Empowered by Innovation NEC

International Conference on Computing,
Networking and Communications (ICNC 2014),
Honolulu, Hawaii, USA
February 3-6, 2014

Collaborative Innovation for ICT-Enabled Future Society Solutions

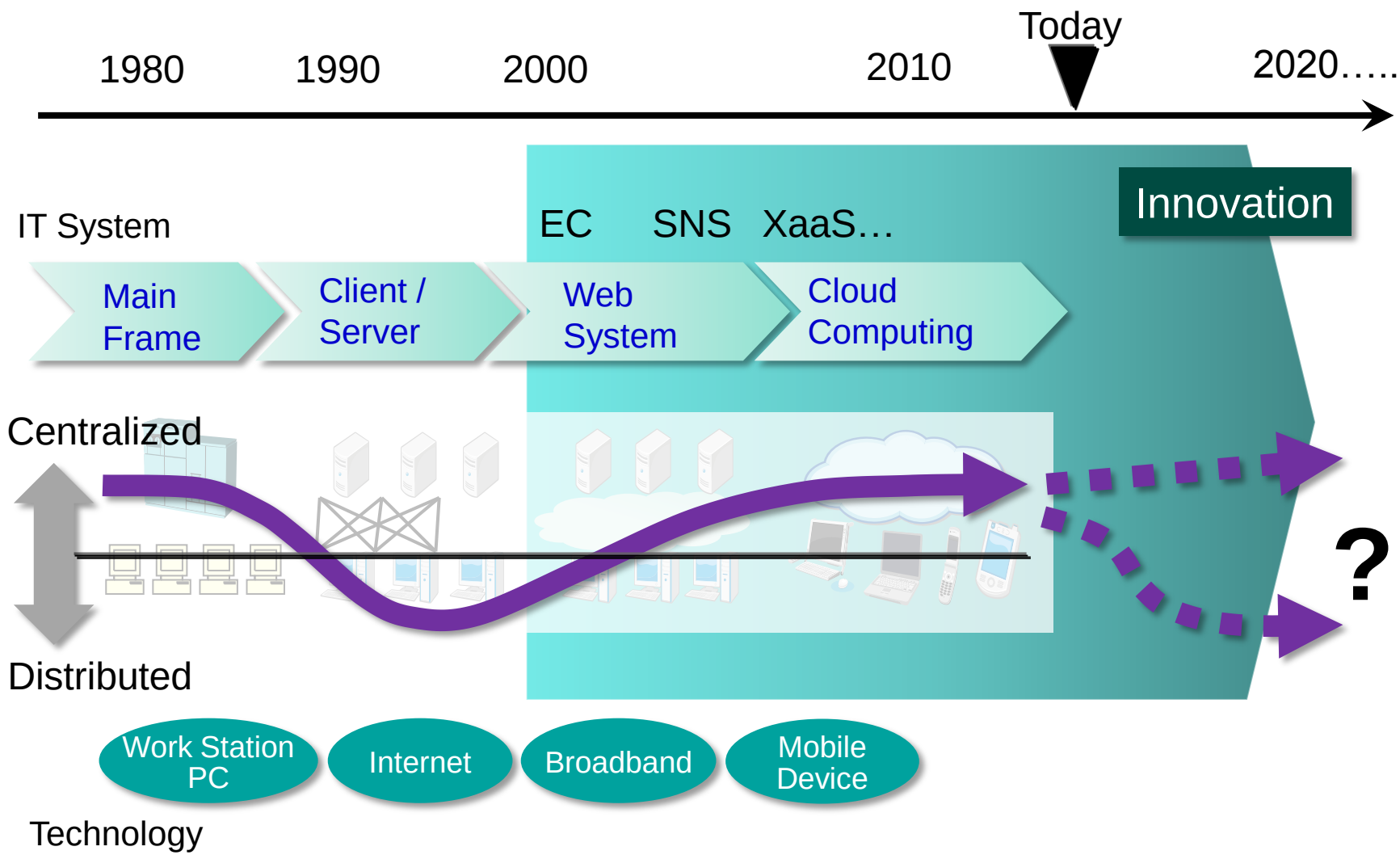
Yasunori Mochizuki

Central Research Laboratories,

NEC Corporation

Tech drives Innovation, Innovation drives Tech

Role of Apps playing the central role to ICT's evolution



Cloud Application Landscape

- Cloud application is expanding from consumer services to enterprise and to society

Consumer → Enterprise → Society

Public Cloud

Web Search
EC
Storage
SNS

Private Cloud

Groupware
CRM
BI

SCM
Finance
Human resource

Energy
Disaster Recovery
Safety

Social Infrastructure

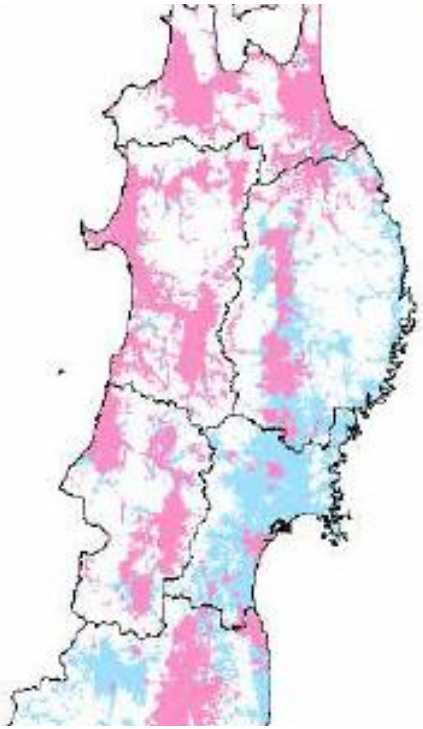
(Vender list: based on IDC 2013)

3.11 Tohoku Earthquake and Tsunami

- Communication services were down
  - 1,000,000 landlines outage
  - 14,800 mobile base stations damaged
- Internet was not completely dead, but at a very limited quality

- Google: “Google Person Finder”
  - Safety check service was launched in 1h 46min after the earthquake
- Twitter
  - Played a critical role in sharing local info (food, doctor, blackout, etc.)
  - New registration world-wide jumped up by 25% on 3/12
  - Local governments relied on twitter for info transmission

Mobile service map (3/12)



Service outage

Service available

Source: NTT docomo

Source: www.47news.jp

3.11 Impact on Enterprise / Public IT systems

- IT customer's mindset was changed
  - before: On premise in convenient large cities

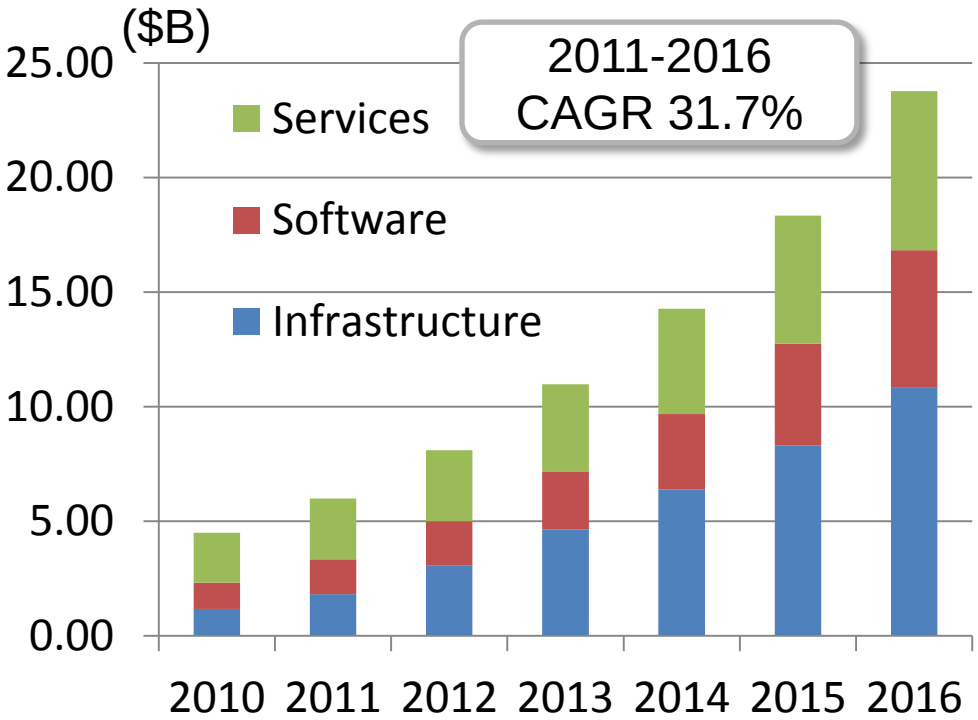
    after: Cloud in remote / distributed data centers
    - ✓ Electricity saving became more important in view of power shortage and rise in electricity price
    - ✓ Disaster recovery / BCP was revised to be viable

- Government started twitter information services as a social infrastructure

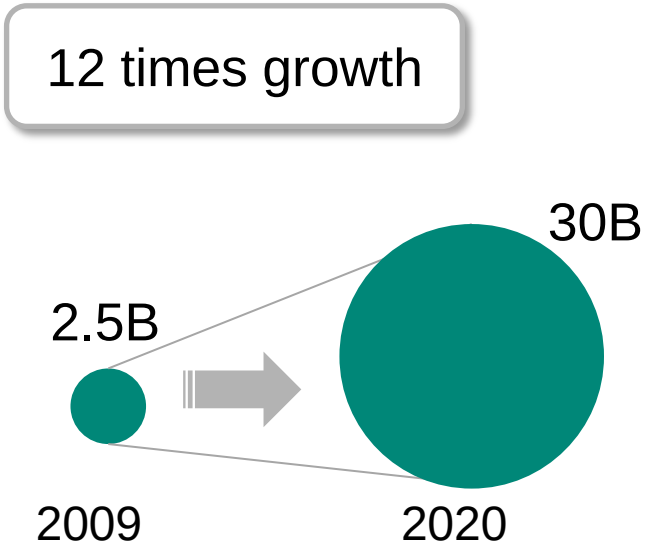
Source: www.47news.jp

Big Data, IoT/CPS as booming trend in IT Apps

- Discovering value from Big Data is becoming the mainstream
  - e.g. CDO (Chief Data Officer) as an emerging trend
- IT app. of IoT/Cyber-Physical System. is also increasing rapidly
  - 12x growth from 2009 to 2020, $300B in 2020



Big Data technology and services revenue

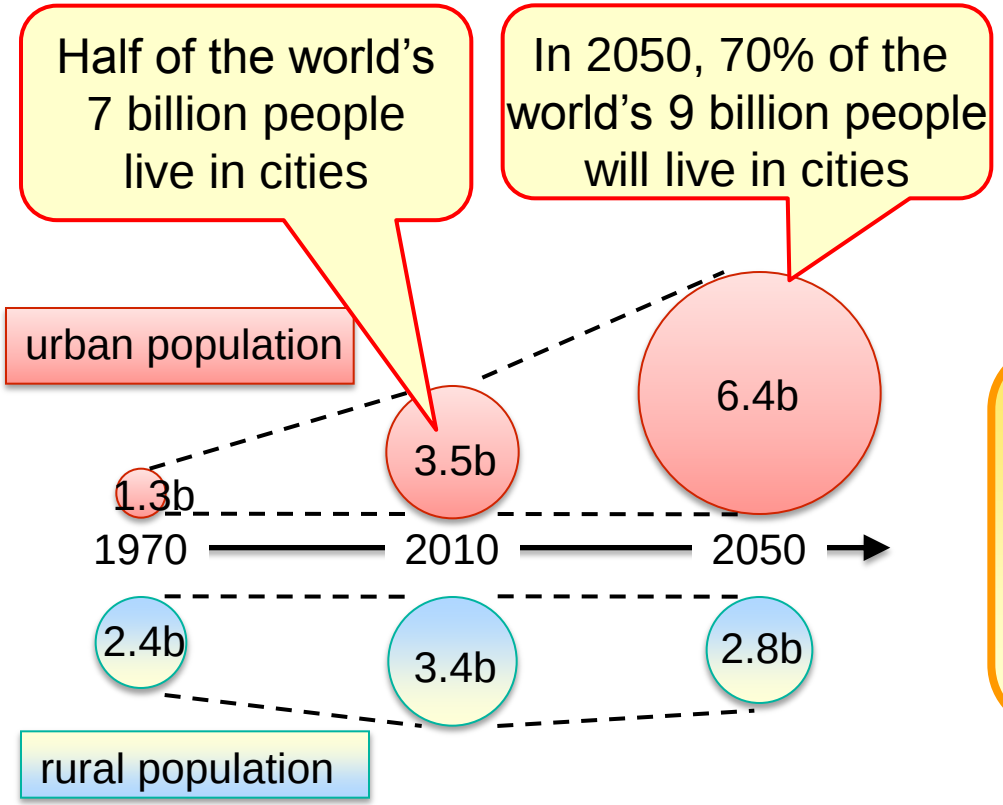


The # of connected IoT devices

(Source: IDC 2013, Gartner 2013)

21st Century is the Age of Cities

- Cities are swelling, with rapidly increasing populations and problems.



Growth of world's urban and rural populations (UN statistics)

? Why do people gather in cities?

Job and Infrastructure

Where people gather, industries prosper, economy grows, allowing investment in social infrastructure, attracting more people and more industry…

If such a positive spiral fails, people leave and the city decay.

Perspective I want to share is on collaboration

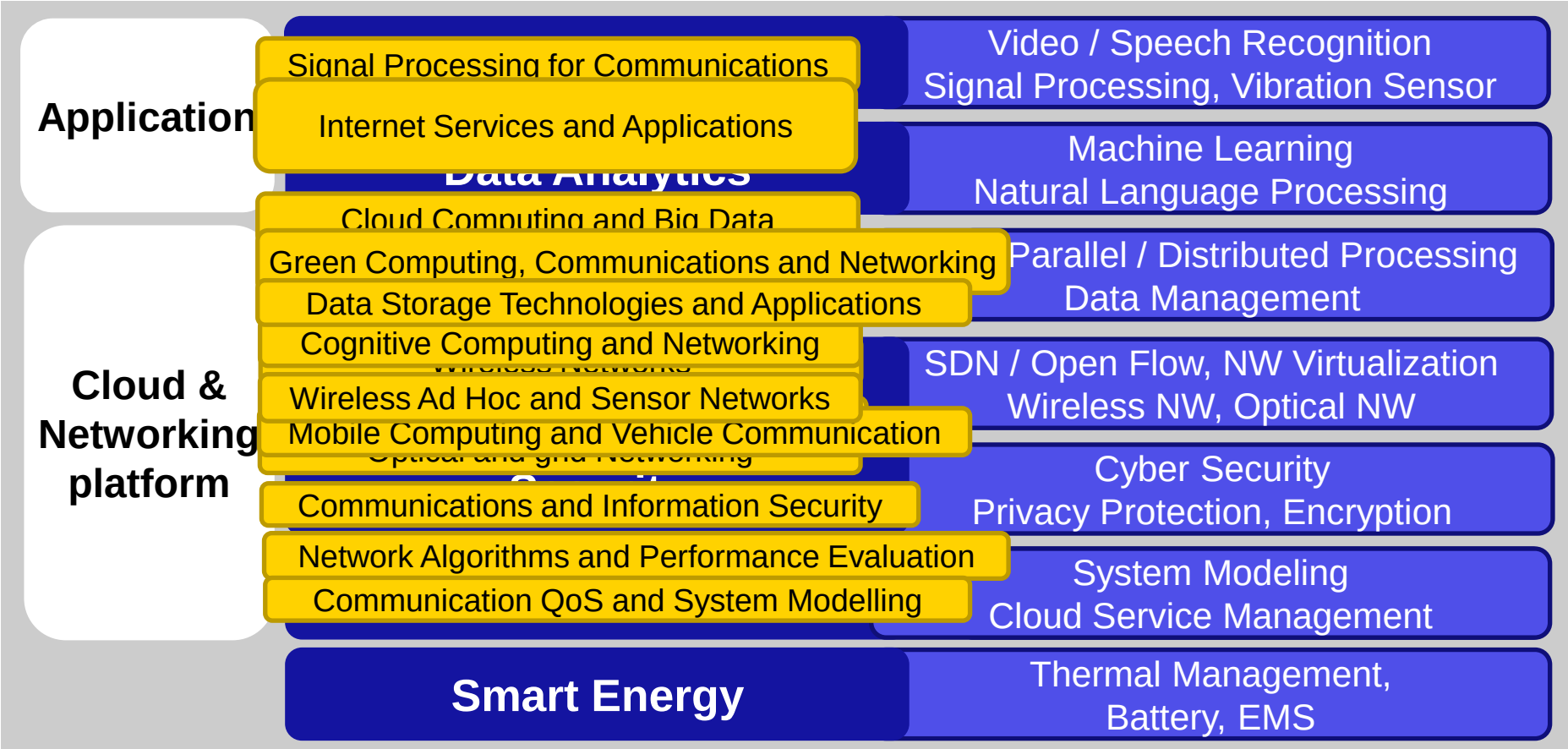
Today, importance of “collaboration” is of no doubt for innovation, and not new

Still, I think it makes sense for ICNC colleagues to take a look at NEC’s research as a case study of “collaboration for innovation”

because …….

Comparing NEC's Research and ICNC

There is a similarity in the broad coverage of technical areas, IT and NW, from PF to APP.



NEC Mid-term Management Plan 2015

Realization of an affluent and equitable society which makes efficient use of resources and whose members are safe and personally secure

Solutions for society

- Supporting the advancement of social infrastructure and systems throughout the world via ICT
- Create new business models with the understanding that social problems provide an opportunity for growth

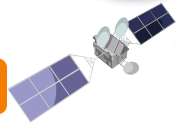
Transformation into Social Value Innovator

Social Value Creation via ICT

Collection of large-scale data

Diverse sensors and human interface technologies — **CLOUD**

- Diverse sensors
  - From the seafloor to outer space



- Surveillance cameras

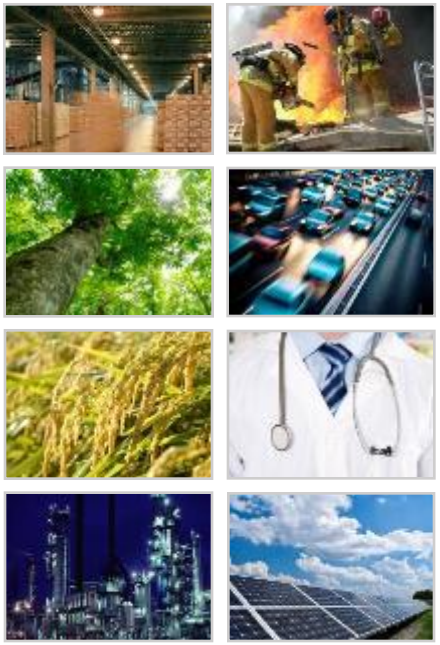
- Smart devices
- Accumulated data

Analysis and prediction

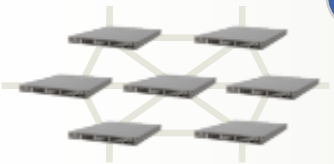
High-performance/high-reliability core IT technologies — **BIG DATA**

- Unique — Invariant analysis
- Unique — Heterogeneous mixture learning
- * No.1 — Facial image analysis
- Unique — Behavior analysis
- * No.1 — Textual entailment recognition

Solution of social issues



Next-generation network technologies — **SDN**



- Network virtualization — World's first SDN switches
- Cyber security — Essential to future information system

SDN : Software-Defined Networking

Leveraging information captured by our unique and highly competitive ICT assets to become a social value innovator

* Rated as No. 1 among organizations participating in an evaluation task organized by the U.S. National Institute of Standards and Technology (NIST)

Perspective I want to share is on collaboration

Today, importance of “collaboration” is of no doubt for innovation, and not new

Still, I think it makes sense for ICNC colleagues to take a look at NEC’s research as a case study of “collaboration for innovation”

because …….

ICT Trend Summary

NEC's direction has a lot to do with the general ICT trend

- Technology evolution becoming more innovation-driven (i.e. app driven) than performance driven
- IT apps expanding from consumer to enterprise, and to society
- For IT apps, central value to users is migrating towards value extraction from Big Data (by analytics)
- Another booming app field is for real world/physical issues (Cyber Physical Systems, Internet of Things)

Focused Area of NEC Research

Focused area

Big Data	Real World Recognition	Video / Speech Recognition Signal Processing	Vibration Sensor Natural UI
	Data Analytics	Machine Learning Natural Language Processing	
	Big Data Processing	Parallel / Distributed Processing Data Management	Storage Embedded System
	SDN (Software-Defined Networking)	Open Flow, Network Virtualization	Wireless Network Optical Network
	Security	Cyber Security Privacy Protection, Encryption	
	SI Engineering	Model-based System Integration Cloud Service Management	Human Centered Design
	Smart Energy	Thermal Management, Battery, EMS	Low Power Circuit

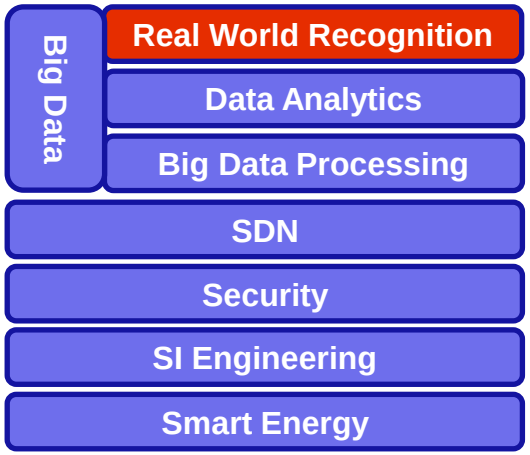
R&D directions for future social value innovation

Focus on seven research areas towards advancement of social infrastructure

Energy/ Climate | Agriculture | Manufacturing | Distribution/ Logistics | Transportation | Disaster prevention/ Security | Healthcare | …

Big Data	Real World Recognition	Expansion of scope for visualization	Optimization & Control
	Data Analytics	Prediction and forecasting	
	Big Data Processing	Real-time	
SDN		Individualized optimization	Global optimization
Security		Measures to reduce information leakage risks	Defense from unknown attacks
SI Engineering		Customization and downsizing	Facilitation of global deployment
Smart Energy		Energy use optimization	Shift to convenience for individuals/ society

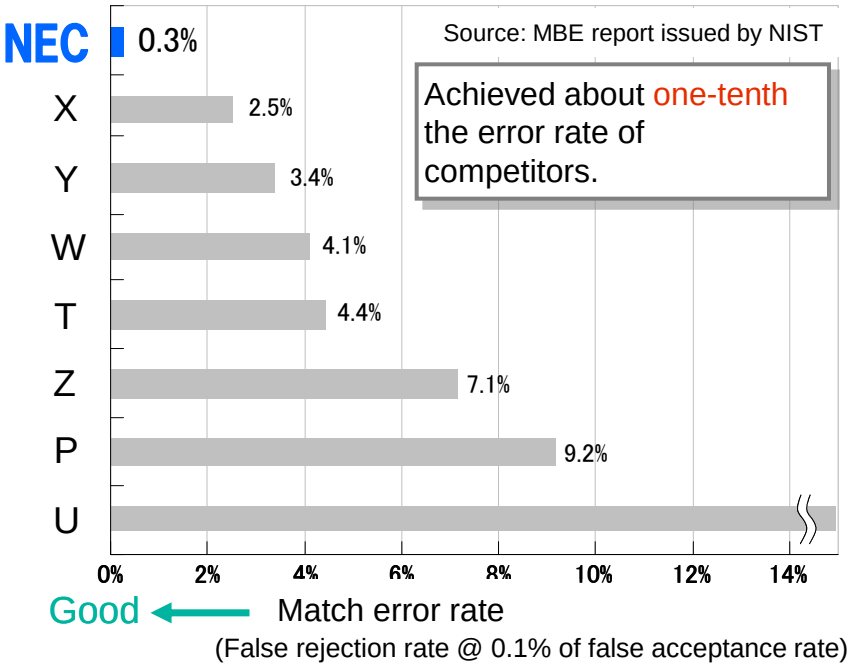
Real World Recognition



Face Recognition / Behavior Recognition

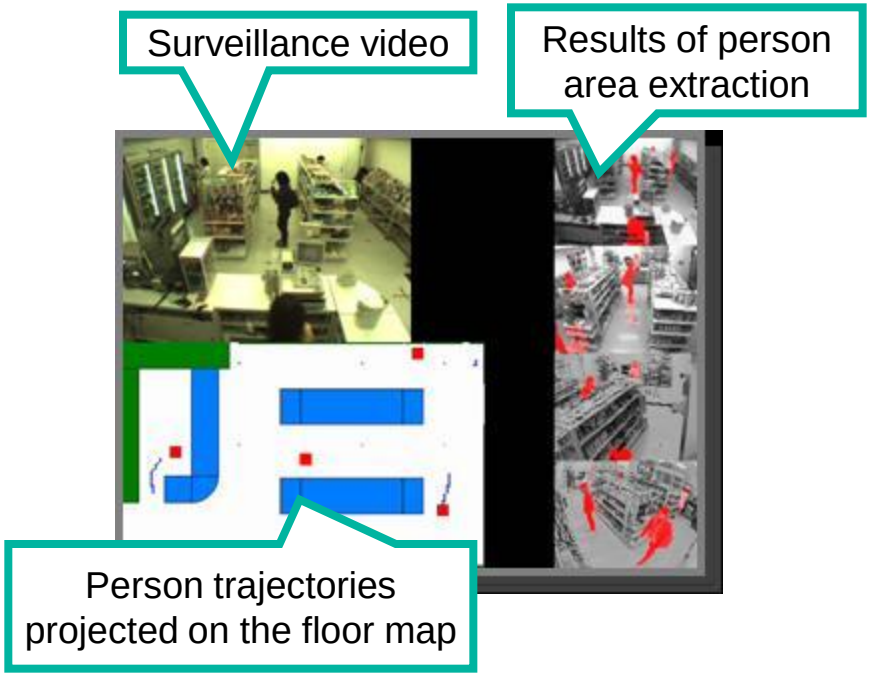
NEC's technological differentiator in public safety solution business

Global No.1 face recognition technology



✓ Achieved high recognition rate for even faces with shadows in bad illumination conditions
✓ Won the first prize with a significant difference from others in the NIST global bench mark (MBE)

Human trajectory analysis using multiple cameras



✓ Estimates person's real world location with high accuracy (about 25 cm)
✓ Makes it possible to analyze person behavior, to detect intrusions and suspect behaviors

Automatic Vehicle Clearance in Hong Kong

Benefits:

Face recognition Implemented at the driving lanes to streamline operation procedures and minimize manual operations

Universal Studios Japan

Your Face can be a pass : An ultra user friendly entry system

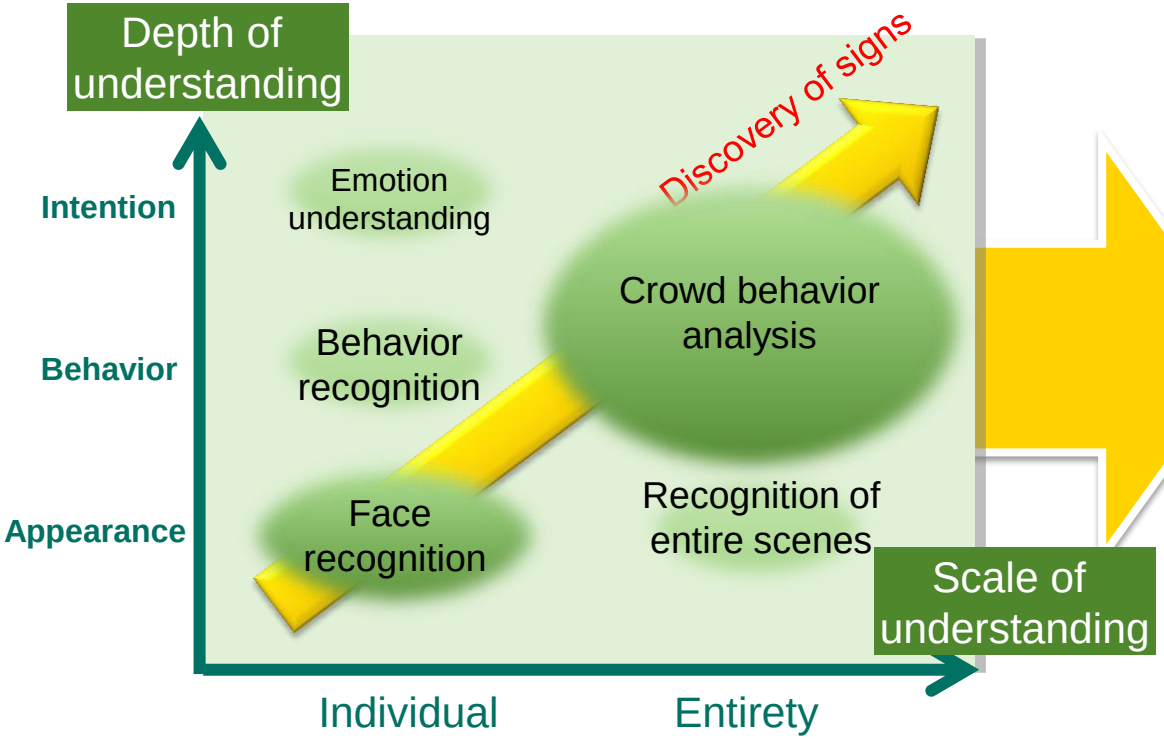
Universal Studios Japan™ : Access Control System（Japan）

- Provide a way to prevent spoofing of annual pass
- Cost reduction of pass card issuing process
- Visitors enjoy it as a new entertainment

Real World Recognition: Research Direction

Tech Challenge: Acquisition and analysis of real-world data through the <u>understanding of diverse meanings</u>

Visualization of signs of future events

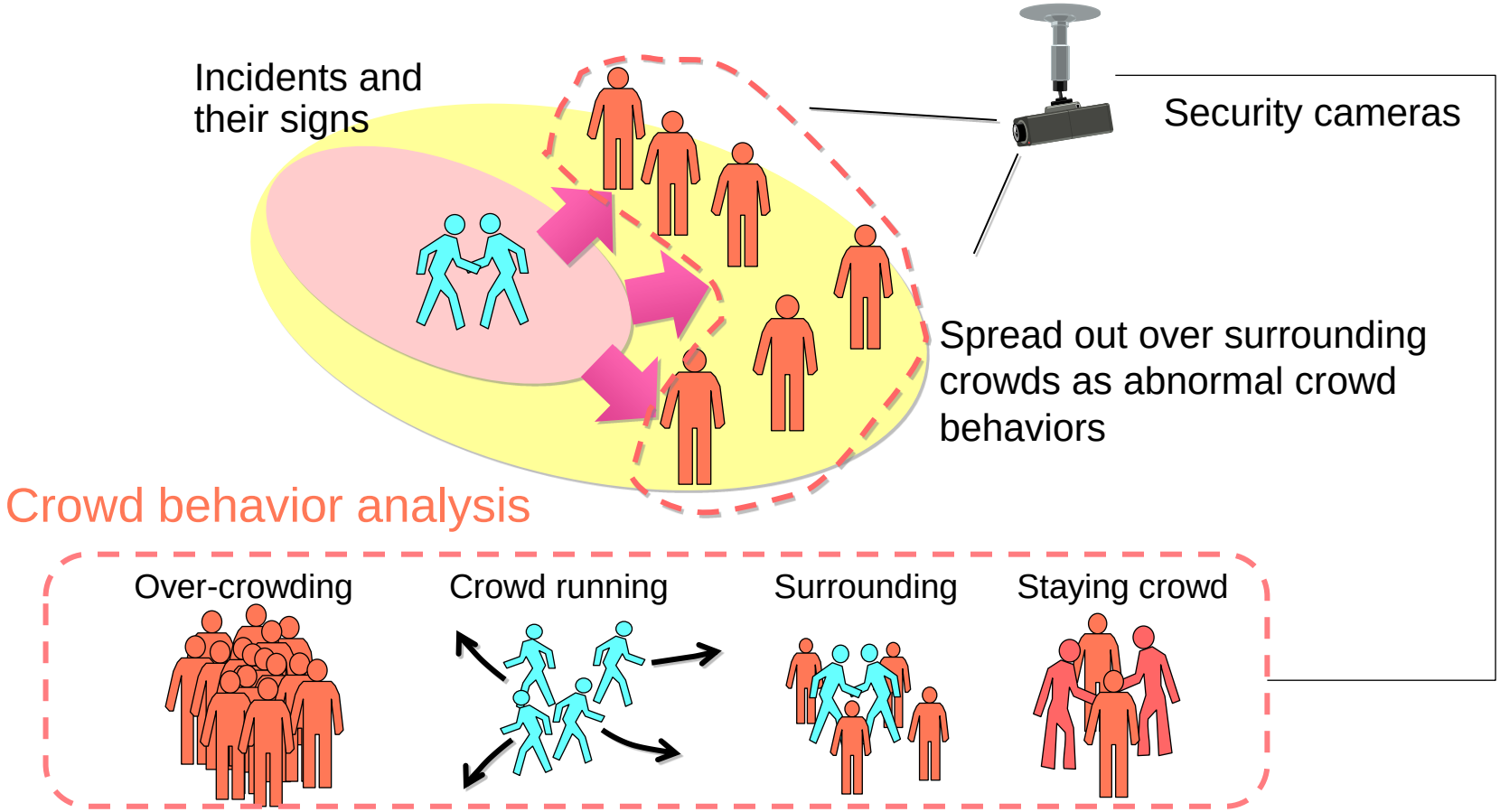


New business creation

- City wide-area surveillance and management
- Efficient social infrastructure maintenance
- Smart store management

Crowd Behavior Analysis for Anomaly Detection

- Early abnormal event detection of crowd in a dense situation
- Analysis by using crowd patches without individual recognition



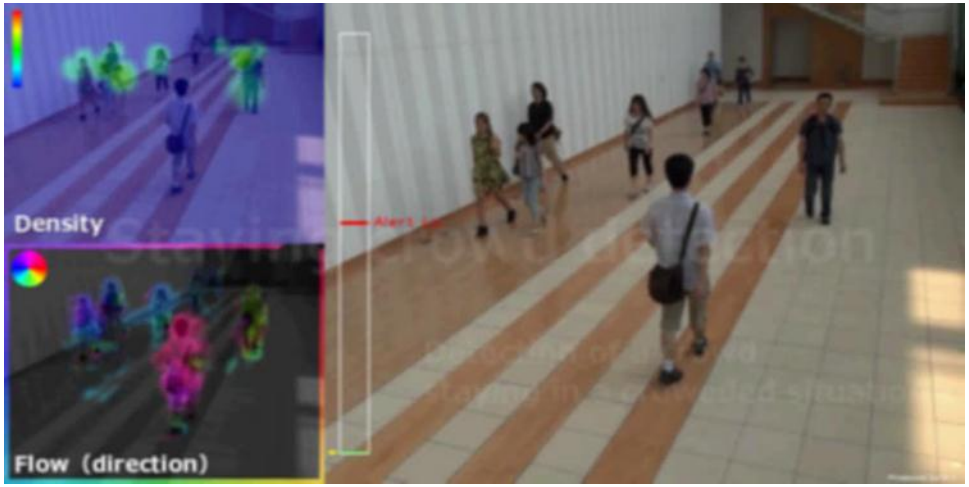
[Video demo] Crowd Behavior Analysis (1)

- Detection of people rushing

- Detection of overcrowding

[Video demo] Crowd Behavior Analysis (2)

- Detection of people stopping and hanging out



- Detection of people surrounding an accident

Singapore Safe City Test Bed

Supported by Singapore government, Economic Development Board (EDB)

Intent of Test Bed

To develop new capabilities to keep Singapore safe and secure.

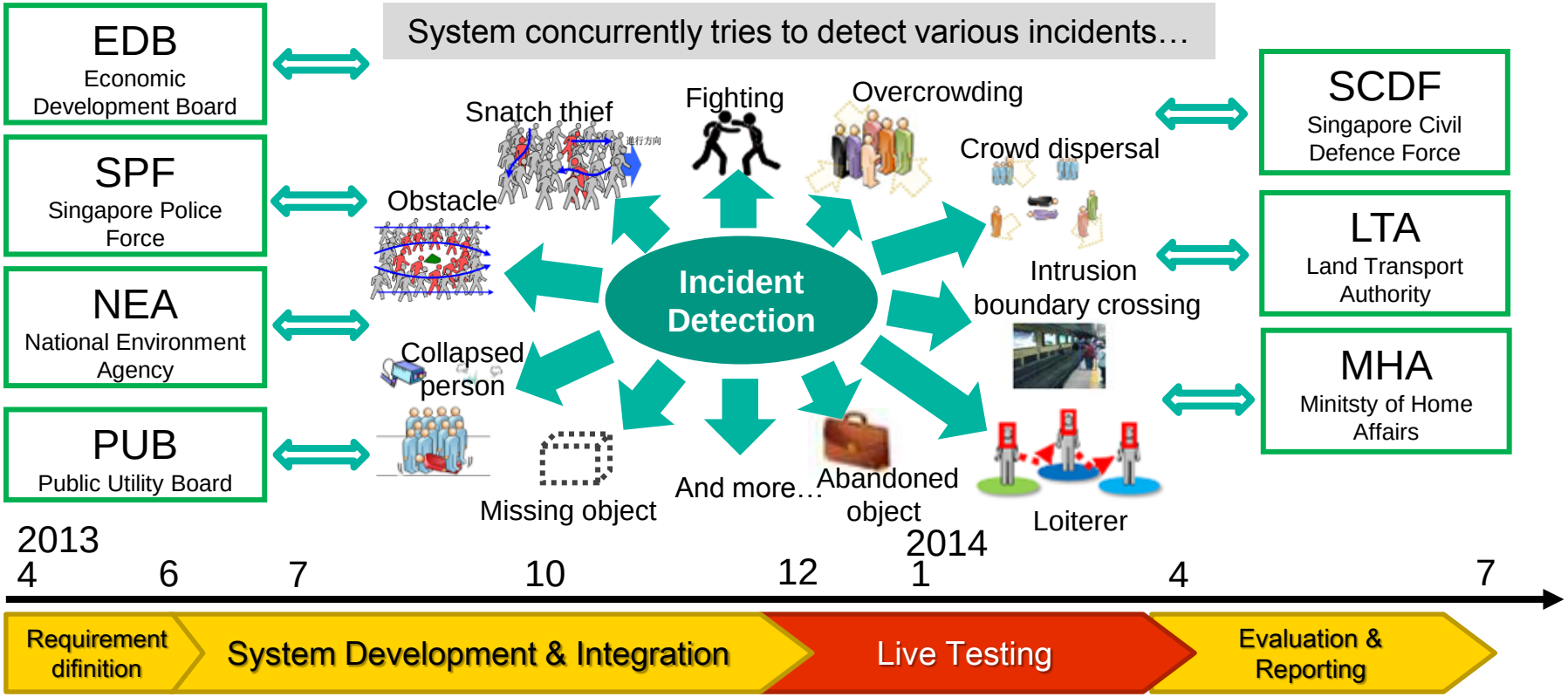
Scope

Setting up test beds to enable different government agencies to integrate and analyze data collected from existing sensors and network systems using advanced analytic and information sharing tools.

Source: EDB's Home Page
http://www.edb.gov.sg/content/dam/edb/en/resources/pdfs/brochures/Alternative%20Energy%20Brochure.pdf

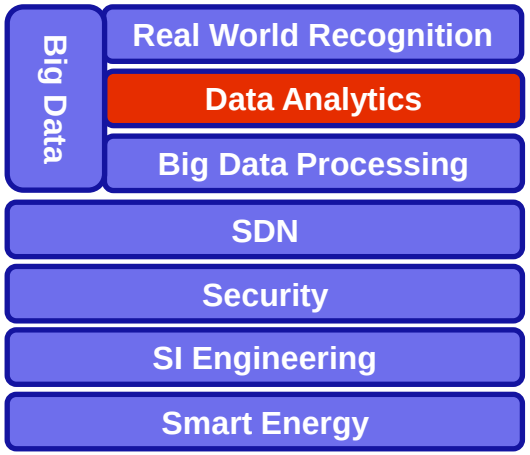
NEC's Solution in the Test Bed: Inter-Agency Collaboration

To build a complete, end-to-end inter-agency collaboration infrastructure that uses cutting-edge technologies, such as advanced data analytics, risk analysis and relationship modeling, to help multiple agencies understand and correlate information from various sources as well as to optimize resource deployment on the ground.



World Cities Summit 2014 ▲

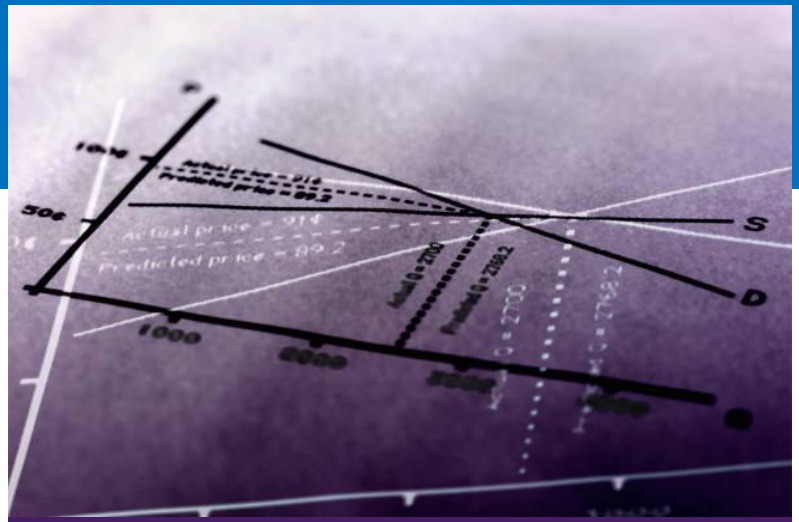
Data Analytics



R&D Direction to Maximize Value for Society/Customer

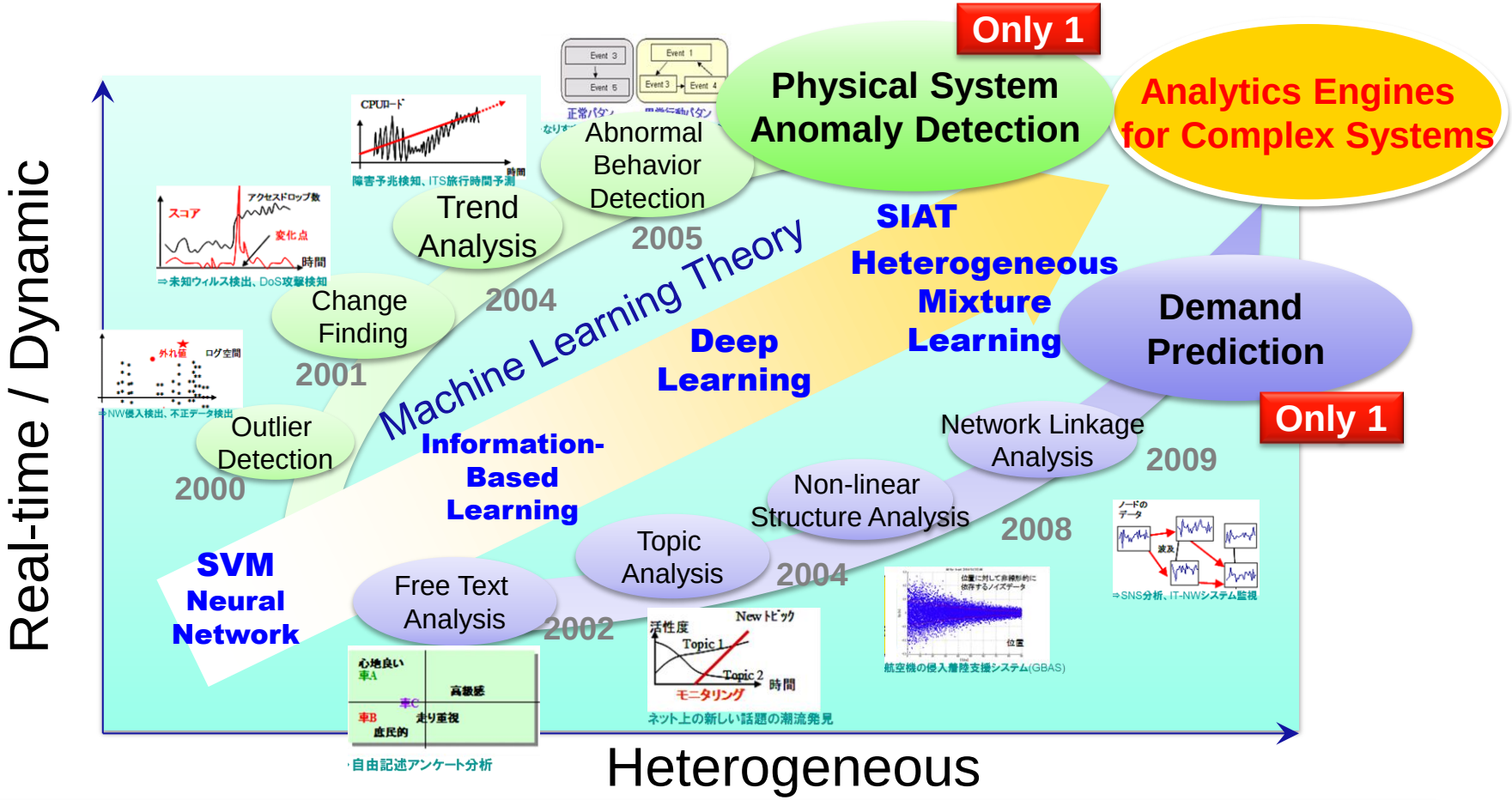
3. Scaling beyond human capability

1. Visualization of data that human cannot see



2. Finding rules that human cannot capture

Data Analytics Engines for Complex Systems

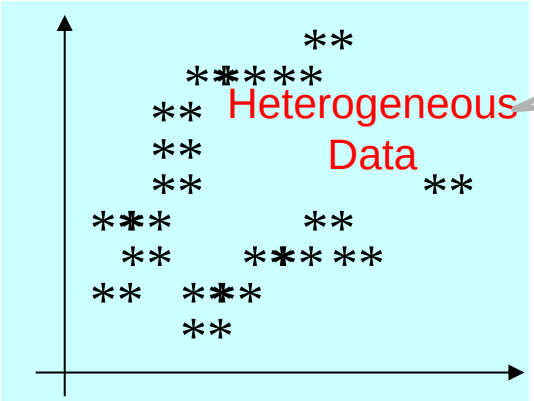


Science-based approach to create state-of-the-art analytic engines enabling real-world analysis from complex and huge-volume data

Data analytics engines for sustainability of social infrastructure

Heterogeneous Mixture Learning

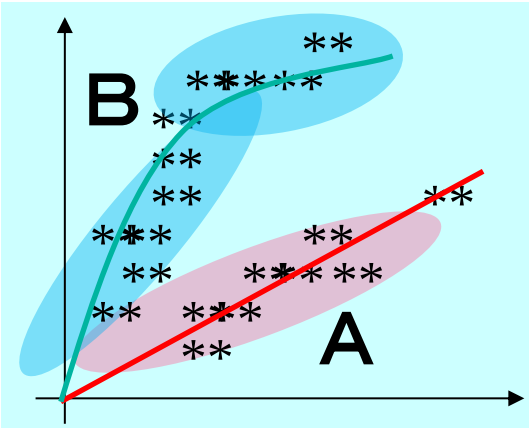
Automatically discovers "hidden rules" by finding the optimal way to partition data without experts' hypotheses



"How many kinds of data mix?" "How should we partition?"
"What model does each data have?", These are all unknown.

× Conventional methods needed a lot of trial & error and relied upon on the experts' hypotheses

Heterogeneous Mixture Learning (NEC original)

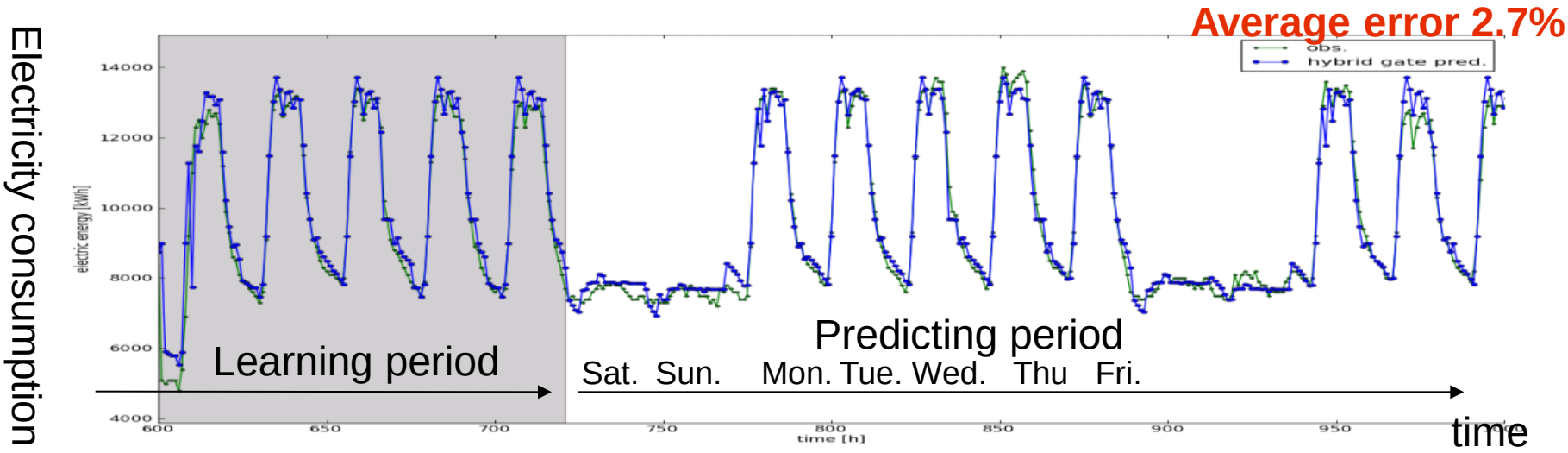


Using "FAB Inference" [KDD 20011] [AISTATS 2012] [ICML 2012]
(FAB: Factorized Asymptotic Bayesian Inference)

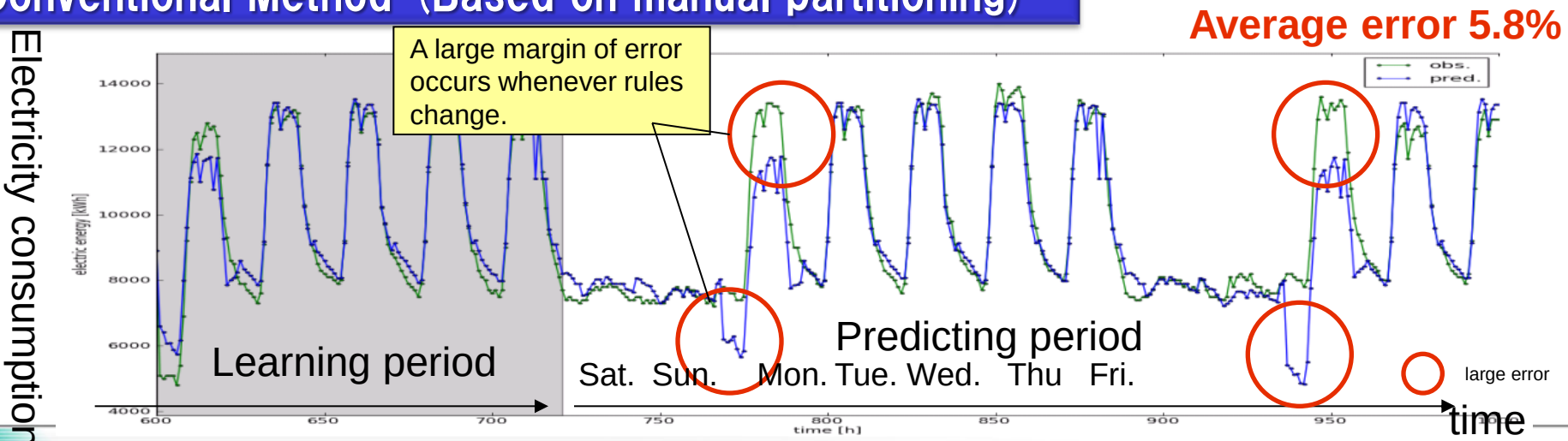
- Particularly useful for social solutions due to
  - ✓ suitability to real-world problem (i.e. mixed data)
  - ✓ applicability to wide range of problems (i.e. versatility)

Customer Collaboration: Predict Power Consumption of Building

Heterogeneous Mixture Learning (Based on 3 patterns prediction)

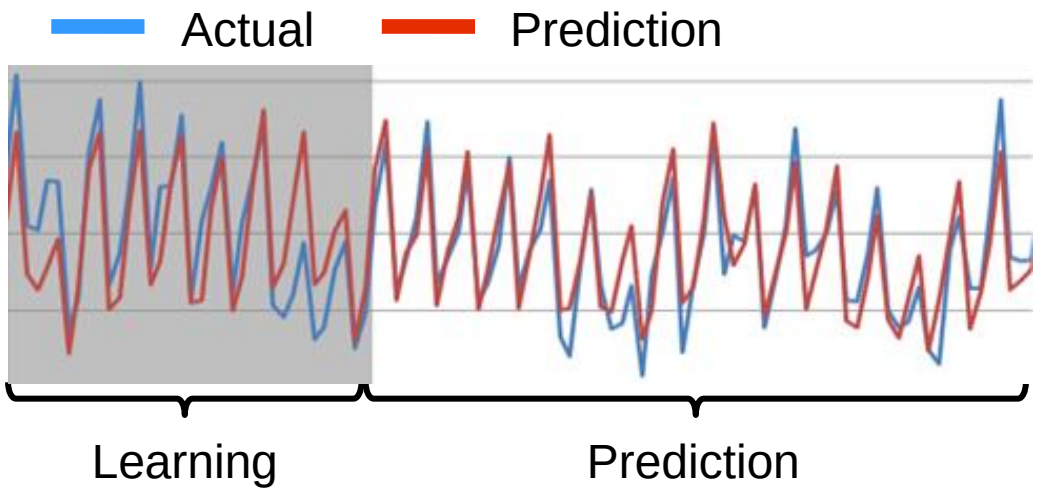


Conventional Method (Based on manual partitioning)



Customer Collaboration: Sales Prediction at Retail Stores

- HML automatically extracts various factors affecting sales of each item
  - The days of the week, weather, temperature, popularity trend, …
- Makes highly accurate sales forecast and optimizes the ordering work



Before

Human driven approach
- Depend on past human experiences and knowledge

Biased by human factor

Applicable to limited items

After

Data driven approach
- Taking into account various data

Unbiased by human factor

Applicable to all items in all stores

Minimizes both abandonment loss and opportunity loss

Detecting Anomalies in Large Physical Systems

Plant

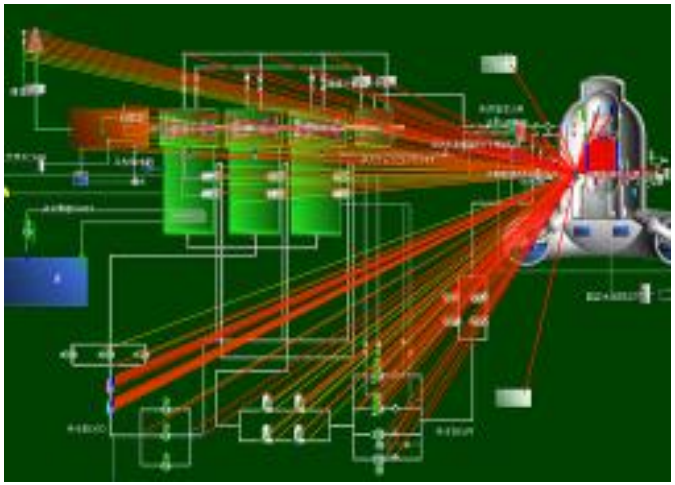
Factory

Airplane

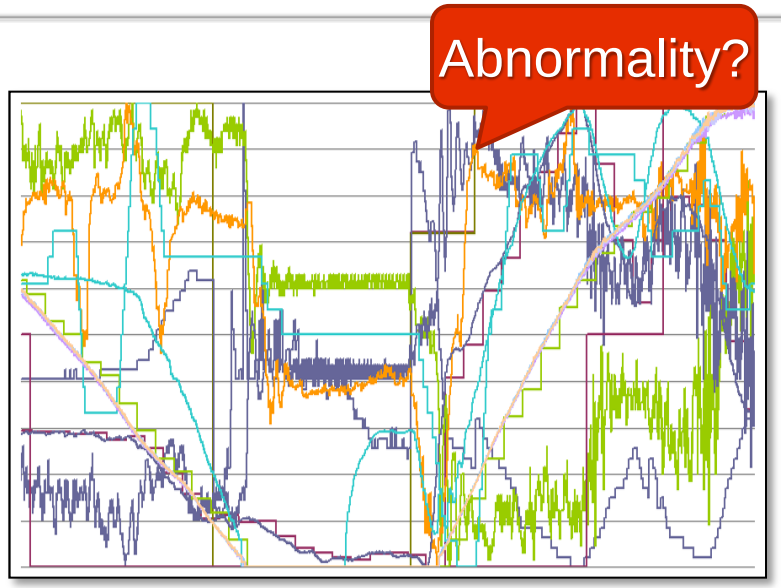
Bridge/Tunnel

Electricity/Water

.....



Thousands of observation points



Time series observation data

Before

- Risk of infrastructure deterioration becomes more serious
- Abnormality detection relies on experts

SIAT（System Invariant Analysis Technology）

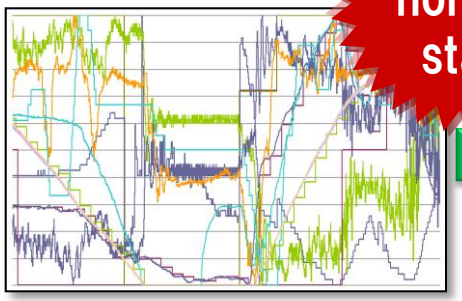
[G.Jiang, H.Chen et al, IEEE Trans. 2007]

After

- Rapid abnormality detection and prevention of failure by SIAT
- Earlier detection than expert

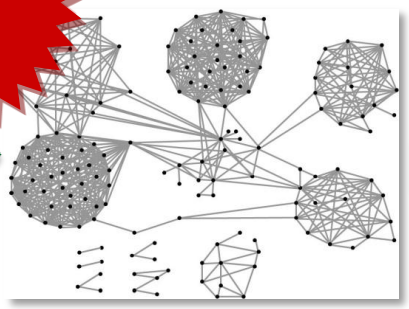
SIAT: System Invariant Analysis Technology

- Automatic modeling of the entire physical system from correlations among the sensor data by using “invariance” relationship
  - Just from the observed data. Domain-specific knowledge not required!
- Early anomaly detection achieved by comparing current data with the ones predicted from the model to determine if unusual event is occurring
  - Much earlier than threshold-based detection



Observed data

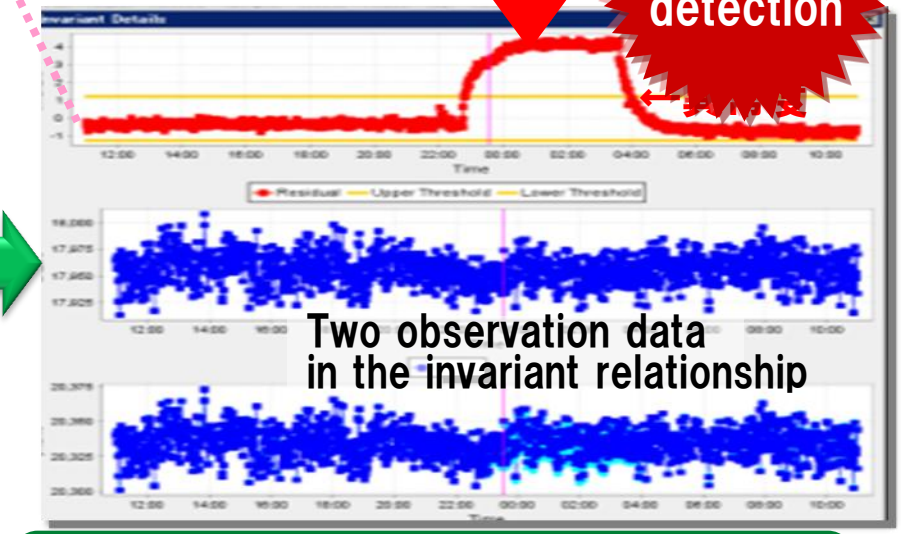
Visualize normal state



Invariant Model

Unusual movement

Anomaly detection



Two observation data in the invariant relationship

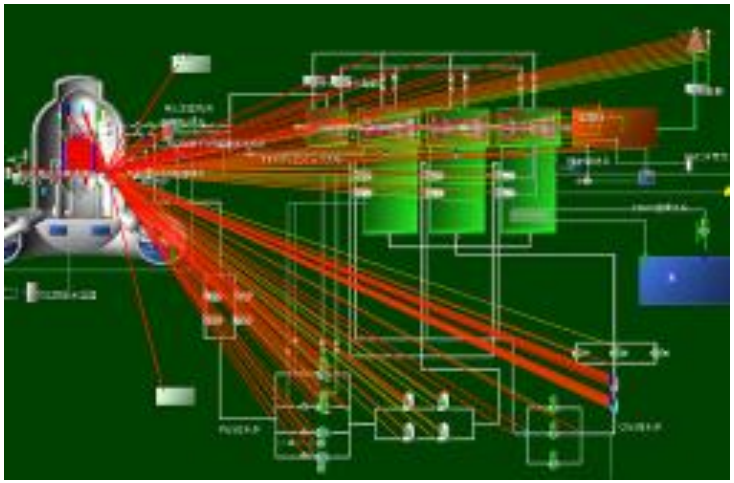
Automatic visualization of the invariance relationship

Detection time shorter by 1/20 than human (expert) ability

Customer Collaboration: Resiliency in Power Plant

At the Shimane Nuclear Power Station, we confirmed the effectiveness of a “large-scale plant failure sign monitoring system” using Invariant Analysis

(with The Chugoku Electric Power Co.,Inc.)



Gathering diverse data

- Number of sensors per reactor: 3,500
- 100 pcs. of data per sensor per second

Advanced analysis

Discovering anomalies from correlations in 3,500 x 3,499 sensor combinations

Collaboration between experts

- Improved the accuracy of warning sign monitoring through close collaborations between the customers’ power plant operation experts and NEC’s analytic experts

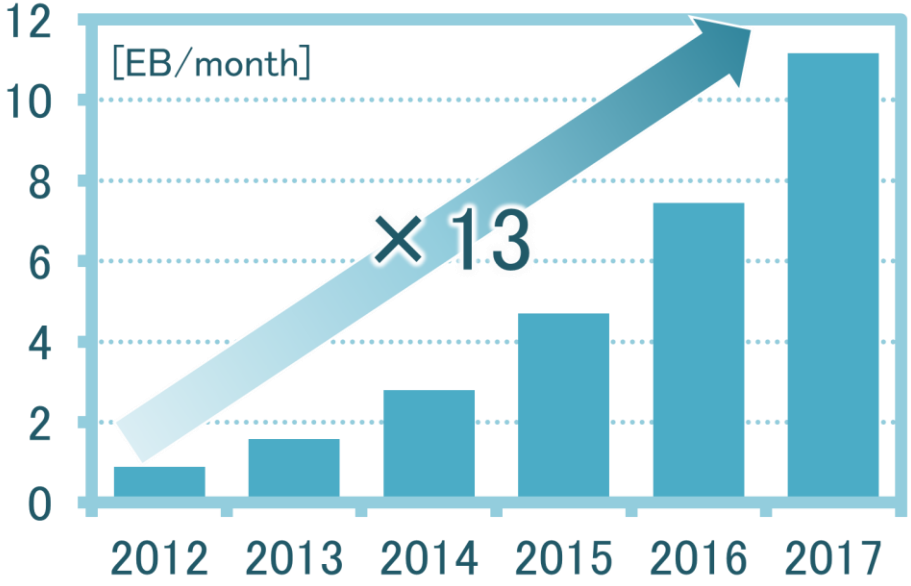
Data analytics for improving internet services

--- REAL TIME predictive analytics for real time services
(of real time video streaming)

Research Background

- Rapid growth of mobile data traffic (CAGR 66%)
- Keeping the quality of communication services under the explosive increase in network traffic is a big challenge

Mobile data traffic [1]



Mobile application traffic share [2]

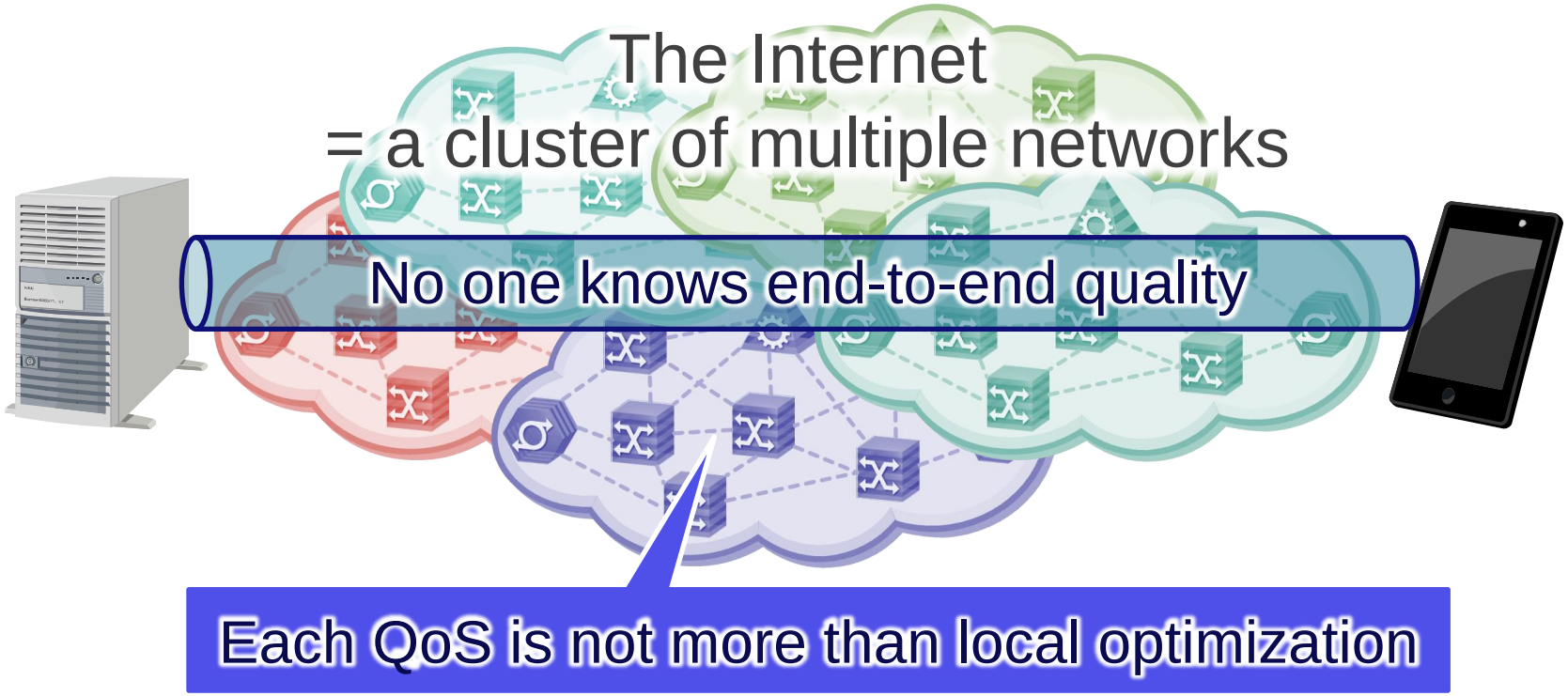
Rank	Application	Share
1	YouTube	31%
2	HTTP	14%
3	SSL	9%
4	MPEG	9%
5	Facebook	7%

[1] Cisco, “Cisco visual networking index,” Feb. 2013.
[2] Sandvine, “Global Internet Phenomena Report,” Nov. 2012.

Conventional Approach

Network-layer approach

- Each network operator controls its own network – QoS
- End-to-end quality is, however, uncontrollable because the Internet is a cluster of various networks.

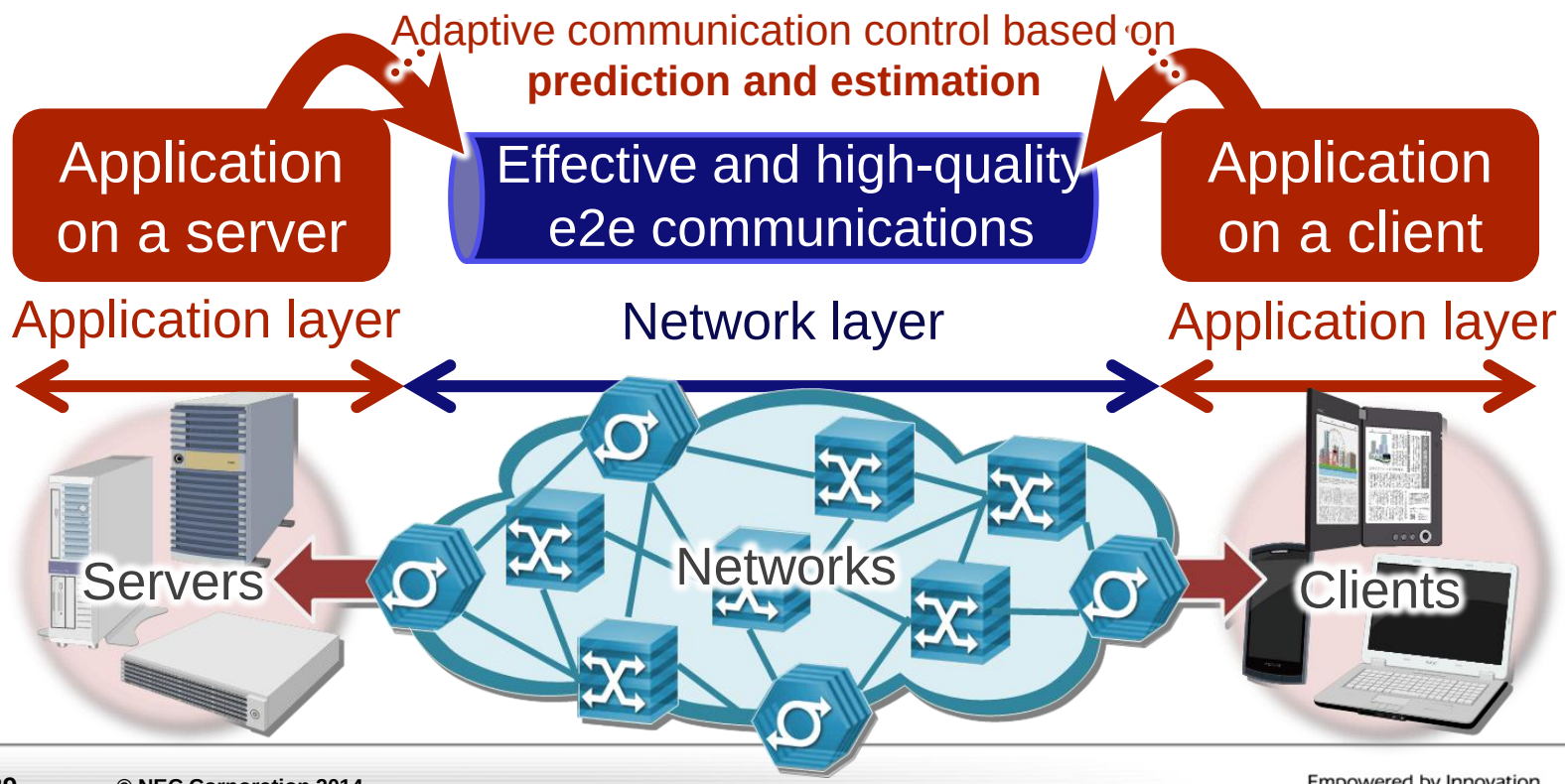


Service-level Communication Optimization

End-to-end approach

[K.Satoda, H.Yoshida, IEEE GLOBECOM 2012, 2013]

- Understanding end-to-end network conditions and improving the communication quality "on the application layer"
- Communication control based on prediction and estimation of the network characteristics (throughput, delay, loss, etc.…)



Core Technologies

- Prediction, estimation, and adaptive communication control using a set of REAL TIME analytics

Network and traffic estimation ← *Rheology and hydromechanics*
Network prediction ← *Financial engineering*
Communication control ← *Robust and optimal control*

Prediction & Estimation

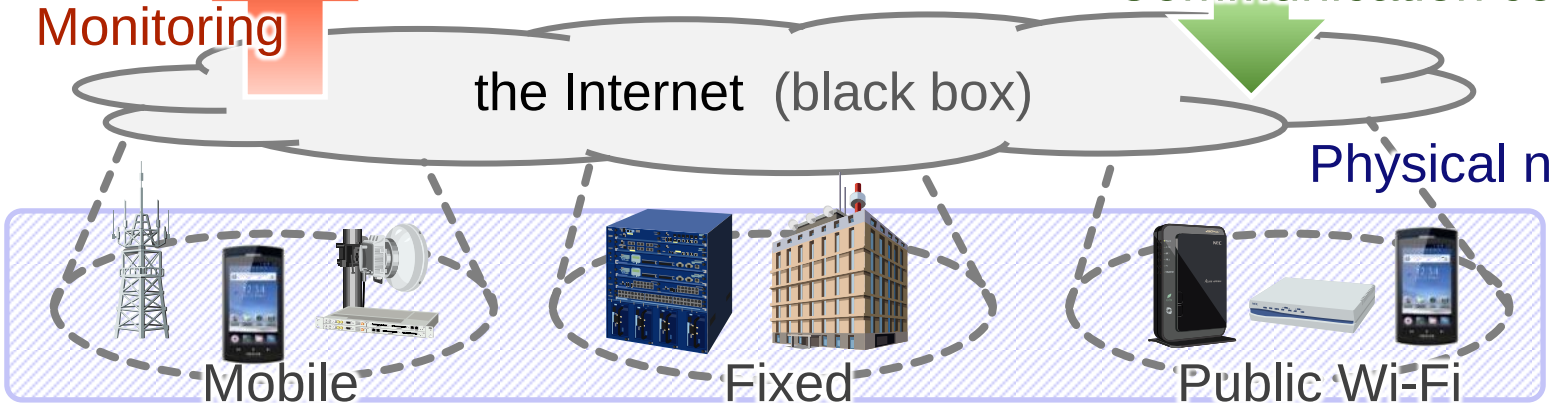
- Throughput
- Bandwidth
- Terminal condition
- Packet loss
- Congestion
- Delay

Adaptive communication control

- Apply to application requirements
- Adaptive to network conditions

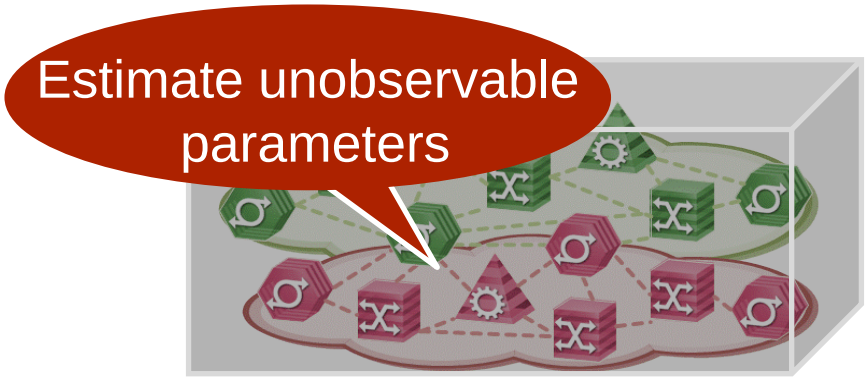
Monitoring

Communication control

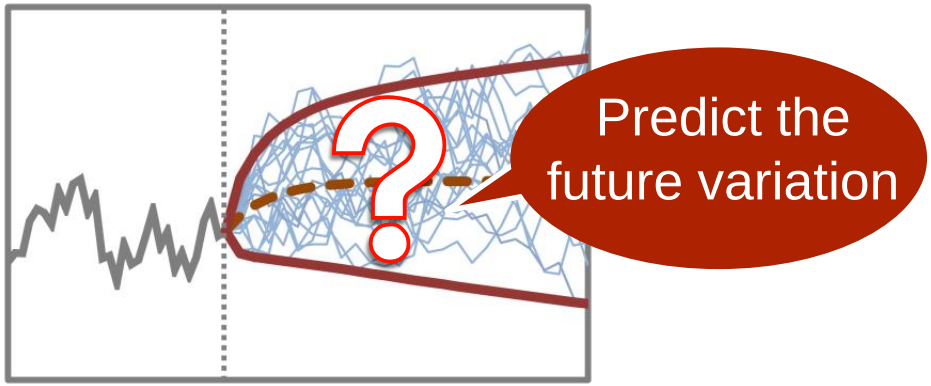


Need for Estimation and Prediction

Need for estimating parameters that cannot be observable at an end host



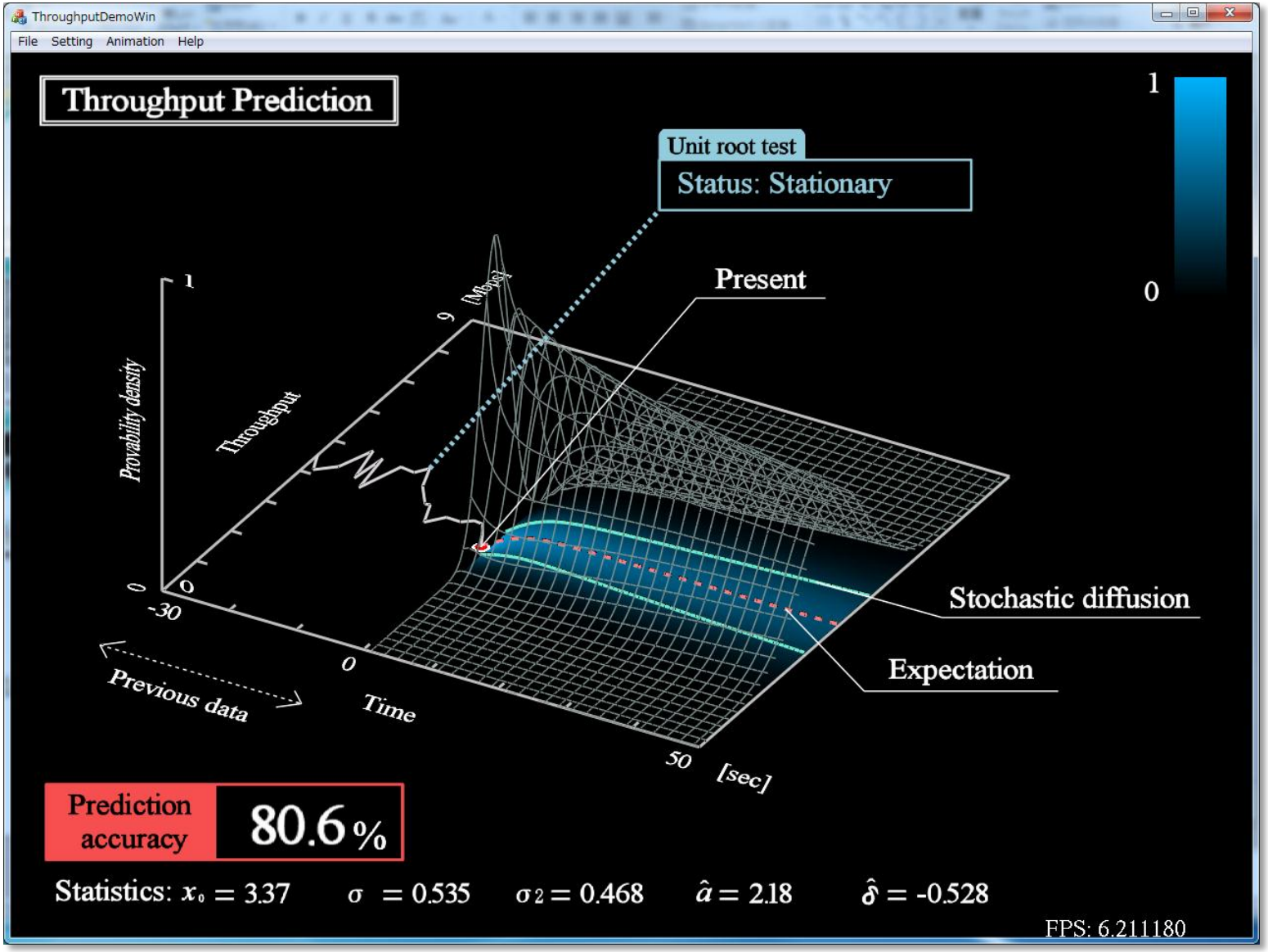
Need for predicting fluctuating parameters for proactive communication control



The world's top estimation and prediction technologies

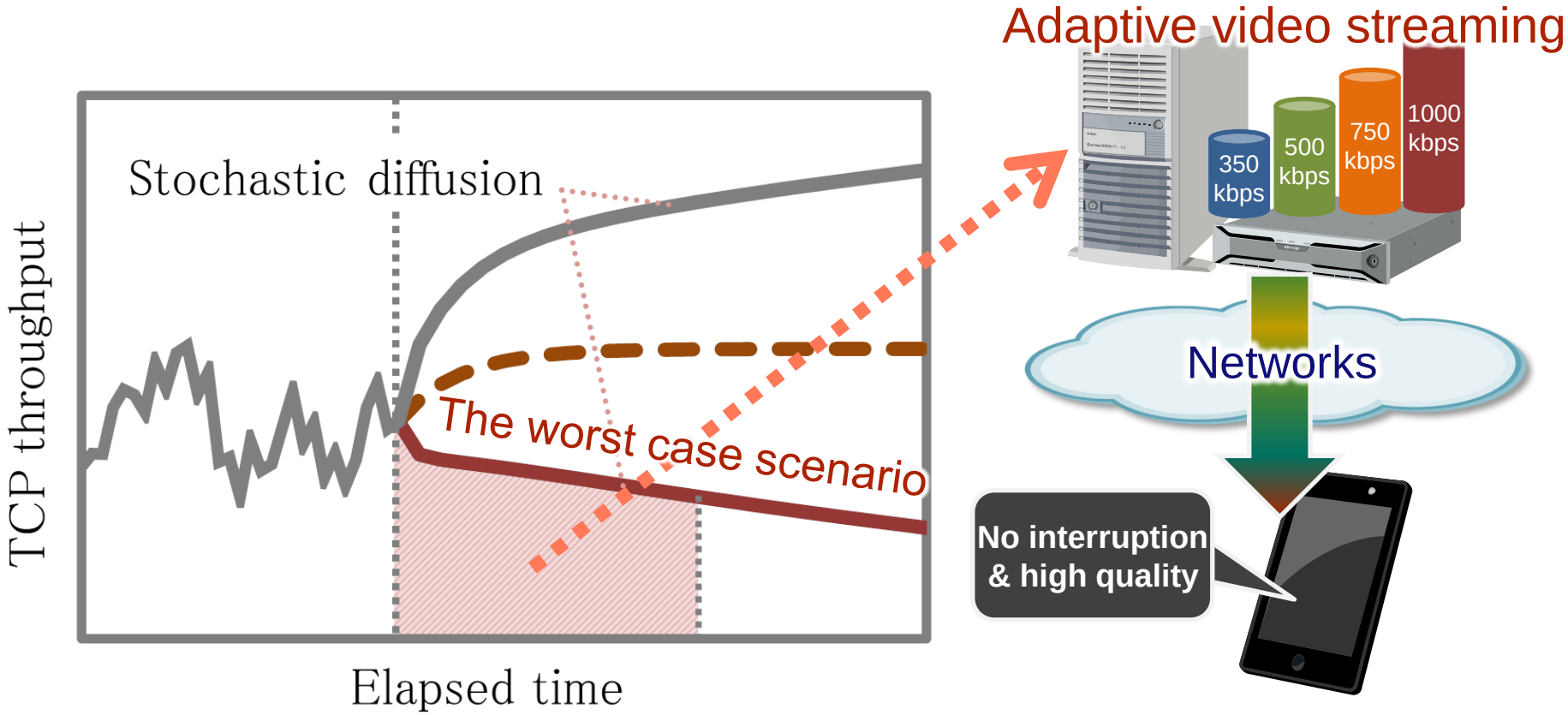
- 40x quicker, 100x lighter, and 3x more accurate end-to-end available bandwidth estimation
- The world's first practical throughput prediction, over 90% accuracy for the next 1 minute

[Video demo] Throughput Prediction



Adaptive Video Streaming based on the Prediction

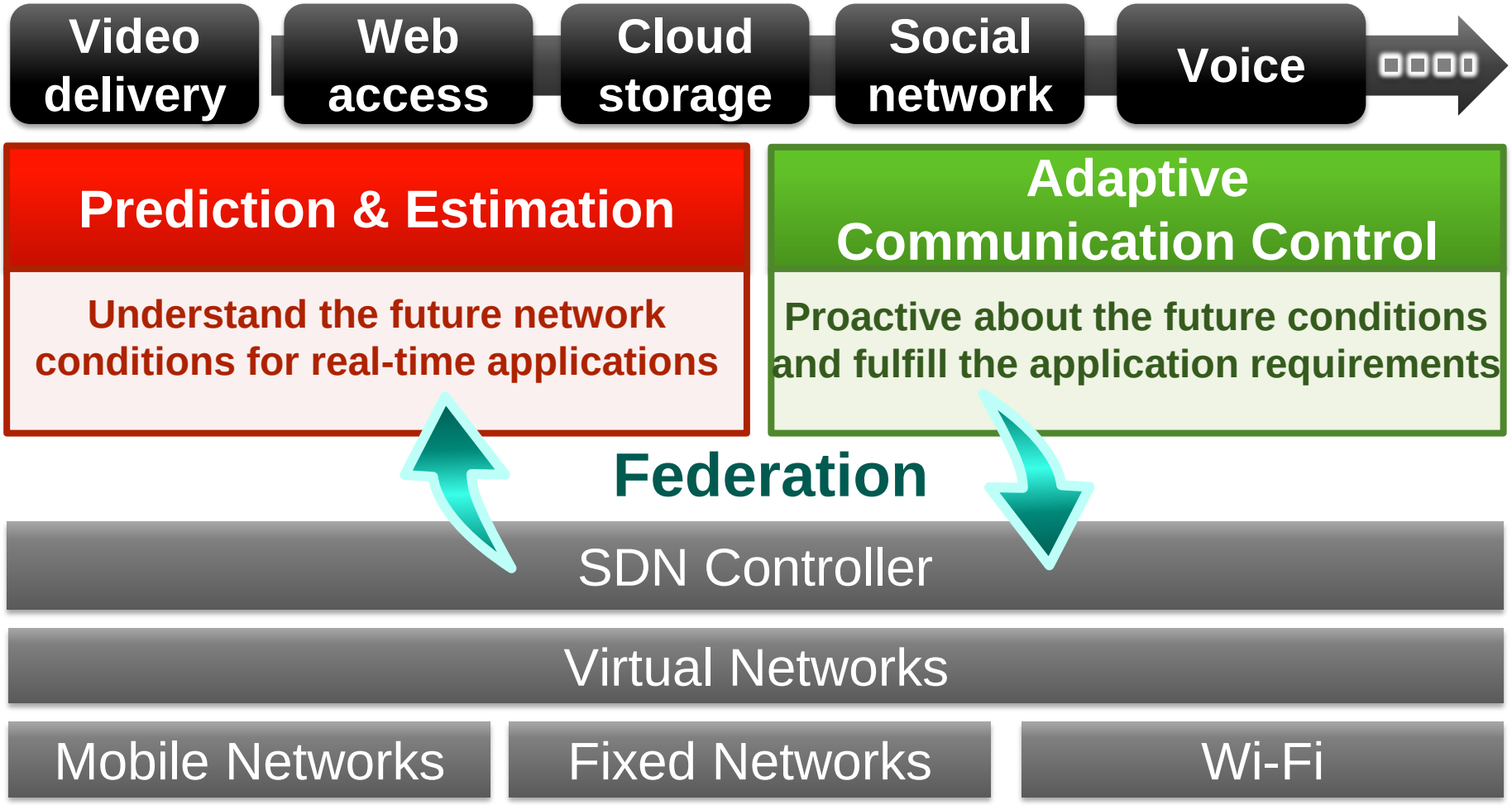
- The throughput prediction tells the worst case scenario
- Controlling the video bitrate according to the worst case scenario avoids interruption, while keeping the bitrate high



[Video demo] Adaptive Video Streaming

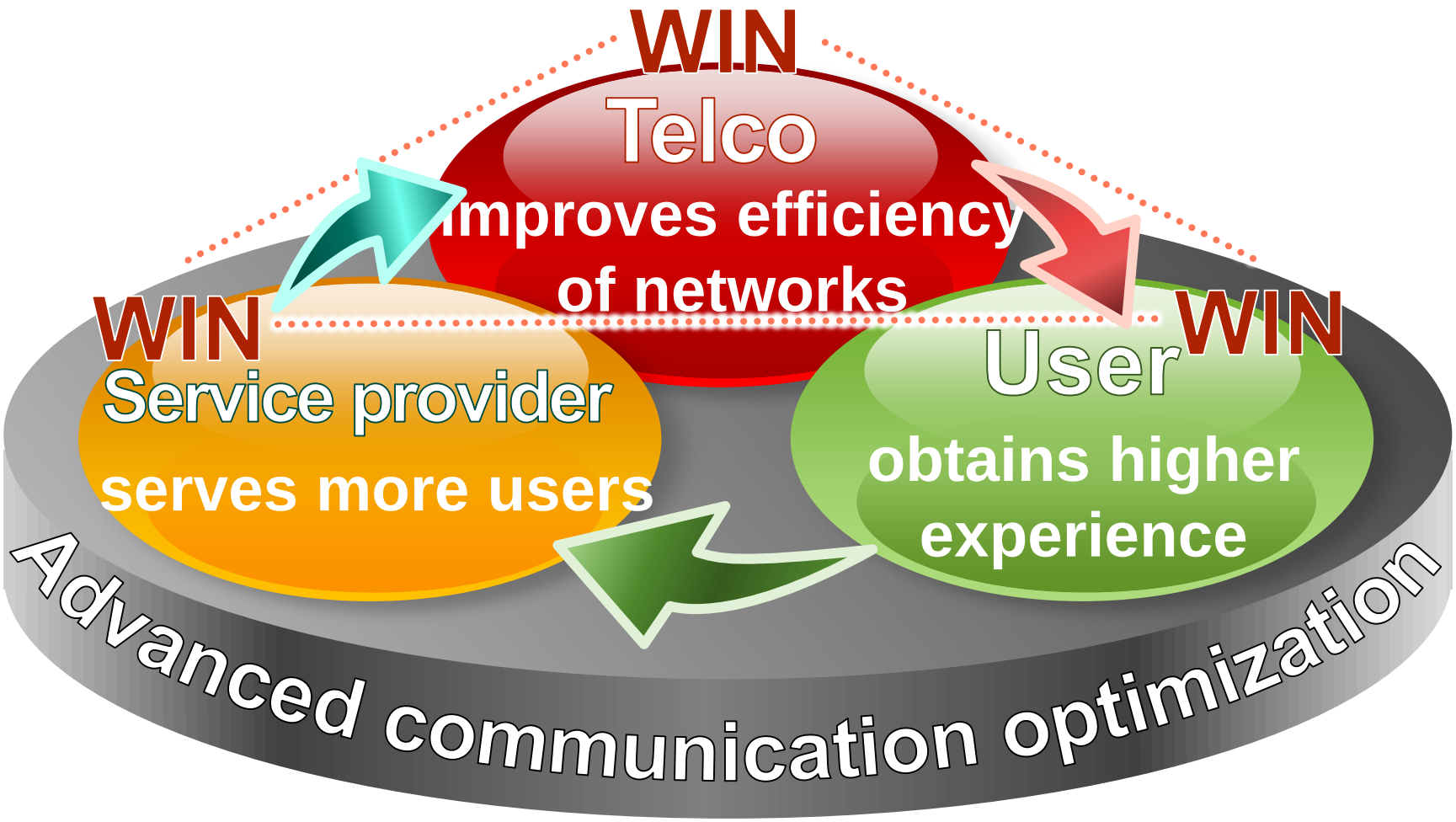
Future Direction : Advanced communication optimization

- Federation with SDN is a key approach to heavier traffic and more latency-critical applications

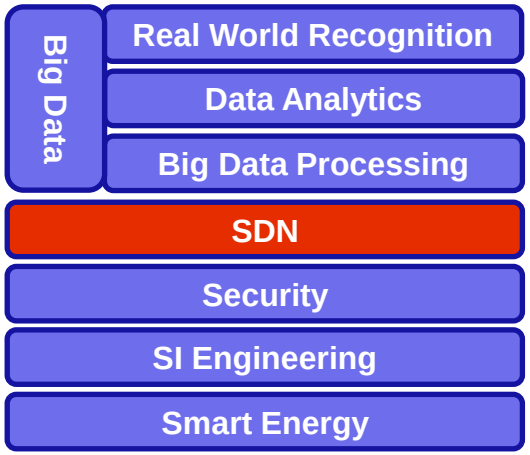


Technology Value

Achieves better communications environments
Achieves ecosystem among the stakeholders



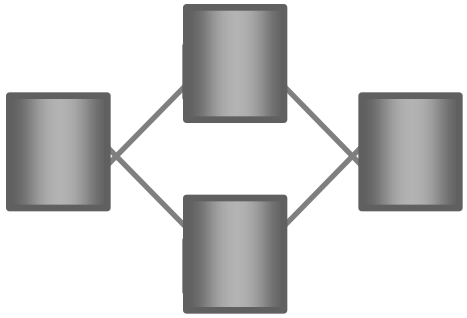
Software-Defined Networking



What is SDN (Software-Defined Networking)?

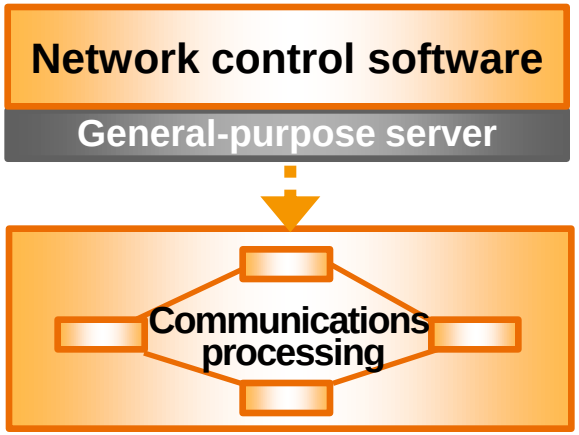
- SDN refers to dynamically controlling networks using software and its architecture

Past	Future
Control and communication processing were tied together within single equipment	Network control and communication processing are separated Communications processing is dynamically controlled by software



Dedicated equipment with network control function

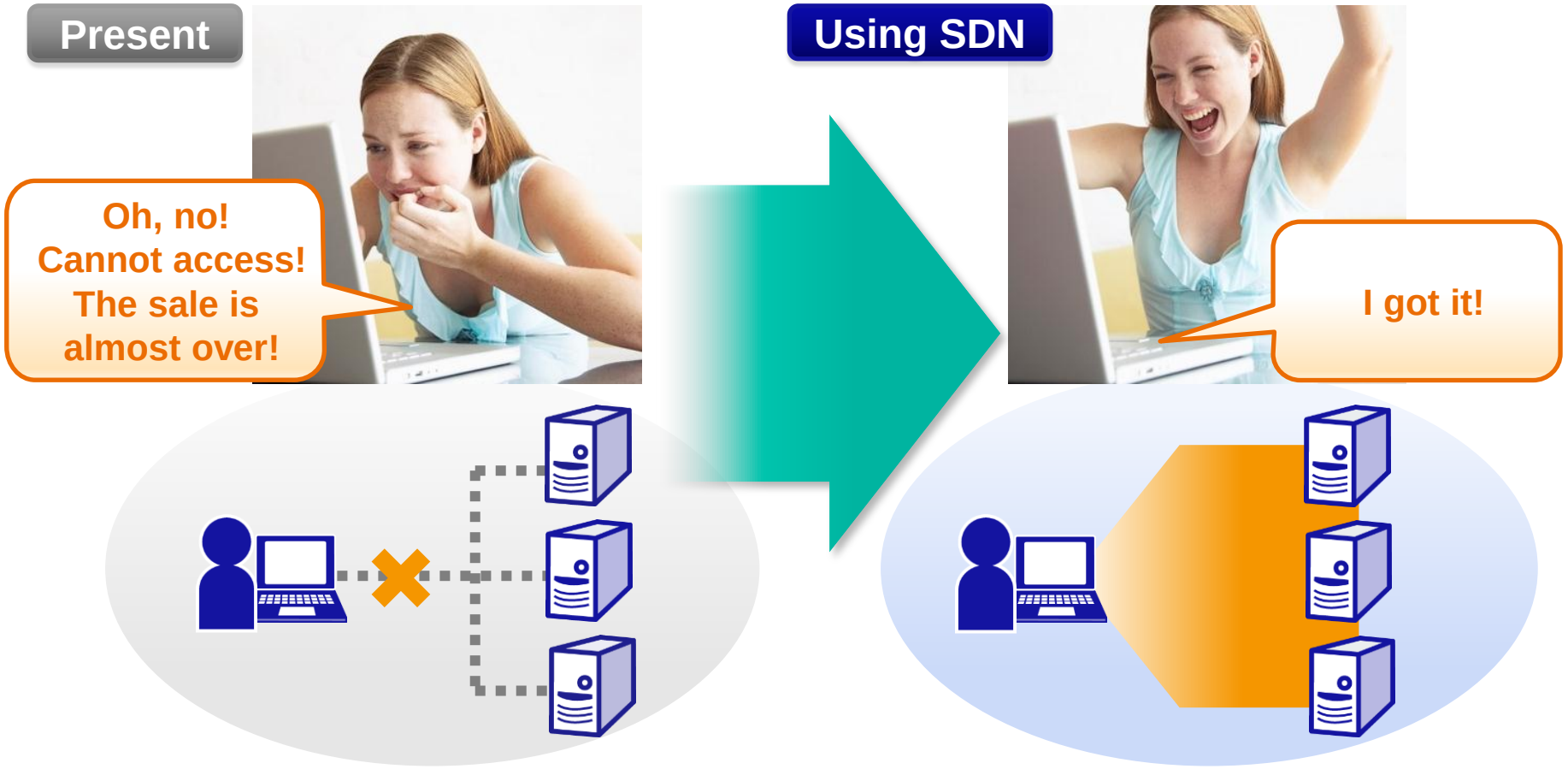
Separated & Dynamically Controlled



Equipment that only performs communication processing

SDN Application Example

- Achieves easy-to-use online services even under heavy internet access



SDN Application Expanding

Present

Mainly focusing on virtualizing data center networks

Future

- **Expanding the applicable market:**
  - **Data centers infrastructures**
  - **Enterprise network**
  - **Telecom carriers infrastructures**

“NEC SDN Solutions”

- Solution menu was established based on our SDN products, and case studies with customers ongoing,
- In addition to the data center market, our solution is also deployed to enterprises, public agencies and telecom carriers*1

Market	Category	Solution
NEC Enterprise SDN Solutions	Network Optimization	•WAN Connection Optimization for Offices and Data Centers •Office LAN Optimization
	Security	•Access Authentication
	Mobile	–
NEC Data Center SDN Solutions	Operation and Management	•IaaS Operation Automation Solution
	Consolidation	•Data Center Network Integration Solution
NEC Telecom Carrier SDN Solutions	Network Management	•Integrated Operations Management
	Network Infrastructure	•Network Virtualization •Transport

Products
WebSAM WebSAM vDC Automation
UNIVERGE UNIVERGE PF Series
Technology
ProgrammableFlow

*1：Availability varies by region

Past Case SDN Studies / Successful Field Tests

Implementation and successful field testing of NEC'S SDN in companies and organizations is accelerating globally

Market	Japan	Worldwide
Enterprises and Public Agencies	•Nippon Express •Kanazawa University Hospital •Minaminihon Information Processing Center •NEC BIGLOBE •tv asahi corporation •Ministries and agencies •Research institutes •Universities •Transportation service industry •Distribution industry •Manufacturing industry •Broadcasting stations •Electronics manufacturers •Trading companies•System integrators	•Stanford University •Selerity Corp (New Jersey)
Telecom Carriers	•NTT Communications (Biz Hosting)	•GenesisHosting (Chicago) * •Tervela (New York) * •Telefónica (Spain) •Portugal Telecom (Portugal) •Myanmar Posts and Telecommunications

* Service provider

NEC's SDN is being used and field tested in the operations systems of many (over 100) companies and organizations.

Network Functions Virtualization Solutions

- Use common general-purpose servers instead of purpose-built equipment for each function, to enable easy maintenance and upgrades
- Flexibly allocate multiple network function resources based on traffic demand

Announced Oct. 22, 2013

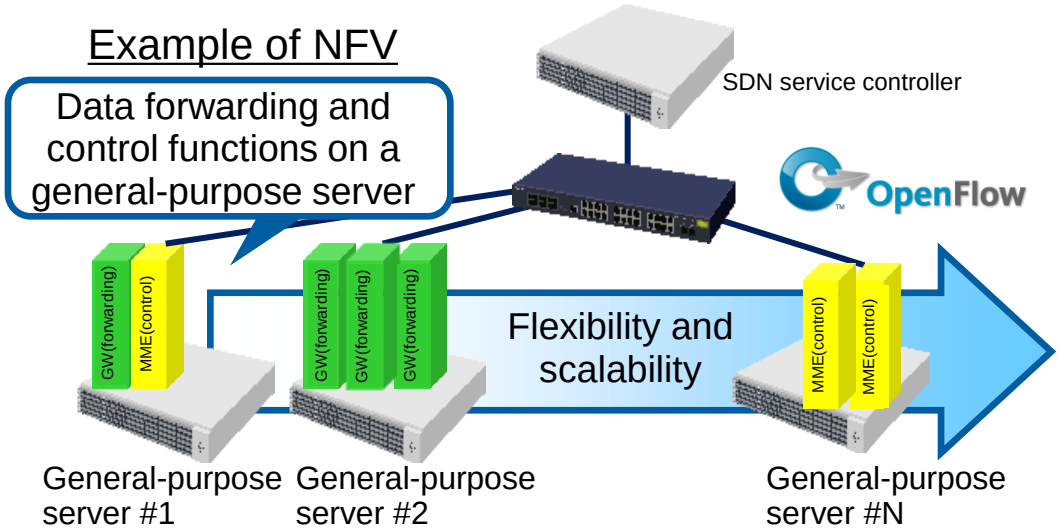
World's first commercial vEPC

(EPC: Evolved Packet Core)

- High scalability
- Carrier grade performance
  Same performance as purpose-built equipment
- Uses general-purpose servers
  TCO reduced by 30-40%

Implemented in Myanmar communications infrastructure project (December 2013)

Example of NFV

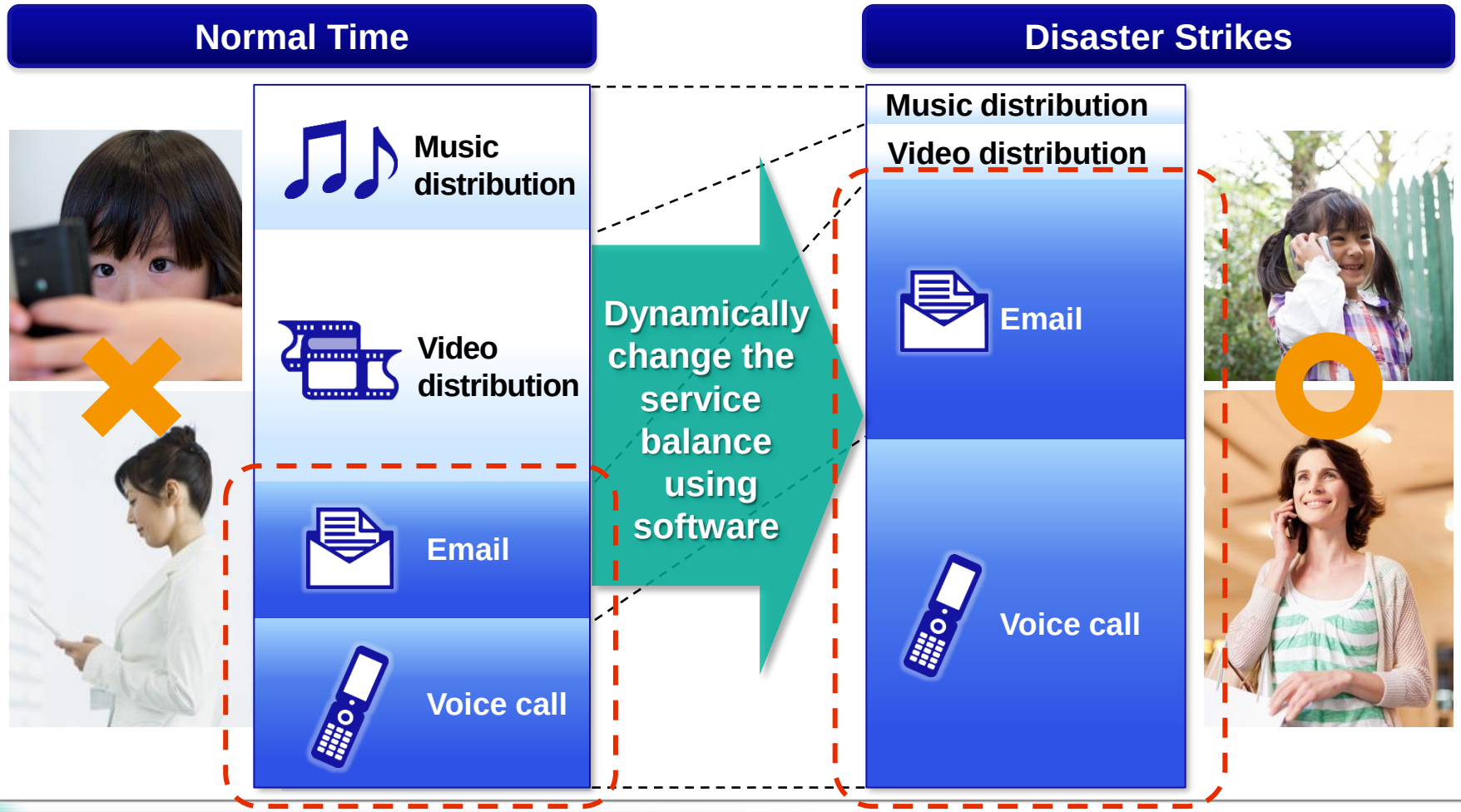


Completion ceremony held in Myanmar, December, 2013

Handling Emergency Situations with SDN

- Increase capacity for communication tools such as email, voice calls
- Test bed trail ongoing under collaboration: NEC, NTT docomo, Fujitsu

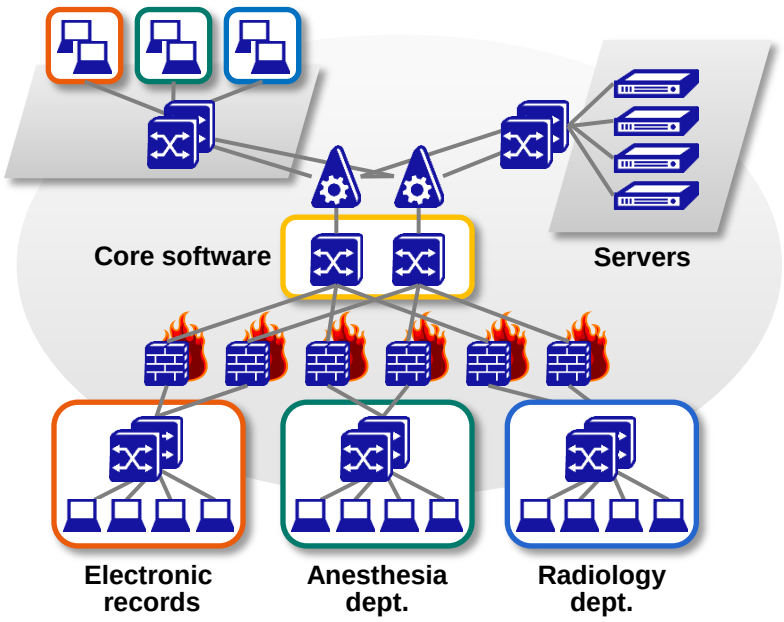
(Government project by Ministry of Internal Affairs and Communications)



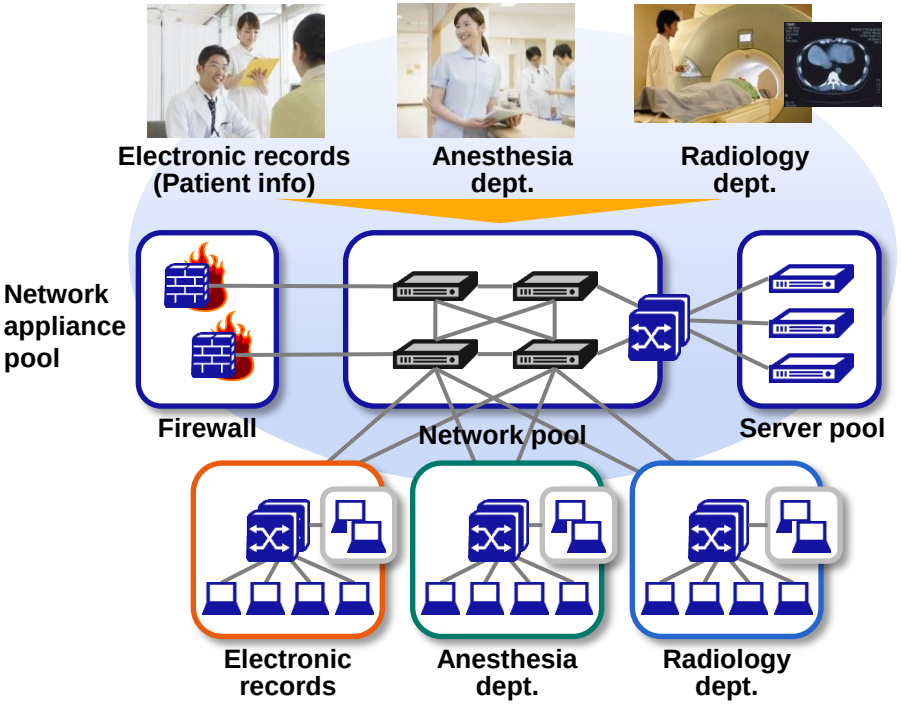
SDN Solution for Kanazawa University Hospital

- Improved hospital network management efficiency to support 24/7 medical services
- Integrated all department LANs with different policies and reduced installation costs
- Provided stable networks and reduced time and labor costs required for operation management and configuration modifications

Conventional Network



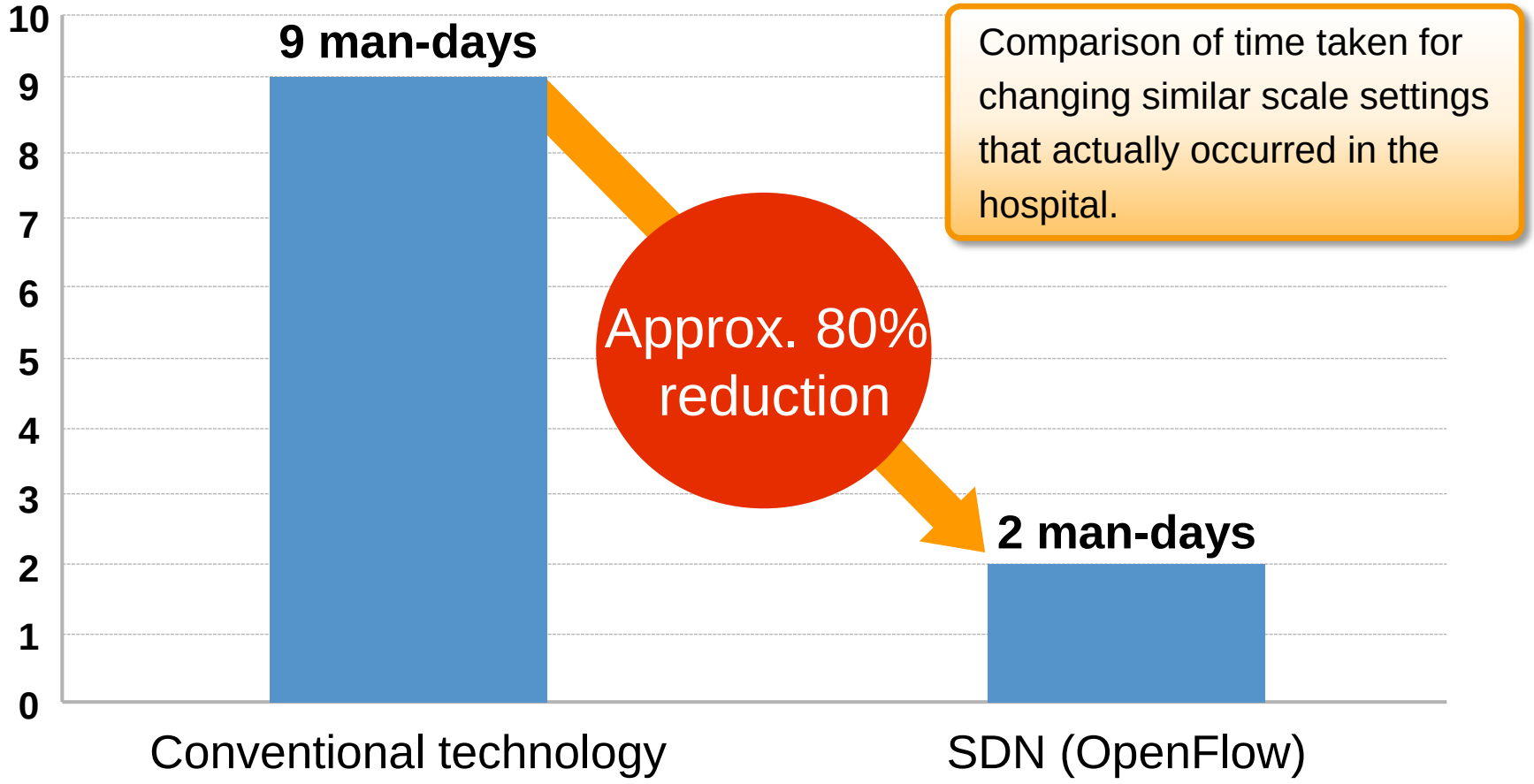
SDN (OpenFlow) Network



Effect of SDN Implementation in Kanazawa University Hospital

Approximately 80% of labor costs for changing network settings reduced by the implementation of SDN

Comparison of the number of man-hours required for network configuration work



FlowComb: App for SDN boosting computation

- **Execution platform for big data analytics like Hadoop is booming.**

However

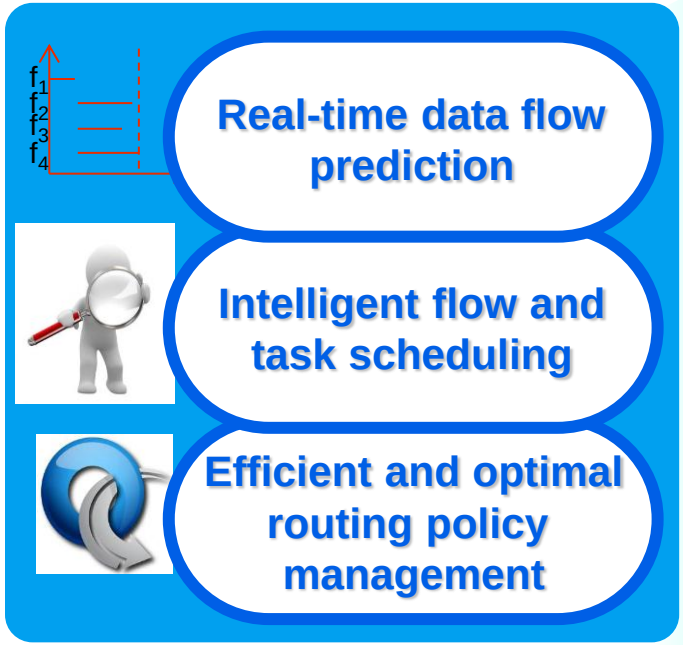
- **Massive data movement in Hadoop leads to network congestion and degraded application performance**
- **Data movement and job scheduling is key for high performance**

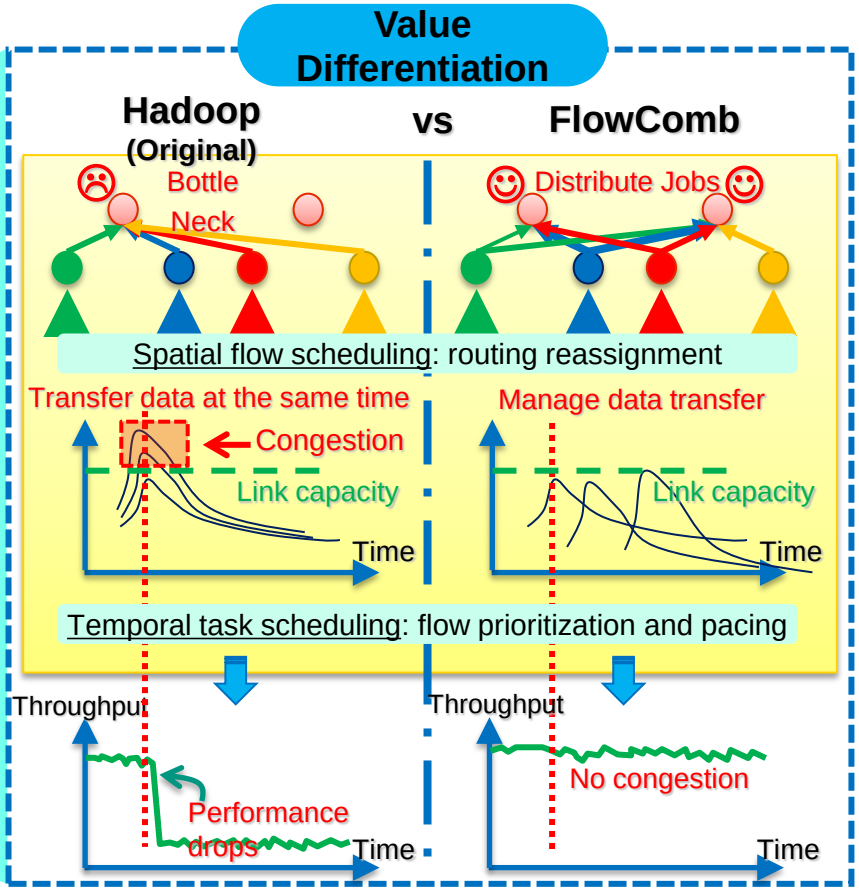
- **FlowComb seamlessly integrates OpenFlow for data movement scheduling with Hadoop job scheduling**

[A.Das, C.Lumezanu, et al., HotCloud 2013]

FlowComb: Basic Concept

Dynamic flow scheduling based on real-time data movement prediction



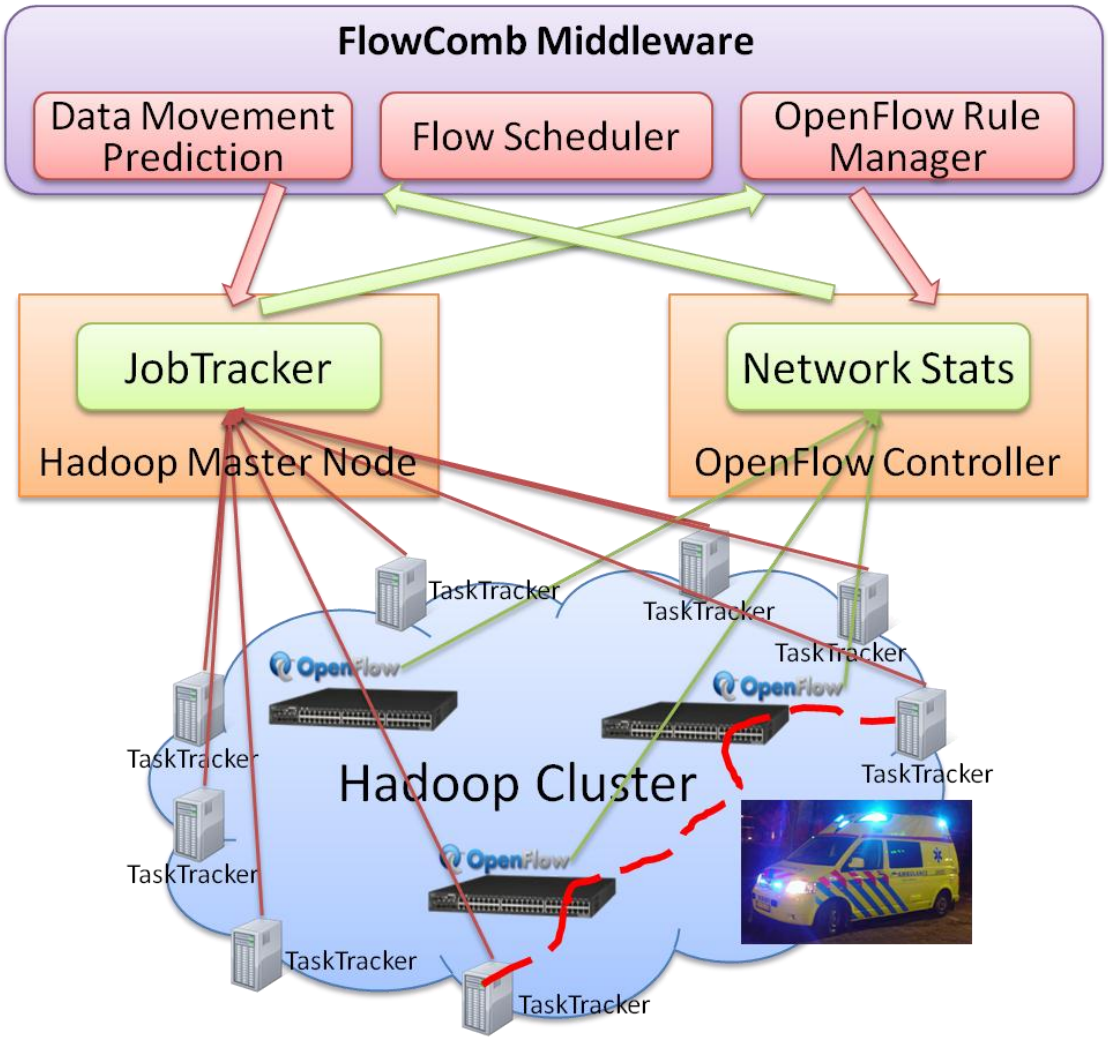


36% faster than Hadoop without FlowComb

(and **28%** faster than Hadoop with ECMP)

Technology Collaboration: “SDN” x “analytics”

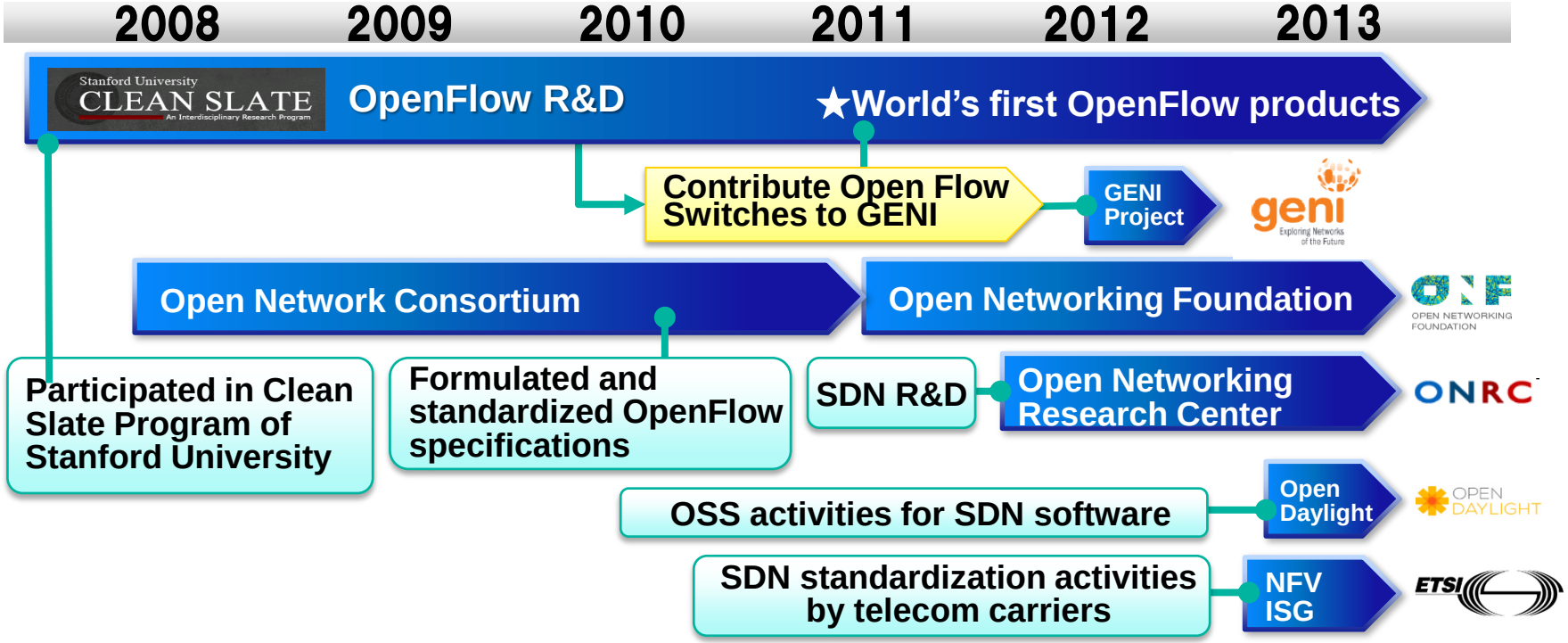
- Prediction capability by real time analytics is the key



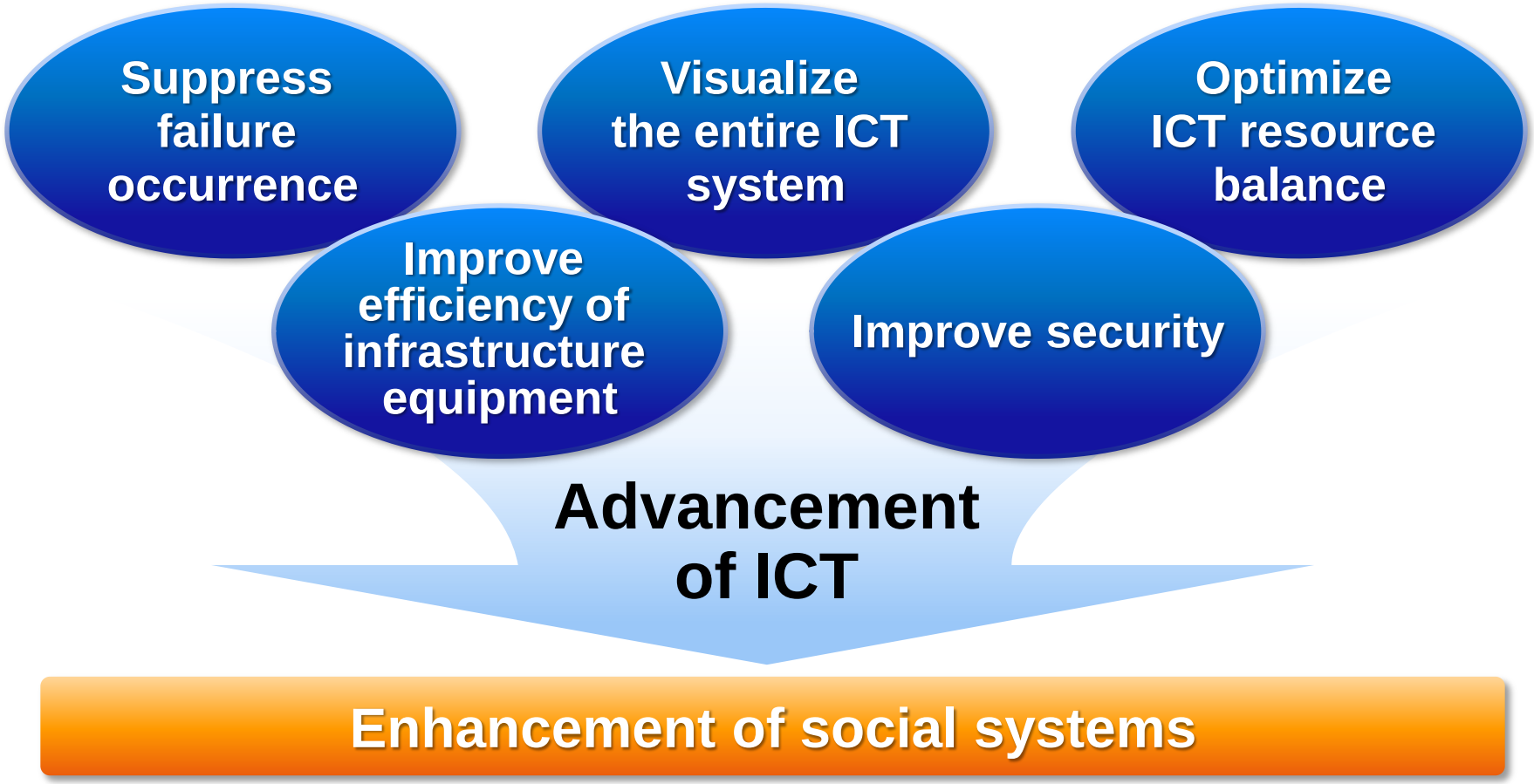
NEC's Multiple Collaboration in SDN

NEC participated in the Clean Slate Program of Stanford University from its foundation, and is currently working with …..

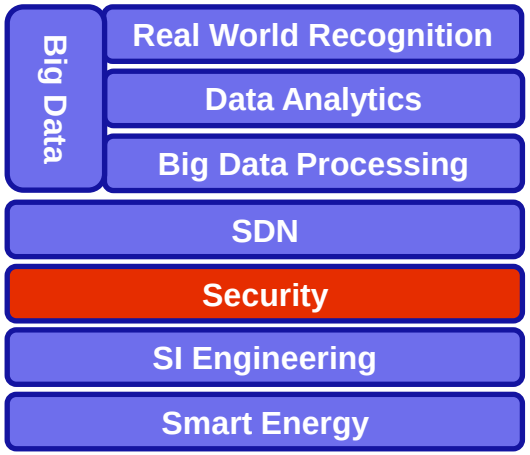
- **R&D :** ONRC (Stanford & UCB) , Geni
- **Standardization :** ONF, ETSI
- **OSS :** ON.LAB (ONRC), OpenDaylight



SDN Contributing to Enhancement of Social Infrastructure



Security



Security: Research Direction

- Challenging increasingly complex and diverse threats with a broad range of technical expertise; system security, encryption, large-scale system analysis and risk analysis

System security

Flexible and supports different work styles
SDN Access Control — **World's 1st**

Database operations without decryption
Secure computing — **No.1**

Privacy protection

Large-scale, fast
Personal data anonymization — **No.1**

Copyright protection

Editing-resistant illegal image copy discovery
Video signature — **No.1**

Compliance

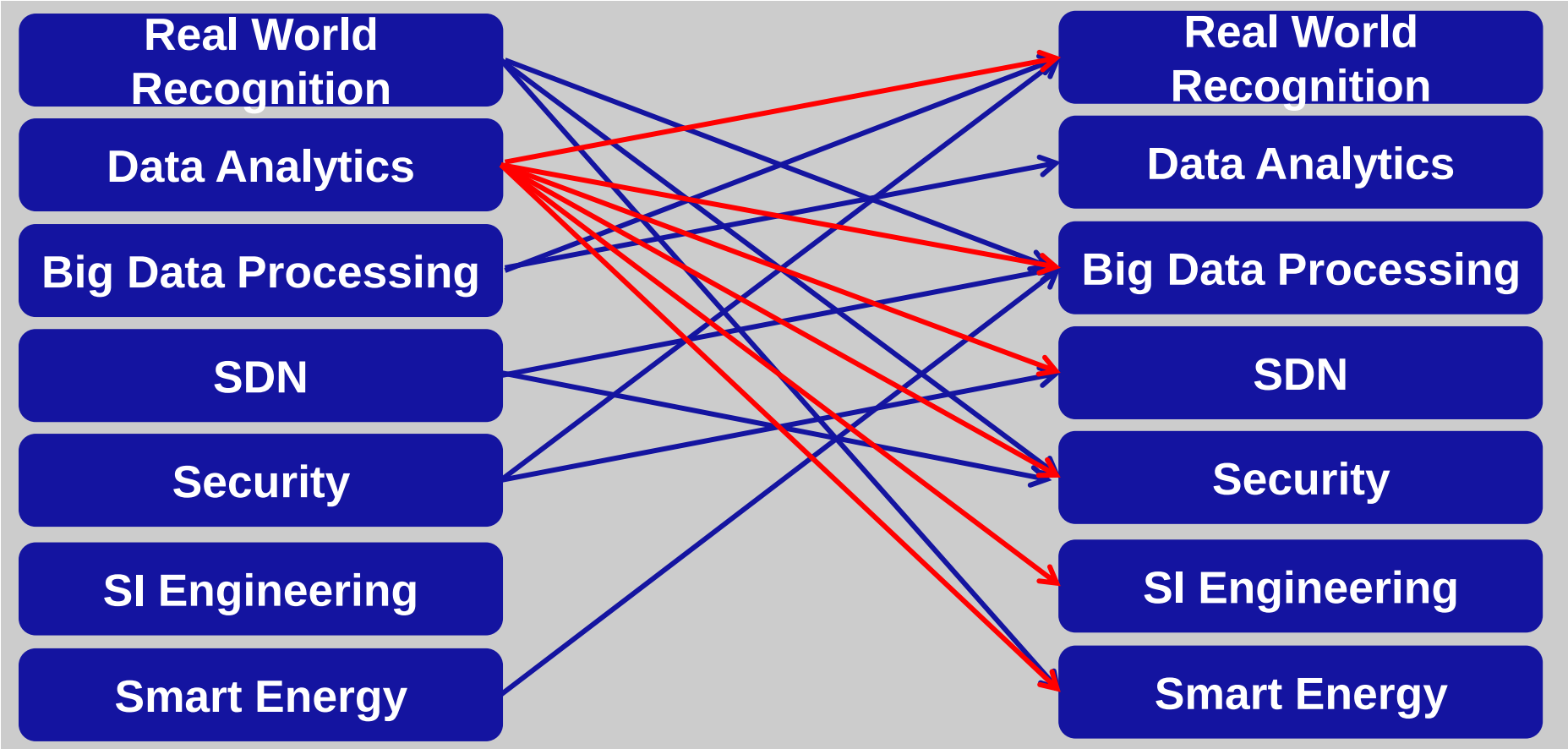
24000x faster than previous technologies
Business document analysis — **No.1**

→ Minimize risk of targeted attack

→ Minimize operations risks

Technology Collaboration

- Important and new aspect in NEC's research for making breakthrough technologies towards social value creation
- Particularly, data analytics becoming the innovator of many other techs



Summary

Transformation of NEC's research towards social value creation by ICT

New journey of discovering customer values in the emerging market

- Focus on 7 technology areas (Data analytics with leading focus)
- Create No.1/Only-1 core techs (unchanged)

Collaborative Innovation is of ever-increasing importance

- Collaboration with customers
  for finding out new direction of innovation
- Collaboration with academia, government, partners
  for open innovation, test bed & infrastructure for trails
- ★ Collaboration between technologies
  for new breakthrough, for new infrastructure paradigm

Management encouraging

- Establishing competitive technical expertise (unchanged)
- Willingness to making collaborations / synergies even more than in the past
- Enhancing individual's sensitivity to broader range of techs & innovations

Empowered by Innovation

NEC