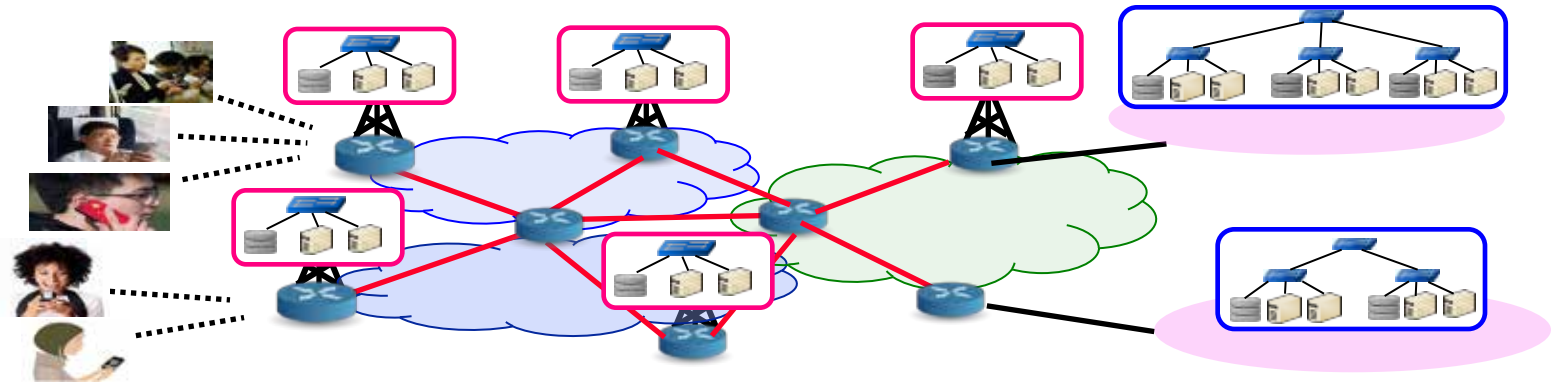


# Smart Cities: Technical Issues and Challenges



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Smart City/IoT Meet up University City, MO,  
August 10, 2017

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

<http://www.cse.wustl.edu/~jain/talks/smrtcity.htm>



1. What's smart about smart cities
2. Multi-clouds for Smart Cities
3. Cyber Security for Smart Cities
4. Blockchains for Smart Cities and Cyber Security

# Trend: Smart Everything



Smart Watch



Smart TV



Smart Car



Smart Health



Smart Home



Smart Kegs



Smart Space



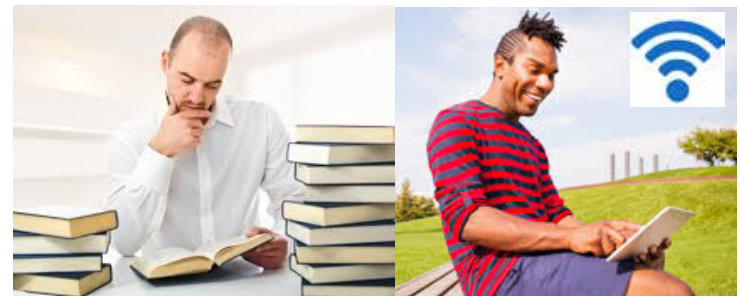
Smart Industries



Smart Cities

# What's Smart?

- q Old: Smart = Can think  $\bowtie$  Computation  
= Can Recall  $\bowtie$  Storage
- q Now: Smart = Can find quickly, Can Delegate  
 $\bowtie$  Communicate = Networking
- q Smart Grid, Smart Meters, Smart Cars, Smart homes, Smart Cities, Smart Factories, Smart Smoke Detectors, ...

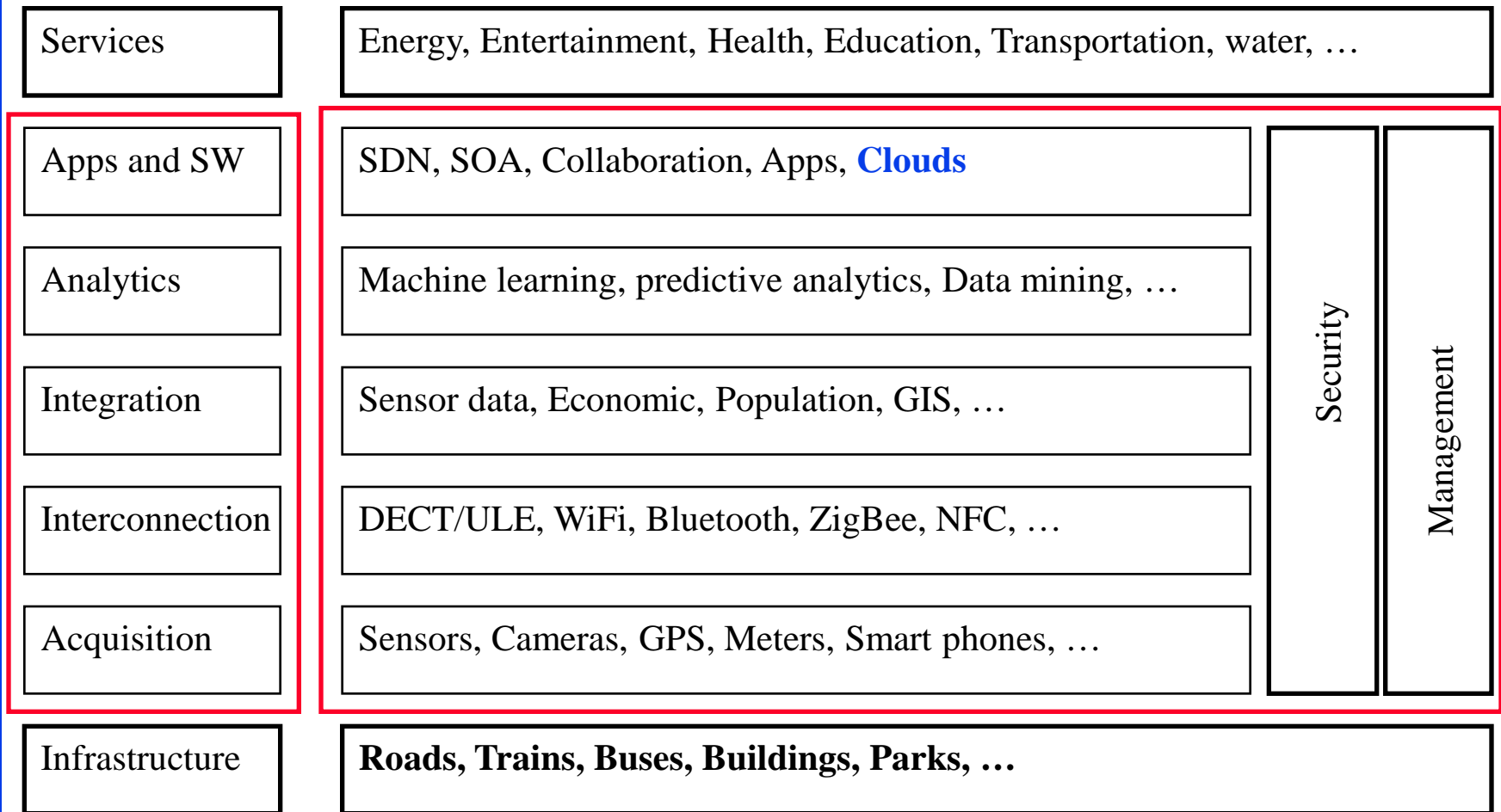


Not-Smart

Smart

# A 7-Layer Model of Smart Cities

ICT



# Areas of Research for IoT/Smart Cities

1. PHY: Smart devices, sensors giving real-time information
2. Datalink: WiFi, Bluetooth, ZigBee, IEEE 802.15.4, ...  
Broadband: DSL, FTTH, Wi-Fi, 5G, ...
3. Routing: Mesh networking, ...
4. Analytics: Big-data, data mining, Machine learning, Predictive analytics, ...
5. Apps & SW: SDN, SOA, Cloud computing, Web-based collaboration, Social networking, ...
6. Applications: Remote health, On-line education, on-line laboratories, ...
7. Security: Privacy, Trust, Identity, Anonymity, ...

# Trend: Micro-Cloud Computing

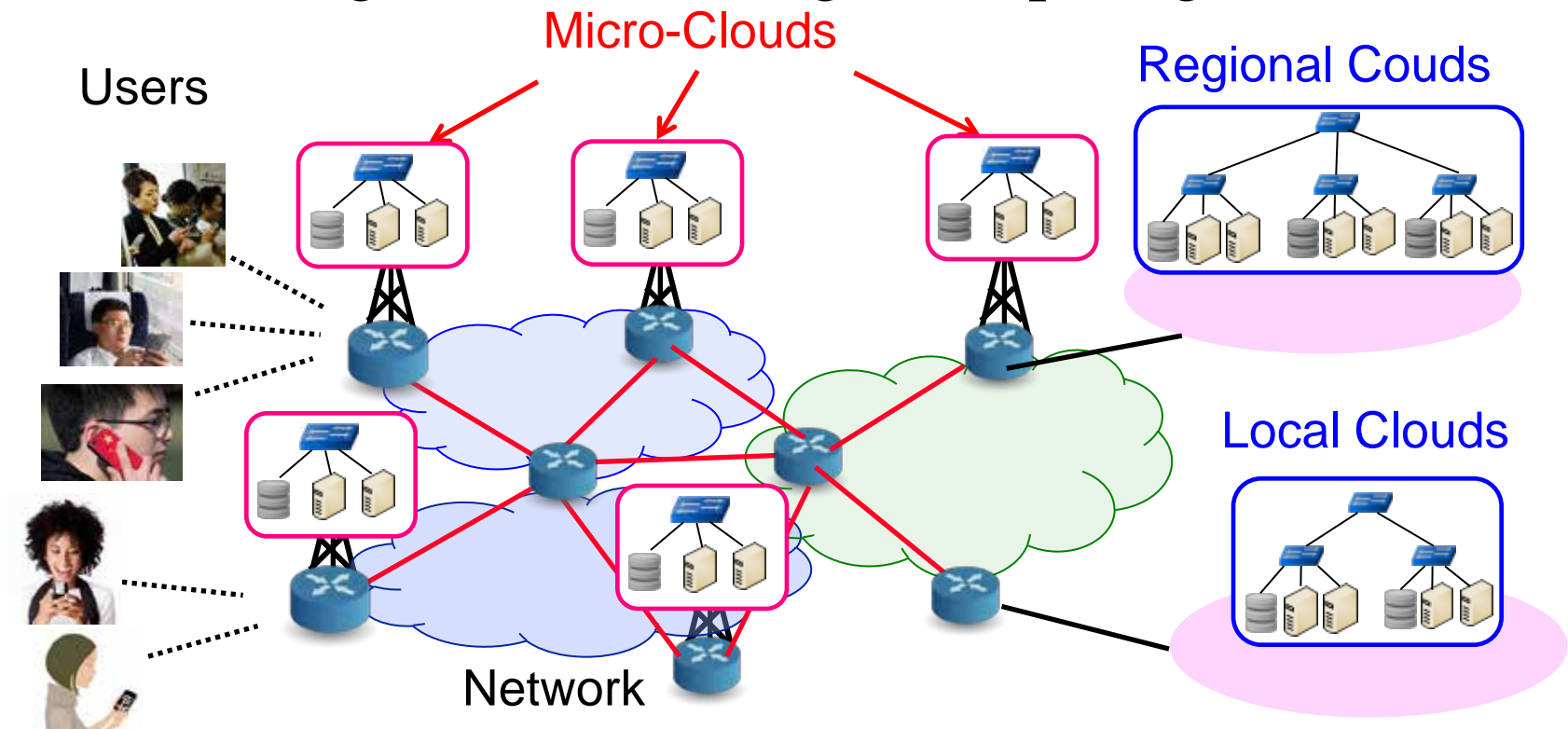
- q Cloud computing was invented in 2006
- q Then: Cloud = Large Data Center  
Multiple VMs managed by a cloud management system (OpenStack)
- q Today: Cloud = Computing using virtual resources
  - ∅ mCloud = Cloud in a server with multiple VMs.
  - ∅ Each VM with Multiple Containers ⊃ Multiple Services





# Trend: Mobile Edge Computing

- q 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>



# Past: Software Defined Networking

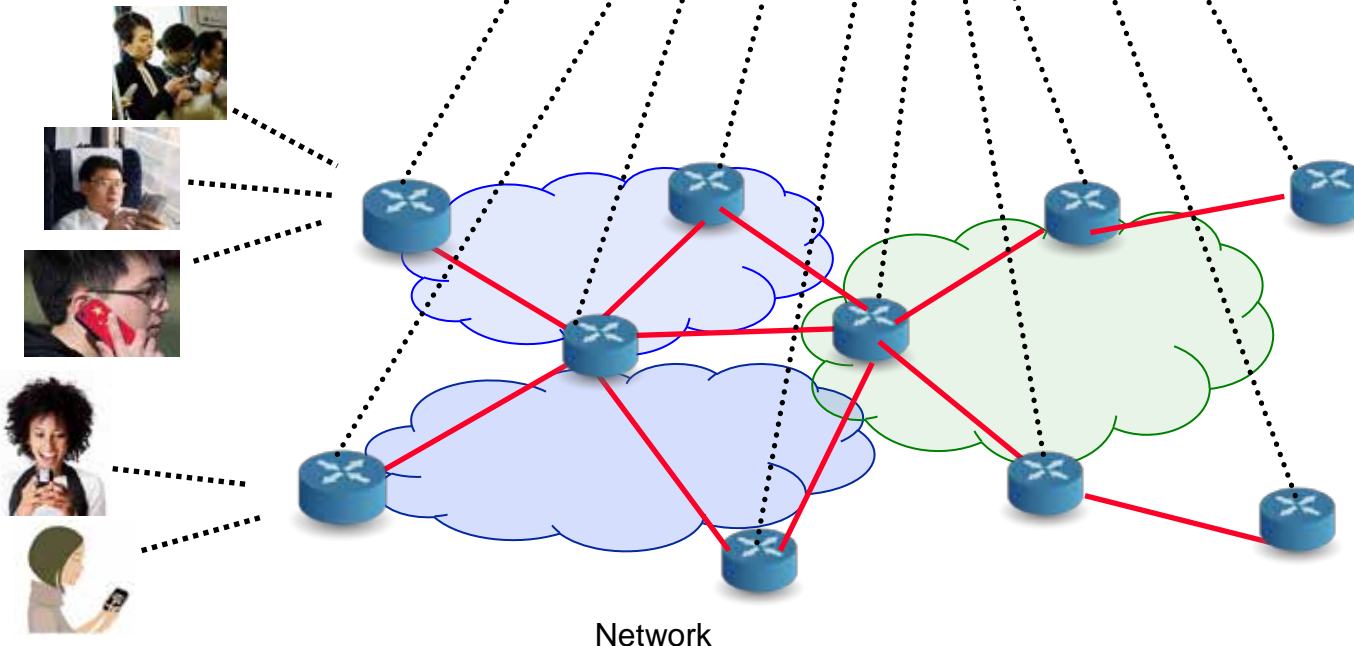
- Network can be managed w/o worrying about individual device hardware



Network Manager

Users

Network Controller

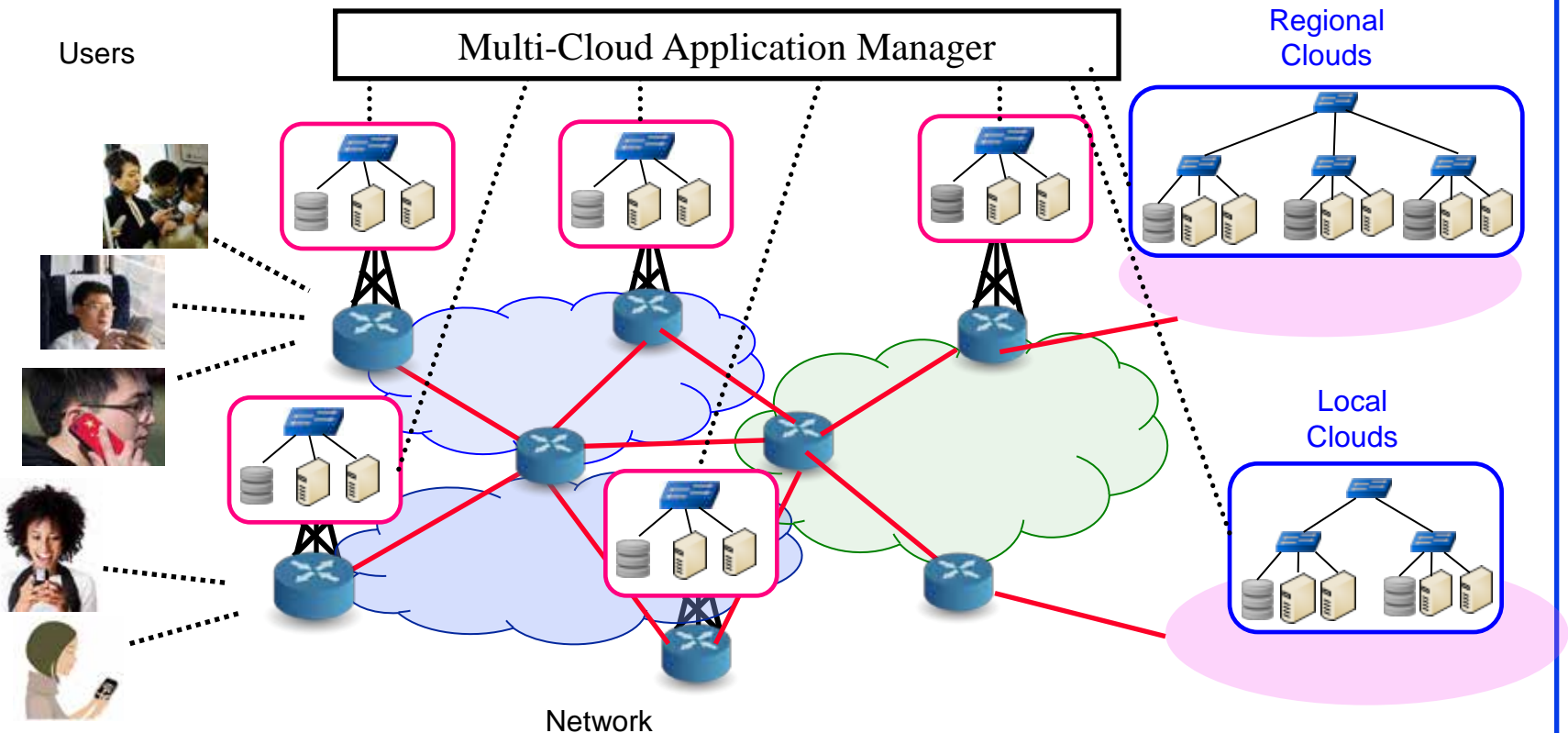


Network

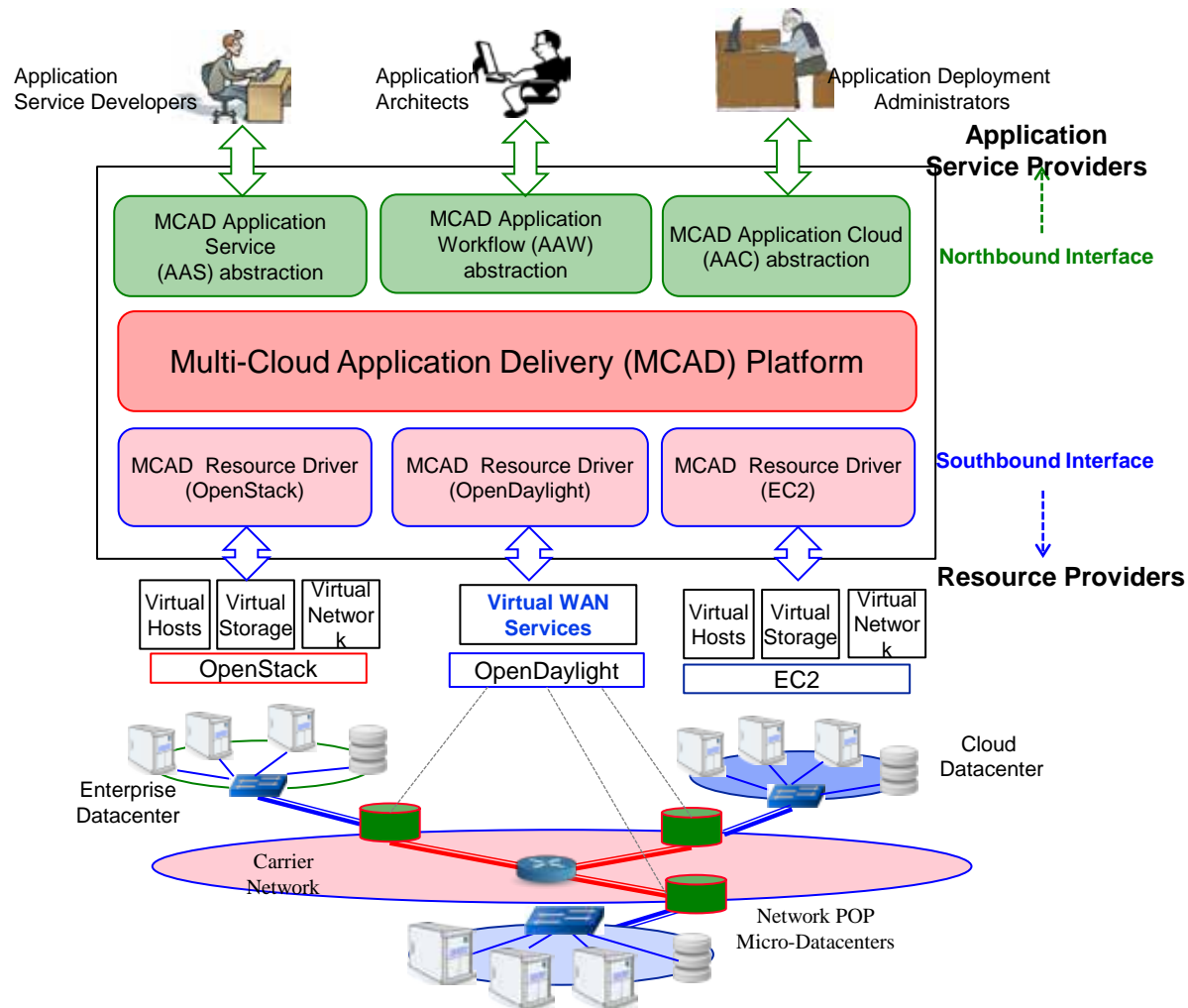
# Software Defined Multi-Cloud Application Delivery



Application  
Developer/Manager/User

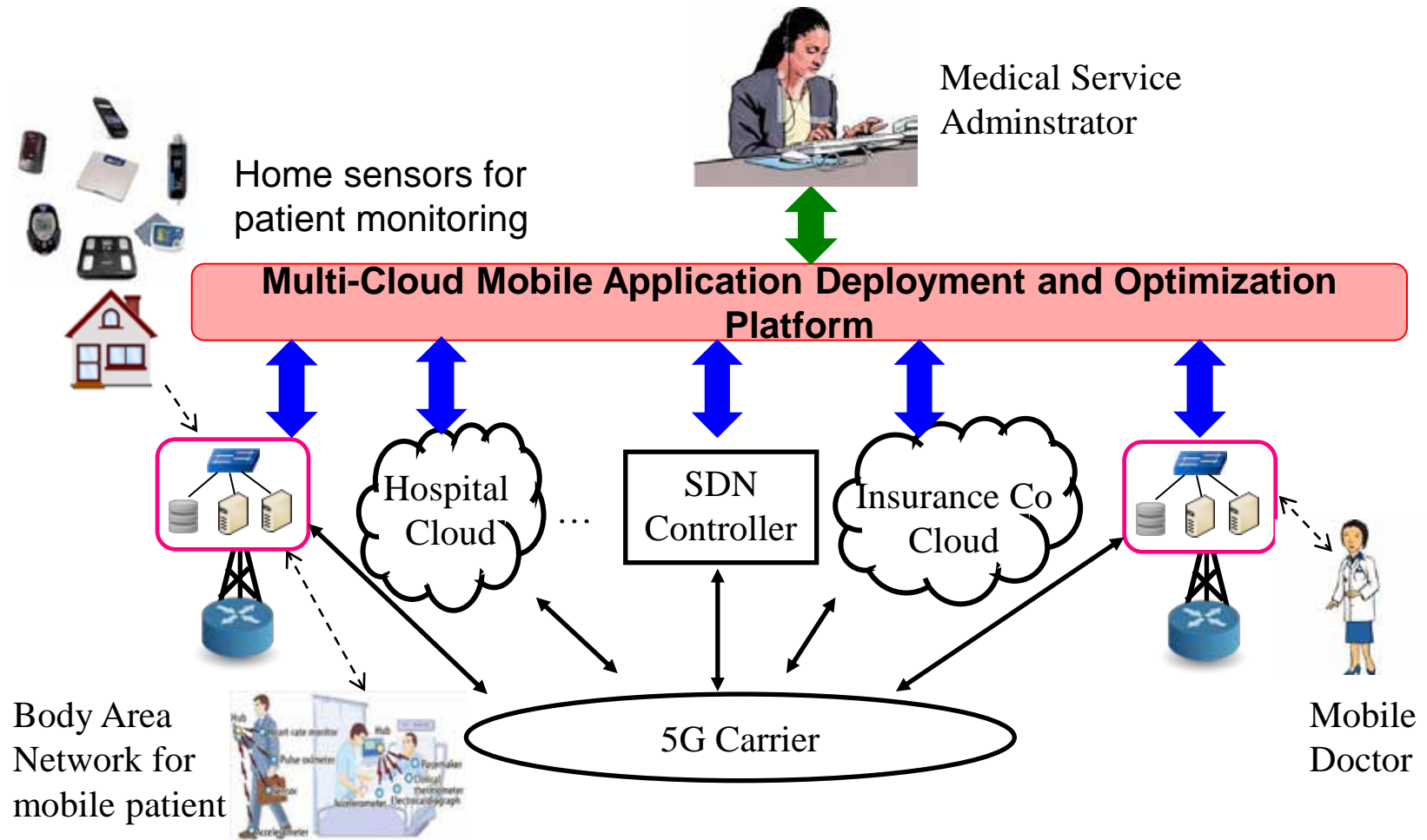


# OpenADN Multi-Cloud Management

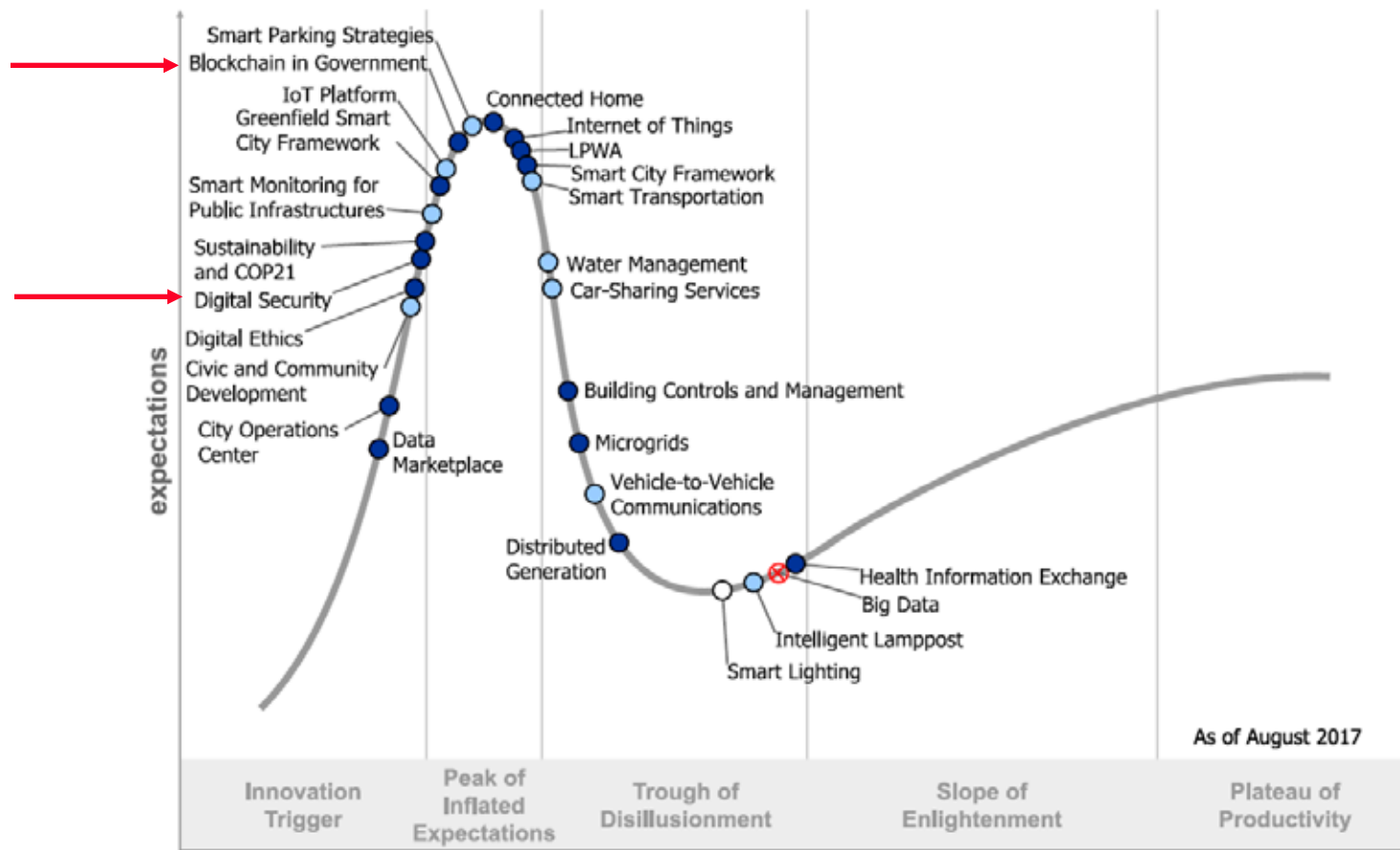


Ref: Lav Gupta, Raj Jain, Mohammed Samaka, "Analysis of Application Delivery Platform for Software Defined Infrastructures," International Journal of Communication Networks and Distributed Systems, 2016, Vol. 5, <http://www.cse.wustl.edu/~jain/papers/ijcnds16.htm>

# Mobile Healthcare Use Case



# Gartner Hype Cycle for Smart City Tech 2017



VC investment | Acquisitions | Mass Production  
 ← By large corporations →

Ref: Bettina Tratz-Ryan, "Hype Cycle for Smart City Technologies and Solutions, 2017," Gartner Report G00314338, 2 Aug 2017

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<http://www.cse.wustl.edu/~jam/talks/smrtc.htm>

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# Public Trust



Ref: [http://macleodcartoons.blogspot.in/2011\\_11\\_01\\_archive.html](http://macleodcartoons.blogspot.in/2011_11_01_archive.html)

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<http://www.cse.wustl.edu/~jain/talks/smrtcit.htm>

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# Smart City Insecurity

- **Smart Court House:** Placer county courthouse accidentally summoned 1200 people to jury duty on a morning in May 2012 causing traffic jams
- **Smart Metro:** Bay Area Rapid Transit (BART) was shut down by a technical problem affecting 500 to 1000 passengers on 19 trains (November 2013)
- **Smart Electricity:** 55 Million people in Northeast USA lost electric power due to a software bug
- Not marking a pipeline on the map lead to a gas pipe line explosion and fire in Johnson County, Texas by workers installing electrical lines
- Nation states and cyber terrorists know how to make use of public data ➤ **Smart Wars**



Ref: C. Cerrudo, "Hacking smart cities," RSA Conference 2015,

[http://www.rsaconference.com/writable/presentations/file\\_upload/hta-t10-hacking-smart-cities\\_final.pdf](http://www.rsaconference.com/writable/presentations/file_upload/hta-t10-hacking-smart-cities_final.pdf)

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# Security: Attack Surface

1. **Users**
2. **Sensors**
3. **Wireless access technology**: DECT, WiFi, Z-wave, ...
4. **Gateways**: Smart Phone
5. **Home LAN**: WiFi, Ethernet, Powerline, ...
6. **IP and higher layer protocols**: DNS, Routers, ...
7. **Clouds**
8. **Management Platform**: Web interface
9. **Life Cycle Management**: Booting, Pairing, Updating, ...



Users

Things

Access

Gateway

WAN

Cloud

# IoT Security: Popular Approach

I have finished studying other companies' IoT Security strategies. "Close your eyes and hope for the best!" seems to be the most popular.



Ref: <http://cloudtweaks.com/2011/08/the-lighter-side-of-the-cloud-the-migration-strategy/>

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<http://www.cse.wustl.edu/~jain/talks/smrtcitcity.htm>

# Internet of Harmful Things

Imagine, as researchers did recently at Black Hat, someone hacking your connected toilet, making it flush incessantly and closing the lid repeatedly and unexpectedly.



Ref: <http://www.computerworld.com/article/2486502/security0/worm-may-create-an-internet-of-harmful-things--says-symantec--take-note--amazon-.html>

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<http://www.cse.wustl.edu/~jain/talks/smrtcitcity.htm>

# DEFCON



# DEFCON (Cont)

- q Hacking the cloud
- q Hacking voting machines
- q Hack connected vehicles
- q Hacking travel routers
- q Breaking the Uber badge ciphers
- q Clone RFID in real time
- q Safe cracking robots
- q GPS Spoofing
- q Abusing Microsoft Office
- q Hacking wind farm control network
- q Counterfeit hardware security devices
- q Fool antivirus software using AI
- q How to track government spy planes
- q Break bitcoin hardware wallets

Ref: <https://www.ethicalhacker.net/features/opinions/first-timers-experience-black-hat-defcon>

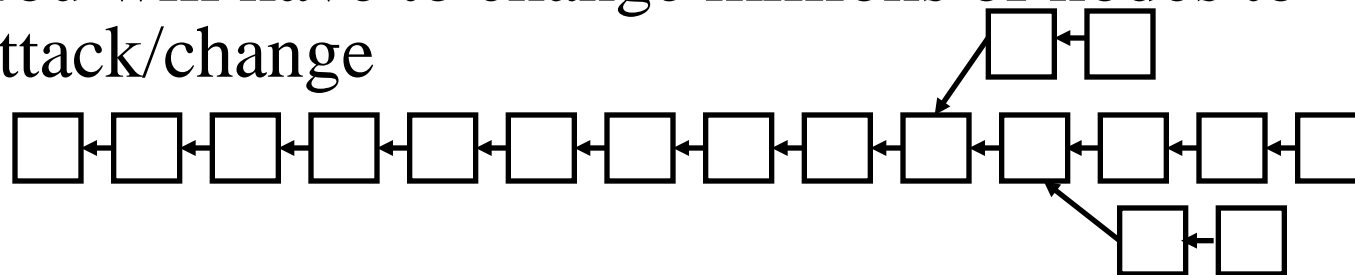
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<http://www.cse.wustl.edu/~jain/talks/smrtcitcity.htm>

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# Blockchain Origin: Bitcoin

- q Blockchain is the technology that made Bitcoin secure
- q After Bitcoin became successful, people started looking into the technology behind Bitcoin and found Blockchain is the key for its success
- q Two complete strangers can complete a transaction without a third party
- q A singly linked chain of blocks of verified signed transactions is replicated globally on millions of nodes
- q You will have to change millions of nodes to attack/change



# Blockchains For Cities

- q Land titles
- q Vehicle registries
- q Business license
- q Criminal records
- q Passports
- q Birth certificates
- q Death certificates
- q Building permits
- q Gun permits

Ref: <http://ledracapital.com/blog/2014/3/11/Bitcoin-series-24-the-mega-master-blockchain-list>

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<http://www.cse.wustl.edu/~jain/talks/smrtcite.htm>

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# Blockchains for Network Security

- q Certificate Authorities issue certificates
  - ∅ Single Point of Failure
  - ∅ CA Keys are often compromised  
(Diginotar – Dutch certificate authority was compromised in 2011)
- q Web of Trust: Anyone can issue a certificate
- q Blockchain solution: Store user ID and public key
  - ∅ Blockstack
  - ∅ Certcoin

# City IQ: Benchmark for Smartness



- ISO 37120:2014 Sustainable Development of Communities: Indicators for City Services and Quality of Life
- Using 17 themes and 100 indicators for city services and quality of life, World Council of City Data (WCCD) give a city one of five levels.

**ISO 37120**



30-45

Aspirational

**ISO 37120**



46-59

Bronze

**ISO 37120**



60-75

Silver

**ISO 37120**



76-90

Gold

**ISO 37120**



91-100

Platinum

Ref: WCCD, "WCCD ISO 37120 Certification," <http://www.dataforcities.org/iso>

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# List of Smart Cities

## q World Council on City Data (WCCD): Partial List

City	Country	Year	Level
Amsterdam	Netherlands	2014	Aspirational
Helsinki	Finland	2014	Aspirational
Johannesburg	South Africa	2014	Aspirational
Shanghai	China	2014	Aspirational
Buenos Aires	Argentina	2014	Gold
Makkah	Saudi Arabia	2014	Gold
Melbourne	Australia	2014	Gold
Barcelona	Spain	2014	Platinum
Boston	United States of America	2014	Platinum
Dubai	United Arab Emirates	2014	Platinum
London	United Kingdom	2014	Platinum
Rotterdam	Netherlands	2014	Platinum
Toronto	Canada	2014	Platinum
Los Angeles	United States of America	2015	Platinum

Ref: <http://www.dataforcities.org/registry>

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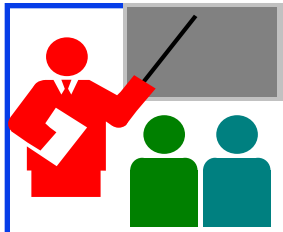
# Areas Measured by ISO 37120:2014

1. Economy
2. Education
3. Energy
4. Environment
5. Finance
6. Fire and emergency response
7. Governance
8. Health
9. Recreation
10. Safety
11. Shelter
12. Solid waste
13. Telecommunications and innovation
14. Transportation
15. Urban planning
16. Wastewater
17. Water and sanitation

# Indicators

- q Indicators: Quantitative, qualitative, or descriptive measures  
47 of 100 are core.
- q Core (Required), Supporting (Recommended), Profile (Informative) indicators
- q Example: Education
  1. % of female school aged population enrolled in schools (core)
  2. % of students completing primary education: survival rate (core)
  3. % of students completing secondary education: survival rate (core)
  4. Primary education student/teacher ratio (core)
  5. % of male school-aged population enrolled in schools (supporting)
  6. % of school-aged population enrolled in schools (supporting)
  7. # of higher education degrees per 100,000 population (supporting)

Ref: ANSI, "ISO 37120-2014 Preview Final V2, [http://publicaa.ansi.org/sites/apdl/ANSI%20Network%20on%20Smart%20and%20Sustainable%20Cities/ISO+37120-2014\\_preview\\_final\\_v2.pdf](http://publicaa.ansi.org/sites/apdl/ANSI%20Network%20on%20Smart%20and%20Sustainable%20Cities/ISO+37120-2014_preview_final_v2.pdf)



# Summary

1. Smart  $\neq$  High-Speed Computation, Smart  $\neq$  Big Data Storage, Smart = Networked
2. Smart Cities research areas are easy via the 7-layer model  
Research issues in every layer: Sensors, datalink, routing, applications, analytics.
3. Clouds are getting smaller, Carriers and enterprises moving to clouds, leading to clouds everywhere  $\Rightarrow$  multi-cloud
4. Our MCAD abstracts/virtualizes the cloud interfaces and allows automated management of security and other policies of multi-cloud applications
5. Cyber security is important for smart cities and blockchains may offer a potential solution to some problems.

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# Acronyms

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

# Acronyms (Cont)

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

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