Context-aware cloud computing for HEP applications

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Context-aware systems in mobile communication

How can we use the information (context) of a user to their benefit?

Location
Direction
Time
Health
Social
The information can meet on-demand request or be proactively sent to the user

- Directions
- Food and lodging
- Financial
- Commercial
- Health
**Entity**
A person, place, or object that is relevant to their interaction

**Context**
Information used to characterize the situation of an entity

**Context-broker**
Combines real-time context

**Action**
Context-trigger action
Entity

Context

Context-broker

Content-aggregator

Store historical context that can be used by the context-broker to initiate an action

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**Entity**
ISGC Physicist

**Context**
Hungry
Dinner time
Central Taipei

**Action**
List of restaurants
Entity
ISGC Physicist

Context
Hungry
Dinner time
Central Taipei

Context-broker

Action
List of fast food

Content-aggregator
Graduate student
Can a context-aware design make it easier, more efficient to run HEP applications?

Utilize dynamic and opportunistic resources
Automatically self-configure clouds and virtual machines
Locate optimal software caches and data repositories
Fault-detection and error correction
Intelligent design and self-learning
Cloud computing in HEP is typically providing 5-20% of the processing of current projects.

**Dedicated**

"Dedicated" clouds
(Owned by HEP)

**Opportunistic**

"Opportunistic" clouds
(private and commercial)
HEP use of clouds for batch workloads

A “VM life-cycle manager” manages VMs based on the job queue.

Cloud has no application-specific requirements.
Multiple remote clouds

User or work load manager

Job Scheduler

VM life-cycle manager

IaaS API

IaaS API

IaaS API

Workload manager has no knowledge of the resources
Distributed batch cloud system

Dedicated and opportunistic resources (ATLAS and BelleII)

17% of BelleII computing in 2015 used clouds

Production use of clouds for 3-4 years with gradual increase in utilization
Technology is still young and rapidly evolving
Integrating new technologies into a production system is challenging
Evolution to a context-aware architecture

**Goal is a system that is dynamic, automated, intelligent, error-correcting and able to exploit any cloud willing to provide resources**

- **Context broker**
  - Batch job VM provisioning services
  - Software caches and repositories
  - Data federation services
  - Monitoring and communication services
  - Other services

**Context information system(s) keeping track of real-time information**
State of clouds, services, squid-caches, data federations

**Use the context information to configure, operate and monitor**
- Identify and monitor clouds – match jobs to resources
- VMs self configure and monitor, locate the software and data
- Recognize changes and errors – take corrective actions
Context-collection

We already collect data and logs on services, clouds, user job, VMs

Real-time (message passing) communication between some services

For example, monitoring page for one of the ATLAS cloud systems in Canada

#active clouds
#jobs (1c/8C)
#VMs
#job slots
VM provisioning

Job Scheduler

User job requirements
Job list
Resource availability

VM provisioning service
CloudScheduler

Entity

Context

Context-broker
VM provisioning

Job Scheduler

VM provisioning service
CloudScheduler

Entity
Action
Context-broker

Finds the cloud that has idle resources and meets the user requirements

Cloud-B boots a VM for the user job and registers with JS

JS sends job to VM
Software delivery service

**Entity**
- CVMFS Server
- CERN VM file system
- Squid HTTP cache

**Context**
- List of squids
- Location
- Load
- Virtual machine location

**Context-broker**

**Shoal**
A group of squids

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VM is given the nearest HTTP Squid cache (OS and App software).

Shoal
A group of squids

CVMFS Server
CERN VM file system

Squid HTTP cache

Context-broker

Entity

Action
Real-time Cloud and VM status

We would like real-time monitoring information of the remote cloud and individual VM

Automated fault-recovery response

Common issues:
Periodically a cloud goes offline
Application job is stalled
VM is stalled – not responsive to the VM-provision service
VM is lost – not registered with the VM-provision service
Local network issues in the cloud
VM evictions due to price fluctuations in commercial costs

Possible actions:
Cloud is automatically disabled
VM de-registered from HTCondor
Data federation service

- Storage element
- Data federation service
- Request for data set

Network Location Data

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Data federation service

List of locations
Retrieve from one site or stream from multiple sites

Data federation service

Storage element
Data federation service

Multiple copies distributed around the world

HEP-specific: FAX
HTTP/WebDav: Dynafed
Typically cloud resources in OpenStack are assigned to projects using “tenants”

Efforts to share resources between tenants in an automated manner to fully utilize the resources (e.g. sharing of ATLAS and BelleII resources)

Connect cloud resources to the LHCONE network? (e.g. Software defined networks – SDN)

Commercial cloud links to research networks
Summary

• Use of cloud computing in HEP is growing
  – Using dedicated and opportunistic resources to provide an increasing fraction of the needs of HEP experiments

• Context-aware cloud computing will enable us to scale our use of distributed resources that is required by HEP projects
  – Utilize technologies developed inside and outside HEP to simplify management, expand functionality and ease of use

• Valuable to other research communities