Dynamic Management and Provisioning of Software Defined Cloud Data Centers

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Agenda

• Dynamic Workloads in Cloud Data Centers
• Open Standards
  – OpenStack – what is it, how will it benefit us
  – OpenDaylight
• A Dynamic SDN-enabled Infrastructure
• What’s in store for the future of SDN?
• A New Approach for Developing Technology and Building Partnerships
• Questions/Discussion
Dynamic Workloads
in Cloud Data Centers
The IT Industry is in transition

Traditional environments can no longer support emerging business needs

Drivers

- New Workloads (Mobile, Social, Big Data)
- Need for Agility & Rapid App Deployment
- Cost Effective Scaling & Automation

Applications & Devices are independent
- Step-by-step, Manual Configuration
- Static Workloads, Inefficient, Add-ons

Service Chains & Software Patterns
- Apps Control Infrastructure thru Software Patterns
- Centralized, Programmable APIs Automated Configuration
- Dynamic, Workload Aware Virtual Appliances
- Efficient, Integrated Security & Analytics
Business needs are driving software defined cloud data centers

Business needs...

I need to reduce my facilities costs through a more efficient use of resources

Cloud computing

I need to keep up with the overwhelming volume, variety and velocity of data flooding the organization

Analytics and big data

I want to increase collaboration to drive productivity and innovation across the value chain

Mobile / social communications & video

Enterprise Connectivity implications...

- Connectivity rationalization
  - Changes in how IT systems are interconnected
- Energy Cost and environmental considerations
- Faster access to compute resources

- Intelligent management of infrastructure
  - Increased complexity of systems
- Increased data traffic and analytics
  - Compute and network scalability on demand

- Network scalability (TB → ZB)
- Increased connectivity requirements (Wireless & Mobile)
- Flexibility to adjust network connectivity on demand
- New resilience requirements
So what is a SDDC?

Image source: http://www.buraguy.com/wp-content/uploads/2013/05/EMC-Software-Defined-Data-Center-EMCBLUEPRINTS.jpg
Workload-Aware Elastic Orchestration & Optimization

Best practices are captured as software and infrastructure patterns

Patterns are used to describe both the software and infrastructure components, relationships, policies and services levels used to provision and manage resources for a business service.

Automation and optimization is a distributed and collaborative approach that is performed with the context of the workloads and business services.

Policies and service levels are derived from the business services and provided in the context of the resources being managed by each component in the system (software, server, storage, network).
Open Standards & Protocol Development
OpenDaylight – A Software Defined Network Controller

Open Daylight is an open source project under the Linux Foundation with the mutual goal of furthering SDN adoption and innovation through the creation of a common industry supported framework [www.opendaylight.org](http://www.opendaylight.org).

Eclipse Public License (EPL)

First Release announced Sept. 2013

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OpenStack Meets OpenDaylight

Enterprise Solutions
- Application Aware
- Cloud Orchestration
- Puppet, Chef

Deliver Optimization
- Live upgrades
- Security and authentication
- Membership services
- Globalization translation integration
- QA enhancements
- Support key middleware

Contribute Platform Support
- Automated service connectivity
- Open Daylight based SDN
- Server enablement
- Block storage enablement
- Cross platform test and assurance
OpenStack: Infrastructure as a Service

OpenStack is a global collaboration of developers & cloud computing technologists working to produce an ubiquitous Infrastructure as a Service (IaaS) open source cloud computing platform for public & private clouds.

![OpenStack Diagram]

Design Tenets…
- scalability and elasticity are our main goals
- share nothing, distribute everything (asynchronous and horizontally scalable)
- any feature that limits our main goals must be optional
- accept eventual consistency and use it where appropriate

Code available under Apache 2.0 license. Design tenets – scale & elasticity, share nothing & distribute everything

OpenStack is becoming the defacto-standard API for IaaS with a broad ecosystem being established…..
OpenStack is a global collaboration of developers & cloud computing technologists working to produce an ubiquitous Infrastructure as a Service (IaaS) open source cloud computing platform for public & private clouds.

OpenStack Compute (Nova)
Provision and manage large networks of virtual machines

OpenStack Object Store (Swift)
Create petabytes of secure, reliable storage using standard HW

OpenStack Dashboard (Horizon)
Enables administrators and users to access & provision cloud-based resources through a self-service portal.

OpenStack Image Service (Glance)
Catalog and manage massive libraries of server images

OpenStack Identity (Keystone)
Unified authentication across all OpenStack projects and integrates with existing authentication systems.

OpenStack Networking (Neutron)
Manage network connectivity for virtual machines

OpenStack Compute Storage (Cinder)
Managed persistent storage

OpenStack Compute (Nova)
Provision and manage large networks of virtual machines

OpenStack Object Store (Swift)
Create petabytes of secure, reliable storage using standard HW

Code available under Apache 2.0 license. Design tenets – scale & elasticity, share nothing & distribute everything
Dynamic Provisioning & Management of an SDN-enabled Infrastructure
Many Use Cases Benefit from SDN

- Bandwidth calendaring
- Cloud bursting & VM Migration
- Workload balancing & High Availability
- Secure multi-tenancy & DDos Prevention
First, let’s consider physical flow control

Let’s take a simple Ethernet Switch as an example...
OpenFlow Controller

OpenFlow Protocol (SSL/TCP)

Control Path  OpenFlow

Data Path (Hardware)
OpenFlow Example

OpenFlow Client

Flow Table

<table>
<thead>
<tr>
<th>MAC src</th>
<th>MAC dst</th>
<th>IP Src</th>
<th>IP Dst</th>
<th>TCP sport</th>
<th>TCP dport</th>
<th>Action</th>
</tr>
</thead>
<tbody>
<tr>
<td>*</td>
<td>*</td>
<td>*</td>
<td>5.6.7.8</td>
<td>*</td>
<td>*</td>
<td>port 1</td>
</tr>
</tbody>
</table>

PC

Controller

Software Layer

Hardware Layer

5.6.7.8

5.6.7.8

1.2.3.4

port 1

port 2

port 3

port 4

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# OpenFlow Basics

## Flow Table Entries

<table>
<thead>
<tr>
<th>“Match” Rule</th>
<th>Action</th>
<th>Stats</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Packet + byte counters</strong></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

1. Forward packet to zero or more ports
2. Encapsulate and forward to controller
3. Send to normal processing pipeline
4. Modify Fields
5. **Any extensions you add!**

<table>
<thead>
<tr>
<th>Switch Port</th>
<th>VLAN ID</th>
<th>VLAN pcp</th>
<th>MAC src</th>
<th>MAC dst</th>
<th>Eth type</th>
<th>IP Src</th>
<th>IP Dst</th>
<th>IP ToS</th>
<th>IP Prot</th>
<th>L4 sport</th>
<th>L4 dport</th>
</tr>
</thead>
</table>

+ mask what fields to match
### Examples

#### Packet Switching (bandwidth calendaring)

<table>
<thead>
<tr>
<th>Switch Port</th>
<th>MAC src</th>
<th>MAC dst</th>
<th>Eth type</th>
<th>VLAN ID</th>
<th>IP Src</th>
<th>IP Dst</th>
<th>IP Prot</th>
<th>TCP sport</th>
<th>TCP dport</th>
<th>Action</th>
</tr>
</thead>
<tbody>
<tr>
<td>*</td>
<td>*</td>
<td>00:1f:..</td>
<td>*</td>
<td>*</td>
<td>*</td>
<td>*</td>
<td>*</td>
<td>*</td>
<td>*</td>
<td>port6</td>
</tr>
</tbody>
</table>

#### Flow Switching (service chains, VM migration)

<table>
<thead>
<tr>
<th>Switch Port</th>
<th>MAC src</th>
<th>MAC dst</th>
<th>Eth type</th>
<th>VLAN ID</th>
<th>IP Src</th>
<th>IP Dst</th>
<th>IP Prot</th>
<th>TCP sport</th>
<th>TCP dport</th>
<th>Action</th>
</tr>
</thead>
<tbody>
<tr>
<td>port3</td>
<td>00:20..</td>
<td>00:1f..</td>
<td>0800</td>
<td>vlan1</td>
<td>1.2.3.4</td>
<td>5.6.7.8</td>
<td>4</td>
<td>17264</td>
<td>80</td>
<td>port6</td>
</tr>
</tbody>
</table>

#### Firewall (virtual network security)

<table>
<thead>
<tr>
<th>Switch Port</th>
<th>MAC src</th>
<th>MAC dst</th>
<th>Eth type</th>
<th>VLAN ID</th>
<th>IP Src</th>
<th>IP Dst</th>
<th>IP Prot</th>
<th>TCP sport</th>
<th>TCP dport</th>
<th>Action</th>
</tr>
</thead>
<tbody>
<tr>
<td>*</td>
<td>*</td>
<td>*</td>
<td>*</td>
<td>*</td>
<td>*</td>
<td>*</td>
<td>*</td>
<td>*</td>
<td>*</td>
<td>22</td>
</tr>
</tbody>
</table>
Centralized vs Distributed Control

Both models are possible with OpenFlow

**Centralized Control**
- Controller
  - OpenFlow Switch
    - OpenFlow Switch
    - OpenFlow Switch

**Distributed Control**
- Controller
  - OpenFlow Switch
    - OpenFlow Switch
    - OpenFlow Switch

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We can add virtual flow control with an overlay

**Postal service analogy**

- Look up **target** address through directory service
- US Postal Service delivers mail to target address
- Only target receives mail, scales to huge networks
- Also enhances Security

### Network Overlays (SDN VE, VXLAN, NSX)

- A service analogous to a DNS is maps “VM@ / Tenant” and “Physical server or Gateway”
- Physical fabric delivers packets to physical server address.
- Switches cache “VM@ / Tenant” to “Physical server or Gateway” DCS mappings
NFV (Network Functions Virtualization)

A network architecture that virtualizes physical appliances into virtual functions that can be chained together to create a service.

The relationship between NFV and SDN

**NFV** uses standard IT virtualization to consolidate network equipment onto industry standard high volume, availability, and reliability servers, switches, and storage. Saves energy, space, etc.

**SDN** separates the control and data planes of a network to create a centrally controlled, intelligent, agile, software network.
Orchestrating Applications in the Network
Network Agility

• How do we achieve this?
  – Create custom solutions to abstract the complexity and allow multiple layers of the stack be orchestrated

• How can we change today’s behavior?
  – Let the administrator and engineers work on more meaningful tasks other then repetitive tasks
    • Such as:
      – Reconfiguring a specific switch port for a different vlan
      – Modifying firewall rules an layers of firewalls

Getting life back for the Network Administrator

- Dynamically provisioned
- Scalable capacity
- Abstracted HW complexity
- Virtualized programmable Optical network (Bandwidth on Demand)
MARIST: SDN Innovation Lab - Dynamic Infrastructure Test Bed

OF Controller (VM)  OF Agent (VM)  VM Cluster

Datacenter A

Datacenter B  Storage  VM Cluster

dual 10G

dual 10G

Datacenter C  Storage

Metro Fiber Network
An OpenFlow Network Management Application
Avior - Overview

• Avior is an easy-to-use graphical application for network monitoring and testing.

• Avior talks directly to the SDN controller via REST.
  – Eliminates the need for programming or scripting in order to monitor or manipulate the network.

• Features
  ✓ Monitor Openflow network statistics in real time
  ✓ View live network topology
  ✓ Configure static network flows
  ✓ Administer firewall rules and other policies
  ✓ Mobile friendly design runs in any Web browser
What Problem Does Avior Address?
Avior – Overview of all switches
Avior – Hosts on the Network

**Hosts on the network (15)**

- 10.11.18.1
- 10.11.18.50
- 10.11.18.61
- 10.11.18.62
- 10.11.18.63
- 10.11.18.101
- 10.11.18.102
- 10.11.18.104
- 10.11.18.106

**IP Address:** 10.11.18.1
**Mac Address:** 28:00:da:3c:3c:60
**Attached to switch:** 00:01:34:40:b5:3c:18.00, on port 20
**Last Seen:** 9/11/2013 11:09:05 AM
Avior – Topology View
Avior – Static Flow Editor

BEFORE

AFTER
Avior – Firewall

• Enforces behavior with flows against proactive Firewall rules
  – Allow - Normal forwarding
  – Deny - Drop Flow (No action)
A Dynamic Provisioning Application
Marist SDN Innovation Lab: Application and UI

1. User (or automated tool) decides to modify network
2. Call ADVAlanche through Avior
3. User or automated trigger modifies transport network through ADVAlanche
4. Lambda provisioned
5. Complete application aware action

Top Image source: http://www.boomerangtv.co.uk/sites/www.boomerangtv.co.uk/files/imagecache/character_image/characters/flinstones-fred1.gif

Marist: SDN Innovation Lab -

- Overview
  - Graphical user interface to observe and provision optical links on the WAN
  - Web application design allows access from tablets, phones, and personal computers
  - User can interact with the optical network by drawing links between nodes
  - Current topology can be provisioned with one click
Orchestration in Action
Orchestration in Action - Completed
Pieces to the Puzzle

• Software
  – Avior – Opensource Openflow Management Application
  – ADVAlanche – Dynamic Optical Provisioning Application
  – Ganglia – Opensource Network Monitoring Application
  – VMware – Server Virtualization Hypervisor & Management

• Hardware
  – ADVA FSP 3000 – Agile Optical Networking Hardware (ROADM)
  – NEC & IBM OF Switches – Openflow Capable Switches
  – Physical x86 Servers
  – Storage Area Network
What’s in store for the future of SDN?
What does the Future hold for SDN?

• Predictive Analytics
A New Approach for Developing Technology and Building Partnerships

SDN Innovation Lab
New Technologies Require a New Approach: The Marist SDN/NFV Innovation Lab

Corporate Partners

- IBM
- ADVA
- NEC
- PLEXXI
- big switch networks
- ciena
- lightower

and others... that prefer to not be listed
Marist SDN Innovation Lab Academic Partners
What’s Next for Network Engineers?

The student story along with the Marist Philosophy
Thank you!!!

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ANY QUESTIONS?
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