FY2017 R&D Strategy Briefing

September 20, 2017

Fujitsu Laboratories’ R&D Strategies

CEO
FUJITSU LABORATORIES LTD.

Shigeru Sasaki
Outline of Fujitsu Laboratories
Fujitsu Laboratories: Mission

Driving the Fujitsu Group growth with leading-edge technologies

Fujitsu’s consolidated financial targets – Achievement goals

- Operating profit margin → 10% or more
- Overseas sales ratio → 50% or more
Global Activity

- Employees: Approx. 1200 in Japan, Approx. 230 overseas
- Open Innovation: 123 Projects in Japan, 44 Projects in 14 Countries

Quantum Computing/AI

Big Data Analysis

Healthcare AI

Traffic Surveillance AI
Fujitsu Laboratories’ R&D strategic scheme

- Solve social problems with advanced technologies by predicting the future and global trends

Fujitsu Technology and Service Vision

Technology Vision: Hyperconnected Cloud

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

Fujitsu Labs’ R&D focus areas:

- Connected Business Platform
- Security
- Intelligent Computing
- AI
- One Network
- Foundational Research
- Computer Architecture
- Network Architecture
- Nine-Sensecomputing
- Social Science
- Physical and Chemical

Digital Co-creation

Human Centric Innovation

Social innovation
Life innovation
Mobility
Manufacturing Healthcare

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Megatrends and Fujitsu Laboratories’ R&D strategies
Changes and trends of the world which will be generated by technologies

"Information sharing" and "Quick decision making" with digital technologies will promote companies' new value creation and continuous development.

"Human creativity" × "Digital technologies" will enhance abilities and change work styles of people, and bring about the world where each person can play his/her role actively in various fields with delight.

Innovative digital technologies will transform social regulations, etc. and open ecosystem will generate evolvable values and systems.
Trends of Fujitsu Laboratories’ 8 Emerging Technologies

- Computing Revolution
  Digital Annealer

- Explainable artificial intelligence
  Deep Tensor+Knowledge Graph

- Data-driven platform connecting various industries:
  Connected Digital Place

- Dramatic increase in the number of connected things:
  Zero Limitation Networking

- System transformation toward the connected world:
  Microservice Transformation

- Data reliability assurance:
  Borderless IoT Security

- Understanding human five senses, feelings, illusion, etc. for human-machine collaboration:
  Nine-Sensecomputing

- Fusion of Physical and Chemical:
  Materials Informatics
Future Trends of Logistics / Distribution Industry

World's E-Commerce market

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$35 Tril.

Source: Analysis of ICT Industrial Trends in the IoT Era: 2016 White Paper on Information and Communications in Japan (by MIC)

Logistics/Distribution Industry Forecast
- Increase of logistics resources
- Shifting to global/borderless market
- Increase of logistics resources/demands for workers
- In 2030
  - World population: Approx. 8.3 billion
  - Megacities with populations of over 10 mil.: 41 cities
  - Expansion of Cross-border EC (Volume of cross-border transactions: 3 times
  - Fully automated transport/delivery of goods

Source: UNIDO, International Yearbook of Industrial Statistics 2016 by MIC
- 2016 the Future Direction of the Active Use of Big Data in the Distribution and Logistics Field by METI study group

Keys to the solution of social issues:
- Global logistics management across borders of land, sea and air
- Optimization of SCM, required time for delivery, work hours, and energy consumption
- Smart mobility realization by AI and connected car
ICT Supporting the Future E-Commerce, Logistics / Distribution

Production plan, Purchase/Sales order plans

Digital marketing

Global SCM

Congestion alleviation/elimination

Distribution/Logistics

Environmental pollution elimination

- Transportation route combinatorial optimization
- Last mile transportation

- Merchandise & service matching
- Small quantity & large variety transportation

- Energy consumption minimization
- Working conditions/ Vehicle monitoring

Telematics management system

Camera/Sensor

Automated driving

Wearable device’s driver information

Environmental information

GPS

Traffic information

Meteorological data

AI/Data analysis

- Deep Tensor
- Data Bazaar

Computing

- Digital Annealer
- Edge Computing

Network

- 5G / IoT / Sensor network
- GPS / RFID
Future Trends of Work Style

Transition/prediction of Japanese average longevity

Work style prediction
- In 2030 (Elderly people: at age 65 or over)
  - Number of elderly people in the world: Exceeded the one billion mark
  - Increase of the elderly percentage in the population
    - Japan: 32%, U.S.: 21%
    - China: 16%, Germany: 31%
- Diversified employment patterns
- Increased demand for engineers/professionals in new fields along with advent of advanced technologies

ICT Progress and Future Work Styles: 2016 White Paper on Information and Communications in Japan (by MIC)

Source: Annual Report on the Aging Society: 2016 by Cabinet Office

Keys to economic growth
- Recruit more diverse staffers globally (Value dynamism of individuals)
- Create new job categories and services by increasing business demand
- Expand/provide work opportunities and improve work quality/productivity
Maximize the performance of human resources all over the world and raise productivity

Future work styles

**Human Empowerment**

- Maximize the performance of human resources all over the world and raise productivity
- Remote collaboration at the global level

**AI/Data analysis**
- Deep Tensor
- Data Bazaar

**Computing**
- Digital Annealer
- Cloud/Edge Comp.

**Network**
- 5G / IoT
- Sensor Network

**VR/AR**
- Automatic translation

**Routine task automation/Work support**

**Sales/Service**

**Office**

**HR support**

**Healthcare**

**Education/School expense subsidy**

**HR matching**
- Job orders ↔ HR data

**HR optimization**
- Work volume / Quality / Health conditions ↔ Skill / Work hours

**New business creation**
- New products / Services ↔ Demand / Consumption

**Human resources/ICT infrastructure resources**

**Conveyance of Realistic Sensation**

**Mobile Work**

**Telework**

**Factory Automation**

**Space UI Technology**
Collaboration between Human Beings and Human Centric ICT

Breakthrough in Human ability and performance by ICT

Human + ICT

Ontology (Reasoning)

Semantic analysis (Understanding of meaning)

Natural language recognition

Image recognition

Symbol processing

Information processing

Human + AI + ICT

What we should do with Human-in-the-loop

General AI

Nine-Sensecomputing

Social issue solution

Optimization/Combination (Logistics, Disaster prevention, ...)

Decision-making support (Healthcare, Finance, ...)

Materials Informatics

What ICT and AI can do

Deep Tensor

Knowledge graph

Digital Annealer

Knowledge accumulation

Human ability enhancement

Customer contacts enhancement

Manufacturing transformation/SCM

Work style reform

What ICT can do by itself

Big data analysis

Permanent recording/storage

Automation/Autonomization

Human

Expertise

Intelligence x Processing ability

Generality

Human + ICT

Operating instead of human beings

ICT + AI

Human + AI

Human + ICT

Human
Human Empowerment

Human in the loop

Quick Decision Making

Info Sharing and Analysis

World’s Huge Knowledge Base

Data Collection
Info Sharing

Info Sharing and Analysis

Data Collection
Info Sharing
Connected Digital Place (CDP)

**Co-creation platform for connecting data**

- Fintech
- Healthcare
- Mobility
- Social infra
- ICT automation
- Security
- Maintenance
- Food/agriculture
- Manufacturing
- Fintech
- Healthcare
- Mobility
- Social infra
- ICT automation
- Security
- Maintenance
- Food/agriculture
- Manufacturing

**Human Centric Innovation Digital Co-creation**

**Grasping the whole picture by seeing other industries’ data, find the customer contacts.**

Matching marketplace, Place for freewheeling thinking, Ecosystem implementation

**Company A**

**Company B**

**Company C**

**Individual Person**

**Fujitsu**

Technologies / Applications / Services

**Cloud**

**Operation/Management**

**Data Distribution/Utilization Platform**

**Data Bazaar**

**Software Transformation**

**Media**

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The World of Hyperconnected Cloud

Driving Human Centric Innovation
Digital Co-creation

Service-Oriented Connection:
Integrate various services dynamically and promote Co-creation business

AI (Artificial Intelligence):
Make all products, functions and services intelligent through AI

Security:
Integrated security system protecting cyberspace, IoT, personal identity data, and products

Web Scale ICT Infrastructure:
Novel ICT architecture toward intelligent cloud era

Core/Front Network Fusion:
One network virtually connecting all things from physical networks to front-end devices and services

Leading-Edge Basic Research:
Challenging the limitations of ICT
Main Topics for Today's Press Release
Concept of Key R&D Strategy

"Information Sharing" and "Quick Decision Making"

**Reasoning/Thinking are important**
- Big Data analysis
- Existing and Empirical knowledge learning
- Data cleansing

**Swiftness is important**
- High-speed data analysis
- Optimization problems
- Data sampling

**Challenge Currently Unsolvable problems**
- Operation/Route planning
- Medical care (Radiotherapy)
- Investment portfolio
- Chemical substance search
- Disaster prevention plan
- Electric network optimization

**Explainable machine learning**
- System automation
- Emotion/feeling understanding
- Medical care (Gene analysis, Drug discovery)
- Matching pattern recognition
- Cyber security
- Network automation

**Knowledge Graph**
- Deep Tensor
- Deep Learning Unit

**Digital Annealer**
- Domain Specific Computing

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Strategy of Quantum Computing

Achievement of Computing Revolution by Global Co-creation

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Digital Annealer

University of Toronto
Social System Application Software
Vector, MaRS

1 QBit
Quantum Computing Software

• Strategic partnership
• A new research center is established in Toronto

Medical care Radiotherapy
Finance Portfolio optimization
Security
Disaster Measures
Transportation / Logistics

Challenge Currently Unsolvable Problems

Digital Annealer

Evolution

Quantum Annealer
Quantum Gate

Quantum Computing

Computing Revolution

Brain Computing
Neural Computing
Approximate Computing
Explainable Artificial Intelligence

- Fusion of Deep Tensor and Knowledge Graph

Data from all over the world
- Databases
- Texts
- Theses
- LOD
- Symbol strings
- Plot data
- Numerical strings
- Character strings

Knowledge Graph
- Healthcare
- Human Resource
- Finance

Growing knowledge data base with meaning, grounds, and relationship

Deep Tensor

Inquiry of AI

New Insights
- Judgement / Discovery / Explanation

Output by AI

Experts
An Honorable International Award: Receiving the 33rd Kyoto Prize

Dr. Takashi Mimura, Honorary Fellow
- Invention of a HEMT (High Electron Mobility Transistor) by using compound semiconductors
- Significantly contributed to the innovation of communication technologies
- Parabolic Antenna, Vehicle Radar, Power Device

HEMT was invented in 1979

GaN on Si

Grand Prize of the 26th Global Environment Award
High-Efficiency AC Adaptor
Communication Module/Power Unit
Satellite-Television Antenna

IP has been registered

GaN-HEMT
Technology Exhibits
Web Scale ICT Infrastructure

01. Strategy for a “Digital Annealer”: Challenge to Explore a New Computing Technology
02. Solving Customer Problems by Practical Implementation of High-Speed Image Retrieval Technology in Retail and Healthcare fields
04. Reducing Data Preparation Time: Data Bazaar Technology for Generating Automatic Data Conversion Logic
05. Designing Technologies for Microservices Enabling the Rapid Change of Business Applications
06. Speed-Up Technology for Blockchain Transaction Processing

Core/Front Network Fusion

07. Network Technology to Accelerate Secure Data Exchange Market Using Blockchain
08. Operation Management Platform for IoT Field-Area Systems
09. World first 5G Wireless Technology for On-demand High-Definition Video Distribution Service
AI
02. Explainable Artificial Intelligence with Deep Tensor and Knowledge Graph
11. Practical Application of Deep Tensor for Identifying Cyber Attacks

Security
11. Practical Application of Deep Tensor for Identifying Cyber Attacks
12. Human Centric Personal Data Store (PDS) and Risk-Aware Anonymization

Applied Innovation Research
13. New AI Analysis Technology Using Sensor Data for Estimating Internal Damage to Bridges
14. World’s First Wearable Hands-Free Speech Translation Terminal for Multilingual Communication

Leading-Edge Basic Research
01. Strategy for a “Digital Annealer”: Challenge to Explore a New Computing Technology
03. Invention of High Electron Mobility Transistor (HEMT) Contributing to Great Advances in ICT
Fujitsu Laboratories' Group: Overview

- **CEO:** Shigeru Sasaki
- **R&D Budget:** Approx. US$ 167 million
- **Total Employees:** Approx. 1,400 worldwide

**Fujitsu Laboratories Ltd.**
- Kawasaki Laboratories (Japan) Established 1968
  - Computer, cloud system, Network, IoT, Software, AI, Knowledge processing, Security, User Interface, etc

**Fujitsu Laboratories Ltd.**
- Atsugi Laboratories (Japan) Established 1983
  - Materials, Devices, Packaging, Environment, Energy, etc

**Fujitsu Laboratories Ltd.**
- Fujitsu Laboratories of America, Inc. (U.S.) Established 1993

**Fujitsu Laboratories Ltd.**
- Fujitsu Laboratories of Europe Ltd. (Europe) Established 2001

**Fujitsu R & D Center Co., Ltd.**
- (China) Established 1998
### Organization, form April 1st, 2017

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- Computer Systems Laboratories
- Software Laboratories
- Information Systems Technologies Laboratories
- IoT Systems Laboratories
- Network Systems Laboratories
- Front Technologies Laboratories ★
- Artificial Intelligence Laboratories ★
- Security Research Laboratories ★
- Devices & Materials Laboratories
- Applied Innovation Research Center
- Fujitsu Laboratories of America, Inc.
- Fujitsu Research and Development Center
- Fujitsu Laboratories of Europe, Ltd.
- R&D Strategy and Planning Unit
- R&D Management Unit
Technology Value Chain of R&D Themes

Fujitsu’s Business Innovation

Solutions

Systems

Networks

Advanced Materials

Software

Next-gen Devices

Web Services

Big Data

AI

Security

5G

Sensors

Optical Communication

SDN

Operating System

API, OSS Validation

Compiler

Cloud

Data Centers

Domain-Specific Computers

Approximate Computers

Quantum Computers

Media Processing

Environment

Computers

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Positioning of Fujitsu Laboratories

Through Digital Co-creation, create values, develop new markets, and contribute to the core business.
Flow of R&D and Business Deployment

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

Business Deployment

Big Business

Global Markets
Japanese Market
Spin-off
Patent Licensing

Open Innovation

Prototype of Concept
Proof of Concept
Prototype of Market
Proof of Business
Business Deployment

R0 → R → R&D → r&D → D

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

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