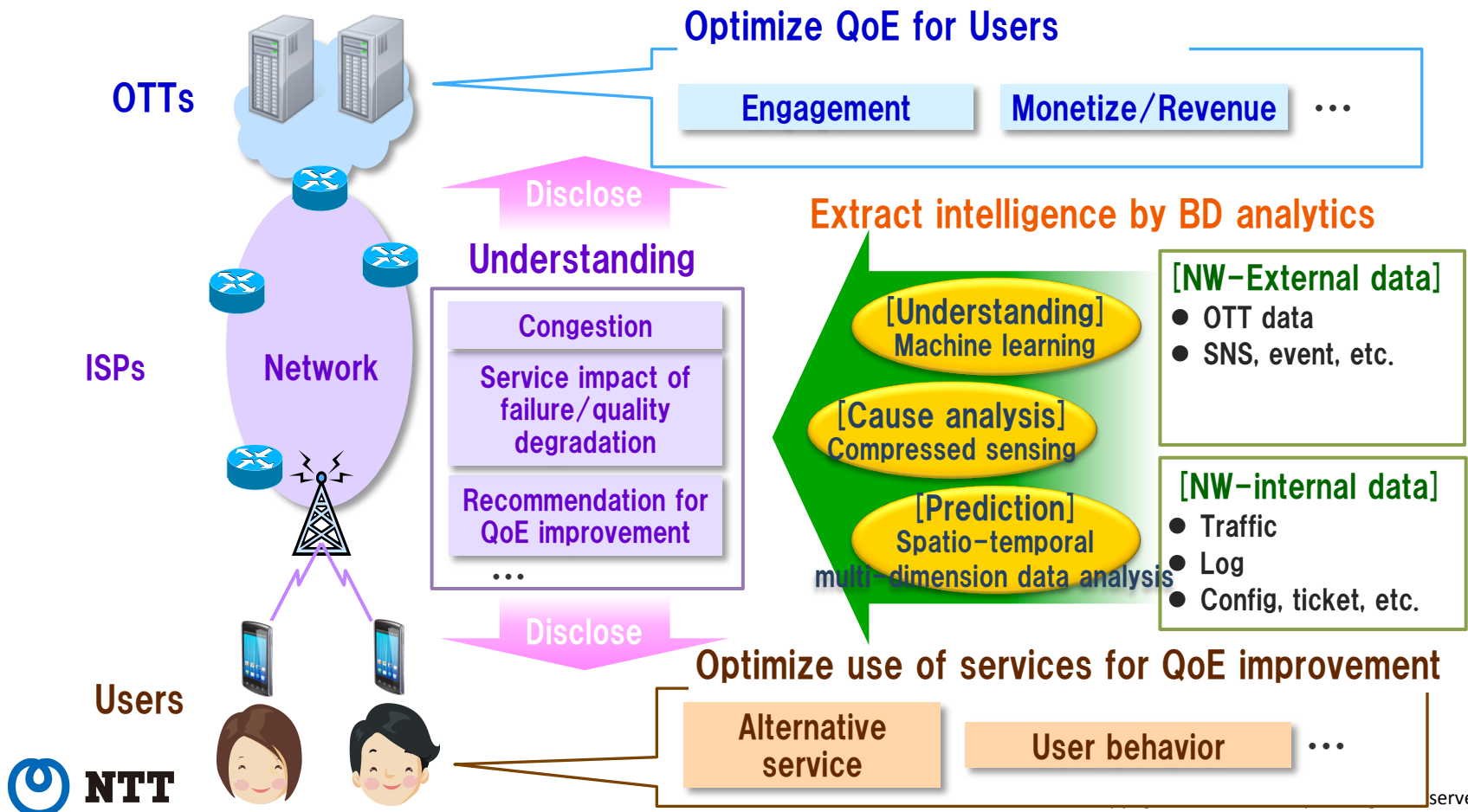
Network Analytics

a key enabler of innovation of carrier
networks beyond SDN/NFV evolution called
"NetroSphere"

Circumstance surrounding telecom carrier



Two-sided QoE management



Inter-disciplinary approach by combining various research fields for innovation.

**Technologies in
different domains**

Space-related
theory
Information theory
Sensitivity analysis
Machine learning
Data mining
Model predictive
control
...



**Network
technologies**

Queueing theory
Quality assessment
Stochastic
Traffic theory
Graph theory
Optimization theory
...

Inter-disciplinary

For more detail, see [1].

[1] K. Shiomoto, "Approach to Network Science—Solving Complex Network Problems through an Interdisciplinary Approach," NTT Technical Review, Vol. 13 No. 9 Sept. 2015

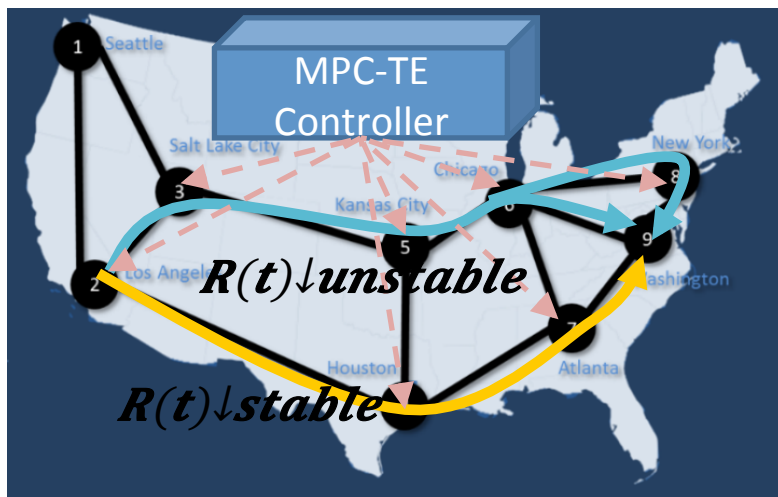
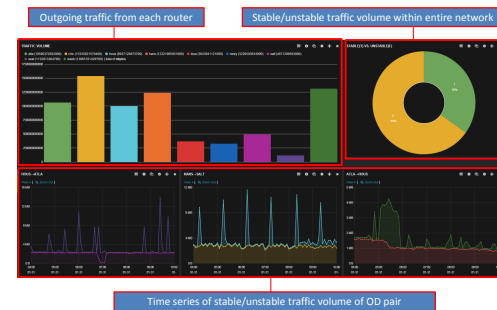
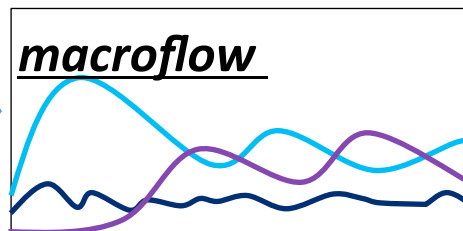
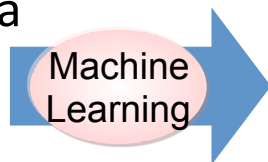
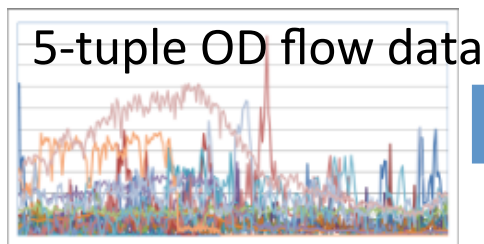
<https://www.ntt-review.jp/archive/ntttechnical.php?contents=ntr201509fa1.html>

Understand “network system behavior” by analyzing data instead of individual elements

- Flow mining
- QoE analytics
- Twitter analytics
- Workflow analytics
- Syslog analytics
- ...

Flow mining

- Cope with unpredictable spiky traffic
 - Classify traffic according to variability
 - Stable (ex. user traffic) and Non-stable (spiky, ex. OS updates traffic)
 - TE-policy
 - Stable traffic → QoS-oriented (throughput, delay, loss, ...)
 - Non-stable traffic → Load distribution



Stable macroflow:

Route $R(t) \downarrow \text{stable}$ computed by MPC-TE to minimize J

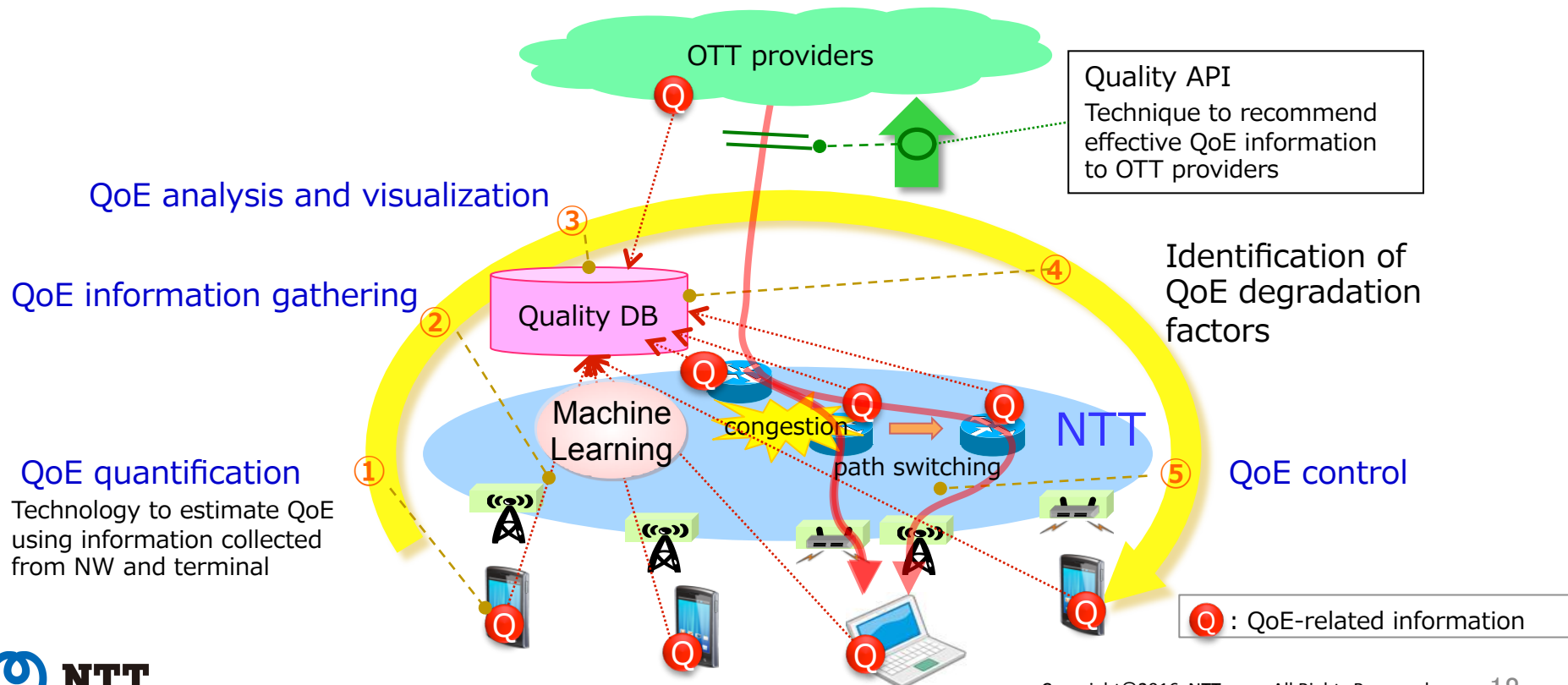
$$\min J = \sum_{k=1}^H (1-w) \zeta(k) + w \Delta R(k)$$

Non-stable macroflow:

Load distribution $R(t) \downarrow \text{unstable}$

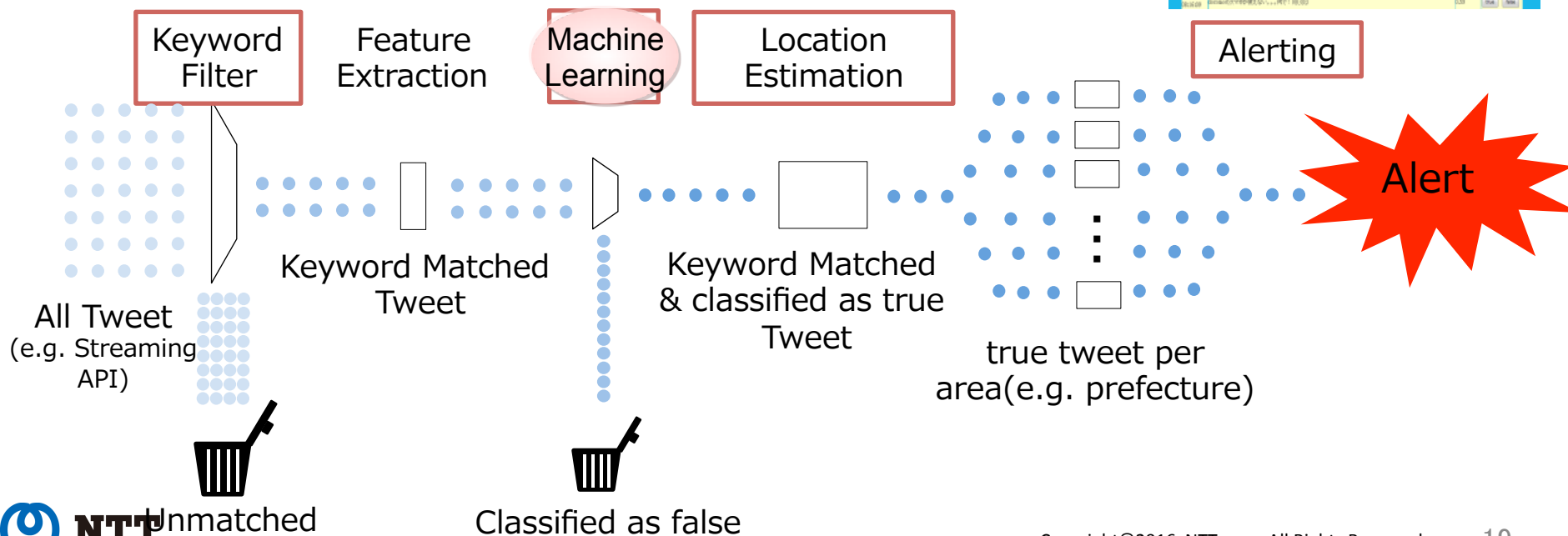
Copyright©2016 NTT corp. All Rights Reserved.

- Understand relationship between end-to-end network/application performance and QoE.
 - QUVE: QoE of Video Streaming Enhancing Framework
 - QoE quantification, information gathering, analysis and visualization, control
 - Quality API: Network status is disclosed to OTT players for QoE optimization



Twitter analytics

- Detect and understand details of network failure
 - Identify tweets related to network failure
 - Identify the area of tweeters

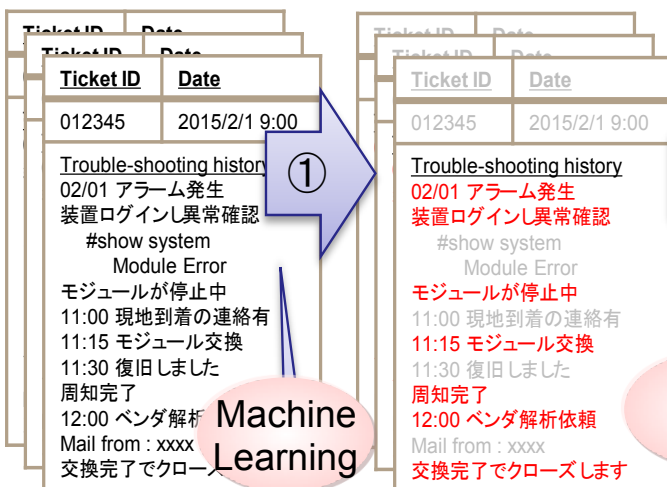


Workflow analytics

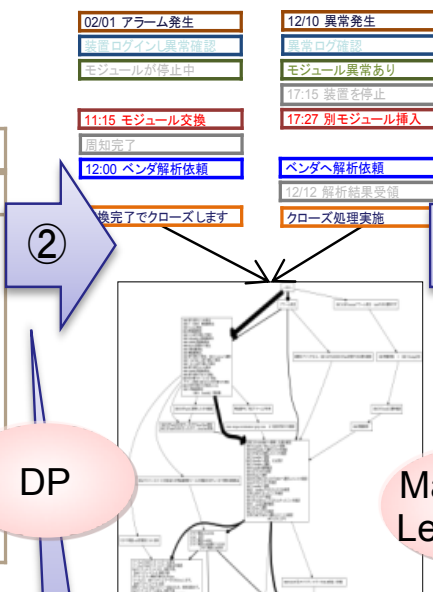
- Reduce Time to repair by analyzing trouble tickets
 - Correlate a set of trouble tickets with an alert message
 - Extract common workflows from a set of trouble tickets (*free-format*)
 - Visualize the workflows of the corrective actions

Output: Workflow

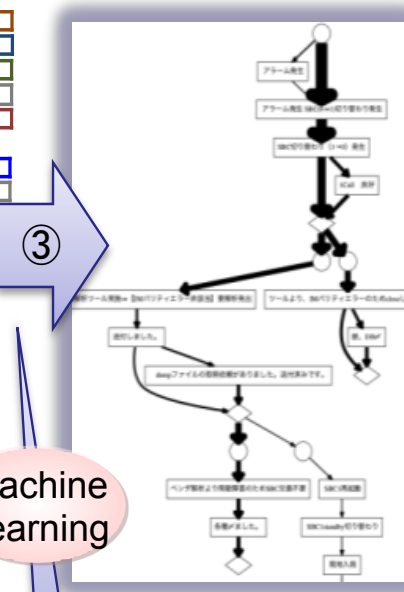
Input: trouble tickets (free-format text)



Extracts action messages by unsupervised learning

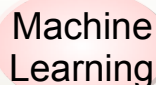


Makes transition diagram of actions from multiple tickets by maximum matching



Extracts branch point which divides different recovery actions by clustering tickets

- Troubleshoot network failure
- Predict network failure

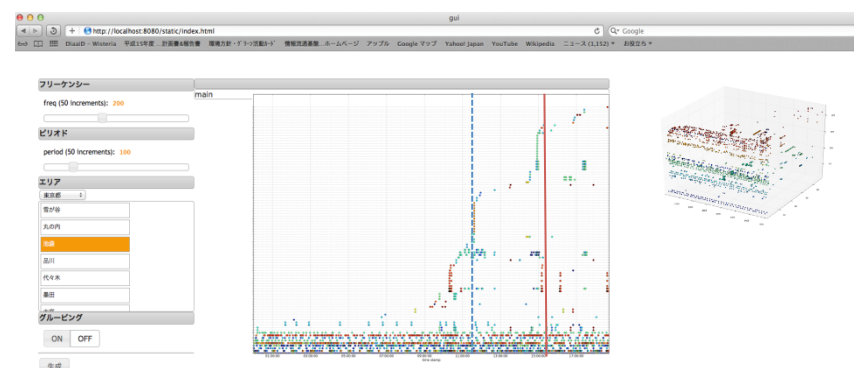


Fault cause candidates

No prior knowledge needed!

Syslog

- ✓ Free format
- ✓ Vendor specific
- ✓ 100M msgs/day



Can't email

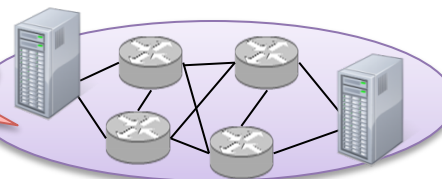
Can't download...

Syslog analytics: What is Syslog?

- Logging messages generated by a device (incl. server, router, switch, ...) to track software and hardware conditions.
 - Intended for debugging software and hardware problem of device.
- Free-form texts
 - Syntax and semantics are different among device vendors and operating systems.
- Huge amount data generated.

```
2013-1-1T01:11:00 msg [100]: STP: VLAN 1 Port 38  
STP State -> DISABLED (PortDown)  
2013-1-1T01:11:00 msg [101]: System: Interface  
ethernet 38, state down  
2013-1-1T03:00:00 msg [200]: STP: VLAN 100 Port 22  
STP State -> DISABLED (PortDown)  
2013-1-1T03:00:00 %NODE%: %HOST% port %I/F%  
detected CRC error in %N% flames  
2013-1-1T03:00:00 msg [201]: System: Interface  
ethernet 22, state down
```

Syslog



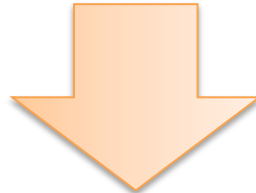
Syslog analytics: Issue1

Template identification



- Free-form texts is used for detailed information.
 - Syntax and semantics varies among device vendors and operating systems.
- Identify template without prior knowledge on syntax and semantics.
 - Words of message is classified into keyword and parameter.

1. %TRACKING-5-STATE : 1 interface Fa0/0 line-protocol Up -> Down
2. %LINK-3-UPDOWN : Interface FastEthernet 0/9, changed state to down
3. %SYS-5-CONFIG I : Configured from console by vty2 (10.11.11.11)



Template

%TRACKING-5-STATE : 0 interface Ga0/0 line-protocol Up -> Down
2 Ga1/0
3 Fa0/0

□ : Parameter
○ : Template

Syslog analytics: Idea1

Template identification

- Scoring frequency of words among similar messages
 - parameter words appear infrequently compared to template words in each position
- Clustering score, and determine parameter words for each message
 - thresholds for score of parameter words differ depending on log messages
 - density-based clustering algorithm (DBSCAN)

raw log messages:

<189> security telnet connection 15720 with 10.7.11.11 broken
<189> security telnet connection 18340 with 10.8.9.123 broken

| 1 | 2 | 3 | 4 | 5 | 6 | 7 |
|-------|----------|--------|-------|------|------------|--------|
| <189> | security | telnet | 15720 | with | 10.7.11.11 | broken |
| <189> | security | telnet | 18340 | with | 10.8.9.123 | broken |

Remove

log template:

<189> security telnet connection * with * broken

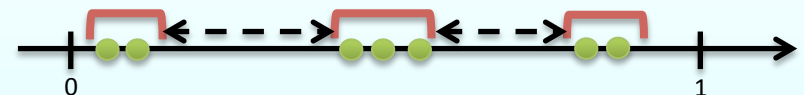
Scoring:

If *word* appears in *P*-th position in log that contains *L* words:

$$Score(word, P, L) = \Pr(word \mid P, L)$$

Clustering scores (DBSCAN):

Distance between each cluster is $> \delta$



Syslog analytics: Issue2

Event identification

- Capture signature of co-occurred syslog msgs.
- Associate a group of syslog msgs with an event of network.

Syslog

Associate network event
(Exploit Co-occurrence)

```
2012-1-1T00:00:00 %TRACKING-5-STATE: 1 interface Fa0/0 line-protocol Up->Down
2012-1-1T00:00:00 %LINK-3-UPDOWN: Interface FastEthernet 0/9, changed state to down
2012-1-1T00:00:00 %SYS-5-CONFIG I: Configured from console by vty2 (10.11.11.11)
2012-1-1T01:11:00 msg [100]: STP: VLAN 1 Port 38 STP State -> DISABLED (PortDown)
2012-1-1T01:11:00 msg [101]: System: Interface ethernet 38, state down
2012-1-1T03:00:00 msg [200]: STP: VLAN 100 Port 22 STP State -> DISABLED (PortDown)
2012-1-1T03:00:00 msg [201]: System: Interface ethernet 22, state down
2012-1-1T00:00:00 %SYS-5-CONFIG I: Configured from console by vty2 (10.11.11.11)
2012-1-1T10:30:00 System: Interface ethernet 1, state down
2012-1-1T10:30:00 System: Interface ethernet 1, state up
2012-1-1T10:30:00 System: Interface ethernet 2, state down
2012-1-1T12:00:00 init: alarm-control (PID 111) terminate signal sent
2012-1-1T12:00:00 init: bslockd (PID 124 ) terminate signal sent
2012-1-1T12:00:00 init: ce-l2tp-service (PID 123 ) terminate signal sent
2012-1-1T12:00:00 init: chassis-control (PID 1111 ) terminate signal sent
2012-1-1T12:00:00 init: class-of-service (PID 11112) terminate signal sent
2012-1-1T12:00:00 init: craft-control (PID 111) terminate signal sent
2012-1-1T12:00:00 init: database-replication (PID 2718932 ) terminate signal sent
2012-1-1T12:00:00 init: diameter-service (PID 2993 ) terminate signal sent
2012-1-1T12:00:00 init: disk-monitoring (PID 7082 ) terminate signal sent
2012-1-1T00:00:00 %SYS-5-CONFIG I: Configured from console by vty2 (10.11.11.11)
2012-1-1T15:45:10 msg [200]: STP: VLAN 100 Port 22 STP State -> DISABLED (PortDown)
2012-1-1T15:45:10 msg [201]: System: Interface ethernet 22, state down
2012-1-1T16:12:40 System: Interface ethernet 1, state down
2012-1-1T16:12:40 System: Interface ethernet 1, state up
2012-1-1T16:12:40 System: Interface ethernet 2, state down
2012-1-1T20:30:00 init: alarm-control (PID 111) terminate signal sent
2012-1-1T20:30:00 init: bslockd (PID 124 ) terminate signal sent
2012-1-1T20:30:00 init: ce-l2tp-service (PID 123 ) terminate signal sent
2012-1-1T20:30:00 init: chassis-control (PID 1111 ) terminate signal sent
2012-1-1T20:30:00 init: class-of-service (PID 11112) terminate signal sent
```

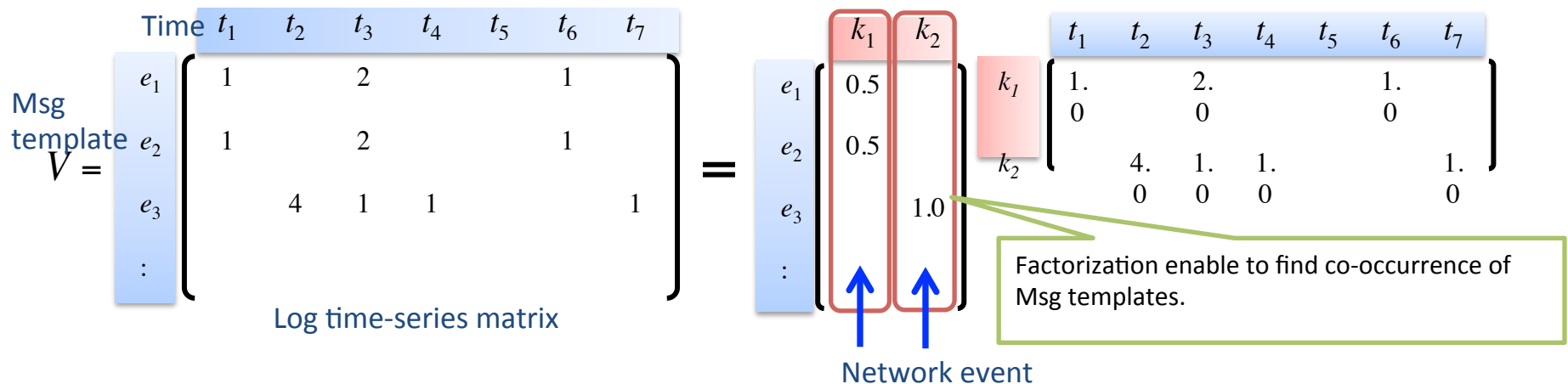
: reboot
: linkup
: linkdown
: IF flap

```
2012-1-1T00:00:00 %TRACKING-5-STATE: 1 interface Fa0/0 line-protocol Up->Down
2012-1-1T00:00:00 %LINK-3-UPDOWN: Interface FastEthernet 0/9, changed state to down
2012-1-1T00:00:00 %SYS-5-CONFIG I: Configured from console by vty2 (10.11.11.11)
2012-1-1T01:11:00 msg [100]: STP: VLAN 1 Port 38 STP State -> DISABLED (PortDown)
2012-1-1T01:11:00 msg [101]: System: Interface ethernet 38, state down
2012-1-1T03:00:00 msg [200]: STP: VLAN 100 Port 22 STP State -> DISABLED (PortDown)
2012-1-1T03:00:00 msg [201]: System: Interface ethernet 22, state down
2012-1-1T00:00:00 %SYS-5-CONFIG I: Configured from console by vty2 (10.11.11.11)
2012-1-1T10:30:00 System: Interface ethernet 1, state down
2012-1-1T10:30:00 System: Interface ethernet 1, state up
2012-1-1T10:30:00 System: Interface ethernet 2, state down
2012-1-1T12:00:00 init: alarm-control (PID 111) terminate signal sent
2012-1-1T12:00:00 init: bslockd (PID 124 ) terminate signal sent
2012-1-1T12:00:00 init: ce-l2tp-service (PID 123 ) terminate signal sent
2012-1-1T12:00:00 init: chassis-control (PID 1111 ) terminate signal sent
2012-1-1T12:00:00 init: class-of-service (PID 11112) terminate signal sent
2012-1-1T12:00:00 init: craft-control (PID 111) terminate signal sent
2012-1-1T12:00:00 init: database-replication (PID 2718932 ) terminate signal sent
2012-1-1T12:00:00 init: diameter-service (PID 2993 ) terminate signal sent
2012-1-1T12:00:00 init: disk-monitoring (PID 7082 ) terminate signal sent
2012-1-1T00:00:00 %SYS-5-CONFIG I: Configured from console by vty2 (10.11.11.11)
2012-1-1T15:45:10 msg [200]: STP: VLAN 100 Port 22 STP State -> DISABLED (PortDown)
2012-1-1T15:45:10 msg [201]: System: Interface ethernet 22, state down
2012-1-1T16:12:40 System: Interface ethernet 1, state down
2012-1-1T16:12:40 System: Interface ethernet 1, state up
2012-1-1T16:12:40 System: Interface ethernet 2, state down
2012-1-1T20:30:00 init: alarm-control (PID 111) terminate signal sent
2012-1-1T20:30:00 init: bslockd (PID 124 ) terminate signal sent
2012-1-1T20:30:00 init: ce-l2tp-service (PID 123 ) terminate signal sent
2012-1-1T20:30:00 init: chassis-control (PID 1111 ) terminate signal sent
2012-1-1T20:30:00 init: class-of-service (PID 11112) terminate signal sent
```

Syslog analytics: Idea2

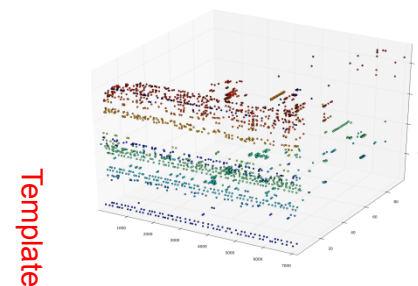
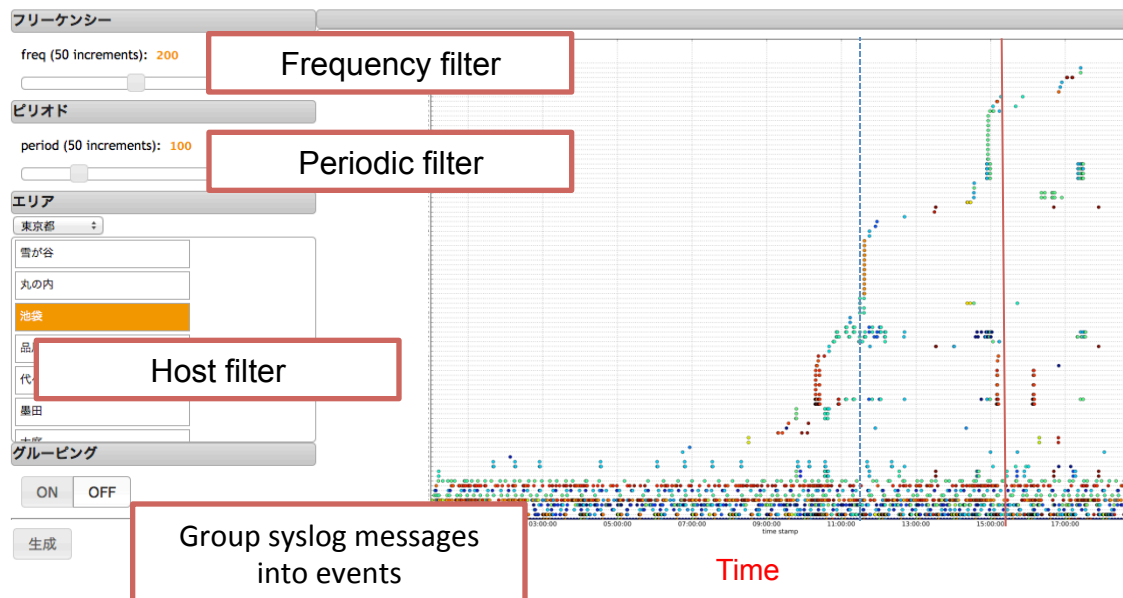
NMF and NTF

- Non-negative matrix/tensor factorization
 - Time-series data of syslog messages are expressed in matrix/tensor form.
 - Matrix/tensor is factorized.
 - Time-series data is considered as a mixture of different network events occurred in the network.
 - Network event is extracted as a combination of templates.



Syslog analytics: visualization

- Visualize massive time-series syslog data for easy understanding.
- Apply frequency & periodic filters to remove unimportant messages.
- Group syslog messages into events.



- NetroSphere

- Innovation of network architecture and operation beyond SDN/NFV evolution

Netro: a prospect that stands upon the deep and wide knowledge of network development and operation which acquired in the past.

+

Sphere: Atmosphere



NetroSphere

- NetworkAnalytics

- Understand network system by analyzing data to decide actions

Thank you for your attention



NetroSphere

