Adaptive Management in Extended Clouds

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Cloud Landscape

- **SaaS Management**
  - Salesforce, Google, IBM

- **PaaS Management**
  - Google, IBM

- **IaaS Management**
  - Amazon, IBM

Software as-a-Service

- **End Users**
  - Marketing Analytics
  - CRM

- **Vertical**
  - Document Management

- **collaboration**
  - Retail & E-commerce

- **Finance & Accounting**

- **Business Intelligence**

- **Infrastructure as-a-Service**
  - Amazon, Google, IBM

- **Developers & IT**

*Download a digital copy or nominate your company: bvp.com/cloud*
Hybrid Clouds

- **Private cloud**
  - Limited capacity
  - Low latency
  - Privacy

- **Public cloud**
  - High capacity
  - Low cost
  - Lack of privacy
  - High latency

We are interested in applications that run/migrate seamlessly across private and public cloud.
Use Case 1: Disaster Mitigation

NYC Data Centers Struggle to Recover After Sandy

by Mark Hachman | October 31, 2012

A number of facilities in lower Manhattan are racing to pump out flooded facilities to keep services up and running. Here’s an update.

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Use Case 2: Cloud Bursting

- **Problem**
  - Applications run in private clouds
  - Few weeks/months a year, e-commerce applications experience high demand (think Black Friday in US, Boxing Day in Canada, etc.)
  - Private clouds cannot handle the demand

- **Solution**
  - Applications “burst” into public clouds during peak intervals
    - Applications are monitored
    - When performance degrades, components of the applications are migrated/instantiated in public clouds
    - Applications are scaled out in public cloud
    - Then they are scaled in back in private clouds, when the peak load is gone
Challenges

- Not all parts of the application can be deployed in public clouds, due to
  - Privacy
  - Regulation concerns

- Need to partition the code into public and private portions

- Private data cannot be moved/accessed from public cloud unless it is anonymized

- What about the network, do we have any control?
A Canadian NSERC Strategic Network

8 universities, 15 companies, over 50 graduate students

Several research themes

- Future Internet Applications
- Adaptive Management of Applications
- Network Management
- Integrated Wireless/Optical Access
- Experimental Testbed
SAVI Goals

- Explore two tier clouds
  - *Edge*: low latency and high bandwidth; limited storage and computing
  - *Core*: infinite storage and computing capacity
- Integrated end to end adaptation (from wireless access to core cloud)
- Enable smart application development and deployment
  - Smart apps: sense the environment, analyze, predict and optimize their execution
SAVI Cloud: Software Defined Infrastructures (SDI)

• In SAVI, the network and the cloud converge, each cloud edge is both a cloud and a router (OpenStack and OpenFlow)

> Install the software I want throughout my network slice (into firewalls, routers, clouds, …)

And keep my slice isolated from your slice, so we don’t interfere with each other
Use Cases for SAVI Clouds

- **Flash Crowds supporting applications**
  - 50000 people in a stadium/main square/emergency
  - 10000 people streaming video from mobiles

- **Sudden surge in demand for bandwidth, computation, storage**

- **Apps are “Smart” (Instrumented, Interconnected, Intelligent)**
  - Monitor, Analyze, Plan and Execute loops
  - Provision/unprovision network, computing, storage
Challenges

- Need to partition the code into edge and core portions (performance driven)
- Integrate different adaptation layers
  - Application
  - Platform
  - Network
- Geographical location of servers and clients need to be considered
Summary so far…

- **Extended Clouds**
  - Have two tiers
    - Private-public for hybrid clouds
    - Edge-core for SAVI clouds
  - Network is programmable and part of the cloud
  - Expose many control actuators
    - E.g. application specific parameters, placement of application components, middleware parameters, network (flows and bandwidth), platform (VM migration, size), storage size and speed
  - Applications need to
    - maintain SLOs (e.g. Response_time < 100ms)
    - subject to constraints: cost, surging workloads, cloud topology, etc..
    - using an adaptive architecture (see next slide)
Extended Cloud Application Management Platform (XCAMP)

- **Controllers**
  - Model Predictive Optimization
  - Rules
  - PID

- **Prediction Models**
  - Queuing
  - Regression
  - Simulation

- **Filters** (Kalman particles)

- **Monitoring Application** (MISURE)

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- **Sensors**

- **Pattern Deployment Service** (PDS)

- **Application(s)**

- **Extended Cloud**

- **Reactive** (black arrows): reacts to current load; implements simple controls (PID = proportional, integrative, derivative); fast but imprecise

- **Predictive** (red arrows): anticipates future load, performance, cost
  - Uses prediction models, filters and predictive optimization. It is slow and effortful but efficient
Parameter Estimation and Tracking

Parameter estimator (Kalman filter): a feedback based system, based on past and current data from the system
Continuously updates the parameters:
- compares the measured and estimated performance metrics (e)
- adjusts the parameter (state) of the model such that \( e \approx 0 \).
Kalman estimators used in radar/missile tracking, autopilot, computer vision, etc.
Model + Estimator: Accuracy

- Measured: servlet response times and CPU utilizations on both tiers, throughput
- Estimated: transaction demands at each tier, no of invocations
Managing Web Applications Deployed SAVI Cloud

Cost and performance

SLO: response time <1500ms
...

As workload changes
...

VM are added and removed

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Cloud Bursting with XCAMP: Results

Private cloud: York Univ (IBM Blade Centre running OpenStack)
Public cloud: Amazon
Bursting architecture: Monitor (Misure), Deployer (PDS), Controller(XCAMP)
Achieving Availability with XCAMP*

Zone B shuts down; zone A takes over

QEMU emulator version 0.14.1, TrueCrypt 7.1a, OpenVPN 2.2.0, OSSEC version 2.6, Ibcd version 3.30, Snort version 2.8.5.2, and both mod-security version 2.6.0 (using default/standard community rules) and mod-evasive version 1.10.1 for Apache.
Summary

- **Extended Clouds**
  - Have two (or more) tiers
    - Private-public for hybrid clouds
    - Edge-core for SAVI clouds
  - Network is integral part of the cloud

- **Expose many sensors and actuators**
  - E.g. application specific parameters, placement of application components, middleware parameters, network (flows and bandwidth), platform (VM migration, size), storage size and speed
  - Constraints: cloud topology, geographic distribution of clients and servers, cost, etc..

- **Multiple complementary feedback loops might be needed**

- **Predictive adaptation mitigates delays and long term goals such as cost and revenue**
  - Performance models
  - Filters (Kalman, particle)
  - Model Predictive Optimization
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2013 IEEE TCSE - Vote by September 15

http://www.cs-tcse.org/

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