Future Dataflow-centric Computing for Streaming data from the Sky

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Abe Administration Statement  （安倍内閣宣言）

『世界最先端 IT 国家創造』宣言 – June, 2013

- Statement on “Forging the World-Leading IT Nation”

Basic Philosophy  （基本理念）

- Japan in Need of Revitalization  （閉塞打破、再生日本）
- Toward the Achievement of the World-Class IT-Driven Society  （世界最高水準IT利活用）
Abe Administration Statement （安倍内閣宣言）

Our Goals for the Future Society to create:

1. A society that enhances the creation of innovative technologies and new services and the growth of their providers
   • 増強革新的新産業・新服務的創作&全產業成長促進社會

2. The most natural disaster-proof society in the world, in order to ensure a safe and healthy lifestyle
   • 健康/安心/快適生活 & 社会抗災能力/安全的世界

3. A society which guarantees that public services are available on a “one-stop” basis for anyone, anytime and any where
Efforts to Make to Fulfill the Goals

1. Creation of innovative technologies…
   a. Promotion to make the best use of both Open data and Big data
      • *Open data* for public, *Big data* for commercial use

2. The most natural disaster-proof society in the world to ensure a safe and healthy lifestyle
   a. Realization of a healthy and long-lived society through appropriate community-based health care, nursing-care support, and health promotion
      • Health monitoring (human and social infrastructure)

3. One-stop public services
   a. Innovation of the government information system across both local and national government
      • “Cloud First” Concept for the system cost reduction
Objectives of the GEO Grid (since 2005)

Help Geo-* scientists to understand

- Global warming, inventory of carbon dioxide
  - Kyoto protocol, environmental burden
- Alternate energy
  - Biomass
  - Wind-power generator network
- Harvest yield prediction/estimation
  - Weather, Soil, temperature, humidity, sunshine, etc.

Help decision makers to plan

- Hazard mitigation
  - Earthquake, Landslide, Flood, Volcano eruption, Tsunami
- Exploration of natural resources
  - Oil, natural gas, mineral

Unbeknown applications

- Games, Amusements, Personal geo-record/history, etc.
- Social science apps
A Workflow example
“Disaster prevention and mitigation (Landslide)”

Geology map (GSJ)

Rain fall (AMEDAS/Fieldserver)

Early warning system based on Susceptibility map

High resolution DEM provided from ASTER

Large scale Computer simulation using actual landslide DB
ASTER hot spot detection system
Wildfire in Russia

Volcano on Nishinoshima island
GEO Grid for Disaster Response
The tsunami reached a very deep part of the bay and changed the shape of the coastline.
Example: Change Detection Application of GEO Grid

1. Metadata Search (OGC CS-W) for a specific area
2. Data Acquisition (OGC WMS) for 2 satellite images
3. Position/Color Fitting of satellite images
4. Change Detection

Workflow constructed with Lavatube

Construction of Temporal Residential Space on High ground area
3.11 Damaged Area (Rikuzen-takada City)
Reconstruction of Breakwater
Lavatube for spacio-temporal data and image/movie processing

1. Support rest-based OGC (OpenGeospatial Consortium) services
2. Support various image/movie processing modules
3. Provide High-Level interaction

Workflow Engine

Browser Interface(HTML5) or Windows engine

Workflow Parts

OGC Services
- Metadata Search
- Database Access
- Processing

Satellite

Sensor/Camera
New Data Sources!

- **Landsat-8** (by USGS)
  - Latest earth observation satellite launched 2013.
  - 15m/Pan 30m/Color
  - 16 days cycle for the same area
  - Free and Open!

- AIST set up the ground station for Landsat-8 (with Tokai-U)
  - Daily data directly from the satellite
  - Upload the images in the Internet < 2hr
  - Thanks to HPC (c.f. 1 day in USGS)
Game Changers: simple sat – low orbit – high resolution

http://dib.joanneum.ac.at/edtr/satsys0.gif

https://www.planet.com/gallery/images/dulles-international-airport.jpg

http://www.firstimagery.skybox.com/2014/7/10/port-au-prince-haiti

https://www.planet.com/flock1/
Big Data Challenges

Unstructured Data (text, video, audio, sensor data)

Structured Data (well-defined, unchanging)

Batch Processing (e.g., Hadoop)

- Store & Compute
- Data Input
- Analyze “facts” of the past

Structured Data Warehouse

- Store & Query
- Discover “facts” from the past

Unstructured Data

- Stream Processing (e.g., CEP)
- No Store
- Data Input Stream
- Discover recent “facts”

Stream Data
Real-time Big Data Processing in 2020

More data will be processed to get better results

- **Video Monitoring**
  - # of cameras = 0. 1 M
  - Joining with Facial feature vector
    - 1 KB x 1 Billion (1 TB)

- **Smartphone GPS Data Analysis**
  - # of smartphones = 100M
  - Car / Train / Pedestrian Traffic analysis, Traffic jam prediction

- **Multi-modal Analysis**
  - Analyze Tweet stream with video stream
  - Analyze Tweet stream with smartphone stream
Issues in Current Systems

Required performance for future real-time big-data applications cannot be achieved

- Usually, independent OS runs at each server, and servers are coordinated by an upper layer middleware
  - Large overhead caused by unnecessary processing in OS
  - “OS jitter” degrades the system performance
- Data transfer and processing are not tightly coupled
  - Poor performance for communication intensive applications
  - Processing performance depends on cache memory. Data transfer to/from cache is a bottleneck.
System Image

DPC: Data Processing Component

DPF: Data Processing Function

DFOS: Data Flow Operating System

Warehouse scale infrastructure

DPF 1

DPC (spec.HW +mem)

DPC (spec.HW +mem)

DPC (GPU+ mem)

DPC (Processor)

DPC (Processor)

DPF 2

DFOS

DPF 3

(Data archive)
AIST has been investigating photonics technology for future data centers.

Wavelength Bank (WB: a centralized generator of wavelengths for DWDM) – light source

Silicon photonics are used for light wave processing at a node, enabling hybrid implementation with electronics

DWDM signals can be switched in one bundle by fiber cross-connect switches

50Gbps x 100 lambdas = 5Tbps/fiber
Data Flow OS

Logical planning and physical mapping of data flow

Resource monitor and management

Data Flow Application

DPF

DPF

DPF

Slice

DPCs

Slice provisioning/monitoring

Data flow planning

Resource Pool

DPCI

CPU

DPCI

GPU

DPCI

FPGA

Data Flow OS
### HP The Machine
- Announced on June 11
- Combines many kinds of specialized cores to tackle different tasks as best as possible
- Cores are connected with non-volatile memory components using photonic network
- New OS will be developed by simplifying Linux and reducing overhead

### Google Cloud Dataflow
- Announced on June 25
- New services that help developers build and optimize data pipelines
- A fully managed service for creating data pipelines that ingest, transform and analyze data in both batch and streaming modes
- Cloud Dataflow is a successor to MapReduce
Dataflow Supercomputer SIGMA-1 for scientific computation in 1988

- It worked!! With 128PE/SE
  - Peak 427MFlops
  - Measured 170MFlops
  - Cray X-MP
  - Processor, Network, OS, Language, Application
  - Dataflow-C
Summary

- The Big Data is drawing public attention.

**Big Data Example**

- Satellite Imagery Data is useful for planning disaster mitigation
- Changing the game will produce more applications

**Workflow/Schematic Editor** is useful for handling streaming data

- Image processing, change detection

**Real time big data processing platform**

- Data movement is a key challenge
- Photo networking – with less overhead
- Dataflow revisited
Thank CCSCD organizers for the kind invitation.