

### Provisioning Software-defined IoT Cloud Systems

**Stefan Nastic** 

Distributed Systems Group, Vienna University of Technology http://infosys.tuwien.ac.at/research/viecom/SDIoTCloud

Advanced School on Service Oriented Computing July, 2014, Hersonissos, Crete, Greece





#### Introduction

## **Data Center**: Processing, Storage, Networking



**IoT devices**: Gateways, Sensors, Actuators







#### Introduction

# **Data Center**: Computing, Storage, Networking



**IoT devices**: Gateways, Sensors, Actuators



- Our aim is to:
  - Abstract IoT Cloud resources in a unified manner.
  - Enable development and operations processes for IoT Cloud applications.

In this talk we focus on provisioning





## Why IoT Cloud?

- Fleet-vehicles management
  - World-wide deployment
  - Different types of vehicles (on-board gateways)
  - Different environments
  - Various stakeholders
- Variety of required services
  - vehicle maintenance (fault history, battery health)
  - vehicle tracking (driving history, geo-fencing)
  - vehicle info (charging status, odometer)





## Why IoT Cloud?

- Fleet-vehicles management
  - World-wide deployment
  - Different types of vehicles (on-board gateways)
  - Different environments
  - Various stakeholders
- Variety of required services
  - vehicle maintenance (fault history, battery health)
  - vehicle tracking (driving history, geo-fencing)
  - vehicle info (charging status, odometer)
- How to connect all the vehicles?
- How to provide a global view on the fleet?
- Where to store the data?
- How to process the data/alarms in a timely manner?



### **Core principles**

 From physically isolated, rigid IoT infrastructure to virtualized, elastic IoT Cloud, by utilizing software-defined principles





### **Core principles**

- From physically isolated, rigid IoT infrastructure to virtualized, elastic IoT Cloud, by utilizing software-defined principles
- From task-specific solutions to fully-fledged IoT Cloud ecosystem and design/management processes, based on DevOps approach





#### Traditional Cloud vs. Software-defined IoT Cloud

- IoT Cloud has virtualization at its foundation, but
  - Unlike cloud computing IoT Cloud combines datacenter resources with IoT resources (sensory data, edge devices and actuators).
  - Unlike traditional cloud IoT Cloud has geographically distributed infrastructure and it is much larger in scale.
- IoT Cloud enables better resource utilization, but
  - New models are required.
  - Also some traditional models can be applied.





# IoT Cloud provisioning challenges

- Managing configurations IoT Cloud systems:
  - Geo-distributed systems (on-site presence?)
  - Very large number of devices
  - Heterogeneity of devices and platforms





# IoT Cloud provisioning challenges

- Managing configurations IoT Cloud systems:
  - Geo-distributed systems (on-site presence?)
  - Very large number of devices
  - Heterogeneity of devices and platforms
- Expressing complex relationships and delivering high-level functionality:
  - Diversity of stakeholders and requirements
  - Plethora of available functions (e.g., communication protocols)





#### Main aspects

- **Software-defined IoT Units** conceptual model to abstract IoT Cloud resources and capabilities
  - Main building blocks of Software-defined IoT Cloud Systems





#### Main aspects

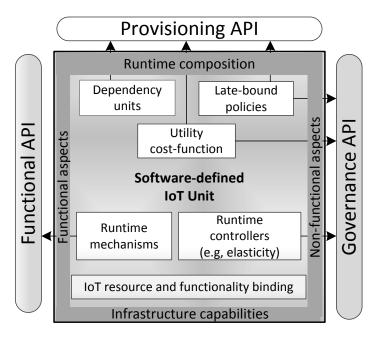
- **Software-defined IoT Units** conceptual model to abstract IoT Cloud resources and capabilities
  - Main building blocks of Software-defined IoT Cloud Systems
- Main mechanisms to support provisioning of Software-defined IoT Cloud systems:
  - Managed configuration models
  - Automated composition of IoT Units





### **Software-defined IoT units**

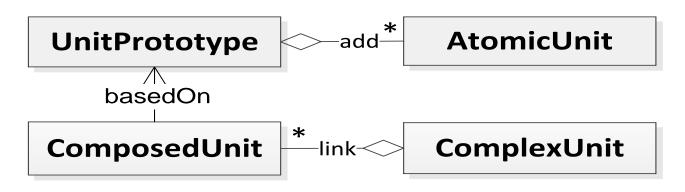
- Provide software-defined API which unifies the view on IoT Cloud resources and capabilities.
- Support fine-grained internal configurations.
- Have utility cost-function that enables pricing the IoT resources as utilities.
- Can be composed at higher levels, in order to provide complex functionality.







#### **Unit types**

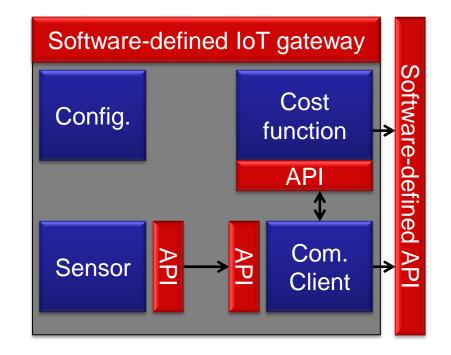


- AtomicUnits represent finest-grained IoT Cloud resources and capabilities (e.g., a communication protocol).
- Lower-level units can be interconnected into more complex (higher-level) units.
- UnitPrototypes can be based on VMs, Linux containers, IoC container, OSGi, etc.





# Example of software-defined loT gateway







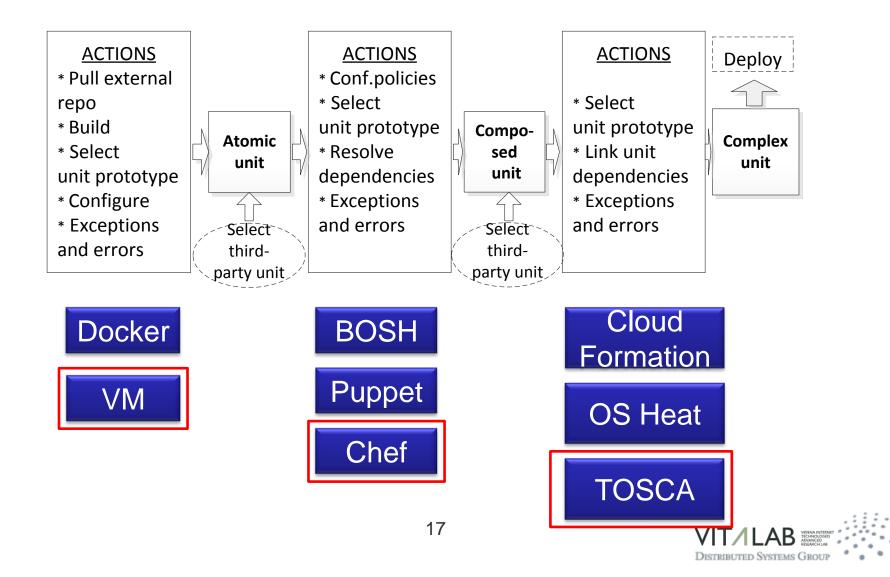
#### Provisioning software-defined IoT Cloud systems

- Managed configuration models:
  - We treat functional units and configuration policies in the same manner
  - They are managed centrally and propagated to the edge of the infrastructure automatically.
  - They support late runtime binding
  - Idempotence of configurations
- Automated composition and deployment of IoT units:
  - Provisioning single gateways
  - Provisioning complex elasticity-aware, reliable topologies of multiple gateways





#### Provisioning software-defined IoT Cloud systems





### DEMO:

# Provisioning a vehicle tracking application with SD IoT Units





#### Demo – part 1

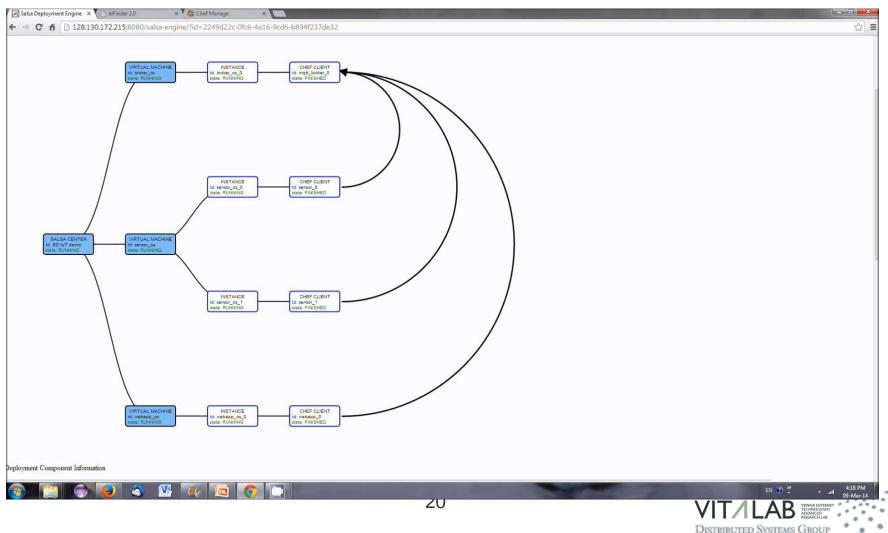
#### Provisioning and deploying virtual topologies atop OpenStack

<ul> <li>deFinder 2.0 × /  Satsa Deployment Engine ×</li> <li>→ C n □ 128.130.172.215:8080/salsa-engine/</li> </ul>	······································
	~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~
w deployment	
ca file: Choose File No file chosen	
sploy! Upload!	
t deployed services	
CTIONS	
) 📋 🍚 🥥 🐼 🔼 🔤 📝 🔯 🌅 🌑 😣 🗛 🖉	EN 🕐 🐔 🔺 3.03 P 09-Mar 109-Mar



#### Demo – part 2

#### Automated provisioning and configuring individual units





#### Demo – part 3

#### Vehicle tracking application

	Nodes Reports	s Policy Administ	tration			Feedback Organization	tuwien - Signed in as Stefan	Nastic 🕶 🛛 🔘 🗎
des	Showing All Nodes						Search Nodes	
lelete lanage Tags leset Key dit Run List dit Attributes	Node Name	Platform	FQDN	IP Address	Uptime	Last Check-In	Environment	Ac
	mqtt-sensor_1	ubuntu	server-924dc1d9-9476-4785-b1f2-0	10.99.0.98	2 hours	a few seconds ago	_default	
	mqtt-brocker	ubuntu	mqtt-brocker.novalocal	10.99.0.48	7 days	4 days ago	_default	
	mqtt-brocker1_0	ubuntu	server-d0095aed-dccf-4962-a18c-3	10.99.0.86	2 hours	a few seconds ago	_default	
	mqtt-sensor_0	ubuntu	server-aa61b7dd-d073-445d-8bc2-4	10.99.0.97	2 hours	a few seconds ago	_default	
	mqtt-webapp_0	ubuntu	server-c91824f4-a568-4c1a-ab04-6f	10.99.0.93	2 hours	a few seconds ago	_default	
	Node: mqtt-webapp	_0	ß		_			
	Node: mqtt-webapp Details	2_0 Attributes Permissio			_			
	Details Last Check In: 20 Min	Attributes Permissio			Environment: Platforms: FQDN: IP Address:	default • ubuntu server-c918244-a568-4c1a-ab04-6f64a4e542ac.novalocal 10.99.0.93	1	
	Details Last Check In: 20 Min	Attributes Permission	ons Uptime: 2 Hours		Platforms: FQDN:	ubuntu server-c91824f4-a568-4c1a-ab04-6f64a4e542ac.novalocal		
	Details Last Check In: 20 Min 2014-03	Attributes Permission	ons Uptime: 2 Hours	▲ ◆ Add	Platforms: FQDN: IP Address:	ubuntu server-c91824f4-a568-4c1a-ab04-6f64a4e542ac.novalocal	1	Ø Edt
	Details Last Check In: 20 Min 2014-03	Attributes Permissi nutes Ago 3-09 15:42:54 UTC	ons Uptime: 2 Hours	* Add	Platforms: FQDN: IP Address: Run List	ubuntu server-c91824f4-a568-4c1a-ab04-6f64a4e542ac.novalocal		CP Edit

DISTRIBUTED SYSTEMS GROUP



#### Coclusion

- Abstracting IoT Cloud resources in a unified manner.
- Fine-grained delivery and consumption of IoT Cloud resources and capabilities (e.g., to support crossdomain applications).
- Simplified provisioning and deploying complex software-defined IoT systems.
- Flexible customization of IoT units, to exactly meet required functional capabilities.
- Automation and managed configuration models.





#### Thank you for your attention!

Distributed Systems Group Institute of Information Systems Vienna University of Technology Austria

http://dsg.tuwien.ac.at/

