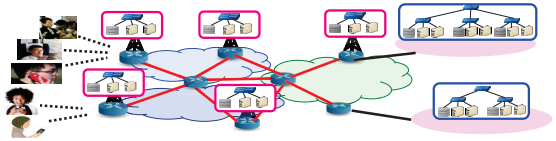
Seven Trends Leading to Opportunities in Multi-Cloud Global Application Delivery



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Keynote at 2016 International Conference on Communications, Image, and Signal Processing (CCISP), Dubai, November 19, 2016.

These slides and recording of this talk are available on-line at:
http://www.cse.wustl.edu/~jain/talks/ccisp16.htm
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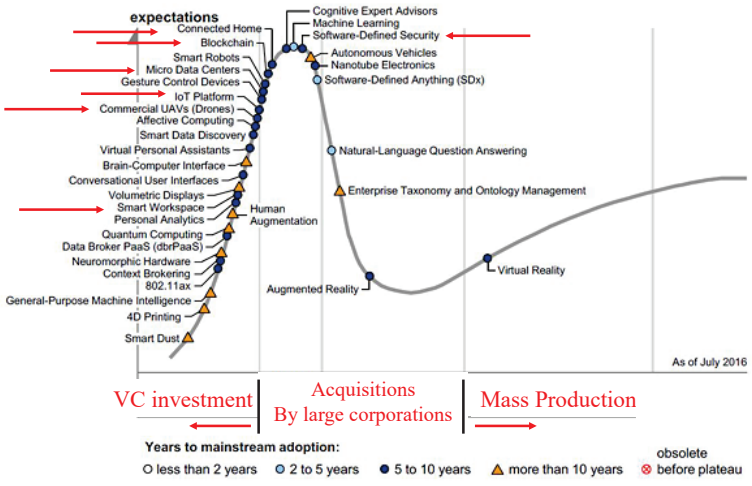
Overview

- Why Multi-Cloud?
  - 1: Micro-Cloud Computing
  - 2. Software Defined Networking (SDN)
  - 3. Smart Everything
  - 4. Network Function Virtualization (NFV)
  - 5. Any Function Virtualization (FV)
  - 6. Mobile Edge Computing
  - 7. Micro-Services
- OpenADN Multi-Cloud Management
- Service Function Placement Problem

Gartner Hype Cycle 2016



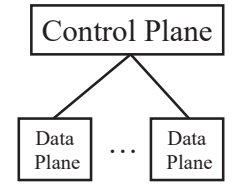
Ref: Gartner, "Hype Cycle for Emerging Technologies, 2016," July 2016, [subscribers only], gartner.com/document/3383817

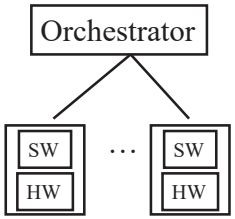
Trend 1: Micro-Cloud Computing

- Cloud computing was invented in 2006
- Then: Cloud = Large Data Center Multiple VMs managed by a cloud management system (OpenStack)
- Today: Cloud = Computing using virtual resources
  - μCloud = Cloud in a server with multiple VMs.
  - Each VM with Multiple Containers ⇒ Multiple Services

2. Software Defined Networking (SDN)

- SDN was invented in 2009
- Then: SDN:
  - OpenFlow Southbound
  - Separation of control and data planes
  - Centralization of Control
- Now: SDN = **Disaggregation** of hw/sw
  - Commodity hardware
  - Software that runs on commodity hw
  - Open Source Software
    ⇒ Service industry
  - Controller replaced by Orchestrator



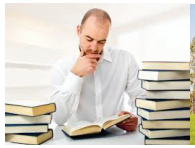


3. Smart Everything

- What's Smart?
  - Old: Smart = Can think fast ⇒ High compute power
  - Then: Smart = Can remember everything ⇒ High storage
  - Now: Smart = Can communicate ⇒ Good Networking
- Smart Grid, Smart Meters, Smart Cars, Smart homes, Smart Cities, Smart Factories, Smart Smoke Detectors, …


Think


Communicate


Not-Smart

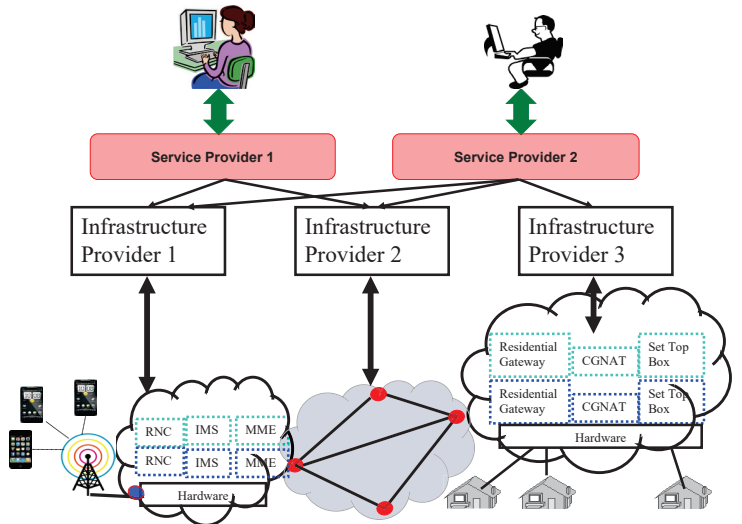

Smart

IoT is a Cloud Data ($) Mine

- Most of the revenue in IoT is not in devices but in Data
- All IoT devices come with their own cloud
  - Google Cloud, Apple Cloud, Microsoft Cloud, …

Ref: https://www.pinterest.com/iofficecorp/humor/

4. Network Function Virtualization (NFV)



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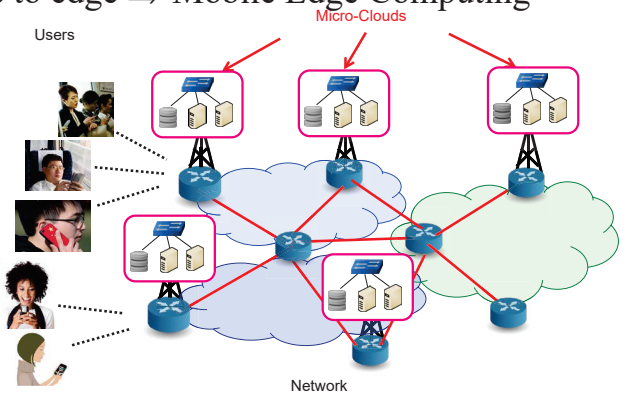
5. Any Function Virtualization (FV)

- "Network" function virtualization of interest to Network service providers
- But the same concept can be used by any other industry, e.g., financial industry, banks, stock brokers, retailers, mobile games, …
- Everyone can benefit from:
  - Functional decomposition of there industry
  - Virtualization of those functions
  - Service chaining those virtual functions (VFs) or **Apps**

Networking App Market: Lower CapEx

6. Mobile Edge Computing

- To service mobile users/IoT, the computation needs to come to edge ⇒ Mobile Edge Computing



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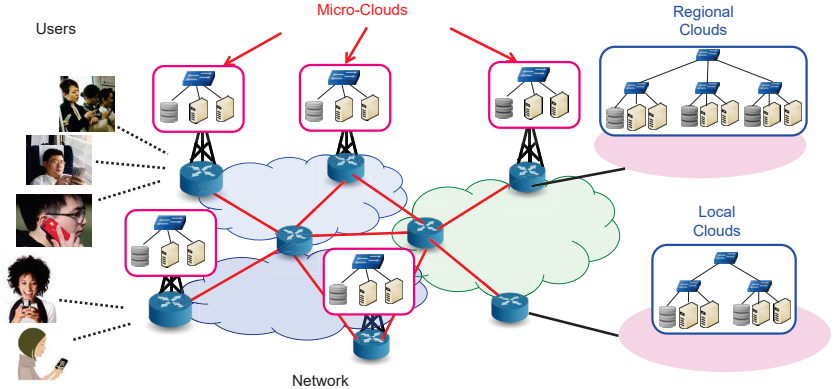
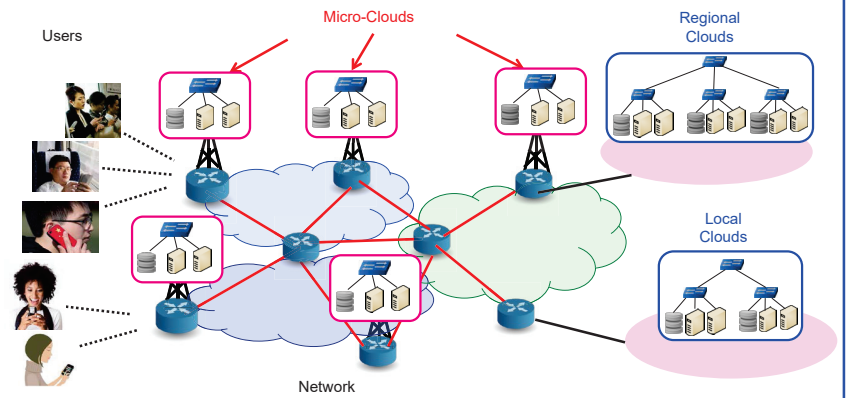
7. Micro-Services

- All major applications, such as, Facebook, Netflix, etc. consist of a number of micro-services that are instantiated on demand on virtual machines

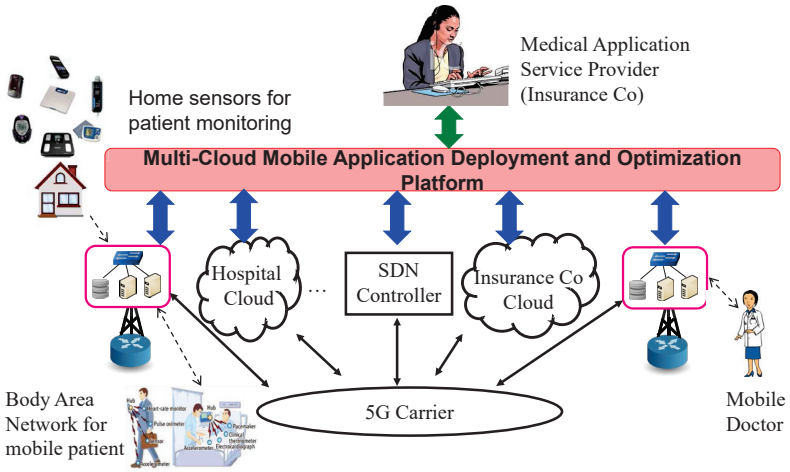


Multi-Cloud Hierarchy

- Wide area clouds, local area clouds (home routers with cloud features), Personal area clouds (cars), body area clouds (smart phone) ⇒ Fog Computing

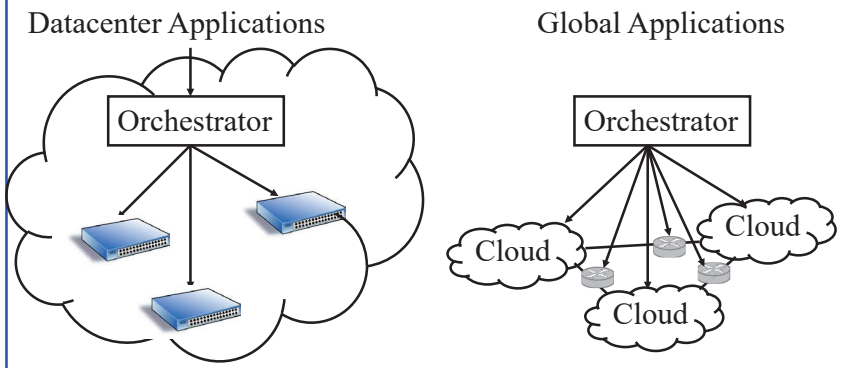


Mobile Healthcare Use Case



Software Defined Multi-Cloud

- Orchestrating devices to Orchestrating Clouds



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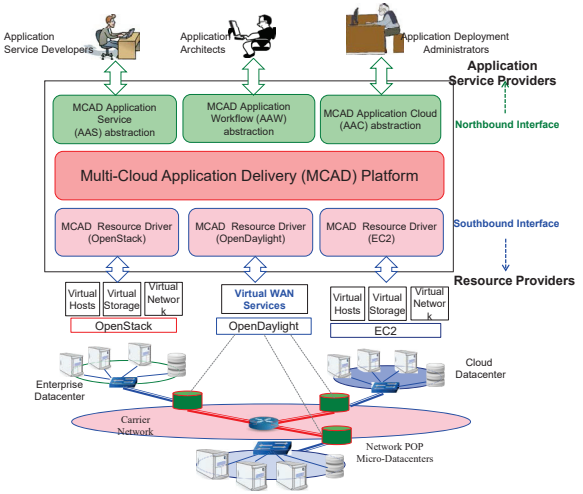
OpenADN Multi-Cloud Management



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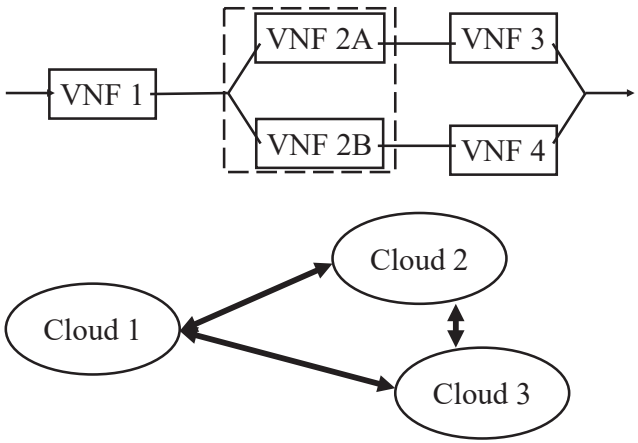
Service Function Placement Problem



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Summary

1. Clouds getting smaller.
   SDN definition changing to disaggregation and orchestration
2. Carriers and enterprises moving to clouds, Internet of things are leading to clouds everywhere ⇒ multi-cloud applications.
   ⇒ Software Defined Multi-Cloud Orchestration
3. Our multi-cloud application management system (MCAD) allows policy-based deployment and management of multi-cloud application. Handles heterogeneous clouds and respects resource ownerships
4. Service function placement problem is NP complete. Challenges included delay constraints, WAN Link bottlenecks, and affinity

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Acronyms

- ATM Asynchronous Transfer Mode
- ECN Explicit congestion notification
- EFCI Explicit Forward Congestion Indication
- FECN Forward Explicit Congestion Notification
- GB Gigabyte
- IEEE Institution of Electrical and Electronic Engineering
- IETF Internet Engineering Task Force
- IoT Internet of Things
- IP Internet Protocol
- IRTF Internet Research Task Force
- ITU International Telecommunications Union
- LAN Local Area Network
- LTE Long Term Evolution
- MHz Mega Hertz
- OpenADN Open Application Delivery Networking
- SDN Software Defined Networking

Acronyms (Cont)

- TCP Transmission Control Protocol
- TV Television
- VM Virtual Machine
- WAN Wide Area Network
- WiFi Wireless Fidelity
- WiMAX Worldwide Interoperability for Microwave Access

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