The Internet of Things Meets Cloud Computing

By William Lumpkins

In June 2012, I had the opportunity to attend the IEEE Standards Association (SA) board meeting series in Beijing. Prior to the meeting, the IEEE SA held a forum for the famed Internet of Things (IoT), a new term for an old concept, that also intersected with cloud computing. Both topics are fresh in the minds of the average entrepreneur. But what are IoT and cloud computing really?

IoT is a new marketing phrase for an old concept known as embedded computing. As consumer devices continue to develop into mobile products for the extension of our social and familial interactions, the need arises for these products to connect to the nearly unlimited resources of the World Wide Web. The mobile product by its very definition is an independent device with a power source such as a battery, a microcontroller unit (MCU), a display unit, and an Internet connectivity device, such as the radio-like 802.11abgn or 802.15.4, also known as "ZigBee." Figures 1–4 show two examples of standard configurations.

As noted in Figures 1 and 2, the Wireless Internet Connectivity for Embedded Devices (WICED) module supports 802.11a/b/g and a single-input single-output 802.11n dual-band 2.4- and 5-GHz radio. The WICED module also supports a transmission control protocol (TCP)/IP network stack (IPv4/IPv6) with small-office home-office and enterprise Wi-Fi security. The WICED module supports the redefined Wi-Fi ad hoc mode called Wi-Fi Direct.

Figure 3 shows an example of the multiple varied blocks inside a standard MCU. Figure 4 shows the same MCU

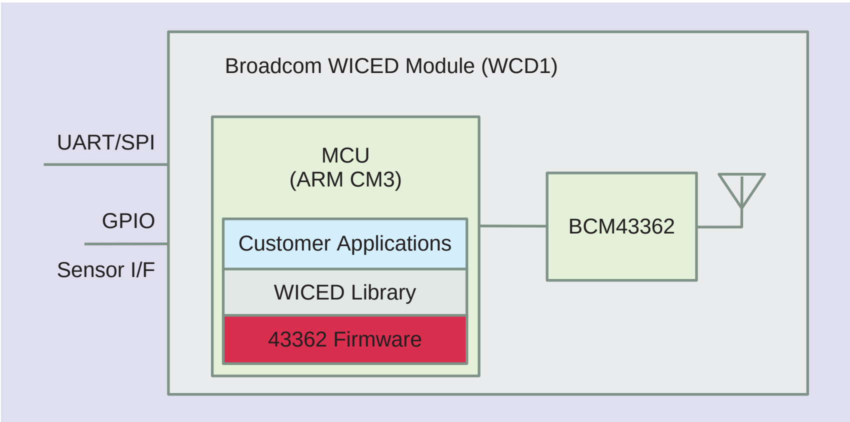

FIGURE 1. Broadcom WICED module (courtesy of Broadcom, Inc., Irvine, California).

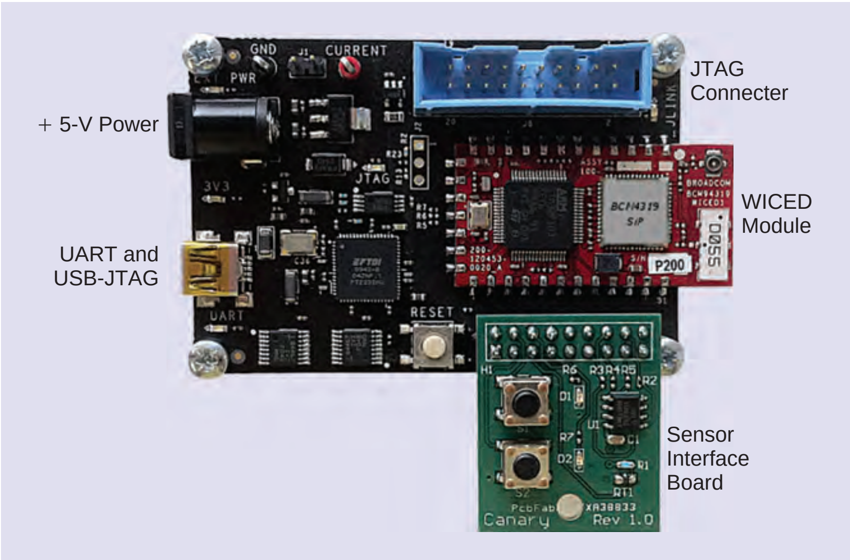

FIGURE 2. WICED module.

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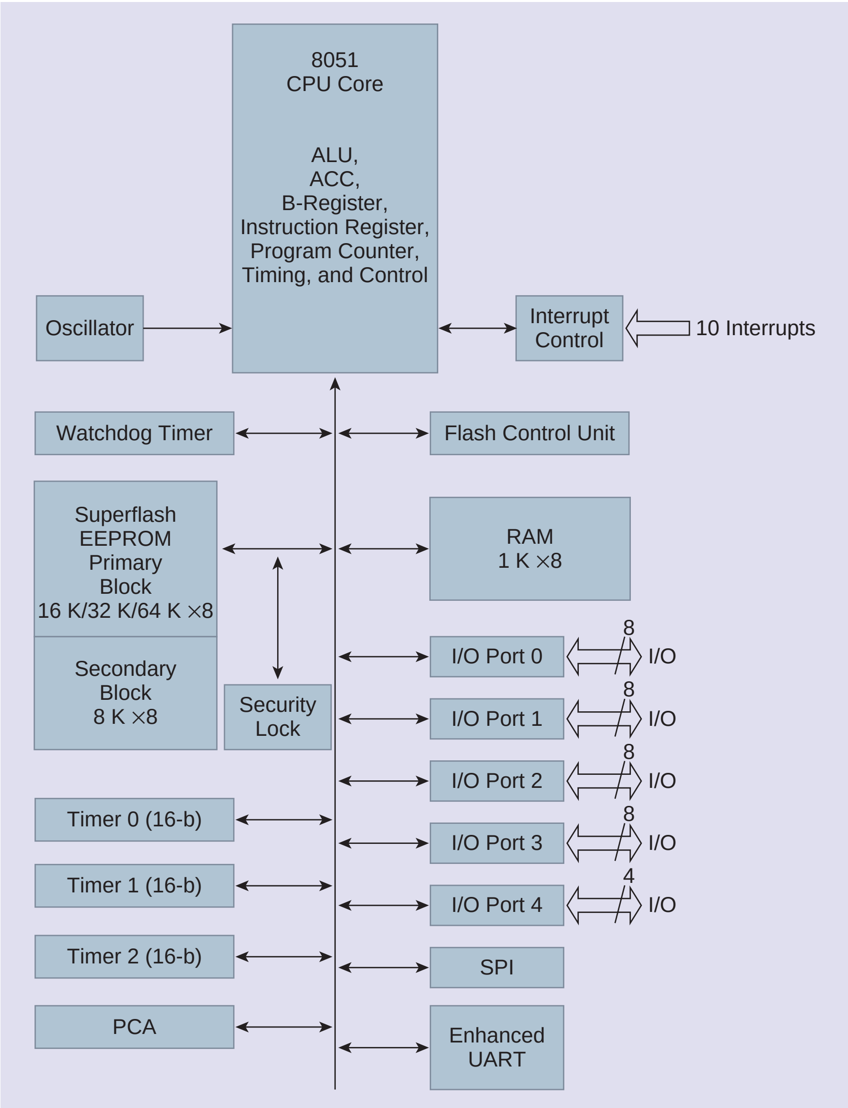

FIGURE 3. An example of internal MCU blocks (courtesy of Microchip Technology, Inc., Chandler, Arizona).

configured as a low-profile USB dongle-like subassembly. The generic features of Figure 4 include:

- a low-power and compact system-on-a-chip (SoC) solution ideal for ZigBee Smart Energy 1.x end points
- a 32-MHz single-cycle low-power MCU
- 400-m line-of-sight range out of the box
- an AES-128 security module and software support for Certicom ECC in a SEP 1.x, 12-b analog-to-digital converter (ADC) for sensor reading
- a 1-μA power mode with a real-time clock for long battery life end nodes
- a USB 2.0 full-speed device on the Texas Instruments CC2531.

Both of these examples are commonly used in mobile video systems, vehicle security, navigation systems, in-vehicle gaming systems, mobile gaming systems, and social networking systems. IoT extends beyond traditional embedded computer applications to "white goods," washing machines, refrigerators, cooking appliances, and cleaning systems as well as home infrastructure such as lighting systems, irrigation control, pest control, and

FIGURE 4. Texas Instruments, Inc., Dallas.

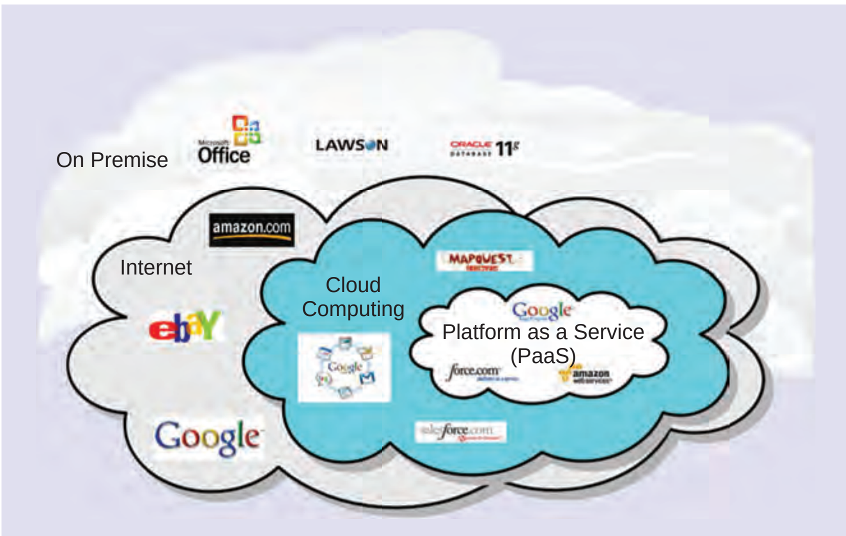

FIGURE 5. The cloud (courtesy of http://www.cloud-computing-network.com/category/cloud-computing/).

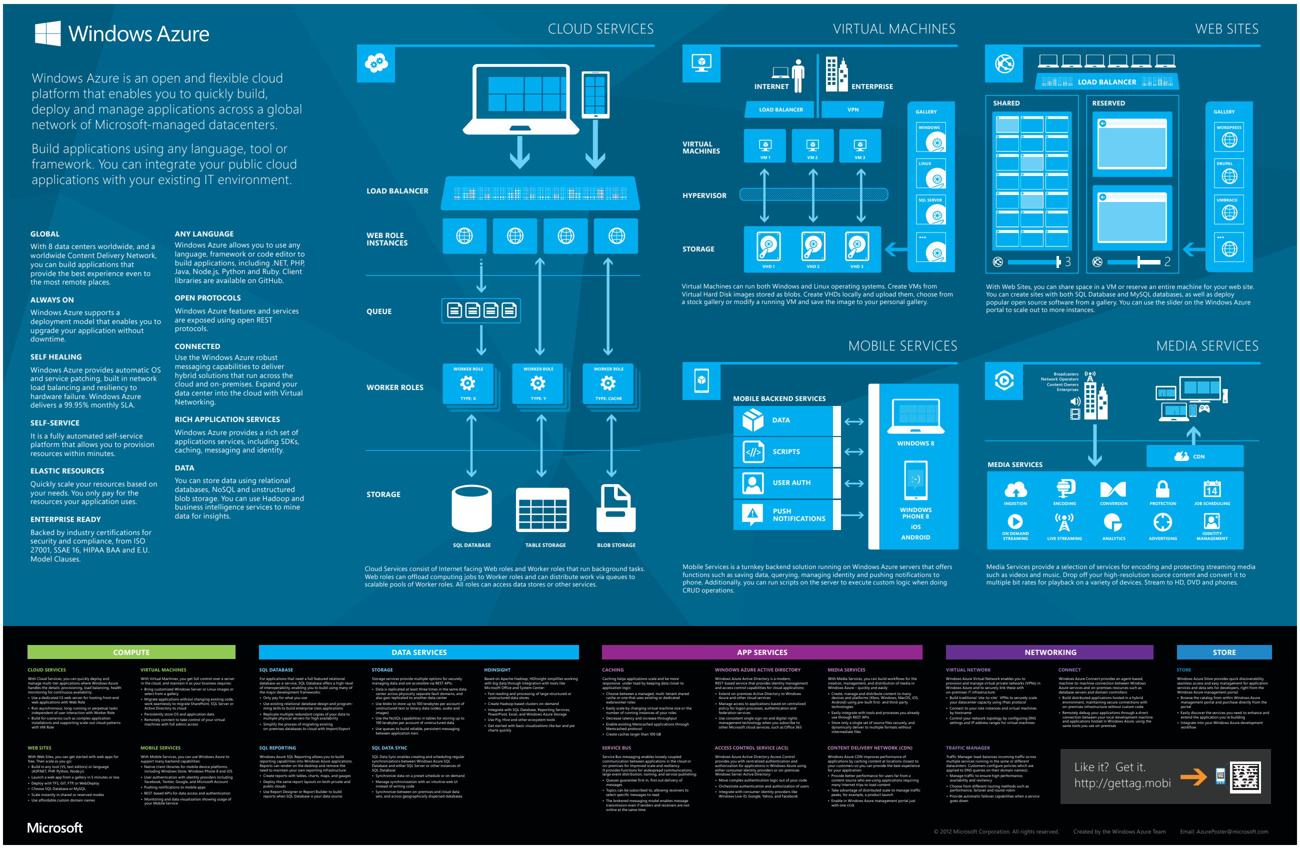

FIGURE 6. Microsoft Azure (courtesy of Microsoft, Redmond, Washington).

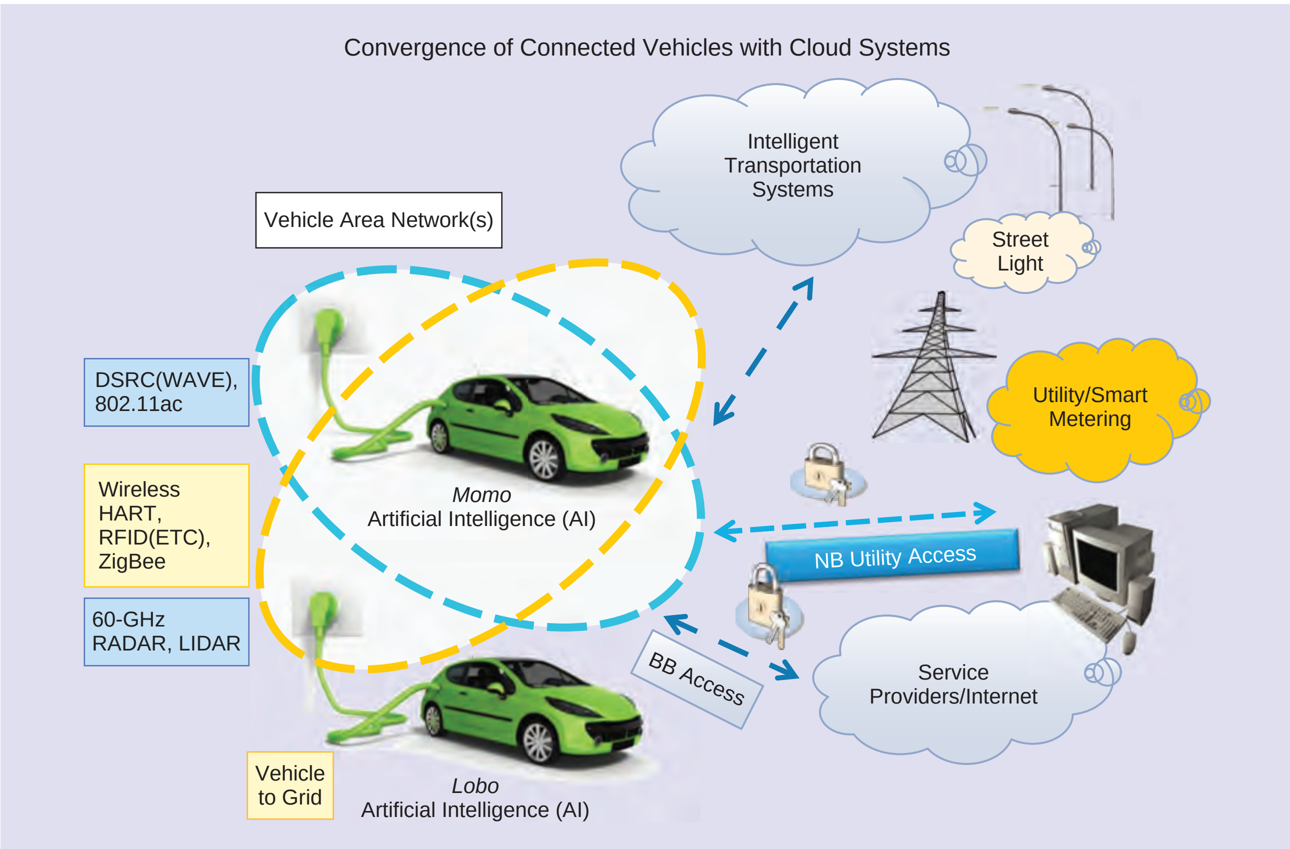

FIGURE 7. Connected vehicle to the ITS cloud.

→ Car Audio

The term *car audio* is included in in-car entertainment (ICE), but ICE can also refer to video, games, or the GPS automotive navigation system. Car audio refers to devices such as radio/CD head units, speakers, subwoofers and their enclosures, and amplifiers.

→ Gaming Consoles

Gaming consoles can be a popular source of entertainment when installed in a car. In addition to playing games, modern consoles can play other media such as DVDs and audio CDs. The main problem to overcome is power, since consoles are designed to operate from mains power. This can be achieved using an inverter or, in some cases, a dc-dc power supply.

→ Carputers

Carputers are specially adapted computers designed to operate in a car environment. Carputers can provide many functions, such as video and audio playback, games, and Internet connectivity. In 2013, every new car built in Europe will be equipped with Internet connectivity, says a study from market researcher Invensity.

→ Infotainment

Infotainment is "information-based media content or programming that also includes entertainment content in an effort to enhance popularity with audiences and consumers."

→ ICE

ICE is a collection of hardware devices installed into automobiles, or other forms of transportation, to provide audio and/or audio/visual entertainment as well as automotive navigation systems (SatNav). This includes playing media such as CDs, DVDs, Freeview/TV, USB, and/or other optional surround sound or DSP systems. Also increasingly common in ICE installs is the incorporation of video game consoles into the vehicle.

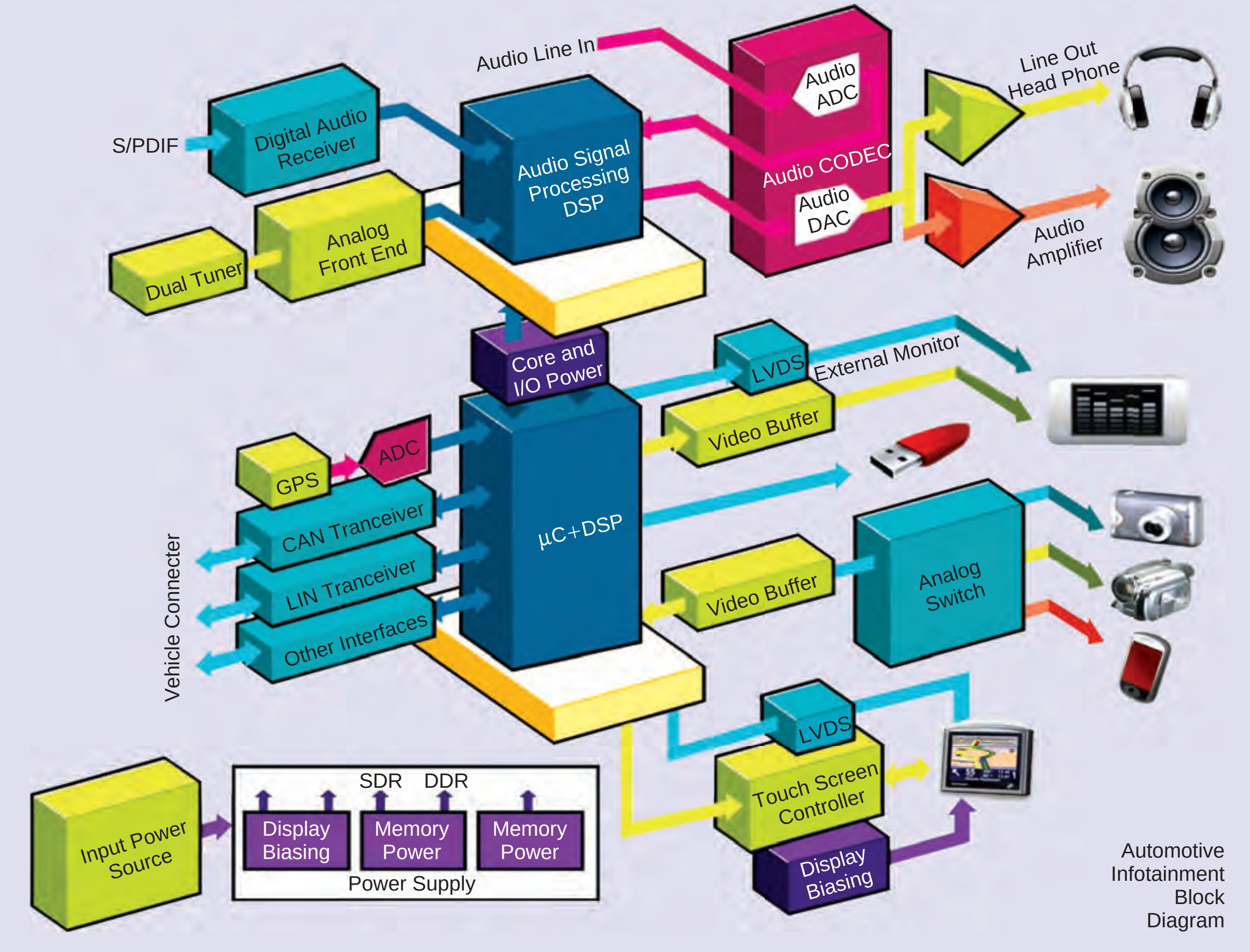

FIGURE 8. Infotainment IoT.

home security systems. The conservative estimates of over 50 billion IoT devices in the world by 2020 will surely be exceeded with the rapid growth and the need to consume innovative content generated by varying sources.

Cloud computing is another new term for a relatively old technical solution. In the early 1960s and 1970s, IBM and Fairchild both utilized mainframe computers to process multivaried programs. Getting "time" on the mainframe could be an arduous waiting game for scientists and engineers, with programmers encoding punch cards and placing them in batches to be processed later. IBM decided that it would save time and resources by enabling employees to access the mainframe from their homes or from remote locations. These dummy terminals consisted of a modem, a display terminal, and a keyboard with an MCU. Using these dummy terminals, an employee could contact the mainframe, load a program, and run it remotely from anywhere on the planet that had a phone line. During the mid 1980s, a shift occurred to move the computing or processing power away from costly mainframes to PCs. This has been the mainstay for the past 30 years. Thus, the dumb terminal was dead until now.

As we reach the physical limitation of the processing speed of CPUs, we are moving toward multiprocessing operating systems. The concept of networked or shared processing power again is not a new idea, but it is gaining traction as companies and individuals struggle to increase their usable processing power without using their retirement savings to purchase new hardware every three years. Companies likewise are moving to PCs that are lightweight, slim, and less expensive to manufacture, attracting consumers with their sleak design and exotic product features. Companies have come to realize that the main storage unit of the Ultra Net Book can be small but fast like a solid-state drive and the processor can be moderate, but the Internet connection must be fast. The new Ultra Net Book concept offloads the main processing of complex programs like games, simulation tools, and video processing to networked processing power, i.e., the cloud (Figure 5). Uploading locally generated content from the Ultra Net Book to the massively networked storage capability of the cloud on a recurring basis frees up the Ultra Net Book to retain its slim/sleek size while retaining access to user-generated and purchased content.

With the resurgence of the concept of cloud computing in the public mindscape and on the technology advancement checklist of modern developers, Microsoft has joined the fray with its Azure cloud platform. Microsoft's Azure platform enables developers to create cloud-based programs for the netbook and mobile product classifications. The poster provided by Microsoft illustrates some of these aspects (Figure 6).

IoT and cloud computing are moving to all aspects of our lives. I again found myself in Beijing in December 2012 attending the connected vehicle conference (See www.icceve.org for more information.), where most of the speakers and attendees were discussing the connected vehicle and the connections to the intelligent transportation system (ITS), which oddly uses IoT devices in the vehicle to connect to the cloud, although the cloud is called ITS (Figure 7).

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ITS encompasses the virtualization of IoT devices along the road/rail side, with a multitude of sensor arrays with a communications backhaul to the immense processing power of the cloud. ITS consists of the following aspects as noted by www.itsa.org:

- vehicle and highway infrastructure-based sensors: "camera-based 'computer vision,' radar, light detection, and ranging (LIDAR), and ultrasonic sensors have been employed to support advanced driver-assistance systems in vehicles and advanced traffic management systems on highways"
- 4G wireless (LTE/802.11ac): vehicle and highway gateways to the cloud
- dedicated short-range communications/wireless access for vehicular environments
- vehicle electrification and sustainable transportation and energy
- cyber security and risk management in transportation
- driver assistance and autonomous driving.

As shown in Figure 8, the various interconnected infotainment systems are actually IoT devices that are connected to each other and to the cloud for content.

As with all IoT devices and the automotive vehicles that have them, the need for extensive user or repair manuals becomes paramount. But, in our current technological climate of continued advances in the cloud and the offloading of information from the local to the cloud, it seems disingenuous to have a trunkload of paper repair manuals in case one of the multitudes of IoT devices was to fail or require maintenance. I suppose some entities would suggest that you just replace the IoT with an upgraded version as, with the advent of the cloud, IoT will be constantly upgrading itself; thus, the need for an extensible user manual will persist.

FIGURE 9. oManual logo.

The IEEE Consumer Electronics Society Standards Committee in conjunction with the IEEE Computer Society/Environmental Assessment of Standards Committee has formed the P1874 "Standard for Documentation Schema for Repair of Electronic Devices" working group, called the oManual working group (Figure 9). (See www.omanual.org for more information.) This standard allows "fixers" to create documents to share multitextual and graphics-rich content for the repair and extended life of electronic products. If you are interested in reducing the world's waste and working toward a better tomorrow, contact me, the P1874 chair, at xillia@ieee.org to start work on the next line of IEEE standards to enhance humanity through direct action.

ABOUT THE AUTHOR

William Lumpkins is the lead technical consultant for Wi2Wi, Inc., where he is helping to integrate Wi-Fi, GPS, and Bluetooth into multiple projects for various customers. He also works with O & S Services, a consumer electronics design services company. He is a Senior Member of the IEEE. He is the IEEE Consumer Electronics Society Standards Committee chair and the P1874 chair.