Telecommunication Systems in Smart Cities

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OVERVIEW: Telecommunication systems play a very important role in the infrastructure of smart cities. A plethora of networked devices interact to provide safe, convenient and environmentally conscious new services. Residents in smart cities can enjoy their lives using these services, seamlessly and without being aware of the existence of the networks. To make such telecommunication systems possible, Hitachi is accelerating research into new network technologies, including gateways, highly reliable wireless communications, and network virtualization. Products and solutions under development include home gateways, wireless sensor networks, and M2M solutions.

INTRODUCTION

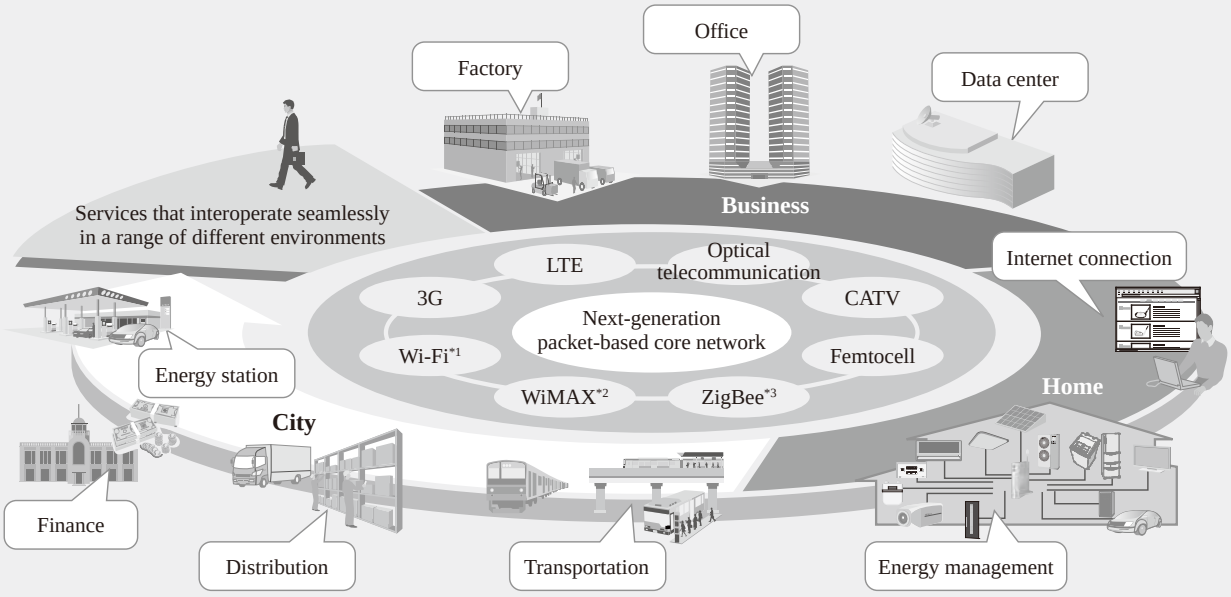
IF people are to enjoy comfortable lives in smart cities, telecommunication systems must be able to connect all manner of things, including human-to-human, human-to-machine, and machine-to-machine connections.

These connections and interactions between things make it possible for people to use energy efficiently while still enjoying comfortable lives. Examples include checking up remotely on what other people are doing, getting the information you need from a portable device as and when you need it, and communication between vehicles and traffic signals to avoid congestion.

This article describes the telecommunication systems necessary for smart cities.

TELECOMMUNICATION SYSTEMS NECESSARY FOR SMART CITIES

Adoption of the most appropriate communication technologies should make possible the seamless provision of a wide variety of services in smart cities (see Fig. 1).



3G: 3rd generation LTE: long term evolution CATV: cable television Wi-Fi: wireless fidelity WiMAX: worldwide interoperability for microwave access
*1 Wi-Fi is a registered trademark of the Wi-Fi Alliance.
*2 WiMAX and WiMAX Forum are trademarks of the WiMAX Forum.
*3 ZigBee is a registered trademark of the ZigBee Alliance.

Fig. 1—Telecommunication Systems in Smart Cities.
Telecommunication systems connect together all the elements that make up a smart city to provide services seamlessly using most appropriate telecommunication technologies.

Greater use of cloud services and visual communication tools using high speed broadband communication networks in the corporate and local government sectors is improving business efficiency and convenience while also being a source of new value creation. Meanwhile, sensor networks utilizing a variety of wireless technologies give access to information on the flow of goods and the status of equipment and the environment. They also facilitate the use of remote control. This makes possible the implementation of systems that are safe, secure, and environmentally conscious.

In the home, network connections for products such as home appliances and cars, as well as telephones and PCs (personal computers), will make life more enjoyable, secure, and comfortable.

In cities, transportation, distribution, finance, and energy services are connected to networks and interact to provide more reliable, convenient, and environmentally conscious new services.

Residents in smart cities will have seamless access to these services without needing to know about the networks on which they are based.

TECHNICAL ISSUES AND R&D

Technical Issues

In smart cities, everything will be connected to the network. This means that networks will not only require the high speed, high reliability, high availability, and other features demanded of today's networks, they must also satisfy new requirements, including the connection of various types of device, effective use of carrier networks, the flexibility to support new devices and services, the economics to provide services at a reasonable price, and consideration for the environment. To satisfy these difficult requirements, Hitachi is undertaking research and development of IP- (Internet protocol) based gateway technologies, highly reliable wireless communication technologies, and network virtualization technologies.

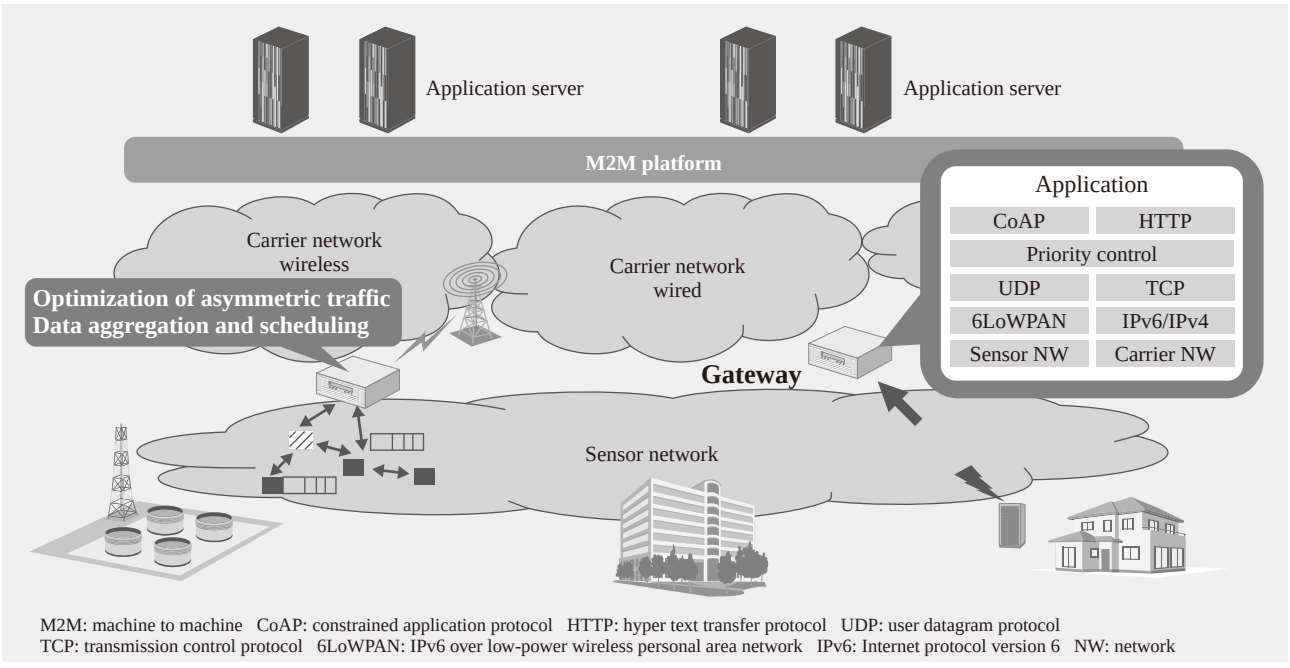
Gateway Technologies

To establish an environment in which objects of all types can link together, gateways for connecting devices to the network play an important role in ensuring support for a wide variety of devices so that they can deliver reliable services (see Fig. 2). Such gateways face the following issues.

(1) Need to ensure interconnectivity with IP networks
(2) Application communications environment for resource-constrained devices
(3) Traffic optimization for effective use of carrier networks

In order to solve these issues, Hitachi is currently carrying out research on protocol conversion, data aggregation, and scheduling technology.

The huge address space of IPv6 (Internet protocol version 6) is needed if large numbers of sensors are to



M2M: machine to machine CoAP: constrained application protocol HTTP: hyper text transfer protocol UDP: user datagram protocol
TCP: transmission control protocol 6LoWPAN: IPv6 over low-power wireless personal area network IPv6: Internet protocol version 6 NW: network

Fig. 2—Gateway Technologies.
Implementing the interconnection environment requires gateways to connect between devices. The Internet also plays an important role.

connect to the network. Because of their constrained resources, if they are to support IPv6, sensor nodes will require a protocol conversion function to convert between standard IPv6 and light-weight 6LoWPAN (IPv6 over low-power wireless personal area network). In addition, support for M2M (machine to machine) applications in an end-to-end web service environment requires mapping between HTTP (hyper text transfer protocol) and CoAP (constrained application protocol). Standardization and prototyping of related protocols are currently in progress at The Internet Engineering Task Force (IETF).

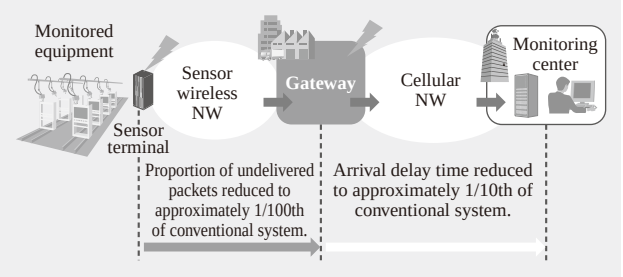


Fig. 3—Configuration of Remote Monitoring System Using Wireless Sensor Network.
Hitachi has developed a remote monitoring system using a wireless sensor network and cellular network. Using a wireless sensor network cuts set-up costs and makes layout changes easier. The advantage of the cellular network is its wide coverage.

Highly Reliable Wireless Communication Technology for Remote Monitoring

The intelligent control of the environment inside smart city facilities will require the use of sensors to measure the equipment power consumption and the temperature and humidity in the facility, as well as the transmission of this data via a communication network to a monitoring center for collection, analysis, and use.

Although most remote monitoring systems currently use reliable wired networks to send data, there is growing interest in the use of wireless networks because of their lower set-up costs and the ease with which layouts can be changed, especially at existing sites where it is difficult to lay new cabling. Furthermore, use of the existing cellular network is likely to be particularly efficient in situations where the factory or building being monitored is a long way from the monitoring center.

However, the use of wireless networks in these remote monitoring systems faces two issues. The first is the potential for radio interference between the signals transmitted by the sensors and those from wireless LANs (local area networks) or other existing equipment when wireless sensor networks are used in factories or buildings. This results in more frequent data communication errors. The second is the risk, when using cellular networks that are experiencing heavy traffic loads, that delays may occur in the arrival of alarm signals from the sensors reporting trouble at a facility being monitored.

Given these concerns, Hitachi has developed wireless communication technologies both for reducing the data communication error rate in wireless sensor networks and for reducing delays in the arrival time of alarm signals carried over cellular networks (see Fig. 3).

The interference avoidance technology for wireless sensor networks monitors the extent of interference and selects a "good" frequency range where communication can proceed smoothly. Combined with time-division multiplexing, which assigns communication time slots to devices, this technology reduces data communication errors without increasing the delay in data arrival time.

Priority control technology was also developed to detect when the cellular network communication speed is slow, in which case the gateway selectively sends only important alarm signals. Use of this technology keeps the arrival time delay for alarm signals within an acceptable threshold.

Network Virtualization Technology

Research and development are underway into a new network concept, called the "New Generation Network" or "Future Internet." In particular, it is anticipated that network virtualization technology will allow flexible responses to the changing demands of smart city residents in ways that are economically and environmentally efficient. Here, the term "network virtualization" means the operation of multiple networks with different characteristics and functions over the same physical network.

The new communication control technology has two key features: (1) The optimal allocation of virtual network capacity based on communication traffic, and (2) The optimization of virtual network routes (see Fig. 4). This technology will enhance the efficiency of network use in terms of the data communication speed and capacity required for each application, and enable telecommunication operators to provide high-speed communication to a larger number of users. At the same time, it allows end-users to use various types of application at a low cost.

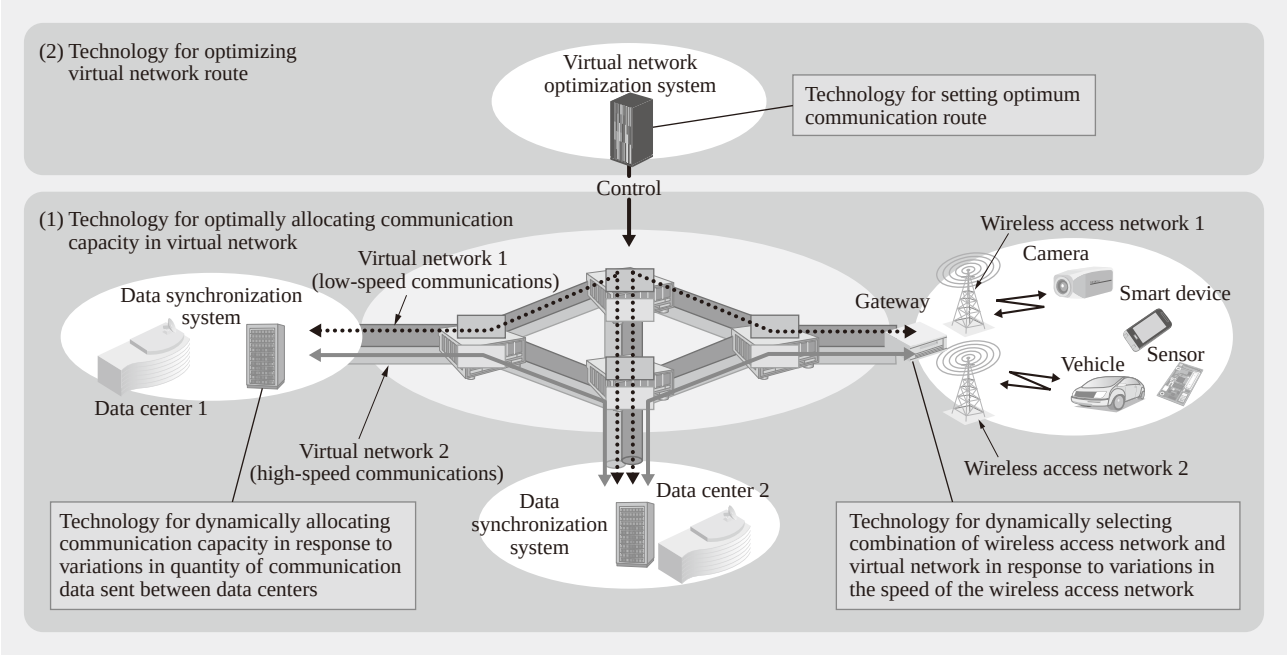


Fig. 4—Network Virtualization Technologies.
Network virtualization allows multiple networks with different characteristics and functions to operate over the same physical network.

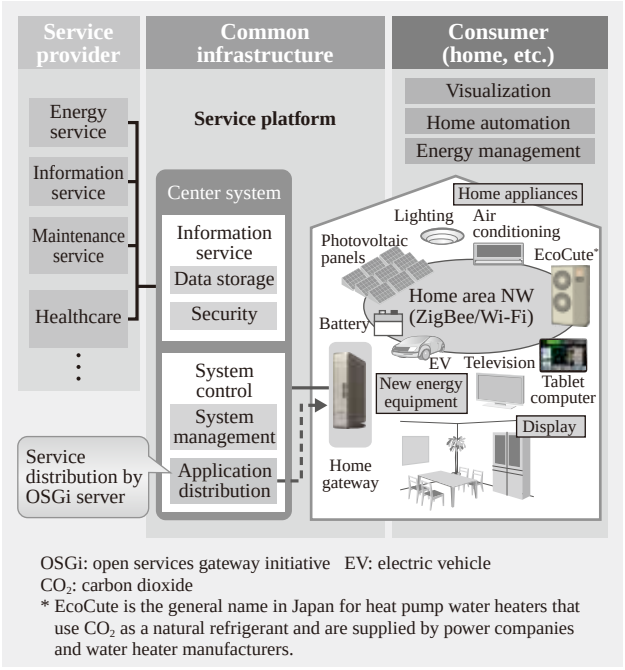
The reliable transmission of high-priority data can be achieved by centrally managing the communication quality of multiple wireless and wired networks and by dynamically selecting the appropriate routing. Lower priority data is then transmitted as network resources allow. The virtualization technology copes with network congestion caused by a heavy traffic load in a particular part of network by connecting automatically to other types of network, thereby increasing the potential for services to continue operating.

PRODUCT DEVELOPMENT

Home Gateway

Recently, more and more people are becoming aware of the need to save energy. In order to reduce energy consumption and carbon dioxide emissions, it is useful to provide users with information on their usage and to use home automation systems to control home appliances. Meanwhile, greater use of home photovoltaic power generation, electric vehicles, and storage batteries is creating a need for energy management. Hitachi is developing a home gateway system to act as a key component in home energy management.

The home gateway functions as a controller in the energy management system where it performs monitoring and control of home appliances (see Fig. 5). It uses the OSGi[*1] framework as a common platform. A variety of service applications are available as OSGi bundles and the system can interoperate with OSGi distribution servers in the center system to add and modify services as required.



OSGi: open services gateway initiative EV: electric vehicle
CO_2: carbon dioxide
* EcoCute is the general name in Japan for heat pump water heaters that use CO_2 as a natural refrigerant and are supplied by power companies and water heater manufacturers.

Fig. 5—Home Gateway.
The home gateway plays an important role in the home network where it controls the energy management system and monitors the status of home appliances and other devices.

*1 OSGi is a trademark or a registered trademark of the OSGi Alliance in the United States, other countries, or both.

Applications suitable for consumer home appliances and services are placed on the OSGi distribution servers and can be added or deleted remotely in accordance with the consumer's service contract. Since an OSGi bundle is a Java[*2] application, development time is relatively short. Furthermore, the open API (application program interface) allows third parties to develop applications, opening up the potential for a variety of new services to be released in the future.

New services planned by Hitachi include information services and support services for the elderly. These use the home gateway to help people enjoy safe, secure, and comfortable lives.

Wireless Sensor Networks

Sensor network systems automatically monitor and detect changes in the status of public infrastructure to ensure the quick and appropriate provision of services. This includes monitoring of people, objects, and equipment.

Sensor network systems are also used for monitoring and control in industry. Typically, sensor network systems have been built using high-performance sensors and highly reliable wired networks. With mobile information technology, however, it is easy to collect large amounts of data at low cost. Wireless sensor network systems provide an efficient way to get data into IT (information technology) systems where it can be coordinated and integrated with a variety of applications, and used to create new services. The visual display and analysis of real-time sensing data, along with use of the results to provide feedback to the field, will help make society safer as well as more secure, comfortable, efficient, and reliable.

The sensor network information system provides powerful solutions for a broad range of areas and operations (see Fig. 6). Use of a wireless sensor network system allows the freedom and flexibility to install and move sensors.

The system provides the following three solutions.
(1) HCCP (hazard analysis and critical control point) and food management
(2) Temperature and humidity control in data centers
(3) Energy management in factories and shops

The sensor network system is also expected to help deal with the aging of public infrastructure, increasing maintenance costs, and the shortage of technicians. While the public infrastructure in Japan was built during a period of rapid economic growth, the country now faces a new problem as this infrastructure deteriorates with age. Solutions are required for issues such as rising maintenance costs and falling numbers of technicians available to work in this field.

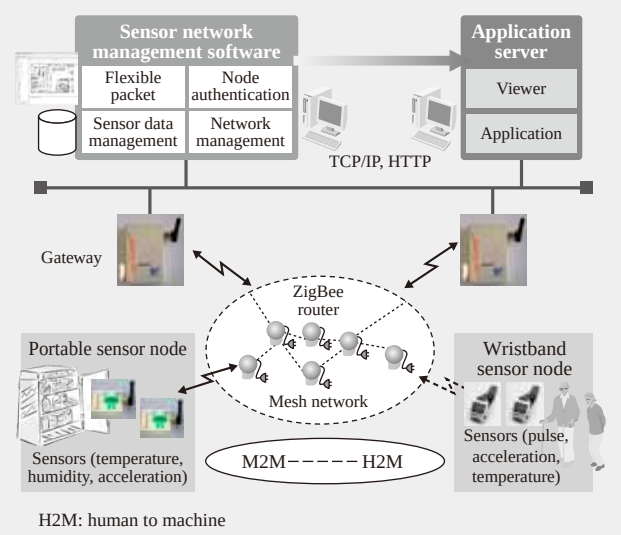


Fig. 6—Configuration of Sensor Network Information System. Sensor network information system is an information system for collecting sensor information via wireless networks and managing the collected information.

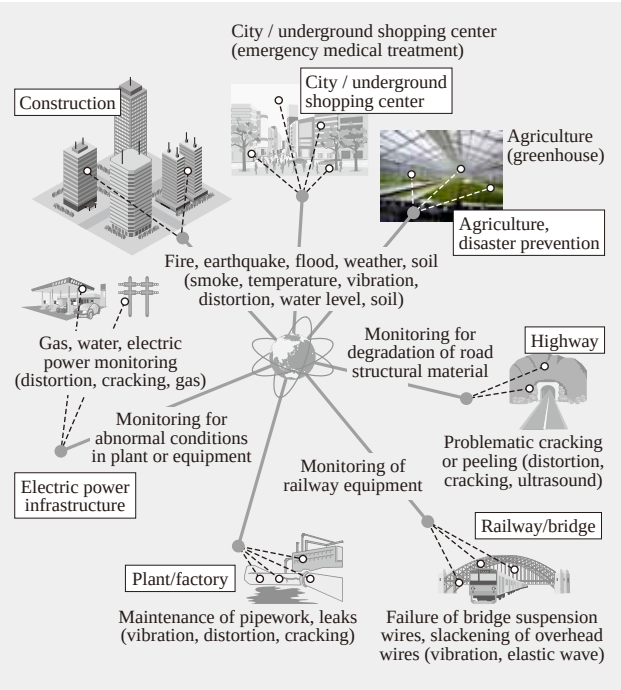


Fig. 7—Wireless Sensor Network System for Public Infrastructure.
The wireless sensor network system will help solve public issues such as the deterioration of public infrastructure over time, rising maintenance costs, and the shortage of technicians.

*2 Java is a registered trademark of Oracle and/or its affiliates.

Sensor network systems offer the possibility of operating and maintaining public infrastructure at a reasonable cost by monitoring the status of equipment and any changes that occur, and by making this information available. To satisfy these requirements, Hitachi is accelerating its research and development of wireless sensor networks with a particular focus on highways, railways, and bridges, electric power infrastructure, plants and factories, construction, cities and underground shopping centers, and agriculture (see Fig. 7).

M2M Solutions

It is anticipated that services and applications in smart cities will continue to evolve over time in response to changes in industrial activity and improvements in lifestyle. This will require service providers and network managers to provide new services and applications in a timely and economical manner. Hitachi is accelerating its research and development of M2M platforms in order to satisfy these requirements.

M2M platforms connect a variety of M2M devices via wired or wireless networks in a way that hides any differences among the networks and devices from the applications. The use of management functions provided by the platform, which include device and line management, network monitoring and operation, activation, billing, and data control, enables service providers to provide reliable and stable services, quickly and easily. Gateway functions are also needed to handle specific protocols, data processing and conversion, and security to allow the connection of a wide variety of devices to the networks, beyond just PCs and mobile phones (see Fig. 8).

CONCLUSIONS

Telecommunication systems play a very important role in smart cities. They must be highly reliable and available as well as flexible, economical, and environmentally conscious. To satisfy these difficult requirements, Hitachi is accelerating its research and development of new telecommunication systems for smart cities.

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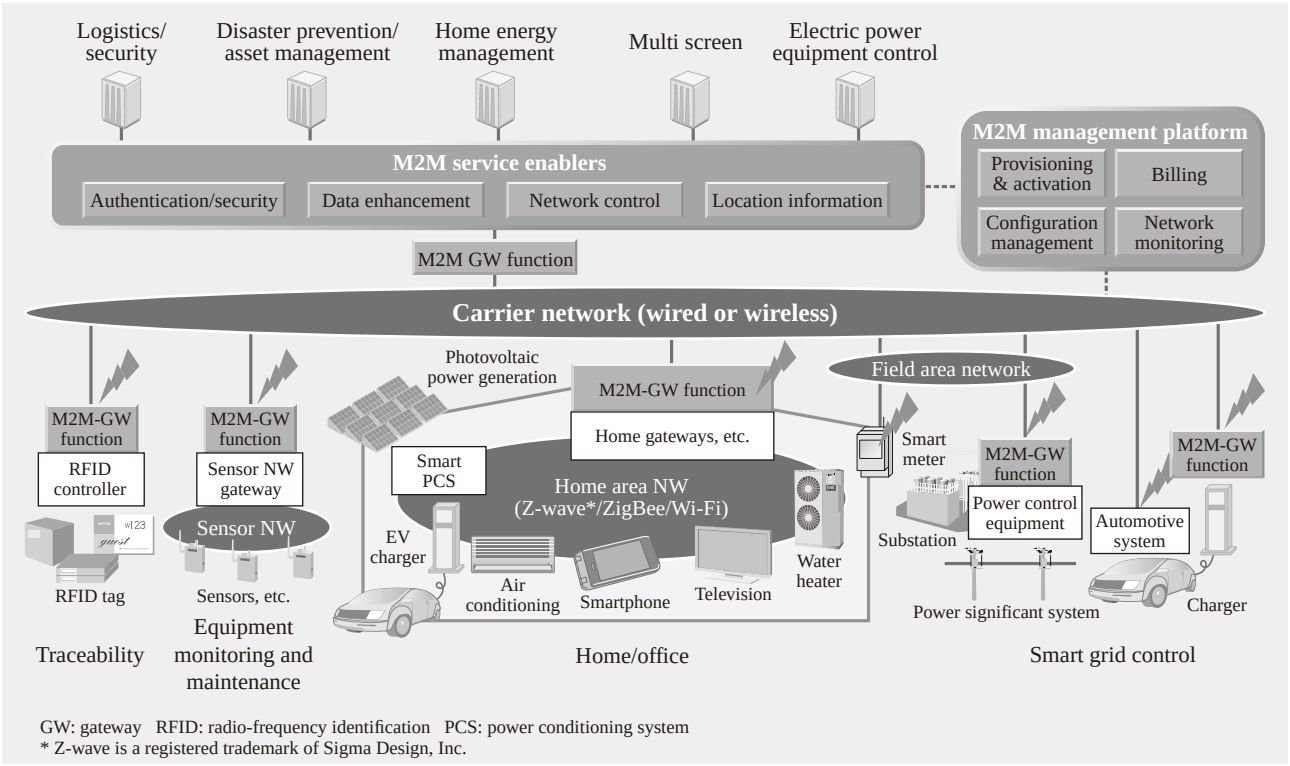

GW: gateway RFID: radio-frequency identification PCS: power conditioning system
* Z-wave is a registered trademark of Sigma Design, Inc.

Fig. 8—M2M Solutions.
The M2M platform and gateways are required to provide new services quicker and more economically, handle completely new telecommunication protocols, and connect networks reliably.

would like to acknowledge our appreciation to those involved in this project.

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