Advanced Academic Information Infrastructure Utilizing Clouds

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National Institute of Informatics (NII)

The National Institute of Informatics (NII) seeks to advance integrated research and development activities in information-related fields, including networking, software, and content. NII also promotes the creation of a state-of-the-art academic-information infrastructure.
Science Information Network (SINET)

- SINET is a Japanese academic backbone network for more than 800 universities and research institutions, and current version, SINET4, started its operation in 2011.
  - SINET4 covers all 47 prefectures.
  - SINET4 covers 100% of national, 71% of public, and 53% of private universities.

<table>
<thead>
<tr>
<th></th>
<th>National Universities</th>
<th>Public Universities</th>
<th>Private Universities</th>
<th>Junior Colleges</th>
<th>Colleges of Technology</th>
<th>Inter-Univ. Research Institutes</th>
<th>Others</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of Organizations</td>
<td>86</td>
<td>68</td>
<td>333</td>
<td>60</td>
<td>55</td>
<td>16</td>
<td>184</td>
<td>802</td>
</tr>
</tbody>
</table>

(As of March 2014)
New Directions for SINET5

Collaboration and Promotion in Research and Education

Resource & Service
- Promotion of academic information circulation and open access
- Collaborative promotion of institutional repository expansion

Cloud
- Enhancement of R&E environment by tailored cloud services

Security and ID federation
- Raise of security level for SINET users
- Collaborative enhancement of authentication

Network
- Nationwide 100-Gbps backbone network and scalable network expansion
- 100-Gbps international lines to USA, Europe, and Asia
- Introduction of new technologies such as SDN in response to user needs

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Outline

Building advanced academic information infrastructure utilizing clouds

- Cloud Computing
- Academic Use Cases
- Inter-Cloud
Cloud Computing
Definition of Cloud Computing

Cloud computing is a model for enabling ubiquitous, convenient, on-demand self-service network access to a shared pool of configurable computing resources (e.g., networks, servers, storage, applications, and services) that can be rapidly provisioned and released with minimal management effort or service provider interaction.

Essential Characteristics:
✓ on-demand self-service
✓ broad network access
✓ resource pooling
✓ rabid elasticity
✓ measured service

"NIST Special Publication 800-145"
A user (personnel or enterprise) buys computers and setup hardware/software in the user site.

- **User’s payments**
  - Buying/maintaining a (powerful) computer
  - Buying software licenses

- **User’s operations**
  - Installing OS
  - Installing applications
  - Running applications
  - Updating OS/applications

**Personal user**

**Enterprise user**

- **User’s payments**
  - Employing operators
Cloud computing offers computing environment (or “cloud”) that allow a user to run applications on demand.
Datacenter

- A facility used to install/operate computer systems for computing and communication services
  - A collection of servers, storages, network switches and other associated components
  - Power supply and air conditioning
A virtual machine (fully) virtualizes a physical machine.

- **bare-metal (native) hypervisor**
  - guest OS
  - VM
  - hypervisor
  - hardware

- **hosted hypervisor**
  - guest OS
  - guest OS
  - VM
  - hypervisor
  - host OS
  - hardware

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A virtual machine can be migrated between physical computers.
Service Models

- **Software as a Service (SaaS)**
  - A service to offer applications running on servers in a cloud.
  - The user (= app user) can use applications offered by the provider running on the cloud.

- **Platform as a Service (PaaS)**
  - A service to offer a platform to build and run applications in a cloud.
  - The user (= app developer) can build and run their applications on the platform using tools offered by the provider.

- **Infrastructure as a Service (IaaS)**
  - A service to offer computing resources (e.g. computer, storage, network) in a cloud.
  - The user can deploy software (e.g. OS and application) on the resources.
Deployment Model

- **private cloud**
  - a cloud infrastructure provisioned for exclusive use by a single organization (e.g., a university and a company)

- **community cloud**
  - a cloud infrastructure provisioned for exclusive use by a specific community (e.g., a research community)

- **public cloud**
  - a cloud infrastructure provisioned for open use by the general public

- **hybrid cloud**
  - a cloud infrastructure composed of two or more distinct cloud infrastructure above.

"NIST Special Publication 800-145" Kento Aida, National Institute of Informatics/Tokyo Institute of Technology
Merits

- compared with on-premises…

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Academic Use Cases
Computers for Research

- simulation and analysis
- storage for data obtained by experiments/observation

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Computers for Education

- lectures and training
- learning management (LMS)
- course registration
- grades
Systems Move to Clouds

- **ICT**
  - email, web, CMS,…
- **education & library**
  - online lecture (MOOCs), LMS, …
  - course reg., grades, …
- **research**
  - computers, storage, …
- **enterprise**
  - accounting, personal management, …

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Example of Cloud Use in JP Universities

- **Hokkaido Univ.**
  - operates community cloud service (IaaS) for **research**

- **Shizuoka Univ.**
  - moved **enterprise/research** servers to private/public clouds.

- **Hiroshima Univ.**
  - defined a guideline to use cloud in a university
  - moved **enterprise** servers to public clouds
JAIRO Cloud

- NII operates hosting services (SaaS) for institutional repositories of universities/research institutes.
- JAIRO Cloud users expect to reduce IT costs for their institutional repositories.

Universities/research institutes store/manage contents on JAIRO Cloud. They do not need to install/operate servers (HW).

- 191 institutes use JAIRO Cloud and 63 institutes plan to use.
- More than 1.4M contents are available.

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http://www.nii.ac.jp/irp/repo/
Direct Connection to Cloud DC

- 11 service providers directly connect to SINET and offer cloud services.
- SINET users expect high-performance, secure, and inexpensive communication for cloud services.

Sapporo: 2, Tokyo: 6, Osaka: 3, Fukuoka: 2

<table>
<thead>
<tr>
<th>DC</th>
<th>ISP</th>
<th>Status</th>
</tr>
</thead>
<tbody>
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<tr>
<td>Osaka</td>
<td>NTT DATA</td>
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http://www.sinet.ad.jp/

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Cluster as a Service

physical clusters in labs

creating VLAN between the lab cluster and the NII cloud

cluster in Lab A

cluster in Lab B

NII research cloud

Object Store Service tinii

rent

return

rent

return

physical computer pool

rent/return physical computers from the pool

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Inter-Cloud
Future of Research and Education Infrastructure

- Tools and contents for research and education services move to clouds.
  - Advanced research and education infrastructure utilizing clouds

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Support for Cloud Use

- Support universities/research institutes in starting/using cloud services

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Inter-Cloud

InterCloud is a service-oriented architectural framework for cloud federation that supports utility-driven interconnection of clouds.

*Buyya, et.al., “Mastering Cloud Computing”, Morgan Kaufmann, 2013*

**Inter-Cloud Use Cases**
- Guaranteed end-to-end quality of service availability
- Enhanced convenience by service cooperation
- Service continuity
- Market transactions via brokers

"Use Cases and Functional Requirements for Inter-Cloud Computing", GICTF White Paper, 2010
Academic Inter-Cloud

- email, web, search engine
- computing service
- storage service

Public Clouds
SaaS, IaaS

- large-scale simulation
- big data analysis

HPC Clouds
supercomputers, storage

Universities
on-premise/private cloud

- research and education
- enterprise

Univ. A
on-premise/private cloud

- submitting large computing jobs
- offloading processes

- ID federation
- offloading processes

- offloading processes
- backup files/processes
How to Build Inter-Cloud?

A lot of configurations of resources and negotiations with administrators are needed!
- network configurations
- software deployment
- agreement on operational policies

We need a new service that configures inter-cloud instead of the user.
- easy to use
- on demand
- customized
Inter-Cloud Service (planned)

The inter-cloud service enables users to configure the customized inter-cloud environment, which comprises individual distributed cloud resources including related software and a virtual network to connect their resources, on demand.

hybrid cloud with multiple public clouds
secure and high-speed access to public clouds
resource federation among multiple institutes/clouds
accelerating research and education collaboration

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Virtual Cloud Provider

- software system (Software as a Service) to configure user-customized inter-cloud environment on demand

on-demand inter-cloud configuration
✓ creation of virtual network connecting multiple clouds
✓ deployment of software environments over multiple clouds
Overlay Cloud

Applications

virtual cloud provider

Cluster

L2Tunnels

BM

VM

Cluster

Flynn

L2Tunnels

BM

VM

Cluster

L2Tunnels

BM

VM

Real Cloud Provider

Gunnii

Real Cloud Provider

Real Cloud Provider

Real Cloud Provider

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Networking

How do we configure end-to-end virtual network?

We use the SINET5 L2VPLS service (planned) and more techniques to configure virtual network beyond domains.

SINET5 enables the user to configure L2VPLS on demand.

bridge/transit/… over domains

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Software Deployment

How do we deploy software environment (OS and app)?

We use Linux Container (LXC).

A container isolates user space of operating system.

- Docker Engine
- Docker Hub

https://www.docker.com

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Authentication

How do we authenticate users on multiple clouds?

We use ID federation with Shibboleth.

Shibboleth enables user authentication on SP using ID managed in the user's home institution.
The user runs a workflow to analyze big data in DB utilizing clouds and supercomputers.
Backup Site on Cloud

original site

backup

container

virtual network

backup site (cloud)

Proxy

container

container

service admin.

virtual cloud provider

switch

DNS

user

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Backup Site on Public Cloud

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Summary

- Tools and contents for research and education services start to move to clouds.

- NII supports universities/research institutes in starting/using cloud services to build advanced academic information infrastructure.

- Inter-Cloud is one of technologies to build advanced academic information infrastructure by utilizing cloud federation.