Fujitsu Forum 2014

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Human Centric Innovation
Data Will Change Business, But Will It Really Change ICT?

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Agenda

- Data-Driven Innovation
- Data-Centric ICT Platform
- Research Topics
  - Scalable Storage for High-Throughput Data
  - Shingled erasure coding for fast recovery from multiple disk failures
  - Workload-aware Flash Storage
- Summary
Data-Driven Innovation
Background: Data Explosion

- Rapid Growth of Data in Digital Universe
  - Doubling in size every two years
  - Unstructured data explosion

Source: EMC Digital Universe with Research & Analysis by IDC 2014
Examples of Data in Digital Universe

- Amazon sold 426 items per second in 2013 Christmas
- 340 million Twitter tweets per second
- Google processes 38,000 search queries every second
- 100 hours of video are uploaded to YouTube every minute
- Internet users send 204 million emails per minute
- 4.5 billion Facebook likes generated daily

Sources: Twitter, Google Zeitgeist 2012, YouTube, Facebook
Data-driven innovation is changing business

- Latency
- Capacity
- Velocity
- Variety
- Volume

- Mission Critical
- High-Performance DB
- DWH
- Big Data Platform
- Cloud Storage
- Real-Time Bidding
  - In-Memory
- Real-Time Recommendation
- Big Data Analysis
- Online Video / Photo Sharing
  - Cloud/Cold Storage
Examples of Innovation by Big Data

- **“Akisai” Cloud Service for Agriculture**
  - Big data is used for cultivation scheduling
  - Fujitsu succeeded to harvest low-potassium lettuce which is known to be difficult to watering

- **Automated Identification Technology**
  - Airbus selected Fujitsu RFID technology to deliver dependable management and traceability of aircraft parts
Changes in Data-Intensive Computing

Structured Data
- Data Warehouse
- Data Mining

Unstructured Data
- Deep Learning
- Neural Network

Question: How are AI and neural network different from the 80’s?

Answer:
- Increased computer power and algorithms
- Increased amount of data for learning
Computer Chess to Shogi (Japanese chess)

Deep Blue won by evaluating 200 million positions per second

Complexity of Game

<table>
<thead>
<tr>
<th>Game</th>
<th>Game-tree complexity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tic-tac-toe</td>
<td>$10^5$</td>
</tr>
<tr>
<td>Checkers</td>
<td>$10^31$</td>
</tr>
<tr>
<td>Reversi</td>
<td>$10^{58}$</td>
</tr>
<tr>
<td>Chess</td>
<td>$10^{123}$</td>
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<tr>
<td>Shogi</td>
<td>$10^{226}$</td>
</tr>
<tr>
<td>Go</td>
<td>$10^{360}$</td>
</tr>
</tbody>
</table>

Chess: IBM Deep Blue

- Deep Blue defeated Kasparov in 1997
- Evaluated 200 million positions per second
- Brute force searching was used


Computer Chess to Shogi (continued)

- Shogi has the distinctive feature of **reusing captured pieces**
- Deep Blue-style approach is not enough to defeat human champion
- Top five strength computer programs used **machine learning** in 2014 World Computer Shogi Championship

Example: Nine Day Fever (4th in 2014 World Computer Shogi Championship)
- 30 billion games generated by computer versus computer
- CPU processing time for machine learning is 3,000 times longer than total calculation of moves in one game
- Learning Time: 1 month calculation on 12-node PC Cluster
Applications of Data Processing

- Importance of retrieving useful information from large and/or unstructured data
  - Location-aware recommendation
  - Real-time advertisement
  - Personalized video search

- Machine learning and other knowledge computing

Need more and more computing power for data processing
Data-Centric ICT Platform
# User Requirements for Data Processing

## Velocity
- Rapid Decision Making

## Variety
- Voice and Video Data
- Social Media Data
- Linked Open Data

## Volume
- M2M
- IoT

**ICT system capable of processing various kinds of data**
Problems of Traditional ICT Platform

- One system is designed for a specific application
- Data characteristics are different between applications and it is difficult to apply one solution to another
  Video sharing: write once/read many

Goal: Flexible Data-Centric ICT Platform
Data-Centric ICT Platform

ICT Platform that handles various types of data

Various types of data
- Enterprise data
- Web, SNS Lifelog
- Sensor data
- Open/Public data

Application

Knowledge Solutions

Machine Learning

Virtual Data Integration

Flexible Data Store Software
- RDB
- DWH
- NoSQL
- File

Hardware Acceleration

Big Data

Data-Centric ICT Platform
Technologies for Data-Centric ICT

- **Flexible Data Store Software**
  - For various kinds of data characteristics
    - Low-Latency
    - High-Throughput
    - Reliability
    - Faster Recovery time

- **Acceleration by Utilizing New Hardware**
  - Flash-based storage
  - Many-core processor

- **Virtual Data Integration**
  - Integration of different data stores
Research Topics

- Scalable Storage for High-Throughput Data
- Shingled Erasure Coding for Fast Recovery from Multiple Disk Failures
- Workload-Aware Flash Storage
Research Topic 1: Scalable Storage for High-Throughput Data
High-Throughput Data

- Rapid traffic increase in SNS and Sensor Network
- Challenges in capturing and storing speedy and voluminous streams of data

If we can accumulate data, useful business information can be analyzed from data.
Technological Challenges

High-Throughput Data Capturing
- 40Gbps
- Short packets

Scalable Storage
- Data volume depends on the traffic
  • High-traffic: $10\text{Gbps} \times 1\text{day} = 108\text{ TB}$
- Storage system should scale-out easily

Real-Time Search
- Search at high-speed without affecting storage performance
Technology Enabling High-Speed Search while Accumulating Data at 40-Gbps

Technology Features
- Captures and archives all packets in 40 Gbps network which is four times faster than conventional product
- Hardware independent software technology
- Cost-effective and easy-to-deploy

Customer Benefits
- Helps to ensure data center security
- Network forensics
  - Intrusion detection
  - Legal evidence

Booth S1
Press Release and Award

■ Press Release

■ April 14, 2014 Fujitsu Develops Technology Enabling High-Speed Search while Accumulating Data at 40-Gbps


■ Award

Interop Tokyo 2014
Best of Show Award: Grand Prix
Research Topic 2: Shingled Erasure Coding for Fast Recovery from Multiple Disk Failures
Importance of Protecting Contents Data

- Digital media data, which plays a central role in web services, has been experiencing an explosive rate of growth.

- The crucial importance of data to these services leads to a number of methods to guard against digital media data loss.

- Copying data is one approach, but the cost of storage cannot be ignored.
Methods of Protecting Content Data

- **Triple-Redundant Copy**
- **RAID Technology**

  Long established method of protecting mission-critical data

  Rather than storing copies of each piece of data, introducing "parity" - redundant pieces of data that summarize other data as part of a protection system - allows for the same degree of protection as triple-redundancy but with significantly less actual redundancy

![Diagram of Triple-redundant Copying and RAID6 Protection](image)
Our Shingled Erasure Code

- **Multilayered Parity-Protection**
  - An erasure code *only with local parity groups*
  - When a disk fails, only the minimum combination of parity and data needed for recovery is used, which *shortens recovery time*

![Shingled Erasure Code Diagram]

*Image Source: wikipedia*
Features of Shingled Erasure Code

- Multilayered parity-protection reduces data recovery time
- The structure for the parity protection range can flexibly change with usage contexts

More than 20% faster data recovery compared to conventional RAID (4TB, 48HDDs)
Press Release and USENIX HotDep 2014

Press Release

- October 6, 2014 Fujitsu Laboratories Develops Fast Recovery Process for Multiple Disk Failures


USENIX HotDep

Erasure Code with Shingled Local Parity Groups for Efficient Recovery from Multiple Disk Failures
Takeshi Miyamae, Takanori Nakao, and Kensuke Shiozawa, Fujitsu Laboratories Ltd.

Ongoing discussion with Open Source Scalable Storage Ceph Community

http://ceph.com/
Research Topic 3: Workload-Aware Flash Storage
Workload-Aware Flash Storage

- Conventional Flash Storage Problems
  - Legacy SAS/SCSI API interface never takes advantage of flash storage features such as parallel reading

- Our Workload-Aware Flash Storage
  - Moves flash controller into software layer
  - Total optimization including OS, driver, and software controller
  - New API takes advantage of flash features according to the workload

- Customer Benefits
  - Faster storage performance for data-intensive computing
Workload-Aware Flash Storage Prototype

- Optimized for SAP in-memory database systems

One example of HANA micro-benchmark shows 5 times speed-up by parallel reading

PCle Flash Storage

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Summary

- Data-Driven Innovation
- Data-Centric ICT Platform
- Three Research Topics
  - Scalable Storage for High-Throughput Data
  - Shingled Erasure Coding for Fast Recovery from Multiple Disk Failures
  - Workload-Aware Flash Storage

Changes are needed towards a data-centric ICT platform