YORK UNIVERSITÉ UNIVERSITY

ASRL
Adaptive Systems Research Lab

Adaptive Management in Extended Clouds

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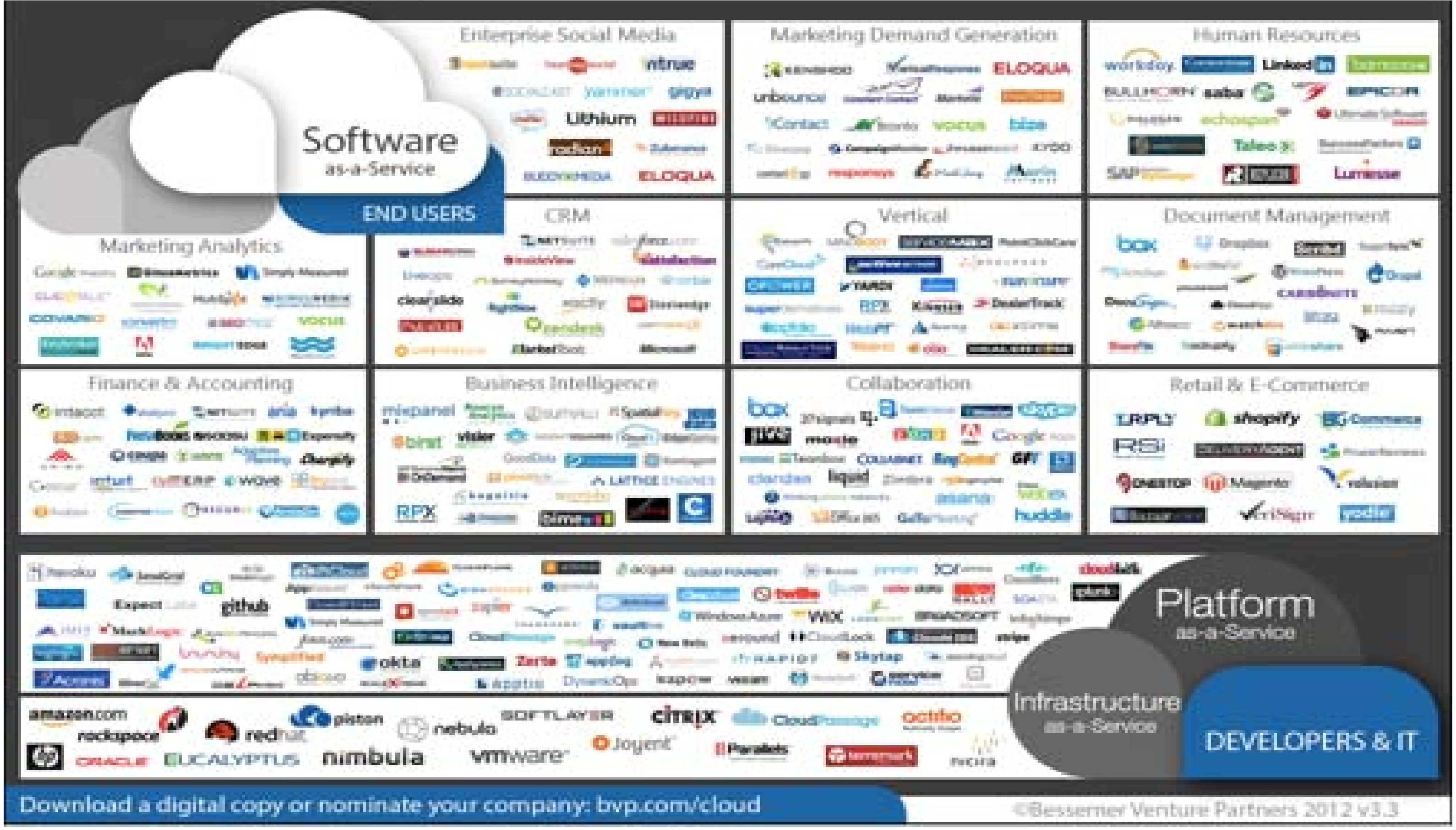
Content

- **Extended Clouds**
  - Hybrid Clouds
  - SAVI Cloud
- **Extended Clouds Adaptive Management Platform**
- **Conclusions**

Cloud Landscape



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

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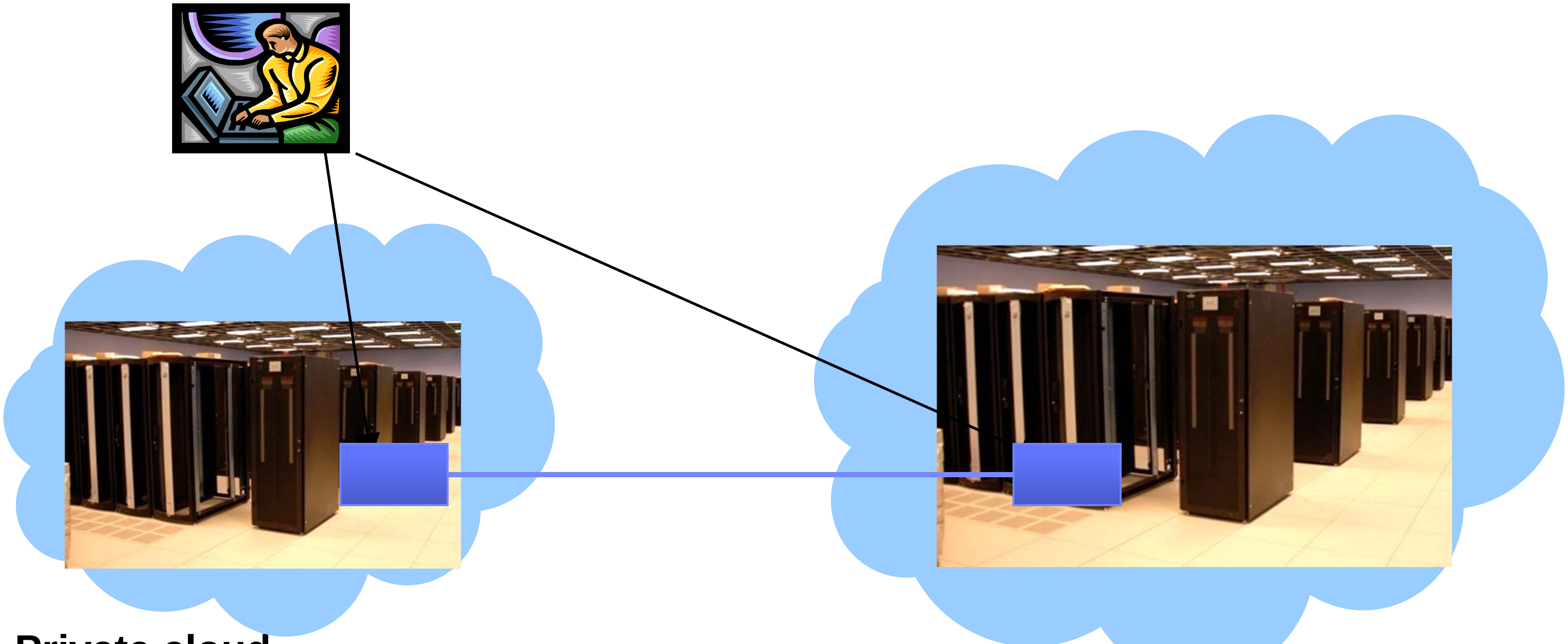
Hybrid Clouds

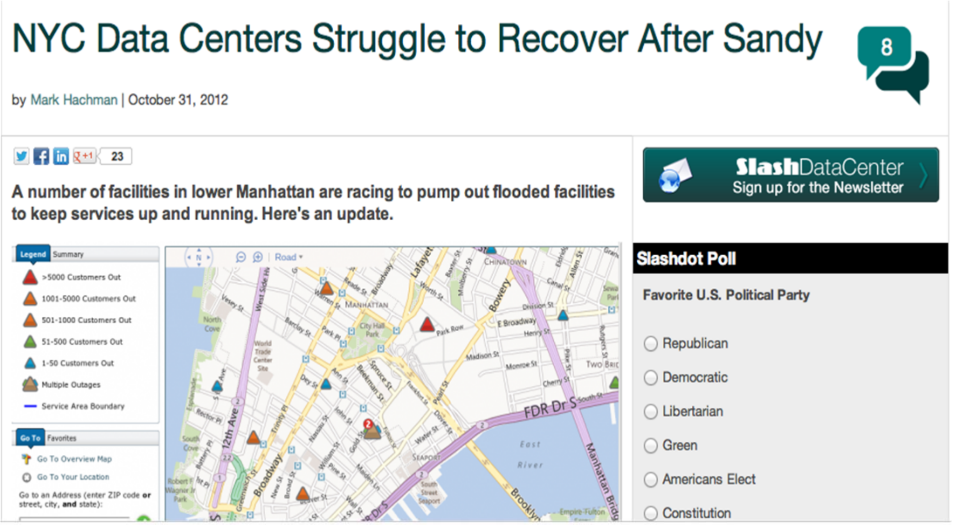


- **Private cloud**
  - Limited capacity
  - Low latency
  - Privacy

- **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

8

by Mark Hachman | October 31, 2012

23

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

Legend Summary

- 🔺 >5000 Customers Out
- 🔺 1001-5000 Customers Out
- 🔺 501-1000 Customers Out
- 🔺 51-500 Customers Out
- 🔺 1-50 Customers Out
- Multiple Outages
- — Service Area Boundary

Go To Favorites

- Go To Overview Map
- Go To Your Location

Go to an Address (enter ZIP code **or** street, city, **and** state):

SlashDataCenter
Sign up for the Newsletter

Slashdot Poll

Favorite U.S. Political Party

○ Republican
○ Democratic
○ Libertarian
○ Green
○ Americans Elect
○ Constitution

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

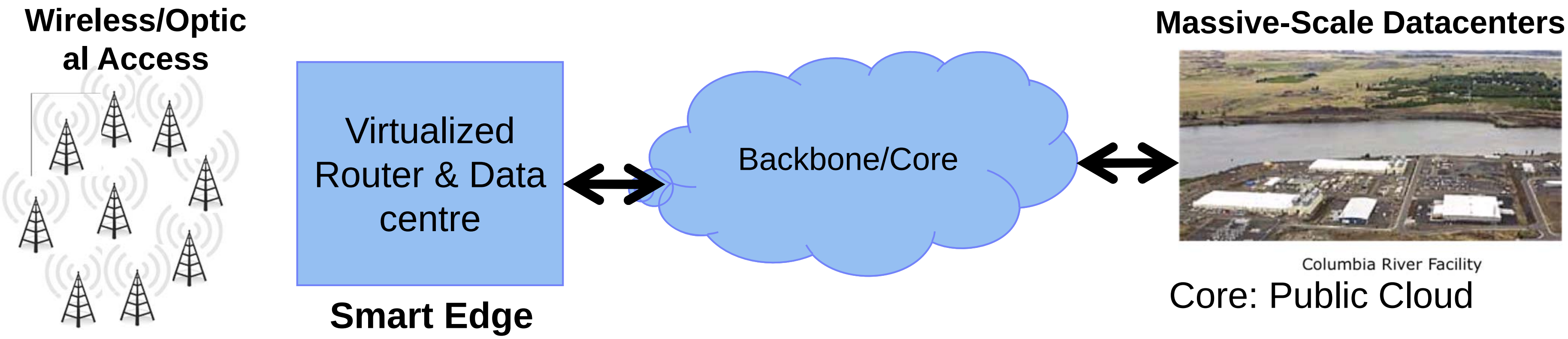
- **Not all parts of the application can be deployed in public clouds, due to**
  - Privacy
  - Regulation concerns
- **Need to partition the code into public and private portions**
- **Private data cannot be moved/accessed from public cloud unless is annonymized**
- **What about the network, do we have any control?**

Smart Applications on Virtual Infrastructure (SAVI)

www.savinetwork.org

- **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



Wireless/Optical Access

Virtualized Router & Data centre

Smart Edge

Backbone/Core

Massive-Scale Datacenters

Columbia River Facility

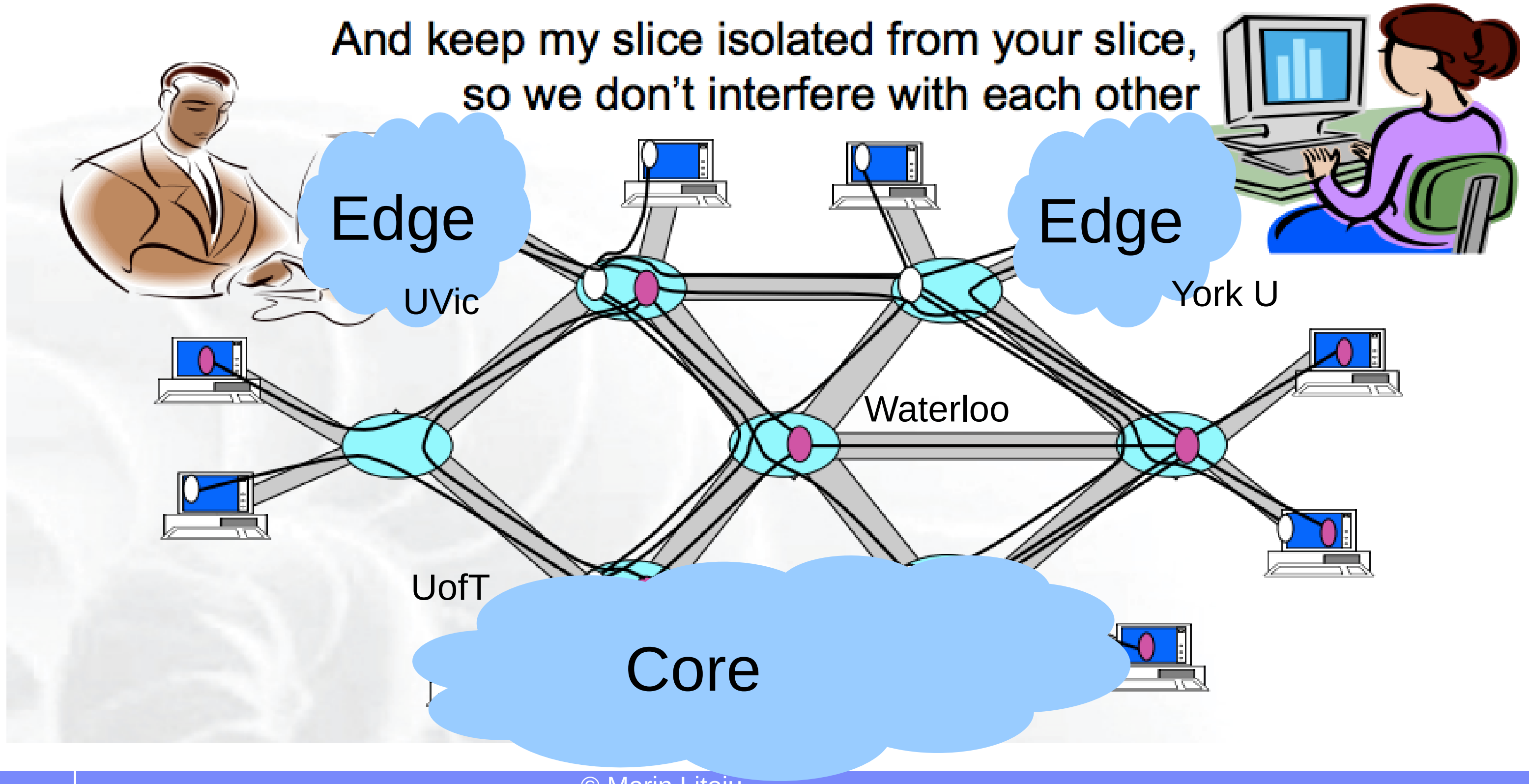
Core: Public Cloud

- 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)

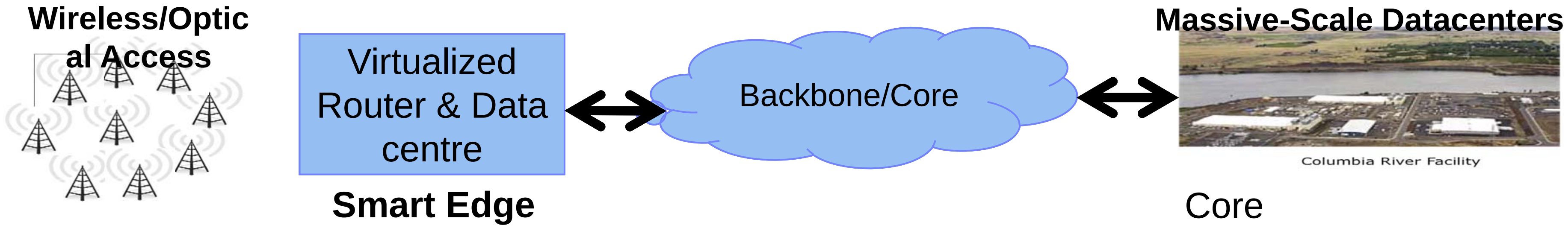
Install the software I want *throughout* my network slice (into firewalls, routers, clouds, …)



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



Wireless/Optical Access

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Core

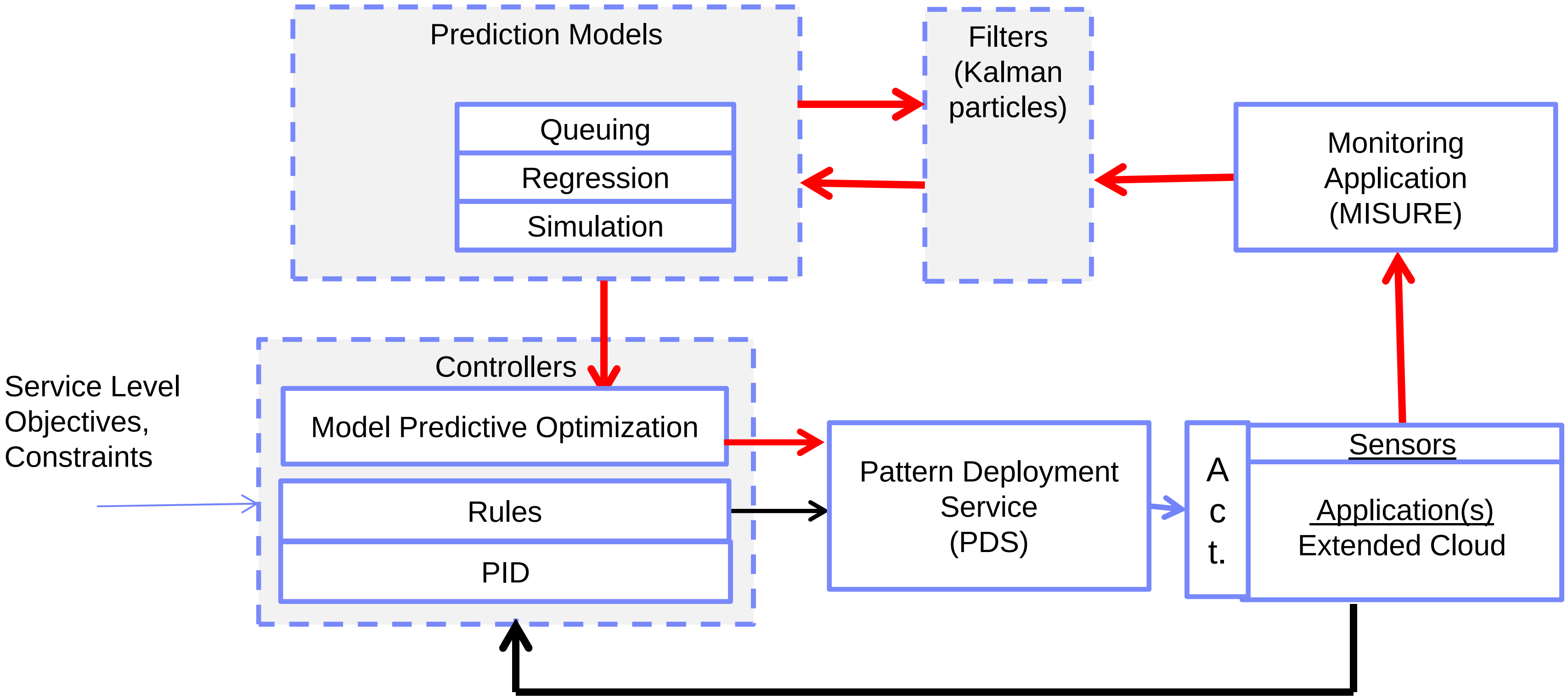
Challenges

- **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…

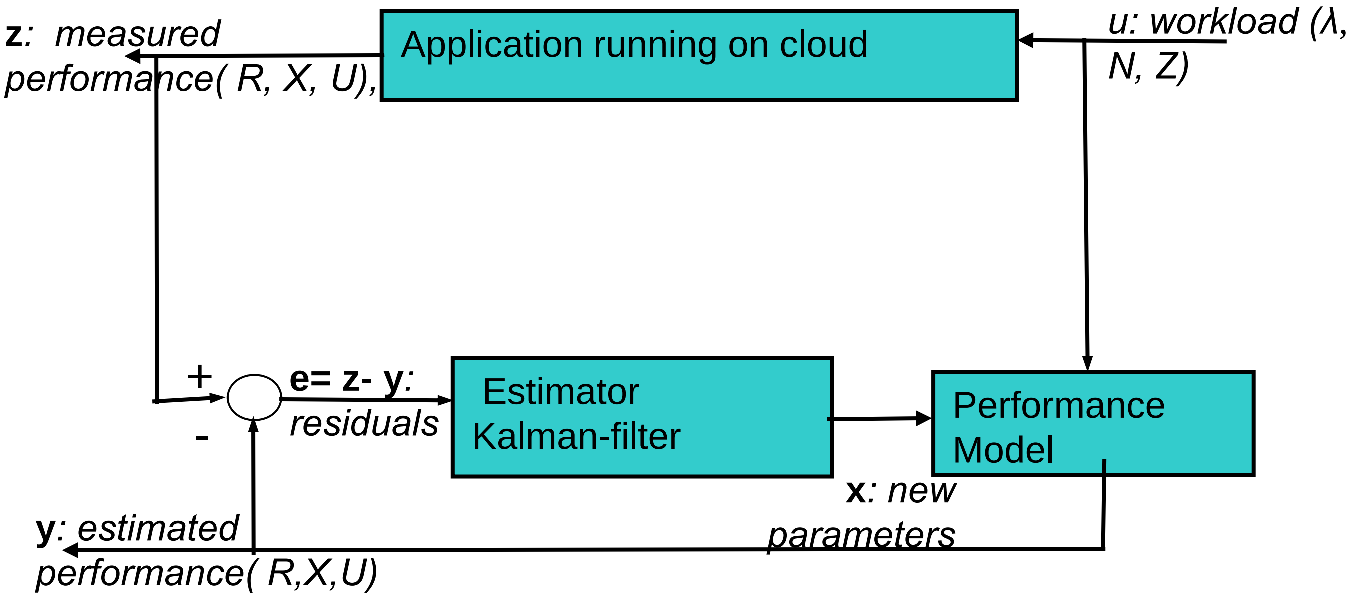
- **Extended Clouds**
  - Have two tiers
    - Private-public for hybrid clouds
    - Edge-core for SAVI clouds
  - Network is programmable and part of the cloud
  - Expose many control actuators
    - E.g. application specific parameters, placement of application components, middleware parameters, network (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)


Prediction Models
Queuing
Regression
Simulation
Filters (Kalman particles)
Monitoring Application (MISURE)
Service Level Objectives, Constraints
Controllers
Model Predictive Optimization
Rules
PID
Pattern Deployment Service (PDS)
A c t.
Sensors
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



z: *measured performance(R, X, U),*

Application running on cloud

u: workload (λ, N, Z)

+

-

e= z- y: *residuals*

Estimator Kalman-filter

Performance Model

x: *new parameters*

y: *estimated performance(R,X,U)*

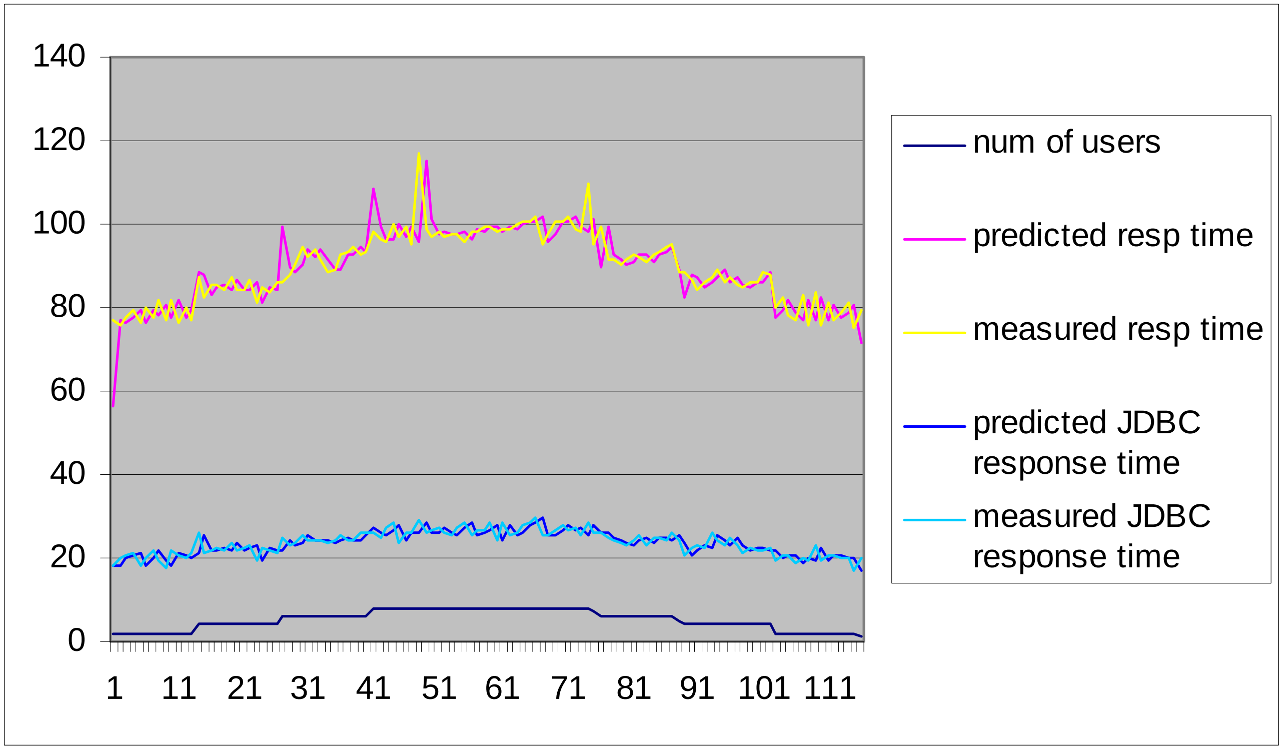
Parameter estimator (Kalman filter): a feedback based system, based on past and current data from the system

Continuously updates the parameters:

- compares the measured and estimated performance metrics (e)
- adjusts the parameter (state) of the model such that e~0.

Kalman estimators used in radar/missile tracking, autopilot, computer vision,etc.

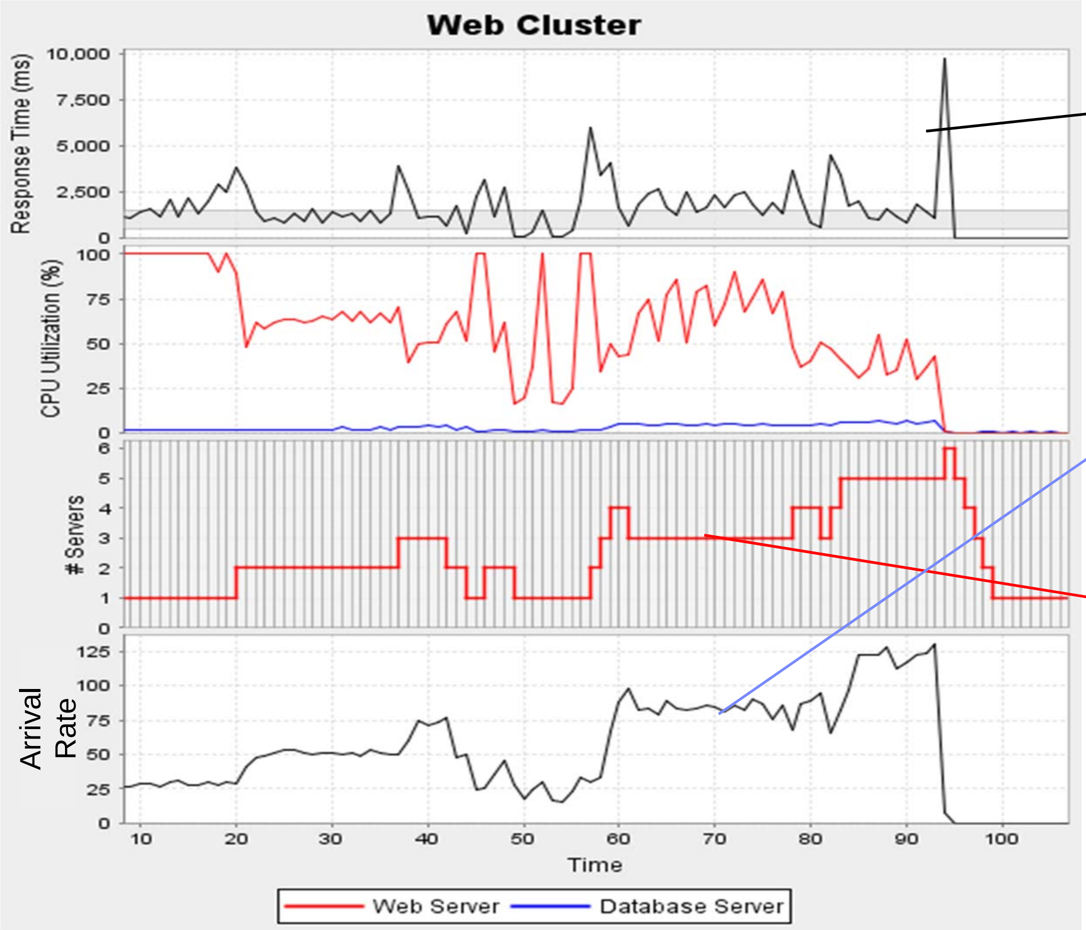
Model + Estimator: Accuracy



- 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

…

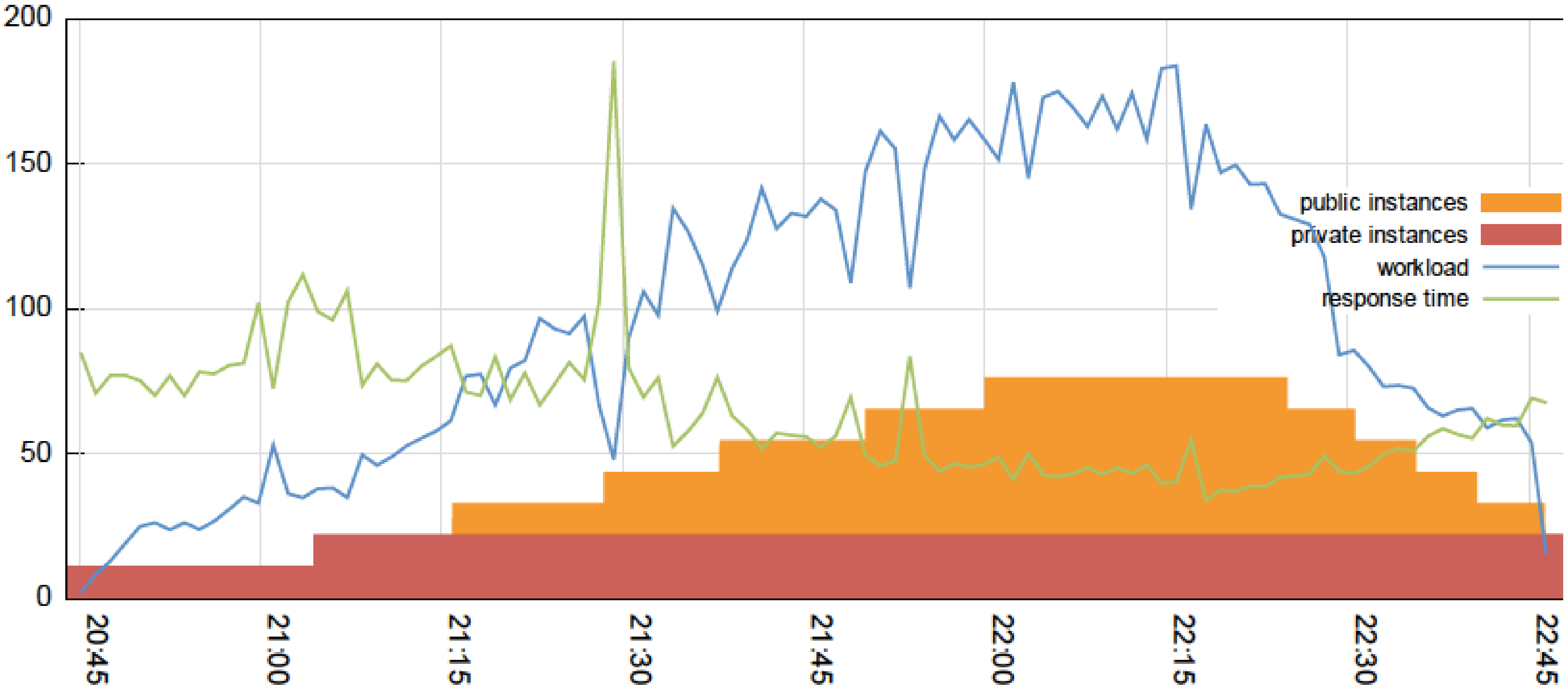
As workload changes

…

…

VM are added and removed

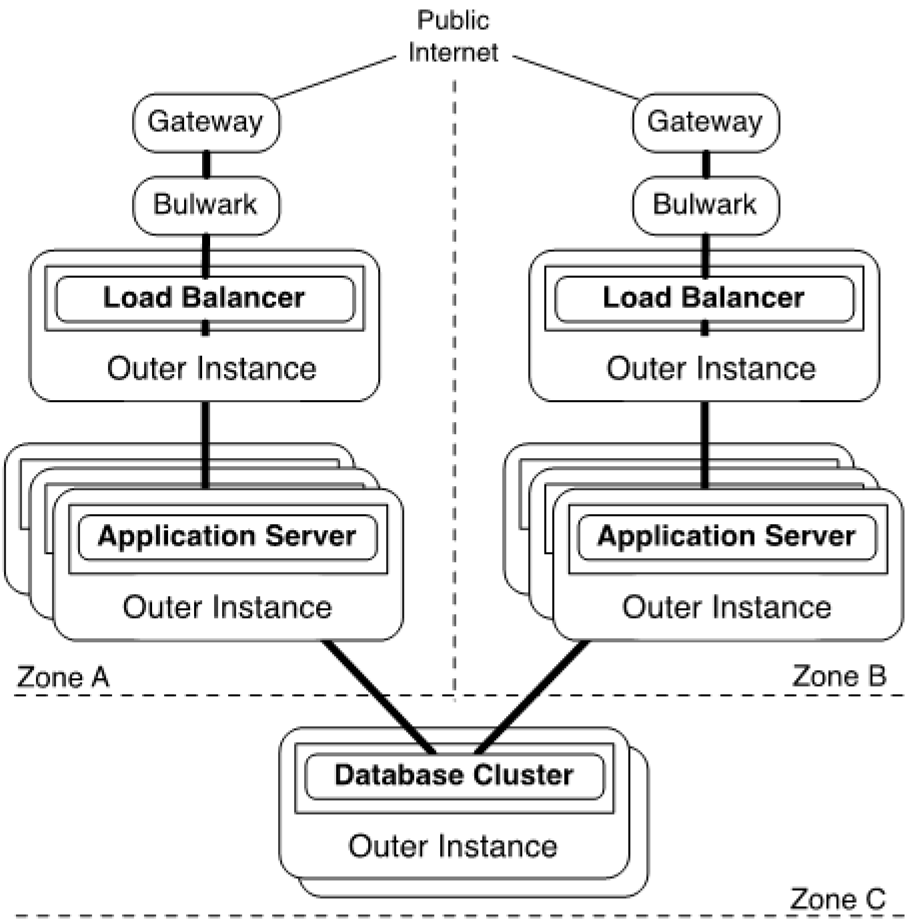
Cloud Bursting with XCAMP: Results

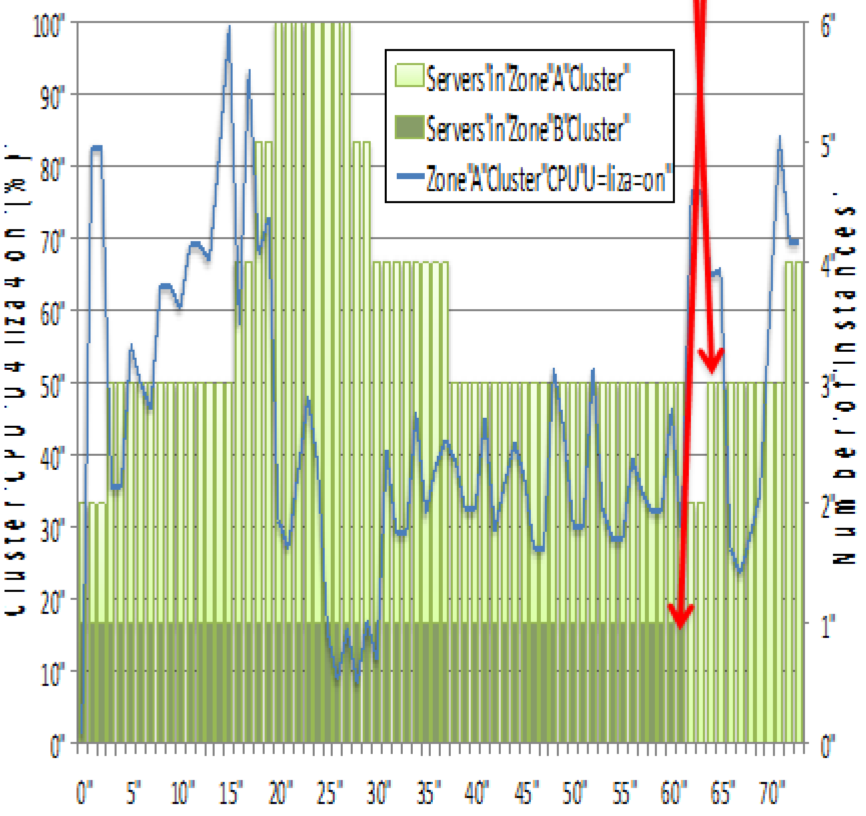


Private cloud: York Univ (IBM Blade Centre running OpenStack)
Public cloud: Amazon
Bursting architecture: Monitor (Misure), Deployer (PDS), Controller(XCAMP)

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, lbcd version 3.30, Snort version 2.8.5.2, and both mod-security version 2.6.0 (using default/s- tandard 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

Acknowledgements

- **ASRL Team**
  - Post Doctoral Fellows: Brad Simmons, Mike Smit , Mark Shtern
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IBM

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SAVI

amazon webservices

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Ontario Centres of Excellence

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