

# Application Deployment in Future Global Multi-Cloud Environment



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These slides are available on-line at:

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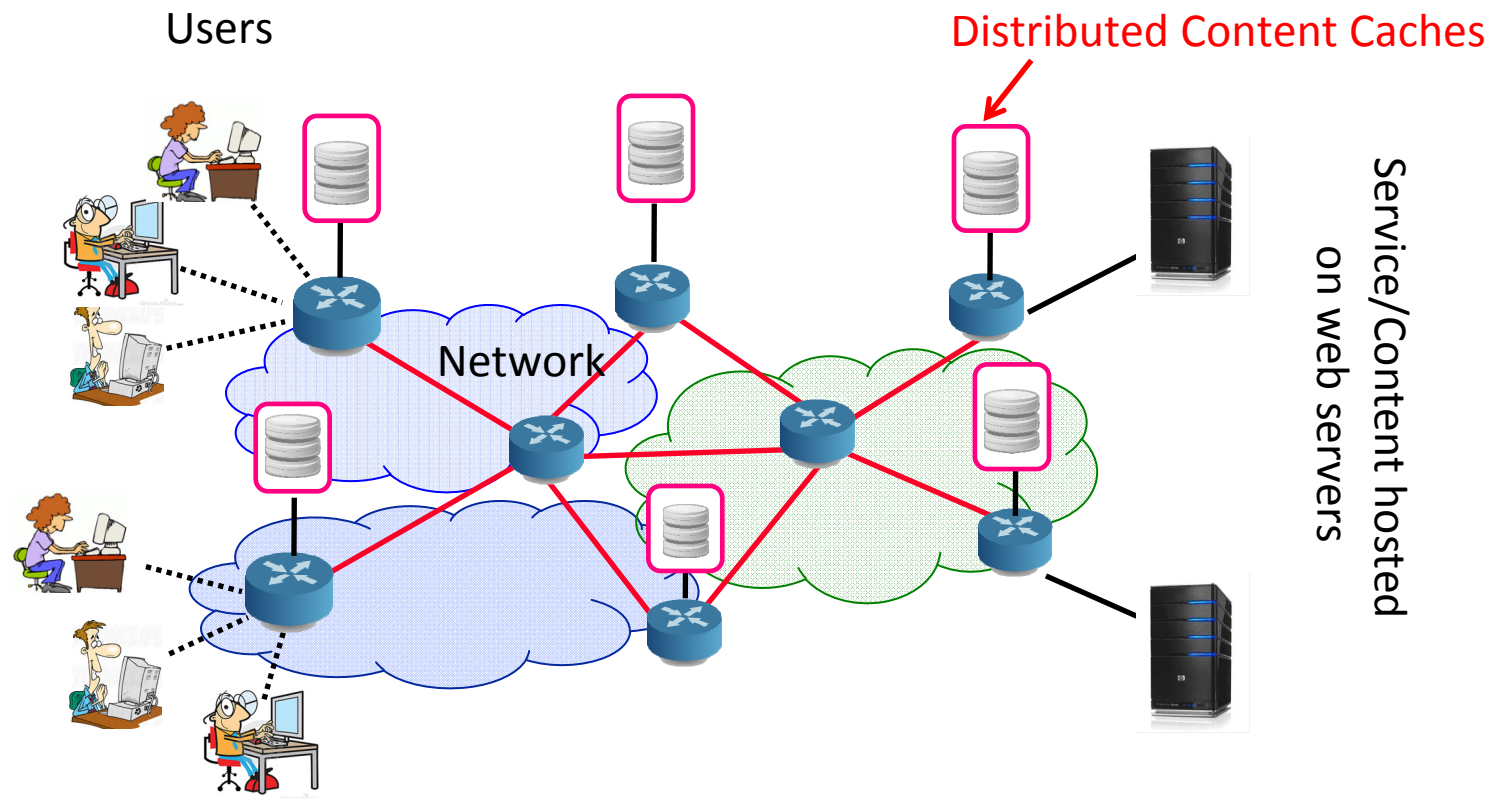


- ❑ Recent Trends in Networking:
  - Trend 1: Computation in the Edge
  - Trend 2: Hierarchical Computation
  - Trend 3: Liquid Applications
- ❑ Solution: Generalized Application Delivery Networking

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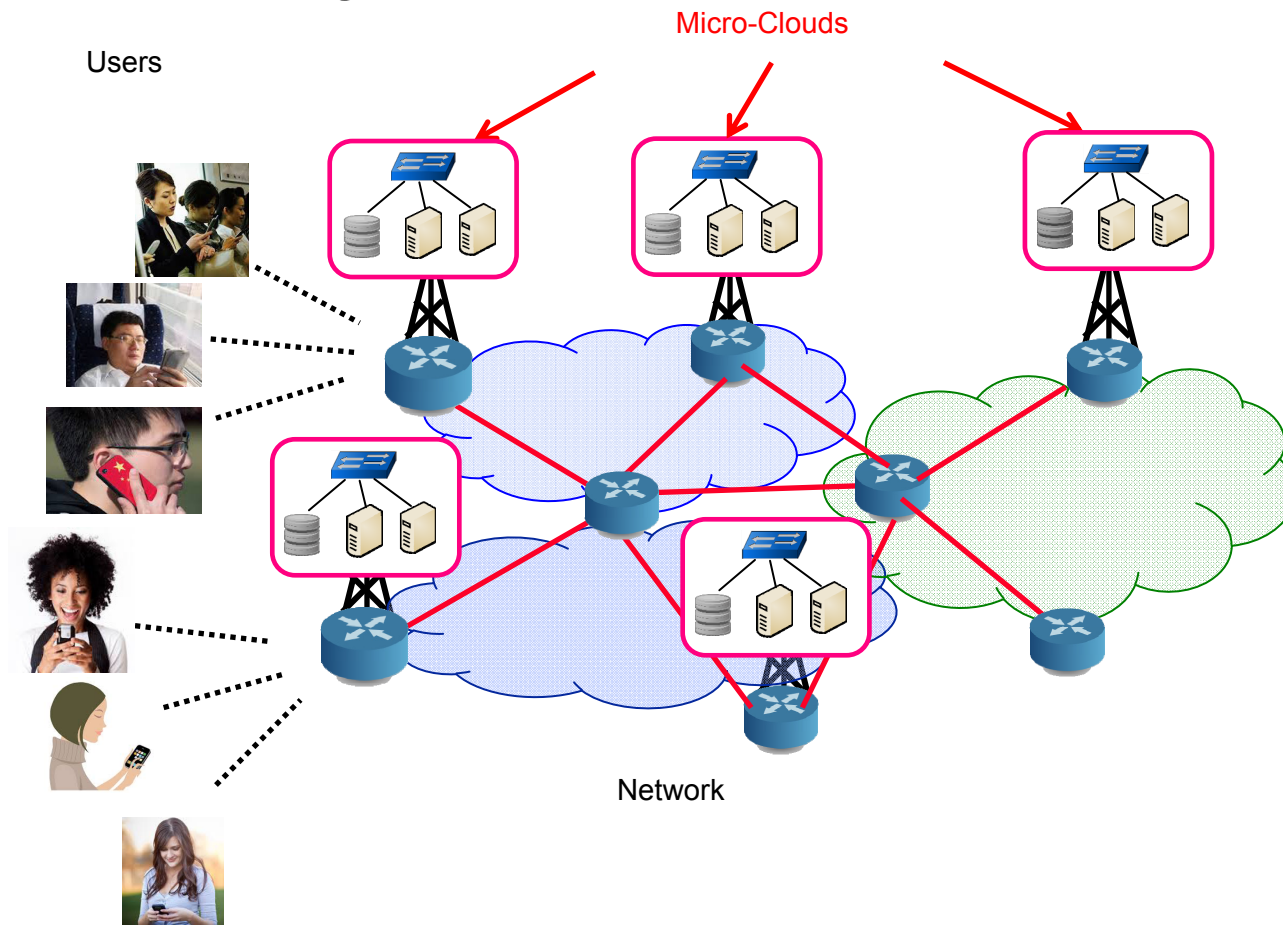
# Trend: Content Distribution Networks (CDN) – Evolution of a Data-Centric Internet

- ❑ To serve world-wide users, latency was critical and so the data was replicated and brought to edge



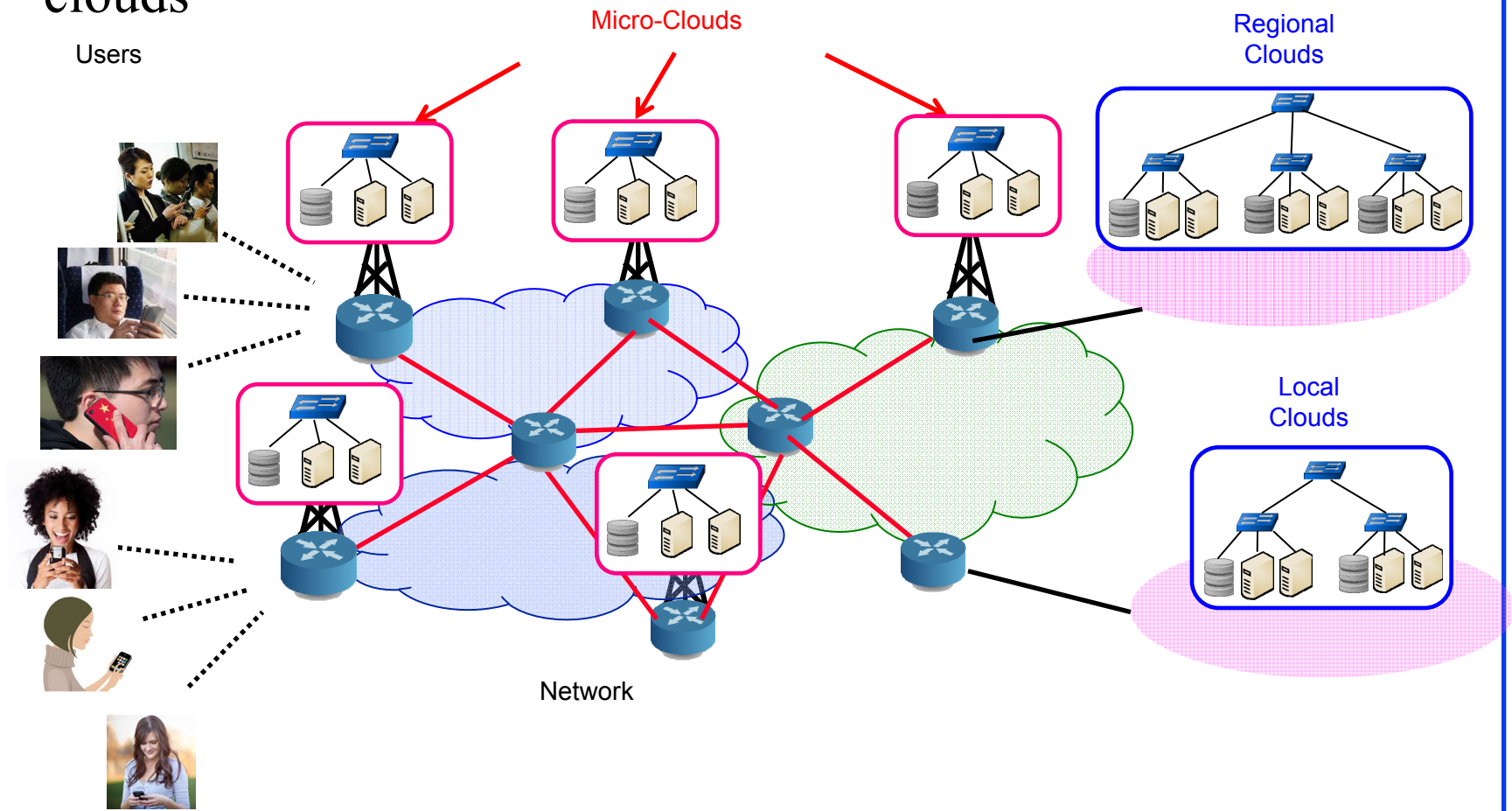
# Trend 1: Computation in the Edge

- To service 5G smart phone users, the computation needs to come to edge  $\Rightarrow$  Micro-cloud on the tower



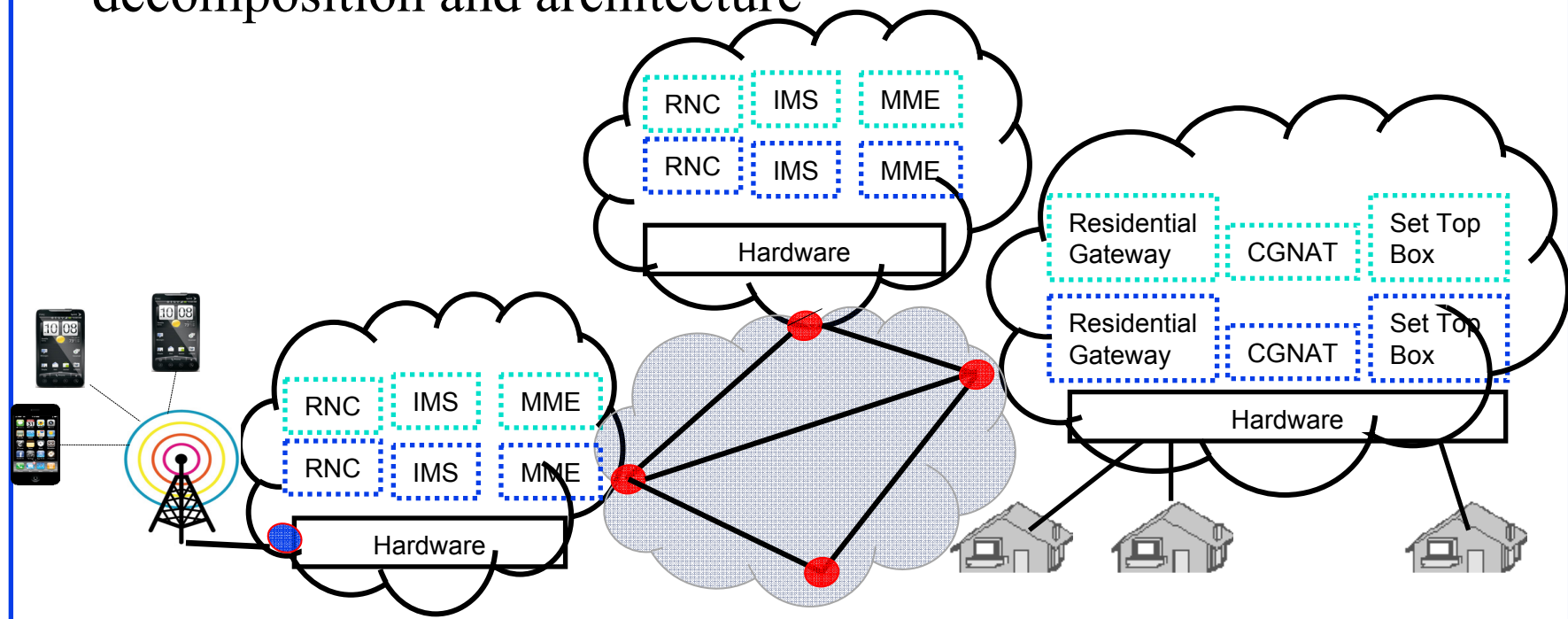
# Trend 2: Hierarchical Computation

- Larger and infrequent jobs serviced by local and regional clouds



# Trend 3: Liquid Applications

- ❑ Current networks designed for voice applications  
⇒ Network function virtualization (NFV) is looking at functions that are designed for voice applications
- ❑ Future 5G Mobile networks need a more general functional decomposition and architecture



# Service-Infrastructure Separation

- ❑ With cloud computing, anyone can super-compute on demand.
  - Physical infrastructure is owned by Cloud Service Provider (CSP). Tenants get virtual infrastructure
  - **Win-Win** combination
- ❑ With virtualization, an ISP can set up all virtual resources on demand
  - Physical Infrastructure owned by NFV infrastructure service provider (NSP) and tenant ISPs get virtual NFVI services
  - **Win-Win** combination





# High-Level Requirements

- ❑ Automatic provisioning and deployment
- ❑ Automatic runtime control
  - Elastic load balancing
  - Handling failures
- ❑ Dynamically change the application's distributed footprint
  - Launch application on new sites
  - Shutdown existing sites



# High-level Challenges

- ❑ Massively distributed:
  - Virtual resources distributed geographically
  - Virtual resources from multiple providers
- ❑ Common platform for:
  - Different device types – Application servers, middleboxes, routers, switches, etc.
  - Different service types: Voice, Video, IoT, Gaming, Apps

Inter-Cloud is of interest in 5G as well as in other applications  
⇒ Cisco announced \$1B investment in inter-cloud

Ref: Network World, “Cisco pumping \$1 billion more into Inter-Cloud,” September 29, 2014,

<http://www.networkworld.com/article/2688819/cloud-computing/cisco-pumping-1-billion-more-into-intercloud.html>

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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)  
⇒ A service provided by the next gen ISPs

# Carrier App Market: Lower CapEx

Virtual IP  
Multimedia  
System

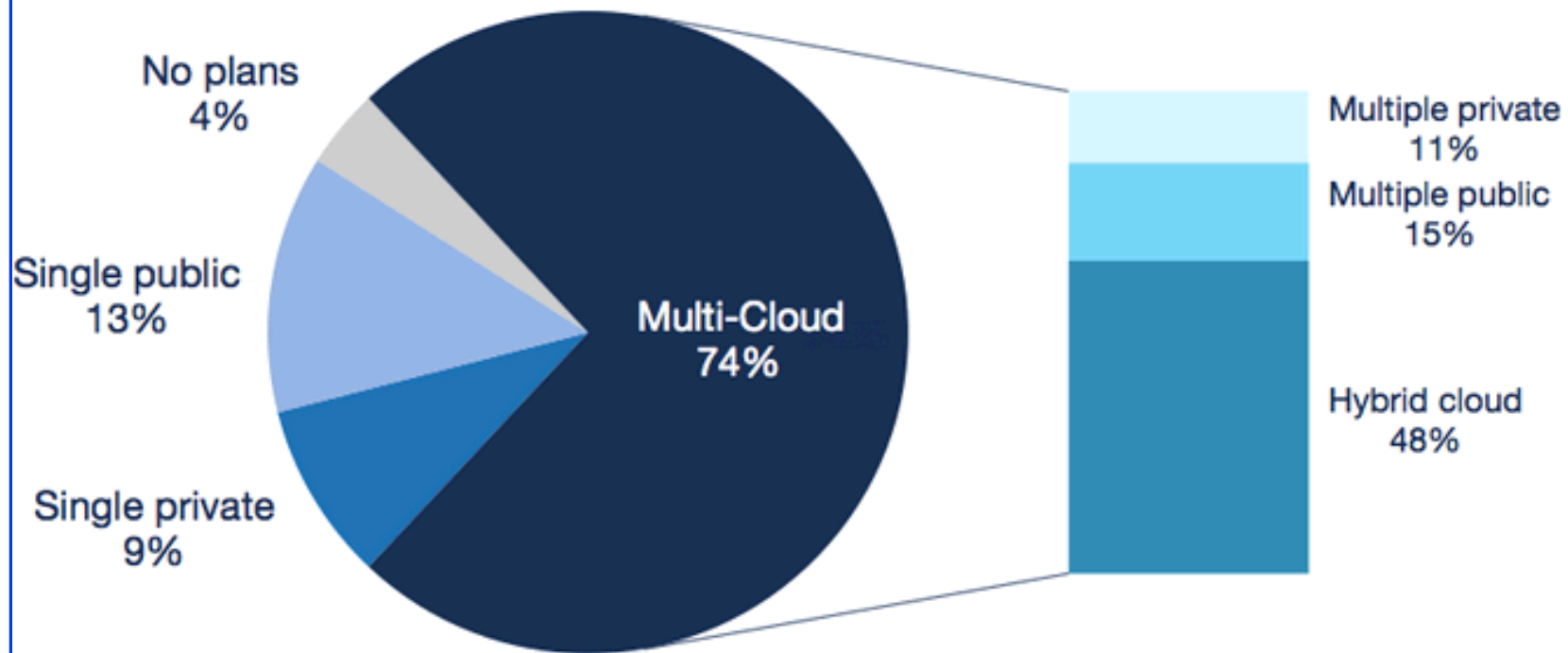
Available on the  
**App Store**



# Trend: Multi-Clouds

## Enterprise Cloud Strategy

1000+ employees



Source: RightScale 2014 State of the Cloud Report

☐ Most companies use more than one cloud.

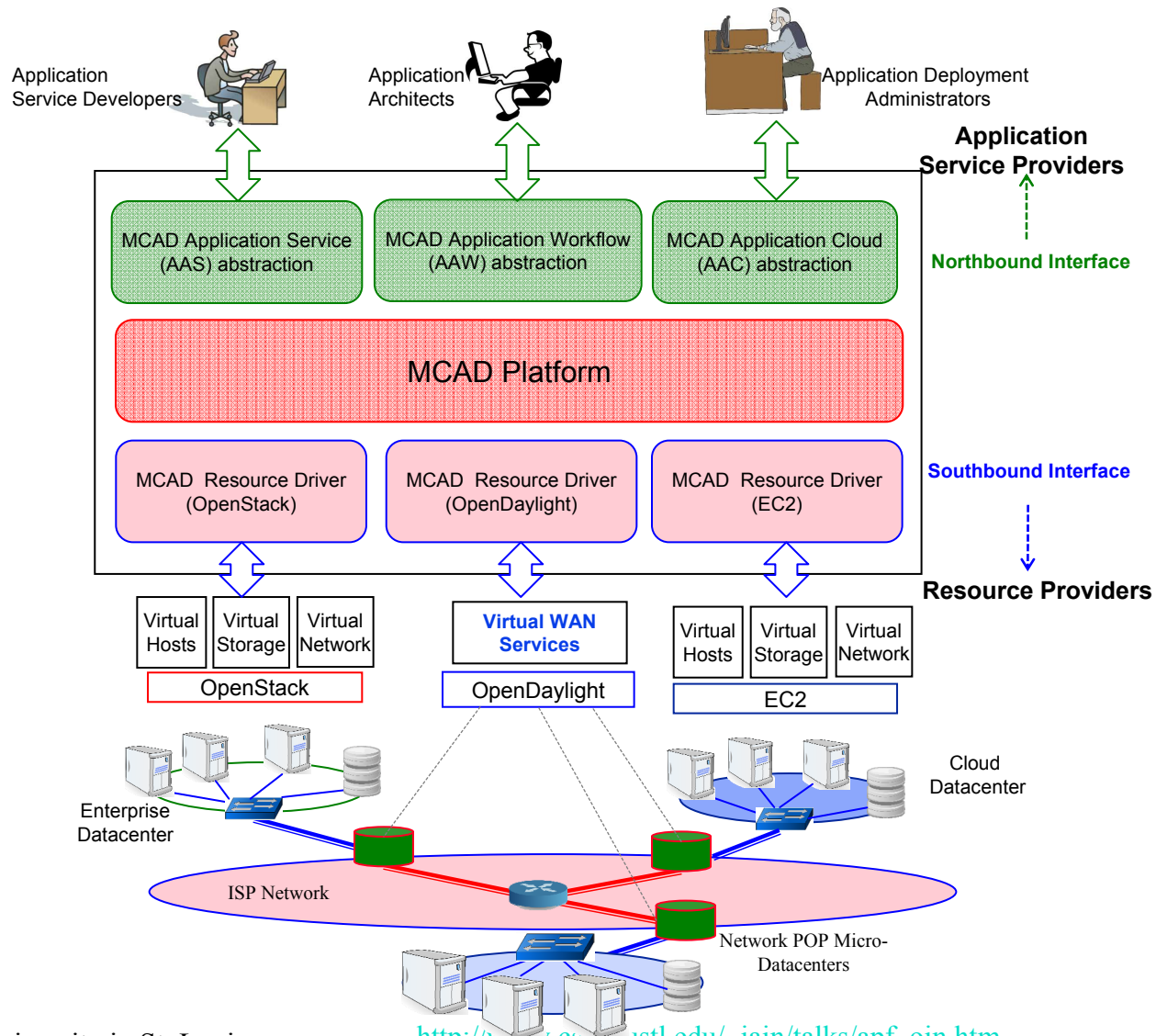
Ref: <http://www.rightscale.com/blog/cloud-industry-insights/cloud-computing-trends-2014-state-cloud-survey>

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# Services in a Cloud of Clouds



# MCAD Features

- ❑ **Automate** the entire process of creating new workflows and installing them, managing them during runtime, uninstalling them as necessary
  - Allow **Deployment Administrators** specify policies for quantity and location of resources inside various clouds.
- ❑ Workflow creation includes virtual networks, computers, storage inside the clouds as well as the network between the clouds
- ❑ **WAN bandwidth** and latency is the key to placement. Allows manual approval and override.
- ❑ Physical infrastructure owners keep complete control over their resources while the tenant service providers can deploy their applications according to their desired policies
- ❑ All communication is via APIs. All interfaces initially XML based. GUI based in future.

# Resource Control

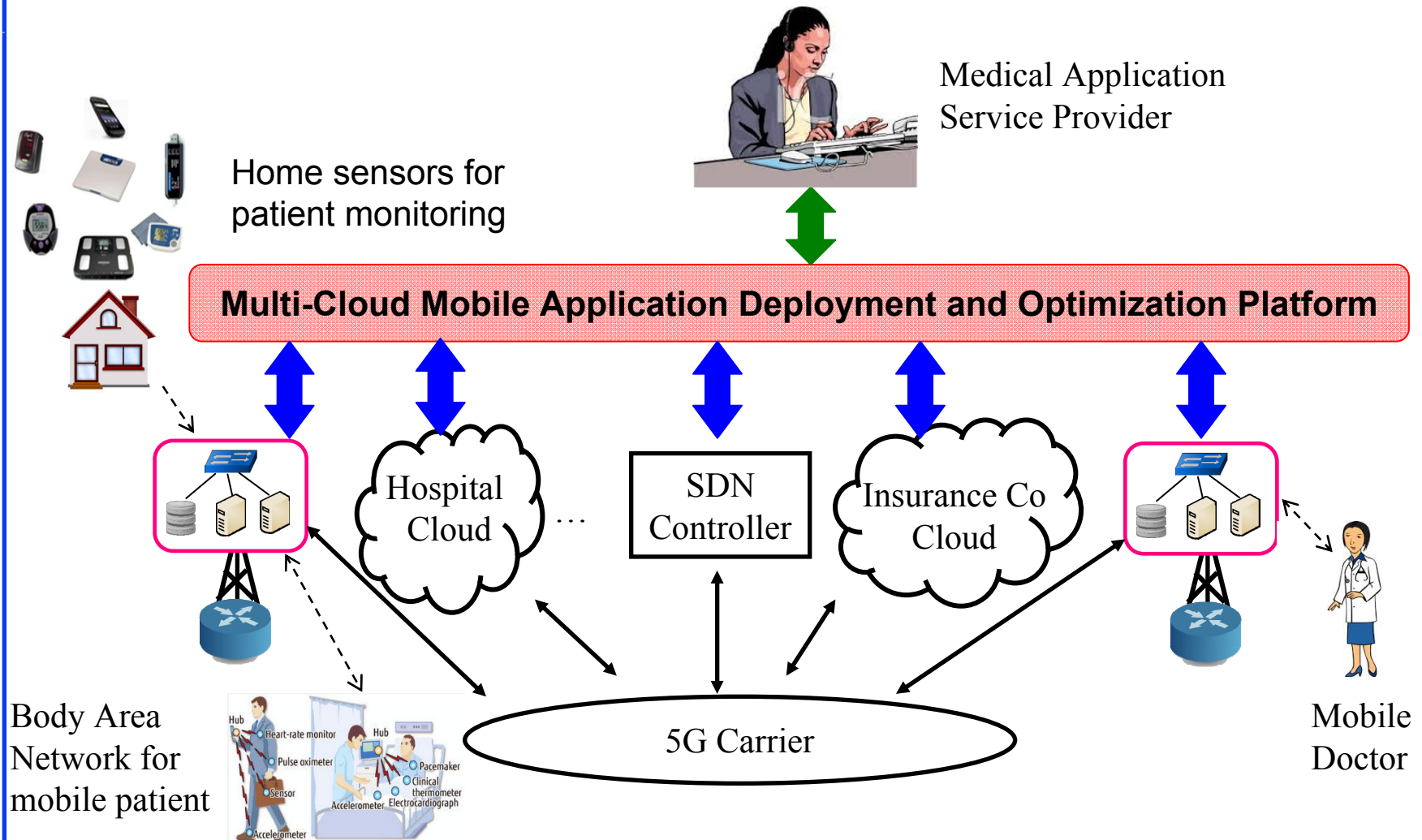
- ❑ Tenants keep complete control of their data.  
NSP does not have to look at the **application data** to enforce application level policies
- ❑ NSPs keep complete control of their equipment.  
tenants communicate their policies to NSP's control plane
- ❑ **VFs and Middle boxes** can be located anywhere on the global Internet  
(Of course, performance is best when they are close by)
- ❑ Tenants or NSPs can **own** OpenADN modules.  
NSPs can offer “Service Chaining” **service**



# Application Delivery for the Enterprise

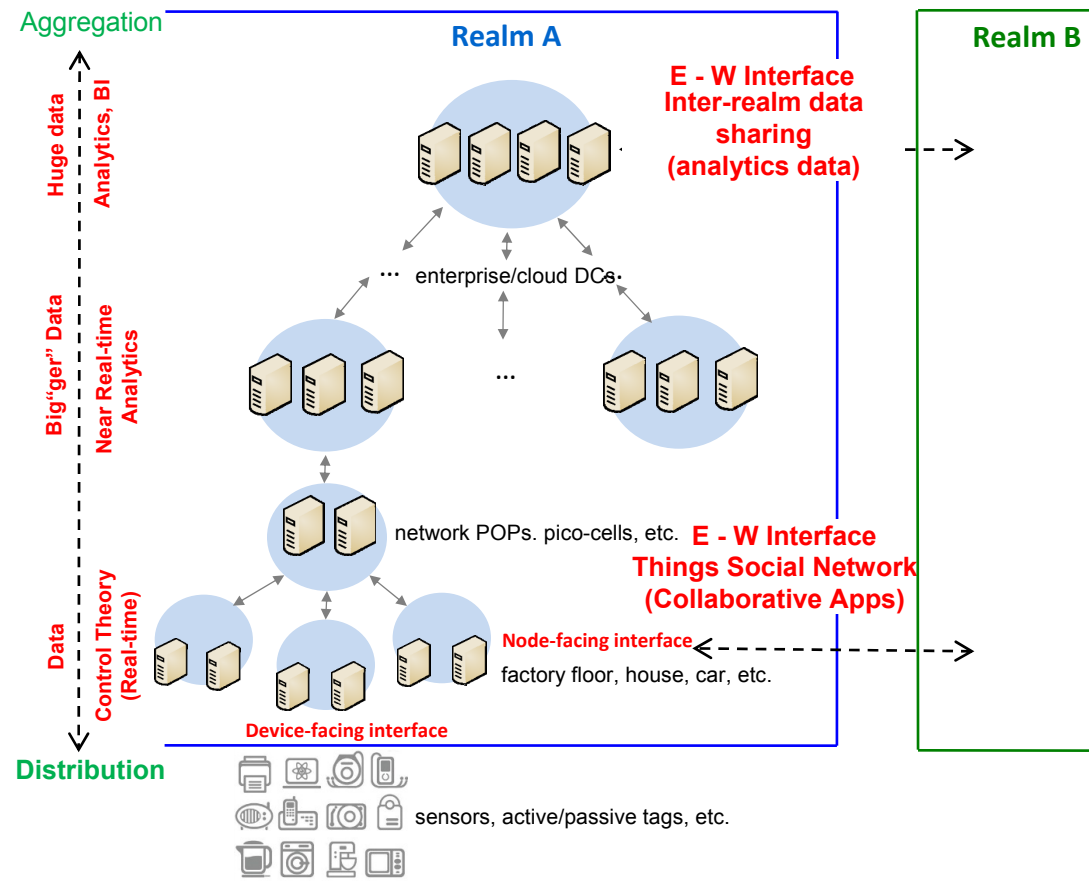
- ❑ MCAD is of interest to 5G Mobile carriers
- ❑ But the same concept can be used by any other industry, e.g., financial industry, banks, stock brokers, retailers, mobile games, ...
- ❑ Everyone can benefit from:
  - Functional decomposition of their industry
  - Virtualization of those functions
  - Service placement of those virtual functions (VFs)  
⇒ A service provided by the next gen ISPs

# Mobile Healthcare Use Case



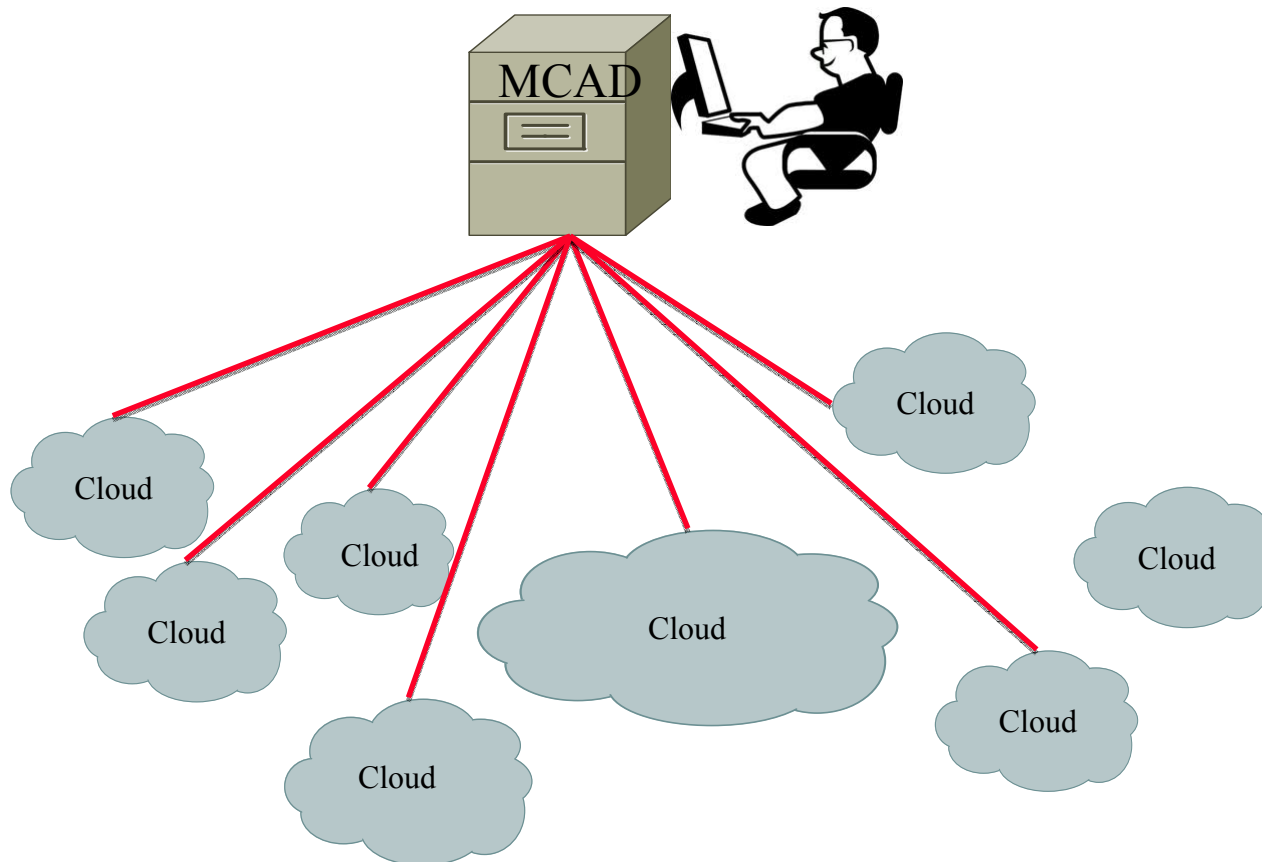
# Use Case 1: Internet of Things

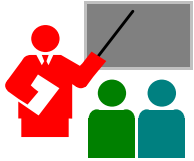
- ❑ Computing everywhere or Fog computing.
- ❑ Data aggregation and analytics at various levels



# Multi-Cloud Security

- Can one cloud provider be trusted by another?  
Would Google trust Microsoft, Amazon, or Apple?





# Summary

1. To meet the quality of experience (QoE) for future 5G mobile applications, the computation will need to come to edge. Computation will be hierarchical with micro-Clouds on Towers, Local Clouds, and Regional Clouds
2. Need software defined inter-cloud management and ability to create/deploy/move applications and functions among clouds while maintaining the required QoE
3. Mobile multi-Cloud Application Delivery (MCAD) platform will solve the problem of optimal application placement. **WAN link capacity, utilization, and latency** are key to the placement of VMs.
4. Infrastructure owners keep complete **control** over their resources. Tenants keep complete control over their traffic.
5. Same solution is application to numerous other applications such as enterprises, internet of things, and apps.

# Recent Papers

- ❑ Subharthi Paul, Raj Jain, Mohammed Samaka, Jianli Pan, **"Application Delivery in Multi-Cloud Environments using Software Defined Networking,"** Computer Networks Special Issue on cloud networking and communications, Available online 22 Feb 2014, <http://www.cse.wustl.edu/~jain/papers/comnet14.htm>
- ❑ 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](http://www.cse.wustl.edu/~jain/papers/net_virt.htm)

# Recent Talks

- ❑ Raj Jain, "**Smart Cities: Technological Challenges and Issues**," IEEE CS Keynote at 21st Annual International Conference on Advanced Computing and Communications (ADCOM) 2015, Chennai, India, September 19, 2015, Chennai, India, September 18, 2015, <http://www.cse.wustl.edu/~jain/talks/smrtcit.htm>
- ❑ Raj Jain, "**Internet of Things: Challenges and Issues**," IEEE CS Keynote at 20th Annual Conference on Advanced Computing and Communications (ADCOM 2014), Bangaluru, India, September 19, 2014, [http://www.cse.wustl.edu/~jain/talks/iot\\_ad14.htm](http://www.cse.wustl.edu/~jain/talks/iot_ad14.htm)
- ❑ Raj Jain, "**AppFabric: Application Deployment and Service Chaining in Future NFV Cloud WAN Environments**," Cisco Research Seminar, San Jose, CA, May 15, 2014, [http://www.cse.wustl.edu/~jain/talks/apf\\_csc.htm](http://www.cse.wustl.edu/~jain/talks/apf_csc.htm)  
Raj Jain, "**SDN and NFV: Facts, Extensions, and Carrier Opportunities**," AT&T Labs SDN Forum Seminar, April 10, 2014, [http://www.cse.wustl.edu/~jain/papers/adn\\_att.htm](http://www.cse.wustl.edu/~jain/papers/adn_att.htm)
- ❑ Raj Jain, "**Networking for Big Data**," IEEE CS Keynote at 19th Annual International Conference on Advanced Computing and Communications (ADCOM) 2013, Chennai, India, October 22, 2013. <http://www.cse.wustl.edu/~jain/talks/adcom13.htm>



# 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