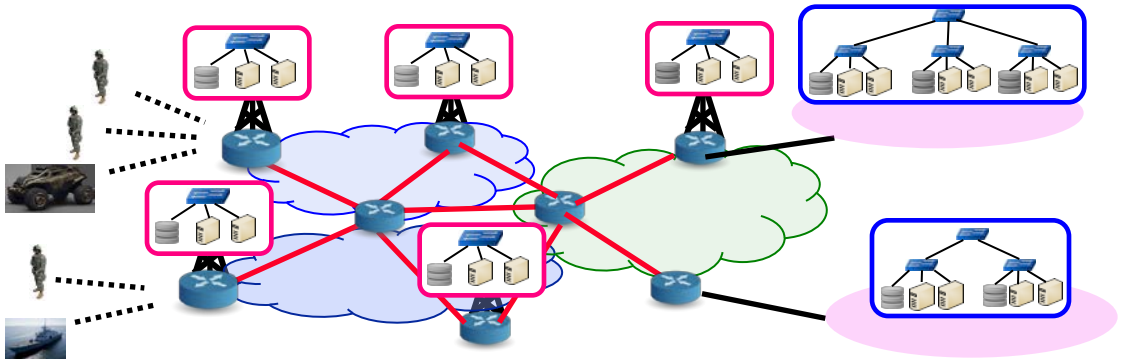
Software Defined Multi-Cloud Networking at the Tactical Edge



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Panel Presentation at IEEE MILCOM 2016 Conference, Baltimore, MD, November 2, 2016

These slides and recording of this talk are available on-line at:

http://www.cse.wustl.edu/~jain/talks/sdn_mlcb.htm

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Any Function Virtualization (FV)

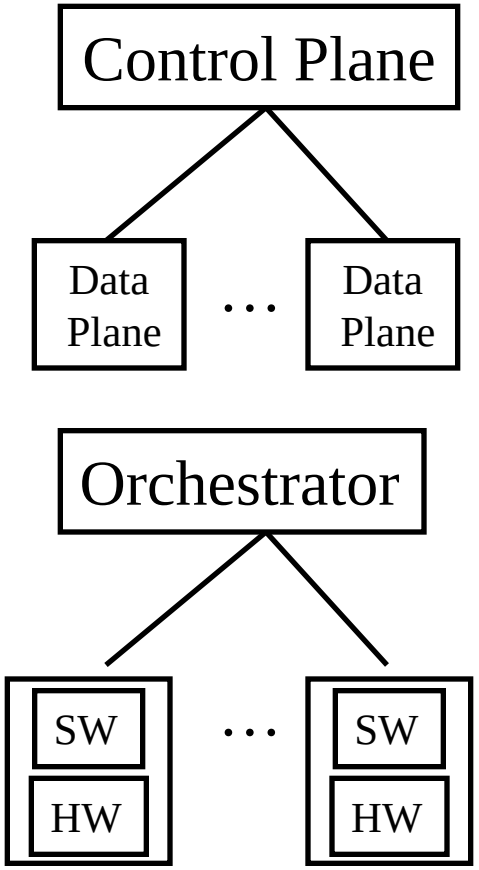
- "Network" function virtualization of interest to Network service providers
- But the same concept can be used by any other industry, e.g., financial industry, banks, stock brokers, retailers, mobile games, …
- Everyone can benefit from:
  - Functional decomposition of there industry
  - Virtualization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

Overview

- SDN then and now…
- Software Defined Multi-Cloud
  - 1. Internet of Things and Smart Cities
  - 2. Mobile Traffic Explosion: NFV
  - 3. Any Function Virtualization
  - 4. Mobile Edge Computing
- OpenADN Multi-Cloud Management
- Service Function Placement Problem

Software Defined Networking (SDN)

- SDN was invented in 2009
- Then: SDN:
  - Separation of control and data planes
  - Centralization of Control
  - Standard Protocol between the planes
- Now: Software Defined Everything (SDE) = **Disaggregation** of hw/sw
  - Commodity hardware
  - Open Source Sw on commodity hw ⇒ Service industry
  - Controller replaced by Orchestrator
  - Centralization of policies



Ref: D. M Batista, G. Blair, F. Kon, R. Boutaba, D. Hutchison, R. Jain, R. Ramjee, C. E. Rothenberg, "Perspectives on software-defined networks: interviews with five leading scientists from the networking community" Journal of Internet Services and Applications 2015, 6:22, http://www.cse.wustl.edu/~jain/papers/jisa15.htm

IoT is a Cloud Data ($) Mine

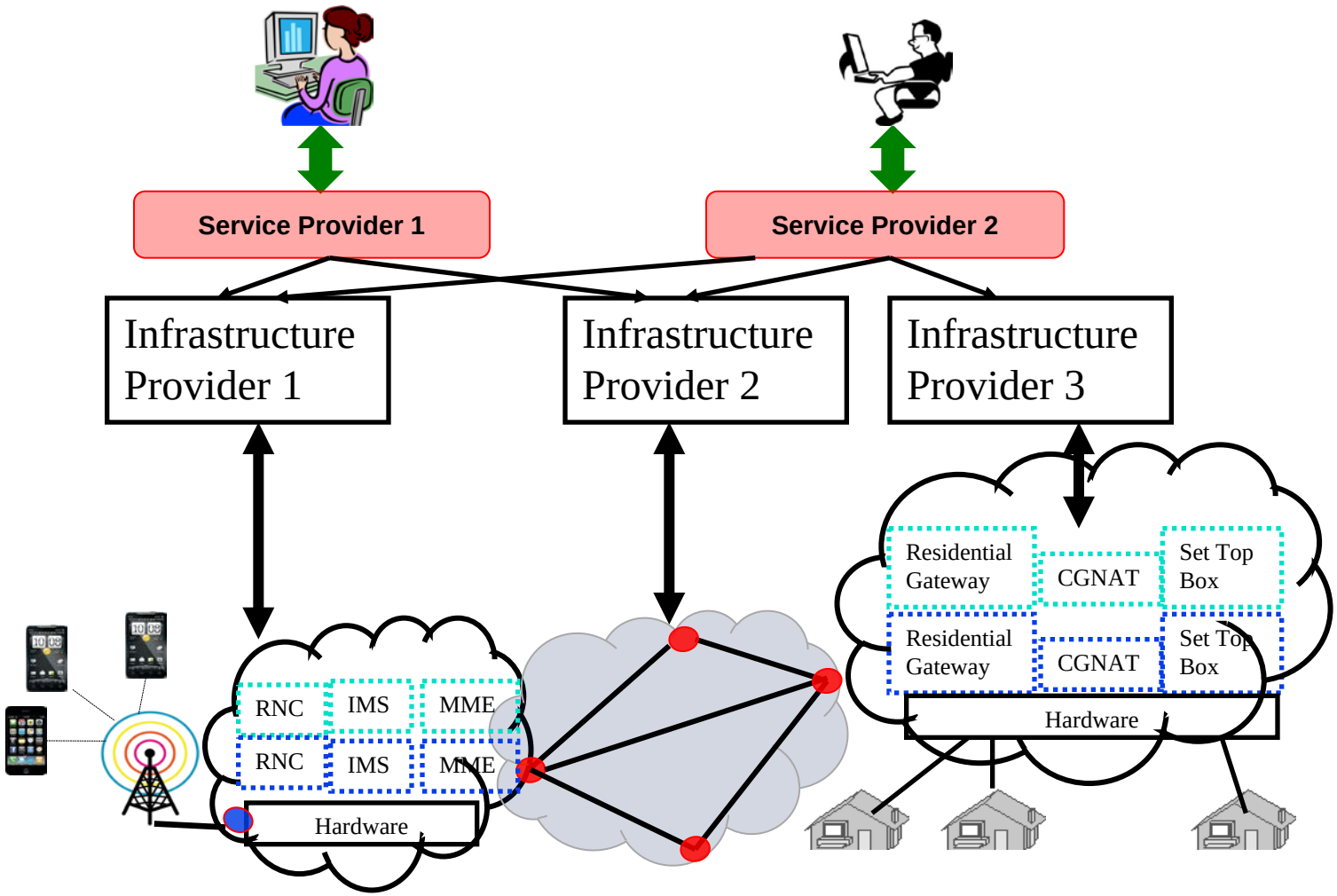
Ref: https://www.pinterest.com/iofficecorp/humor/

Trend: 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

Ref: Raj Jain and Subharthi Paul, "Network Virtualization and Software Defined Networking for Cloud Computing - A Survey," IEEE Communications Magazine, Nov 2013, pp. 24-31, http://www.cse.wustl.edu/~jain/papers/net_virt.htm

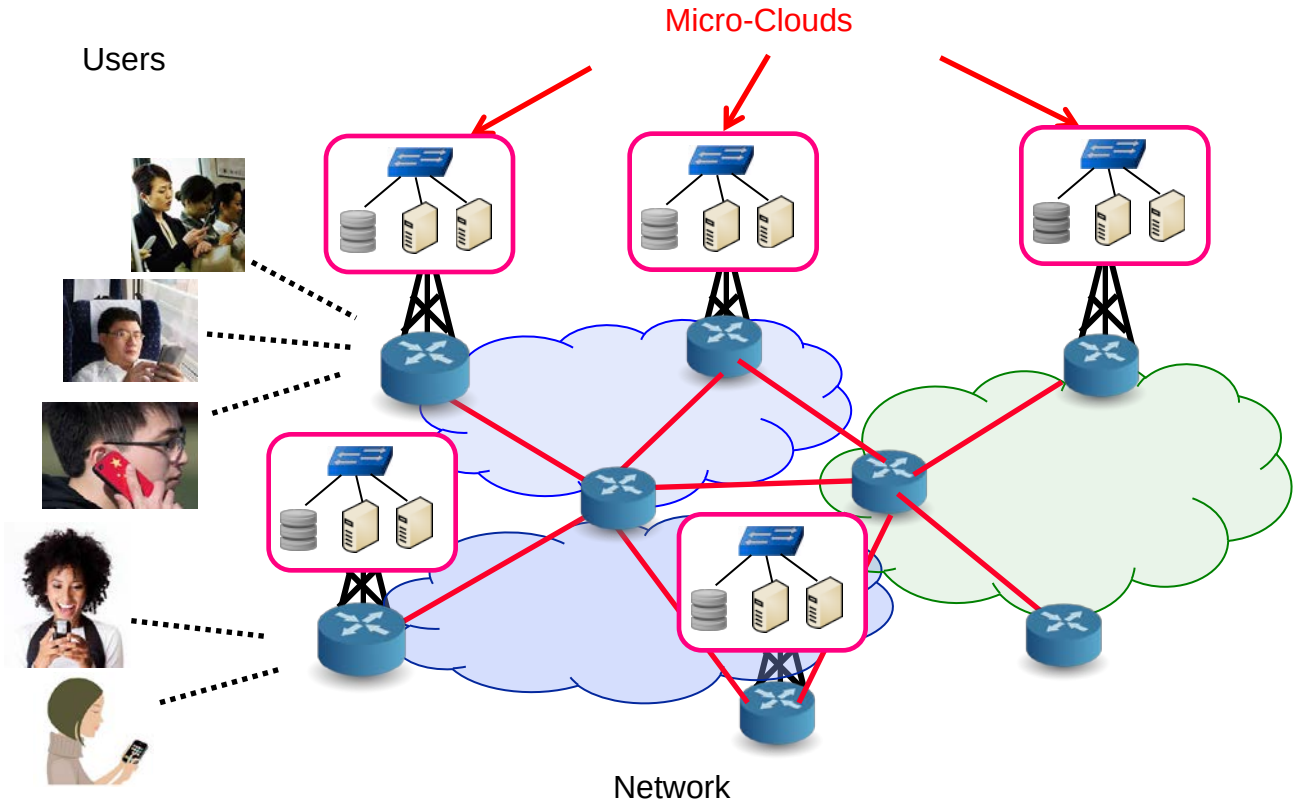
Network Function Virtualization (NFV)



Ref: S. Paul, R. Jain, M. Samaka, J. Pan, "Application Delivery in Multi-Cloud Environments using Software Defined Networking," Computer Networks Special Issue on cloud networking and communications, December 2013, http://www.cse.wustl.edu/~jain/papers/comnet14.htm

Trend: Mobile Edge Computing

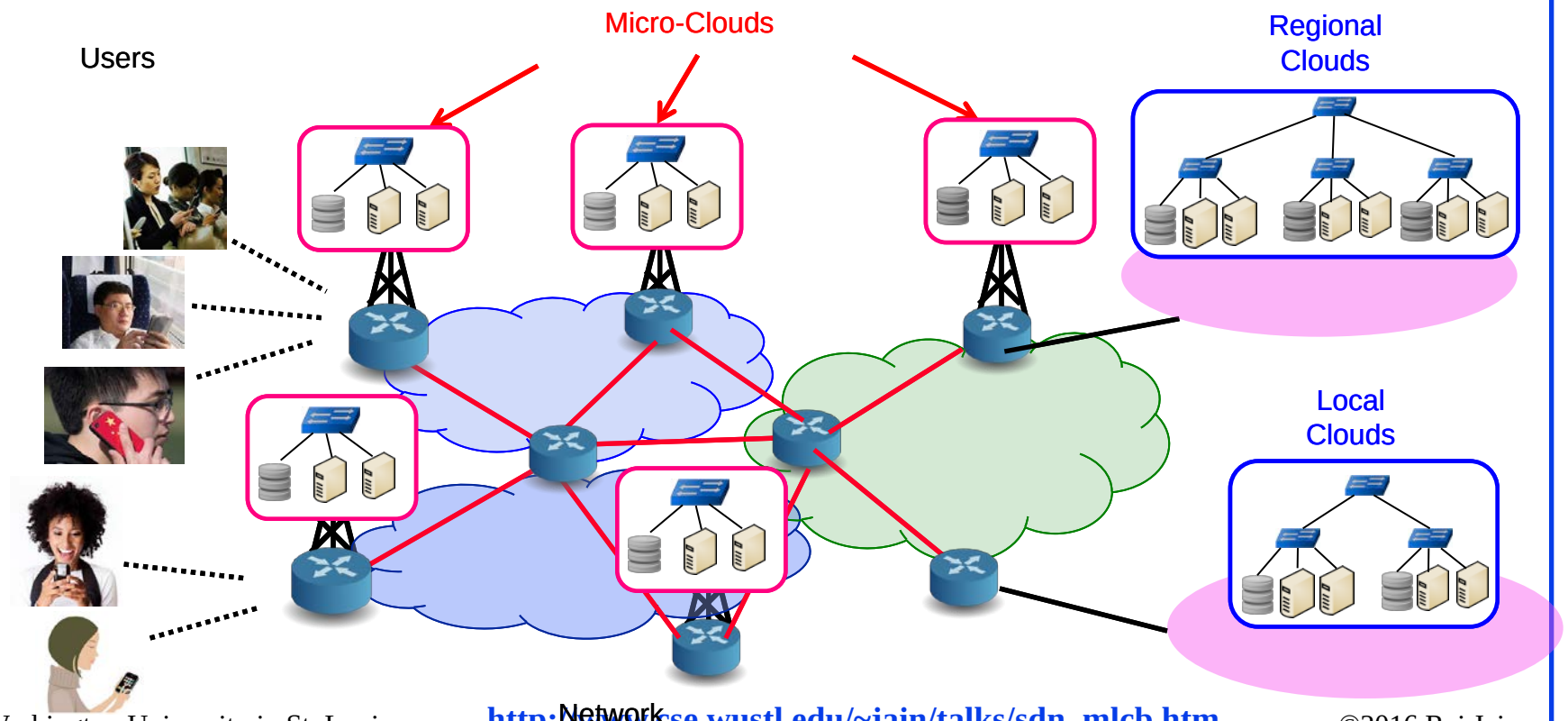
- To service mobile users/IoT, the computation needs to come to edge ⇒ Mobile Edge Computing



Ref: Lav Gupta, Raj Jain, H. Anthony Chan, "Mobile Edge Computing - an important ingredient of 5G Networks," IEEE Softwarization Newsletter, March 2016, http://www.cse.wustl.edu/~jain/papers/mec16.htm

Trend: Micro-Services

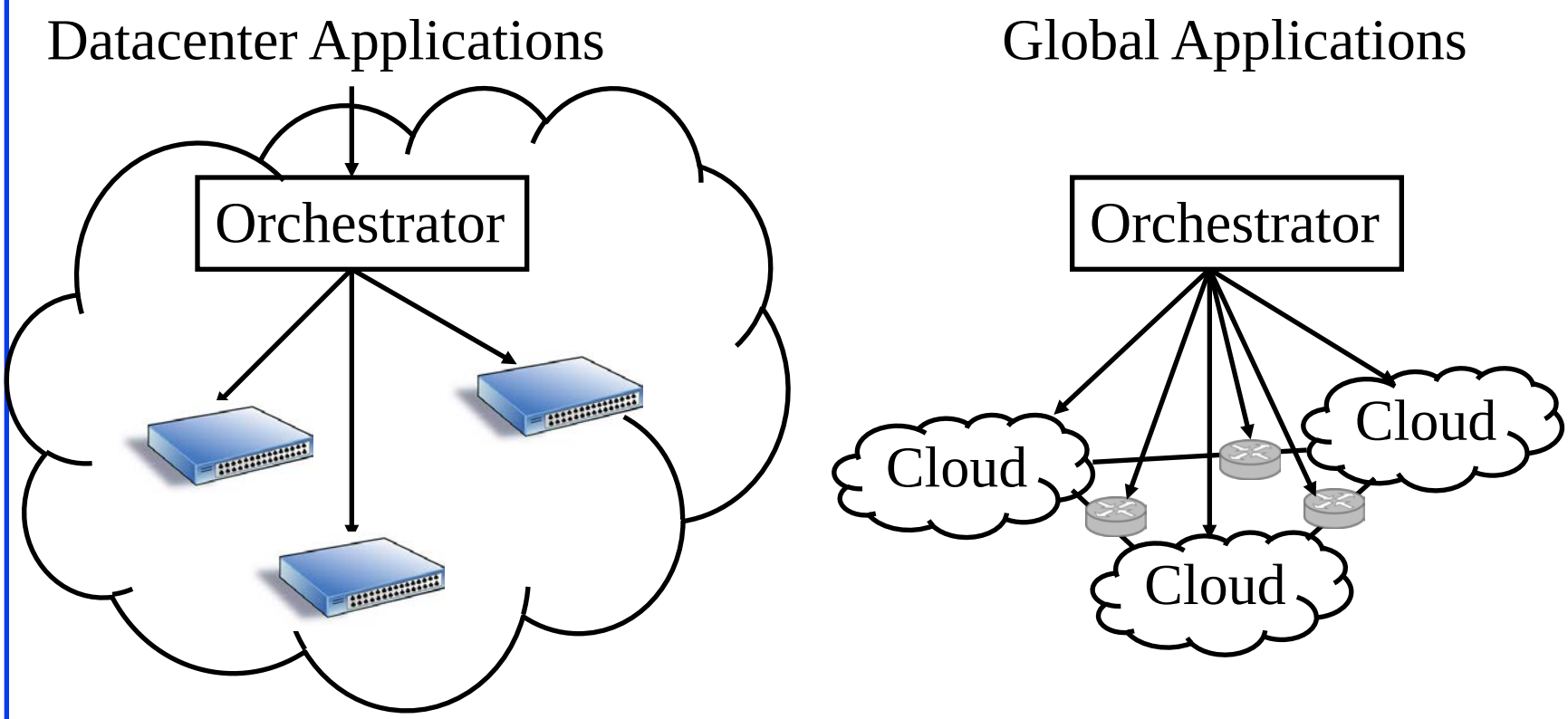
- All major applications, such as, Facebook, Netflix, etc. consist of a number of micro-services that are instantiated on demand on virtual machines



Tactical Use Case

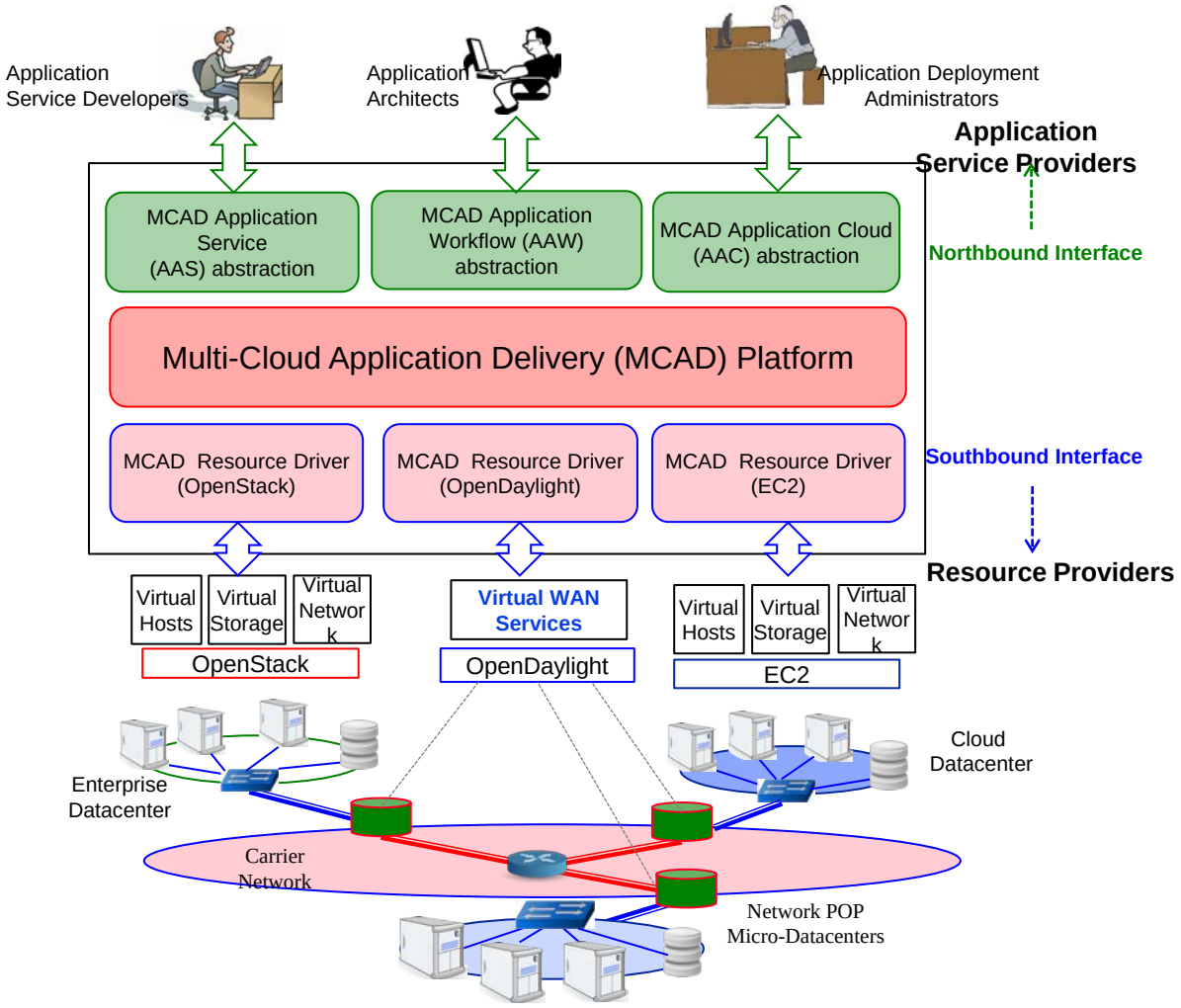
Solution: Software Defined Multi-Cloud

- Orchestrating devices to Orchestrating Clouds



Ref: AT&T, "Domain 2.0 White paper,"
https://www.att.com/Common/about_us/pdf/AT&T%20Domain%202.0%20Vision%20White%20Paper.pdf

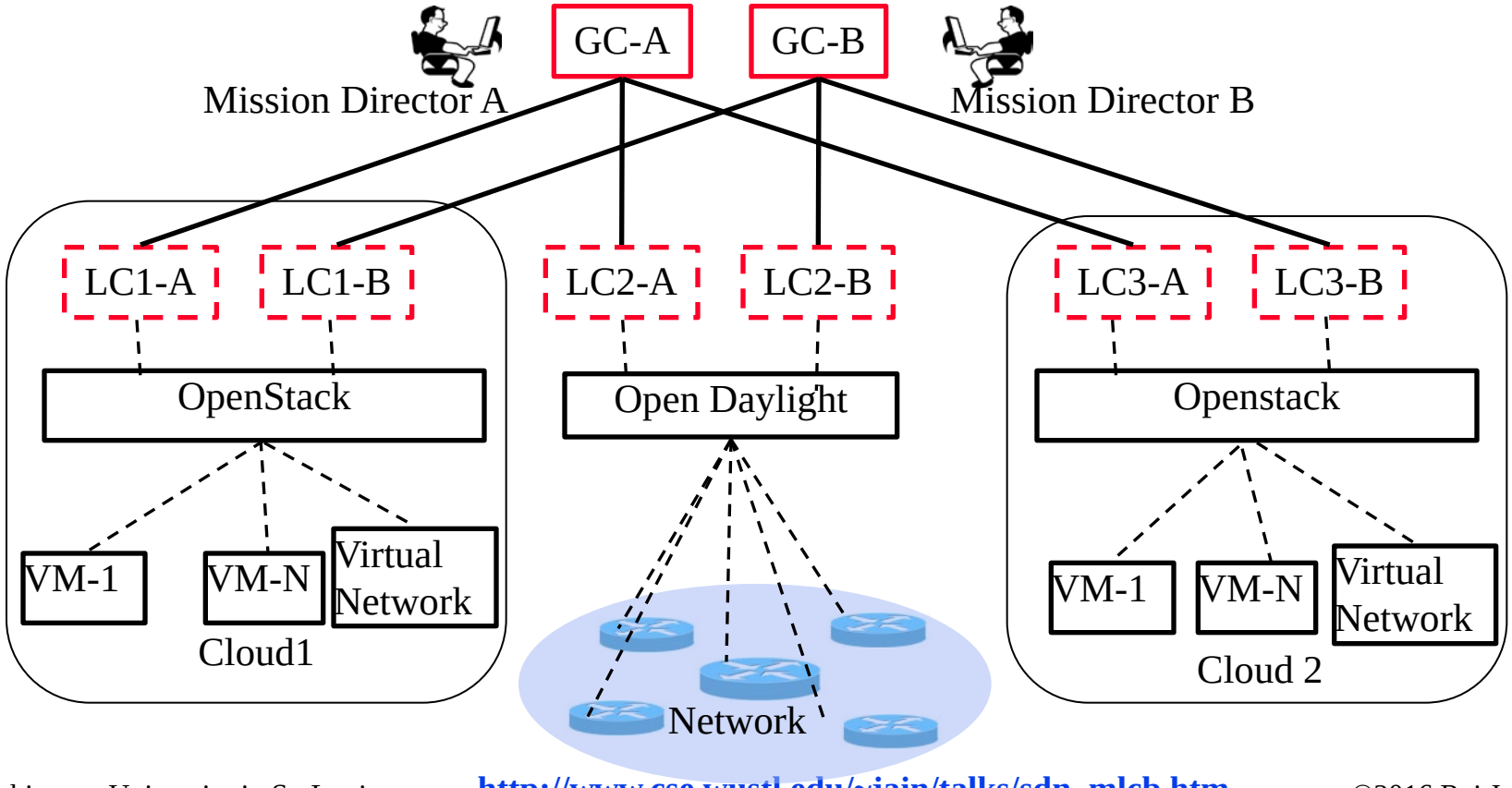
OpenADN Multi-Cloud Management



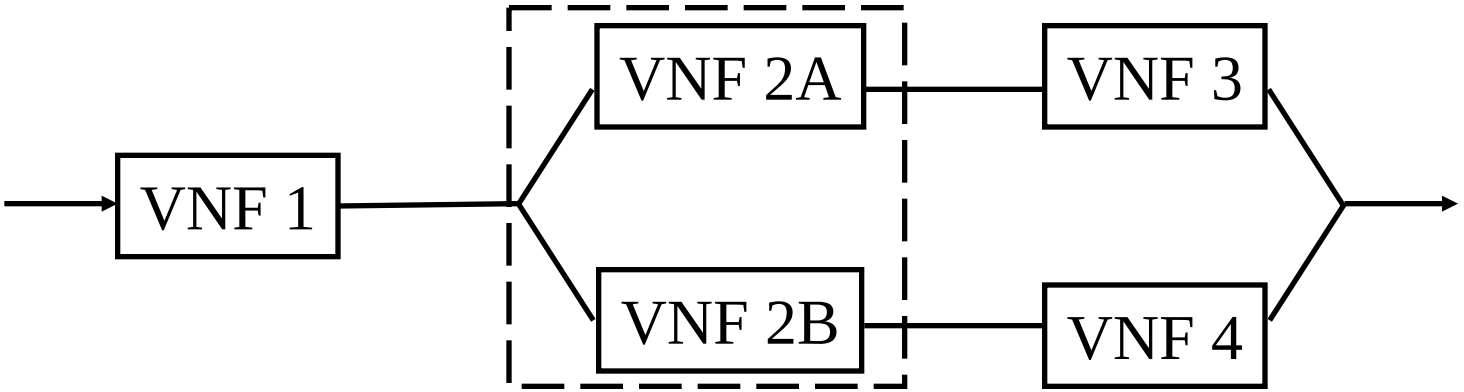
Ref: Lav Gupta, Raj Jain, Mohammed Samaka, "Analysis of Application Delivery Platform for Software Defined Infrastructures," International Journal of Communication Networks and Distributed Systems, 2016, Vol. 5, http://www.cse.wustl.edu/~jain/papers/ijcnds16.htm

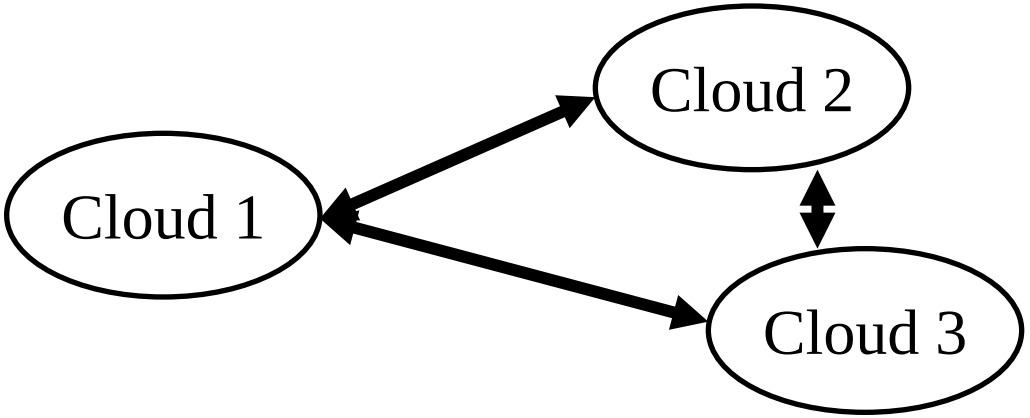
Multiple Applications and Providers

- Each mission has its own Global controller (GC) and local controllers (LC)
- Every one has its own policies and set of providers

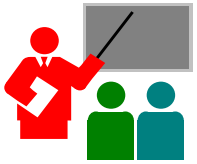


Service Function Placement Problem





Ref: Deval Bhamare, Raj Jain, Mohammed Samaka, Aiman Erbad, "A Survey on Service Function Chaining," Journal of Network and Computer Applications, Sep 2016, 19 pp, http://www.cse.wustl.edu/~jain/papers/jnca16.htm



Summary

1. SDN is about orchestration and centralization of policy. Not about separation of control and data planes.
2. Value of IoT is in the data it produces. Internet of things are leading to clouds everywhere
3. Clouds are getting smaller, Carriers and enterprises moving to clouds ⇒ multi-cloud applications.
4. Software Defined Multi-Cloud Orchestration: Our Multi-cloud application management system (MCAD) allows policy-based deployment and management of multi-cloud applications.
5. Service function placement problem is NP complete. Challenges included delay constraints, WAN Link bottlenecks, and affinity

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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