Fujitsu Laboratories’ Role
Digital Transformation
R&D for realizing Hyperconnected Cloud
Main Topic for Today’s Press Release
Technology Exhibits
Fujitsu Laboratories’ Role
Fujitsu Laboratories: Mission
Driving the Fujitsu Group growth with leading-edge technologies
Positioning of Fujitsu Laboratories

Through Co-Creation, create values, develop new markets, and contribute to the core businesses

Business

Fujitsu Limited and Subsidiaries

R&D

Strategy Taskforce

R&D Investment

Fujitsu Laboratories

Technologies and market trends

Customer and partner needs

Government Projects

Universities & Research Institutes

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Flow of R&D and Business Deployment

- Leading-Edge Basic Research (10%)
- Advanced Research (50%)
- Commercialization R&D (30%)
- Applied Innovation Research (10%)

- RO
- R
- R&d
- r&D
- D

- Prototype of Concept
- Prototype of Market
- Proof of Concept
- Proof of Business
- Big Business

Understanding/Exploration of Rules and Principles → Use/Application in the real world
Outline of R&D Activities

- R&D Budget: Approx. 30 Billion JPY, Approx. 300 Million USD
- Employees: Approx. 1200 in Japan, Approx. 65 in U.S., Approx. 120 in China, Approx. 45 in Europe
- Open Innovation: 84 Projects in Japan, 11 Countries, 58 Projects in overseas

Continuously generating R&D results that will amaze the world

Quickly deploy R&D results to Proof of Concept and Proof of Business on a global scale

Generating innovations, including new business models that resonate through global markets
Technology Value Chain of R&D Themes

Fujitsu's Business Innovation

Solutions
- Web Services
- Big Data
- Artificial Intelligence
- Security

Systems
- Cloud
- Servers
- Data Centers
- Smartphones
- PC s/Tablet PC s
- Media Processing
- Environment

Networks
- 5G
- Sensors
- Optical Communication
- SDN
- Operating System
- API
- Validation

Advanced Materials

Next-gen Devices

Software
- OSS
- Operating System
- API
- Validation

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Providing Useful Values to Fujitsu Customers through Leading-Edge Technologies
Digital Transformation
Number of connections  IPv6 : 340 undecillion
⇒ World population: Approx. 7.5 billion  Approx. 45 octillion NW connections

Human Centric Innovation
Driving Digital Transformation

2016
The New Industrial Revolution
Human Centric Innovation in Action

2015
Digital Ecosystem

2014
Human Centric Innovation
Hyperconnected World

2013
Fujitsu Technology and Service Vision

1999
Everything on the Internet
Trends in the Improvement of Computing Performance

- **1990**
  - Low Power
  - High Performance
  - Enterprise system

- **2000**
  - Dissemination of Internet
  - CMOS Miniatuization and High Integration

- **2010**
  - Multi-Core/GPGPU
  - Approximate Computing
  - Neuromorphic Device

- **2020**
  - 3D Package Silicon Photonics
  - New Types of Nonvolatile Memory
  - Quantum Computers
  - Nanocarbon Transistor
  - Nano wire
  - Social issue solution

- **Future**
  - Application of the hottest technology
  - New approach

- **Limits of Moore's Law**

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Trends in Connection Technology

- Non-linear optical effect
- Fiber phases
- Shannon limit
- Optical amplification band width limit

100T: Input power limit with the existing optical fiber

Backbone Networks
- Digital coherent optical
- WDM technology
- Optical amplification technology
- Electric multiple TDM technology

Innovative Technologies
- Increases in the number of connections
- Latency

1990 2000 2010 2020

Connectable data amount and Transmission capacity

Year

Electric multiple TDM technology
- Analog
- 10G
- PDC
- W-CDMA
- Bluetooth
- ZigBee
- Bluetooth Low Energy
- IoT, Sensor

Fusion
- Ethernet
- Mobile
- 200G/400G
- 100G
- 25G
- LTE
- 5G
- Multi-Cast
- Smart-PAN, BAN
- Electric multiple TDM technology
Trends in Data Volumes and Conversion into Knowledge

Data volume - Data used for AI

- Expert Systems
- Data Mining
- Agent Systems Optimization
- Smart Machines
- Deep Learning
- Machine Learning

Storage

- Hard Disks
- Disk Array
- RAID
- Key-Value Store
- Object-Storage

Data Circulation and Leveraging Platform

- (IoT, Video, Graphics)
- 1Tb/in² Wall

Structured Data

- SOR
- Business Data, Enterprise Databases

Hyper-Converged Infrastructure

- All Flash Array

Unstructured Data

- IoT, M2M, SNS
- Sensor Networks, Web Applications

40 ZB (Z: 10²¹)

Robotics Cloud AI

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Importance of Security Technology Accompanying the Advance of ICT

- **1990**: Internet E-mail
- **2000**: Expansion of Web, Computer Virus
- **2010**: Spread of Mobile Devices, Spread of network virus
- **2020**: Cloud/Virtualized Environments, Malware detection, Targeted Cyber attack, Varied security solutions, Cyber-terrorism, Borderless IoT Security, Hyperconnected World

Key Security Issues:
- Internet E-mail: Computer Virus
- Expansion of Web: Virus epidemic due to generalization
- Mobile Devices: Security hole counter-measures
- Cloud/Virtualized Environments: Personal authentication, Data confidentiality
- Malware detection: Anti-virus
- Targeted Cyber attack: Personal authentication, Data confidentiality
- Varied security solutions: IoT, AI, Big Data
- Hyperconnected World: Blockchain

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Co-Creation by Digital Business Platform

New Services, New Businesses, New Ecosystems

“Digital Business Platform”

Co-creation

Cross-industrial sector / Different field cooperation

A Company

B Company

Applications

Data

Applications

Data

Applications

Public Data

Open Data

Public Sector

Public Domain

Knowledge

Technology

Fujitsu
R&D for Realizing Hyperconnected Cloud

• 5 R&D Domains
• Applied Research
• Leading-Edge Basic Research
Integrate the Front (field area) networks as real world objects and Clouds, and develop a co-creation platform that seamlessly connects all of these networks.

Provide the necessary services easily at a high speed by using data applications that are available from virtually integrated database of integration PaaS.

**Knowledge Integration**

- On-premises
- Private
- Public
- Hybrid
- IoT

**IoT Integration**

- API

Cloud native development

- OSS
- Third Party
- Big Data

Rapid prototyping

- API

Digitization of real world

- People
- Mobile Devices
- Vehicles

Service control

Integration PaaS

- API

Objectization

- Application / Data
- Objectization of People and Things

Virtually-Integrated Database

Existing systems/On-premises
Web Scale ICT Infrastructure

- ICT infrastructure that is continuously evolving while dynamically allocating the required functionalities and resources
- Next generation computing architecture surpassing the limit of existing calculation capability

Next-gen Computing

Data systems in IoT era

New-Generation Cloud Platform

- Software Defined Platform
- DC Networks
- SDN / SDS / SDC

Cloud Management

- Next-gen IaaS ・ PaaS

- Wide-area distributed allocation planning
- API linkage/Operation linkage, DevOps
- Infra/Virtual PF Packet diagnosis

- Integrated monitoring/ Automatic operation
- Expansion of support service applications/devices

- Hyper-Scale Cloud

- Multi Cloud

- Public Cloud

DC: Datacenter, DB: Data Base
RDB: Relational Data Base Management System

DC Networks

RDBMS

SoE

SoR

FPGA

AI specific ASIC

Neuro/Quantum Engine
- Virtual network that connects various things on the network from end to end optimally at a high speed regardless of physical network types.
- Create the required services by One Network that seamlessly connects from Core to Front networks.
Develop a technology that creates new knowledge based on the knowledge obtained from experience and deploy this technology to various fields in the society.

Human-Centric AI that can understand the human 5-sense and affections by media processing technology.
Solving new security issues which are arising along with ICT progress, realize a safe and secure society.

Establish an intelligent and borderless security system utilizing AI.

**IoT Security**

- Collaborative authentication of people/things
- IoT device authentication

**Data and Privacy Protection**

- Personal Data leveraging
- Blockchain
- Anonymity/Concealed search

**Authentication/Approval**

- Personal authentication PF
- Cloud/Authentication PF linkage

**Trust Frame Work**

- PF linkage

**Cyber Security**

- Mitigate the damage and continue the business.
- Analyze/solve the problem automatically.
- Address the cyber attack internally.
Co-create new ICT businesses and services and use them actually in our daily lives through Hyperconnected Cloud that provides various "Technologies and Business models."

New businesses and services

New fields concerning the people’s daily lives/activities

Next-generation growing fields

Robotics
Live innovation
Sports

Co-Creation/Ecosystem

Hyperconnected Cloud

GLOBAL MARKETING INTEGRATED SOLUTIONS MARKETING UNIT ADVANCED TECHNOLOGIES PROJECT OFFICE

New product
New application field

New Business model
New technological field

Academic technology
Enterprise technology
Cross-industrial technology
Business model
Big data
Application

Social innovation
Vehicle
Next-gen healthcare

Next-generation growing fields

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New product
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Cross-industrial technology
Business model
Big data
Application

Social innovation
Vehicle
Next-gen healthcare
Leading-Edge Basic Research

- **Challenging the limitations of ICT**
  - **Computer Architecture**
    Intelligent computing supporting people with autonomous learning (Domain-Specific, Quantum, Neuro, Brain-Type)
  - **Network Architecture**
    Challenging the limitations of optical/radio communications and enhancement of software-defined communication technology
  - **7-Sense Computing**
    Autonomous actions based on understanding of human affections, emotion, five senses, sixth sense (intuition), and illusion
  - **Social Science**
    Analysis/evaluation/verification of social phenomenon and economic change through empirical approach
  - **Physical and Chemical**
    New device/3D packaging/Energy creation technologies, by materials informatics and biomimetics
Main Topic for Today’s Press Release
Fujitsu Laboratories’ Vision for Future Computing

Creating a new computer architecture toward the intelligent computing era

Specialization

Domain-specific computing

- Neuro computing (Inference)
- Neuro computing (Learning)
- Quantum computer
- Brain computing
- Knowledge
- Media
- Numeric
- Supercomputer
- Accelerator

Moore’s Law

Processing amount

Intelligence

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Human Brain and Artificial Intelligence

5-sense (Eyesight, Hearing, Smell, Taste, Touch)
Memory, Recognition, Knowledge, Experience, Illusion,
Forgetfulness, Consciousness,
Unconsciousness, Common Sense, Learning

<table>
<thead>
<tr>
<th>Human: Number of neurons</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cerebrum</td>
</tr>
<tr>
<td>Cerebellum</td>
</tr>
<tr>
<td>Sense organs: Eye, Ear, Nose, Tongue, Skin</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>ICT • AI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Computer</td>
</tr>
<tr>
<td>Storage</td>
</tr>
<tr>
<td>Connectable count:</td>
</tr>
</tbody>
</table>
Fujitsu Laboratories’ Concept of AI

- **Structurization of existing knowledge**: Utilize the vast knowledge produced by human beings around the world.
- **Acquisition of unknown knowledge**: Utilize the vast knowledge accumulated by sensing devices in a real world.
- **Creation of Knowledge**: R&D for learning and discovery science

**Knowledge creation**:
- Perception/Recognition
- Judgment/Support

**Knowledge acquisition**: Mathematical approach
- Discovering science

**Knowledge structurization**: Computing
- Brain science

Massive amounts of media data and five sense information that are collected by sensing devices in a real world

Vast knowledge scattered around the world which is produced by human beings
Technology Exhibits
Technology Exhibits presented today (1/2)

**Service-Oriented Connection (2 out of 14) *
3. Cloud Migration Technologies Enabling Digitization of Business System
4. Service Co-Creation Platform Promoting the Comfortable Place Development

**Web Scale ICT Infrastructure (2 out of 14) *
5. High-Speed/Large-Scale Deep Learning Based on Supercomputer Technology
6. Log-analysis Technologies for Visualizing and Tracking OpenStack’s Internal API Calls

**Core/Front Network Fusion (2 out of 13) *
7. Service Networking Technology Enabling Rapid Deployment of IoT Systems
8. Compact 300 GHz Receiver for Wireless Communications of Tens of Gigabits per Second

**Leading-Edge Basic Research (4) *
1. Novel Architecture to Rival Quantum Computers

*Number inside parentheses indicates the number of press releases issued so far since Apr., 2015
Technology Exhibits presented today (2/2)

AI (4 out of 18) *
2. New Deep Learning Technology Leading to a Discovery from Data Describing All the Connections among People and Things
9. Improving Customer Satisfaction through Appropriate Omni-Channel Support
10. Automatic Generation of Image Recognition Programs in Production Line Using AI Technologies
11. Video Monitoring and Analysis Technology for Intelligent Transportation

Security (2 out of 7) *
12. Biocode Cryptographic Technology for Secure and Simple Use in Cloud Service
13. Integrated Cyber Analysis System for Visualizing Whole Picture of Targeted Attacks

Applied Innovation Research (3 out of 17) *
14. Enhancing Security of Blockchain for Business Use
15. Instantly Visualizing the Excellence: Scoring Support for Gymnastics Competitions
16. Automatic and Hands-Free Multilingual Speech Translation Technology

*Number inside parentheses indicates the number of press releases issued so far since Apr., 2015