Chapter 9

The Cloud of Things

9.1 The Internet of Things and Cloud Computing

The Internet of Things (IoT) and cloud computing are two of the most widely used catchphrases nowadays in media. In the English-speaking world, however, the term *Internet of Things* is not as popular as *cloud computing*, as discussed before and also evidenced by the Google Trends chart (Figure 9.1). Part of the reason is that IoT is referred to by different terms such as machine-to-machine (M2M), connected world, smarter planet, smart grid, and the like in the United States.

However, Google trends (Figure 9.2) show that *machine to machine* is a more popular term than *cloud computing*, while *M2M* is less popular.

Whatever the situation is, both IoT and cloud computing can be categorized as distributed computing and have many things in common or closely related:

- Both are a type of distributed computing that relies heavily on communication networks.
- Cloud computing is an enabling technology of the IoT.

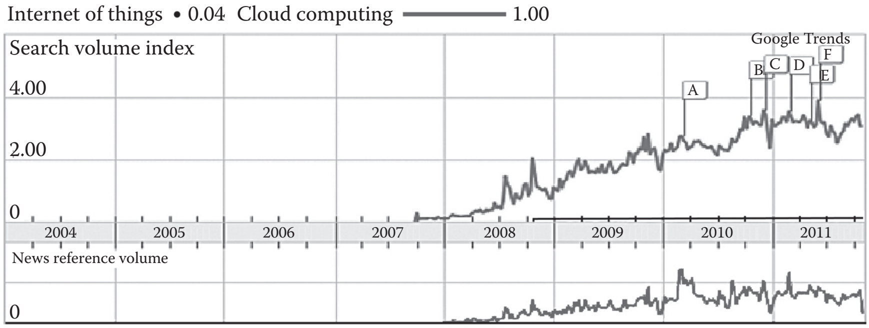

Figure 9.1 IoT versus cloud computing.

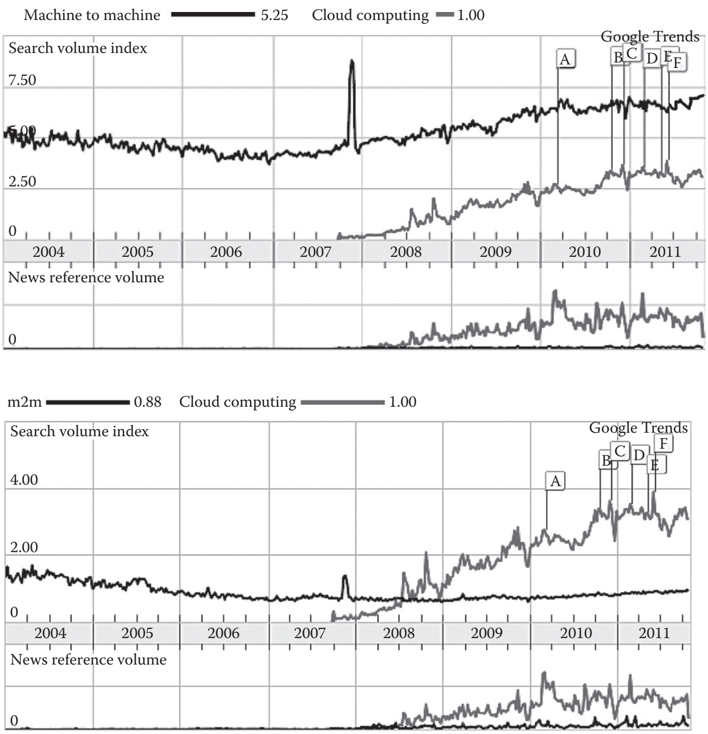

Figure 9.2 M2M versus cloud computing.

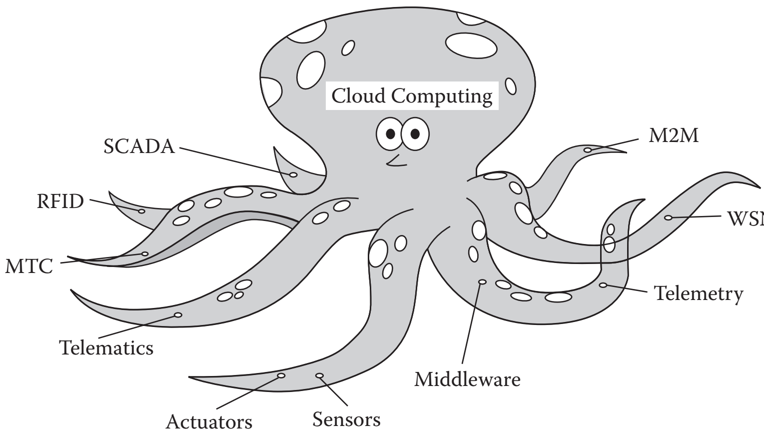

Figure 9.3 Cloud computing and IoT.

- The cloud and IoT are best considered as a continuum of Internet connectivity with cloud as (focusing on) the "head" and IoT as the "tails" of an octopus as shown in Figure 9.3.

We are in the early stages of the Internet of Things, the much-anticipated era when all devices can talk to intermediary services and to each other. But for this era to achieve its full potential, operators must fundamentally change the way they build and run clouds [158]. The reason is that M2M interactions are far less failure tolerant than machine-to-human interactions. Imagine when a fleet of trucks can no longer report its whereabouts to a central control system designed to regulate how long drivers can stay on the road without resting, or when the power in your building goes out and the heating, ventilation, and air-conditioning (HVAC) system dies on a hot day because of a cloud outage.

In the very near future, everything from elevators to cell phones to city buses will either be subject to connected control systems or use networks to report back critical information. The sheer volume of data flowing through networks will mushroom. In a dedicated or colocated hardware world, that would result in prohibitively expensive hardware requirements. Thus, the cloud becomes the only viable option to affordably connect, track, and manage the new Internet of Things.

Current M2M/IoT solutions are focusing on communications (i.e., how information is transmitted from one machine to another) and integration. Future Web of Things (WoT) evolution will effectively integrate *connectivity* and *content* with *context*, *collaboration*, *cloud*, and *cognition*. The future Internet of Things will be a global network of interconnected objects, enabling object identification/discovery and semantic data processing via the M2M-IOT C^6 cube depicted in Interdigital.com website [137], with cloud as the base.

- Connectivity: connection for mobile and constrained objects
- Content: massive data produced from things
- Cloud: cloud service and cloud content storage
- Context: context-aware design to improve performance
- Collaboration: cooperative communications, inter-things, service sharing
- Cognition: mine the knowledge from massive data and provide autonomous system adjustment for improvements

In this expanded role, the cloud will have to step up its game to accommodate more exacting demands. The current storage infrastructure and file systems that back up and form the backbone of the cloud are archaic, dating back 20 years. These systems are familiar and comfortable for infrastructure providers. But over time, block-storage architectures that cannot provide instant snapshots of machine images (copy-on-write) will continue to be prone to all sorts of failures. Those failures will grow more pronounced in the M2M world when a five-second failure could result in the loss of many millions of dollars worth of time-specific information.

Currently, no one is putting truly mission-critical applications in the cloud. But in the coming era of the Internet of Things, that is a near-guaranteed eventuality, either through intentional or unintentional actions. As we build the Internet of Things and slowly ease it first onto private clouds and later onto public clouds, we have no choice but to improve the core of the cloud or risk catastrophic consequences from failures. Because on the Internet of Things, no one can blame it on user error and simply ask that a hotel air conditioner, an airplane, or a bank of traffic lights restart its virtual server on the fly and reset its machine image.

In short, the Internet of Things will not take off without an up-to-date, secure, and scalable cloud computing infrastructure such as the ones from Eurotech Everyware (http://www.eurotech-inc.com/m2m.asp), Jelastic (http://blog.jelastic.com/2012/01/09/using-jelastic-for-the-Internet-of-things/), and so on.

9.2 Mobile Cloud Computing

The potential of cloud computing doesn't stop at turning the personal computer into a thin client. The mobile application market is about to change radically, from the suppliers' standpoint and from the consumer access standpoint due to the emergence of widgets (applications from Apple app stores or Android markets, a ranking is available at http://www.pocketberry.com/2011/02/18/blackberry-app-world-gets-2nd-place-for-global-mobile-app-store-ranking/), the most compelling of mobile cloud applications. Much has been made of the mobile application phenomenon popularized by Apple's iconic iPhone. Smartphones are becoming thin clients of cloud services, which render software and content vendors such as Microsoft, Google, and Apple into the upper streams of the smartphone value chain. Traditional cell phone makers such as Nokia, Sony-Ericsson, HTC, and others are lagging behind and struggling.

Apple's iCloud services, announced in June 2011 that run on Amazon Web Service and Microsoft Azure IaaS, symbolize the start of Cloud Phones (even though Apple's iTunes has been a cloud service for a long time), which is followed by traditional mobile phone firms and Internet services companies such as Google worldwide. With all or most of the computing and heavy-lifting done on the server side, cell phones become a device that handles connectivity. This will also bring down the price of smartphones. A cloud architecture for smartphones is envisioned by NTT DoCoMo [248].

Currently, most widgets downloaded from app stores or Android markets are not cloud applications by definition because they do not receive services from the cloud during runtime. However, a large number of them are cloud applications such as LBS applications, data synchronization, weather forecast, bank client, etc., applications. In fact, a large percentage of Android and iPhone widgets are already cloud services based. This is real mobile cloud computing (mCC). Apple's iCloud services allow users to store data such as music files on remote computer servers for download to multiple devices such as iPhones, iPods, iPads, and personal computers running Mac OS X or Microsoft Windows. Windows Live Mesh is a free-to-use Internet-based file synchronization application by Microsoft that is designed to allow files and folders between two or more computers to be in sync with each other on Windows and Mac OS X computers.

Android Cloud to Device Messaging (C2DM) [249] is a service that helps developers sending data from servers to their applications on Android devices. The service provides a simple, lightweight mechanism that servers can use to tell mobile applications to contact the server directly, to fetch updated application or user data. The C2DM service handles all aspects of queuing of messages and delivery to the target application running on the target device.

Mobile cloud widget applications such as AppStore widgets as we know them today are mostly for the domain of smartphone users. Gartner estimated the total sales of smartphones across 2011 were 472 million or 31 percent of mobile communication. The rest of the mobile subscriber world has generally had to stand by and watch, since their phones are not powerful or fast enough to handle mobile apps. Nevertheless, non-smartphones or so-called feature phones can still get connected with the cloud to receive simple services such as data synchronization, etc.

Smartphone apps are typically custom built for particular smartphone platforms in advanced programming languages, limiting the available pool of developers and driving up costs. Using a stand-alone widget client is in fact a step back technologically due to the limitations of the browsers on the smartphones in the earlier days. With HTML5, the widget client may again be unified with one browser client just as it happened on PCs while at the same time keeping the revenue generation model of charging the users based on application widget download.

The HTML5 has features such as offline support, canvas drawing based on low footprint SVG graphics, GeolocationAPI, video and audio streaming support without flash, WebStorage, CSS3 Selectors, 2D animations for mobile cloud applications. Widgets, whether in the forms of app stores or unified under a browser, will exponentially expand the market for mobile applications with the heavy-lifting done in and contents to and from the cloud (some call it mobility-as-a-service [250]), introducing complex, rich user experiences to a new and much larger mobile consumer audience.

Those mobile cloud computing services have made the "phone" a "thing" in the Internet and they can be easily extended for other IoT applications such as Google Wallet and mobile resource management (MRM, as described in Chapter 2). For example, some of the mobile devices such as telematics terminals are both a M2M device connected to the cloud and a smartphone thin client that receives services from the cloud. ADT's Pulse is a project associated with Android@Home. It not only allows you to arm and disarm your ADT security system, but also includes very impressive controls for lights, security cameras, and even thermostats. Another example is

Figure 9.4 Schlage IoT application.

the Schlage LiNK iPhone applications that can let you turn off your home lights remotely (Figure 9.4) while enjoying a vacation in Hawaii. The parent company of Schlage is Ingersoll Rand, which also owns Trane, a heating, ventilation and air-conditioning (HVAC) company. This relationship also allows the Schlage LiNK to work easily with a Trane thermostat, and so on.

It's fair to say that, without M2M and sensor capabilities, mobile cloud computing has limited value. MCC, especially the so-called micro cloud computing systems such as Hyrax, and sensor networking are in fact very similar technology paradigms.

As IP-enabled, affordable sensor devices of all types become available and are placed around the earth forming a "sensing cloud," integrating the diverse sensor data streams into the web can serve different user or machine queries. In the sensorMap project of Microsoft and the Pachube project, people are encouraged to contribute real-time sensor information to the cloud subject to privacy and security constraints. Intelligent mobile devices can act as hubs or sources and sinks of such real-time streams as shown in the Pachube ecosystem graphic [251].

It's not hard to imagine that, over time, all of the phones and mobile devices will become thin clients that receive cloud services and smart devices that send information such as location or environment data to the cloud, to finally achieve the full potentials of M2M; i.e., machine to machine, machine to mobile, machine to man connectivity.

According to ABI Research, 19 percent of global mobile users will be using cloud-enabled devices in 2014. Juniper Research forecast that the revenue of mobile cloud computing applications will increase from $400 million in 2009 to $9.5 billion in 2014. The predictions (new computing cycles support by 10X more devices) of Morgan Stanley can be found in "Internet Trends" [252].

With the development of software technologies and the increase of the processing power of the devices at lower cost, specific protocols such as WAP for mobile devices are no longer needed. The difference between mobile and non-mobile devices are narrowing, different devices are converging in usage and information delivery methods. For example, smartphones and the telematics terminals as well as the tablet PCs (iPad) could be one unit in the future, TVs, PCs, and smartphones can run the same software suite.

Telecom operators have been investing big money to build cloud infrastructure for M2M applications:

- Verizon Wireless and Sierra Wireless have announced a new collaboration to co-market Sierra Wireless' AirVantage (described in Chapter 4), a cloud-based platform for developing, deploying, and operating the next generation of connected devices and M2M applications;
- AT&T is working with Axeda to build cloud-based applications for telematics, security solutions, monitoring, supervisory control and data acquisition (SCADA), point of sale, asset management and similar M2M deployments. AT&T's innovative service delivery platforms complement its network and expertise for a broad range of wireless data applications and industries;
- In China, China Mobile (Big Cloud), China Telecom (Nebula), and China Unicom are all building cloud computing to support iCloud/iPhone-like "Cloud Phone" and M2M applications.

In the future, with the all-IP technologies such as LTE, cloud phones may become virtual personal phones hosted in the network with a IPv6 address that are accessed via a personal ID from any device without the need of a SIM card. Phone calls become a functionality of a smart M2M device. Cloud services are moving toward serving smaller smart devices with support of robust middleware platforms as forecasted by ABI Research.

For example, announced in December 2010, the Amazon Web Services SDK for Android provides a library, code samples, and documentation for developers to build connected mobile applications. Similar SDK also exists for iPhone, iPad, and iPod Touch devices.

The Open Mobile Terminal Platform (OMTP) was a forum created by mobile network operators to discuss standards with manufacturers of cell phones and other mobile devices. In July 2008, OMTP announced an initiative called Bondi (http://bondi.omtp.org/). The initiative defined new standard-based, vendor-agnostic interfaces (Javascript APIs) and a security framework (based on XACML policy description) to enable the access to mobile phone functionalities (application invocation, application settings, camera, communications log, gallery, location, messaging, persistent data, personal information, phone status, user interaction) from a browser and widget engine in a secure way. This effort would certainly help in building widespread mobile cloud computing (mCC) services.

GSM Association's third-party access OneAPI (http://oneapi.gsmworld.com/) is another standardization effort that aims to provide a set of open-network enabler APIs (OneAPI) that can be supported across mobile operators and other networks. OneAPI is based on lightweight RESTful and SOAP APIs to encourage portability of mobile apps but still allow for competition and differentiation between operators. As mentioned before, HTML5 also provides better support for mobile applications, which might render the widget-based approach currently used by AppStore and Android markets unnecessary.

Ubiquitous connectivity is creating great market opportunity and unlimited application potentials per an ABI Research forecast [253], with Asia-Pacific sharing the largest piece of the pie. Telco operators, equipment, and smart device (including cell phones) manufacturers are taking strategic steps to embrace the mCC and pervasive computing opportunities.

Mobile computing, cloud computing, and IoT are intertwined with each other, like the many facets of a diamond. The core is connectivity and software-enabled resource sharing and services.

9.3 MAI versus XaaS: The Long Tail and the Big Switch

As discussed in Chapters 6 and 7, the difference between EAI and business-to-business/business-to consumer (B2B/B2C) is that one is for internal Intranet and the other is for external Internet integration. The concepts of M2M application integration (MAI) and XaaS (Everything as a Service) were proposed [74]; they are the extensions of EAI and B2B/B2C respectively in the IoT space.

Today, the majority of IoT devices live in the MAI systems that exist in the Intranet and Extranet. Only a fraction of the devices are available on the Internet. The focus of MAI is connectivity and monitoring. In the future, XaaS of IoT will provide more services to a larger audience, as shown in Figure 9.5.

The Long Tail theory was popularized by Chris Anderson in an October 2004 *Wired* magazine article [119], in which he mentioned Amazon and Netflix as examples of businesses exploiting the Long Tail strategy and making enormous profits. The *Long Tail* refers to the statistical property that a larger share of population rests within the tail of a probability distribution than observed under a “normal” distribution. Anderson believes that IoT finally makes sense after so many years [257].

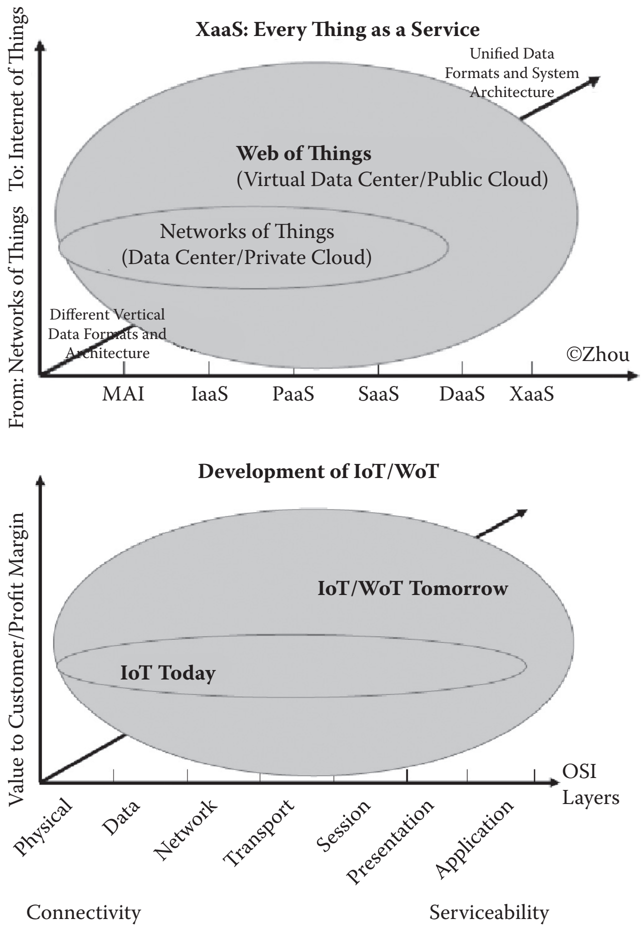

Figure 9.5 Evolution of IoT in the cloud.

The web technology on top of the Internet makes the harvesting of Amazon's online book-selling business Long Tail cost-effective. Based on Figure 9.5, the majority of currently connected *things* are located in organization's intranets, which form the Long Tail of the Internet of Things; only a minority exist in the Internet or extranet. Examples of *things* that are on the Internet are meters or sensors in Google's Powermeter, Microsoft's Sensormap, or on Pachube.com; the list is not long, and most of the projects are currently experimental.

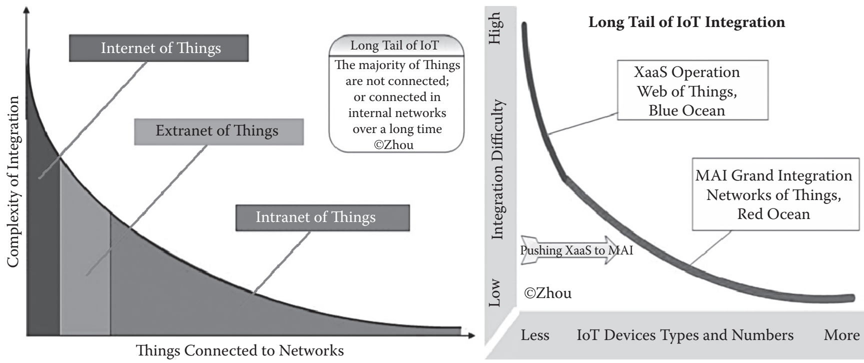

Figure 9.6 The Long Tail of IoT.

By the same token, with the constant development of the Internet of Things, more and more *things* or *objects* will be connected to the intranet, extranet, and finally the Internet with proper security measures, making the harvesting and utilization of the IoT Long Tail cost-effective and secure. (The author is one of the first who had this observation [74] and proposed the intranet, extranet, IoT concepts as depicted in Figure 9.6.) New innovative business models like that of Amazon and Netflix of today will emerge, and the ubiquitous IoT applications will become widespread and prosper.

At the beginning of IoT development, many people thought it was a Blue Ocean [168] opportunity just like when the web and the browser were invented. As we can see now, the MAI of IoT is an extended application of EAI, and the XaaS is an extension of web applications that cover devices and things. Most of the current IoT applications are foundational works that involve "Red Ocean" competitions. However, gold mining opportunities do exist when more and more ubiquitous devices are connected to the web; new application paradigms and new business models are on the horizon, as shown in Figure 9.7.

In *The Big Switch: Rewiring the World, from Edison to Google*, Nicholas Carr [279] walks readers through the history

IoT Strategy ©Zhou	*Red Ocean Competition The Foundation*	*Blue Ocean Strategy The Opportunity*
Device	Device and sensor design and manufacturing, cost reduction	Sensors based on new materials, R&D breatkthrough
Connect	Networking reliability, QoS 3G/4G and new technologies All-IP/IPv6 networks	3-Networks convergence, new models New paradigms: No SIM card, etc.
Manage	Middleware development MAI grand integration XaaS cloud services	New service model innovation Unified system framework Unified data formats

Figure 9.7 IoT Red Ocean versus Blue Ocean.

of electrification and computing. The early years of electrification were technologically limited. An electrical grid wasn't feasible and electricity was generated locally. Technology changed over time and electricity was rapidly centralized and networked. Power was produced remotely and delivered via a vast network of wires and cables.

Based on this historical context, Carr revitalized the metaphor between electrification and the current model of computing that was introduced by John McCarthy in 1961. We have come all the way to the time of cloud computing; computing resources can be used and charged just as electricity is consumed and billed. Examples are Amazon's EC2 (Elastic Computing Cloud) and S3 (Simple Storage Services). To people in the computing industry, Carr's sayings aren't new but thought provoking. In fact, the transportation networks also changed the consumption of goods fundamentally: food isn't homemade, vegetables aren't home grown, and so forth.

With the Internet of Things comes the big paradigm switch: as described before, the power grid becomes a two-way electricity supply, a smart grid system where people can store their electricity surplus generated by their solar system back to the smart grid. The ubiquitous Internet of Things makes the consumption of everything possible, just like electricity and computing resources. Examples include changing the driving route home in a telematics-enabled car by checking on a traffic-congestion map generated using sensor-based vehicle-to-road, vehicle-to-vehicle ITS systems, a service provided by a TSP, and so on. Thomas Friedman's "flat world" [169] will become more flattened and smarter with the Internet of Things [256] as a major flattening factor.

9.4 The Cloud of Things Architecture

Much like cloud computing, no agreed common terminologies, definitions, and architecture specifications for the Cloud of Things existed until Peter Mell and Tim Grace of the Information Technology Laboratory of the National Institute of Standards and Technology (NIST) proposed the NIST definition of cloud computing. Even though the European Union has created definitions, specifications, roadmaps, and so on, it seems that still no agreed definitions and architecture specifications exist.

As mentioned before, IoT and cloud computing have many comparable characteristics. For example, cloud computing has three layers: IaaS, PaaS, and SaaS (SPI). IoT also consists of three layers: devices, connect, and manage (DCM) or devices, networks, and applications (DNA). Cloud computing has public cloud, private cloud, hybrid cloud, and so forth. The IoT also has Intranet of Things, Extranet of Things, Internet of Things, and so on.

Even though the IoT concept and paradigm is still evolving, the basic pieces of the IoT puzzle have been generally agreed.

Mimicking the NIST specification of cloud computing, a tentative IoT architecture/framework specification is proposed in this chapter, hoping to help form a common reference architecture framework and common terminology. One of the foundations of this specification is the four-pillar categorization of IoT.

Figure 9.8 is the general framework of the Internet of Things. Its definition, attributes, characteristics, use cases,

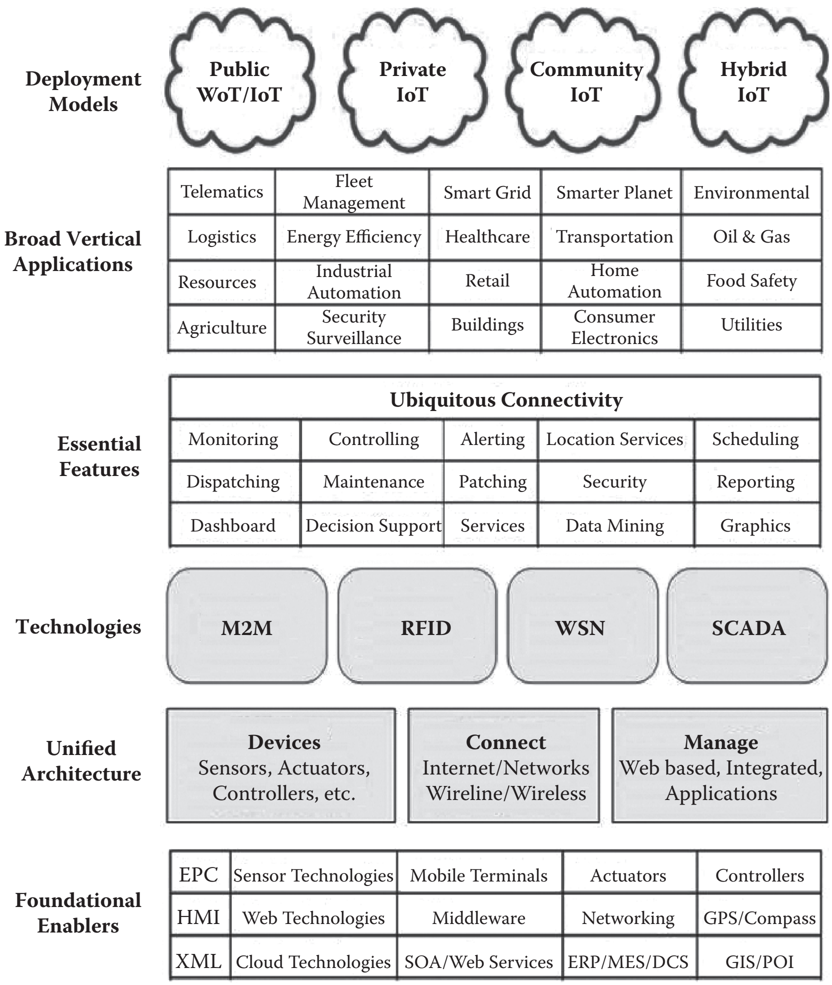

Figure 9.8 The Cloud of Things architectural specification.

underlying technologies, issues, risks, and benefits will be refined and changed over time in spirited debates by the public and private sectors. The IoT industry represents a large ecosystem of many models, vendors, and market niches. This specification attempts to encompass all of the various IoT approaches.

The definition of IoT by the author:

> The Internet of Things provides the means to access and control two categories of ubiquitous and uniquely identifiable devices—those that have inherent intelligence and those that are externally enabled—via all sorts of wired and/or wireless communications in all kinds of networking environments, supported by cloud computing technologies with adequate security measures, to achieve pervasive connectivity and grand integration and to provide services such as monitoring, locating, controlling, reporting, decision support, and so on.

9.4.1 Four Deployment Models

- Private IoT: The IoT MAI system is operated solely for an organization such as a building management system operated by a property management firm. It may be managed by the organization or a third party and may exist on premise (intranet) or off premise (extranet).
- Public IoT: The IoT system is made available to the general public or a large industry group and is owned by an organization, such as Pachube, selling IoT services.
- Community IoT: The integrated system is shared by several organizations and supports a specific community that has shared concerns (e.g., mission, security requirements, policy, and compliance considerations). It may be managed by the organizations or a third party and may exist on premise or off premise.

- Hybrid IoT: The IoT system is an integrated composition of two or more of the above IoT systems (private, community, or public) that remain unique entities but are bound together by standardized or proprietary technology that enables data and application portability.

9.4.2 Vertical Applications

Because there are too many vertical applications, it is impossible to list all of them. Only the vertical applications that are expected to be materialized soon are listed. For example, in China, telematics is expected to receive policy support from the central government sooner than the others. According to MIIT (Ministry of Industry and Information Technology) of China, during the 12th Five-Year Plan period, MIIT will spend more effort to promote telematics in full swing. It is said that telematics has been listed as one of three major projects supported by the central government (State Council) and will receive special financial funding. Informed sources said that support funding will focus on automotive electronics, telematics, fleet management (e.g., mostly due to security reasons, all heavy trucks and long-distance buses nationwide were mandated to be tracked and monitored by the Ministry of Transportation by the end of 2011), ITS, and so forth; and more than 10 billion renminbi (RMB) yuan will be allocated by the central government to support this effort. It's estimated that there will be 200 million vehicles in China by 2020, and all of them (passenger and commercial vehicles) will be mandated to be connected by that time.

- Telematics, fleet management, transportation
- Smart grid, energy efficiency
- Smarter planet
- Environmental protection
- Logistics, retail
- Healthcare

- Security/surveillance
- Resources (such as water resource management, etc.)
- Industrial automation
- Home automation, buildings
- Food safety, agriculture
- Security surveillance
- Consumer electronics
- Utilities, oil, and gas

9.4.3 Fifteen Essential Features

The fundamental feature of IoT is *ubiquitous connectivity*. Other concrete features or functionality (some of them are merged in the list) include the following:

- *Monitoring* and *Controlling*: These are some of the fundamental functionalities of IoT applications, more monitoring than controlling.
- *Location Services*: Based on GPS/compass (Beidou) or other locating technologies such as RTLS.
- *Alerting*: Event-based alerting, sometimes triggering rule-based engine for actions.
- *Scheduling* and *Dispatching*: Time- and event-based scheduling and dispatching.
- *Maintenance* and *Patching*: Maintenance supports remote monitoring, refill, patching (software upgrade), and so forth. For example, equipment from all Kodak shops around the world can be connected in a DRM (device relation management) system.
- *Security*: Security framework is required to support access control, privacy, and so forth.
- *Reporting*, *Dashboard*: Reporting, trending, and dashboard are used for better management and decision making.
- *Data Mining*, *Decision Support*: Analysis of collected device data based on Business Intelligence (BI) algorithms and data mining for decision support.

- *Graphics*: Graphic display of dynamic data, work flows, equipment status, and so forth of real-world things.
- *Services*: All kinds of services, such as postsale services of equipment, vehicles, leasing support and controls, and others.

9.4.4 Four Technological Pillars

1. RFID: IoT starts with radio-frequency identification. It's more of an enabling technology that turns dumb things into traceable items via instrumentation. It can also be used as identification means for counterfeiting and other applications. The usage is unlimited.
2. Wireless Sensor Network (WSN): The last-mile nerves of IoT including OSN, BSN, and others. Information can be gathered at the M2M gateway for uplink integration. Some WSN systems can be stand-alone.
3. M2M: This is an area the telcos [184] are focusing on. Mobile terminals can be connected and integrated for MRM, telematics, fleet management, and other applications. When all networks become IP-based such as LTE, cell phones can be part of multifunctional smart devices that no longer require a SIM or other card.
4. SCADA: It includes IT-controls converged smart system and others, an escalation of control systems. It can be used in buildings, industrial automation, smart grids, and more.

9.4.5 Three Layers of IoT Systems

1. Devices: include ubiquitous intelligent devices (M2M terminals, WSN sensors, SCADA actuators, etc.) and dumb assets that can be RFID instrumented to be electronically traceable
2. Connect: include wired and wireless, long-distance and short-range telecommunication means
3. Manage: integrated applications that are based on middleware and cloud computing back end

9.4.6 Foundational Technological Enablers

1. EPC: all coding and identification technologies such as EPC, UID, UUID, and others
2. Sensor technologies: all kinds of sensors, large and small, that generate MTC data
3. Mobile terminals: all kinds of mobile devices that communicate via telco networks
4. Actuators and controllers: PLC, RTU, DCS, and others that connect via field buses
5. HMI: human–machine interface technologies include graphical control panels, PC-based panels, and so forth
6. Web technologies: include browser/HTML5 technologies on all kinds of devices
7. Cloud technologies: SPI-based backend technologies, multitenancy
8. SOA/web services: for B2B/B2C grand integration over the Internet as well as intranet and extranet
9. XML: provides universal data representation means
10. Middleware: all kinds of middleware for unified IoT framework
11. Networking: provides ubiquitous connectivity
12. GPS/compass: provides location services
13. GIS/POI: help provide location and navigation services
14. ERP/MES: receivers and users of IoT data, part of IoT grand integration

9.5 Summary

In this final chapter of the book, the synergy of IoT and cloud computing was discussed. Mobile computing, cloud computing, and IoT are intertwined with each other, like the many facets of a diamond. Mobile cloud computing pushes the convergence a step further. In the future, with all-IP technologies such as LTE, cell phones may become part of any smart

M2M devices with an IP/IPv6 address without the need of a SIM card.

Most IoT technologies and applications are not new; what's novice is ideologies brought about by IoT. Two new paradigms, MAI and XaaS, are introduced by the author to describe IoT (inside the firewall) and WoT (outside the firewall) systems.

When the deployment of IoT applications and the number of connected devices reach a critical mass and scale, fundamental, innovative, and disruptive changes will emerge, just like prosperity of the web has brought about the Internet revolution. The thought-provoking ideas of the Big Switch and the Long Tail theory have been cited to stimulate creative imagination inspired by the Internet of Things and cloud computing.

As a final summarization of the entire book, the Cloud of Things architectural specification was introduced and explained with the hope of creating a common vocabulary for the IoT community.