1. Introduction
In the past, the typical image of a robot was a machine that works without being connected to a network. In fact, in December 2002, the Ministry of Internal Affairs and Communications set up a Study Group on Network Robot Technology for discussions on network robot technology based on the integration of ubiquitous network technology and robot technology. This project covered topics including autonomy & remote control, interaction with humans, and cooperative links between robots, sensors & software agents, but the response from the rest of the world was not very enthusiastic. However, things have recently changed significantly, to the point where the prime minister’s office has held a meeting on the robot revolution, and has drawn up a robot innovation strategy. The robot innovation strategy emphasizes three points: autonomy, information delivery, and networking. Information delivery is a reference to how robots interact with humans. The points raised regarding network robots exactly thirteen years ago were confirmed at the robot revolution meeting.

2. The inevitability of ICT for robots
In this section, I will examine the inevitability of ICT in today’s robots, while reviewing how network robots have changed since 2002. This 13-year period can be looked at from many different perspectives, but here I will focus on three: (1) IoT and the development of network infrastructure, (2) data-driven society, and (3) the increasing risk of overseas production.

2.1 Network infrastructure development, automation and networking
The first iPhones were released in 2008, and just six years later a government white paper on telecommunications reported that smart phones had achieved a 62% share of the Japanese market, ahead of Internet-ready TVs (46%), TV game consoles (38%), MP3 players (23%) and other Internet-ready home appliances (8%). It could be argued that the smartphone is now the terminal of choice for connecting to networks. Furthermore, Japan’s leading power companies plan to install smart meters in every home by 2024, which means that houses themselves will be connected to networks. The IEEE, which has 400,000 members, also expects houses themselves to be connected to networks. The IEEE, which has 400,000 members, also expects that Internet-connected cars will be on our roads by 2025.

We are therefore approaching the “Internet of Things” (IoT) era, when all sorts of objects will be connected to networks, and will be able to share information without human intervention. It is predicted that the number of networked devices will pass 30 billion by 2020. This will entail the provision of a network infrastructure capable of connecting a huge number of terminals.

Building this infrastructure has of course also made it possible for robots to link with one another, or with environment sensors, or with agents on information terminals. This is called “networking”.

Hitherto, Japan has aimed to produce autonomous bipedal robots, but this has led to robots of increasing size due to the diversity of sensors and large processing power needed to acquire and process environment information. However, networking allows robots to obtain information from sensors installed in their surroundings. Furthermore, processing tasks can be performed in the cloud, allowing any kind of processing to be performed regardless of the robot’s hardware configuration, thus making autonomy a possibility.

An example of a robot that achieves both networking and autonomy is SoftBank’s Pepper, which went on sale on 20th June 2015. Pepper is able to freely download robot apps from a network in the same way as a smart phone. It can also sense when it is touched, can analyze emotions from a speaker’s voice, and can generate emotions by making use of AI (artificial intelligence) running in a cloud computer, enabling it to hold take part in conversations autonomously (See: “Pepper — the world’s first personal robot to have its own feelings”, SoftBank Corp., p. 18).

2.2 Data-driven society and “information delivery”
With the development of network infrastructure, there are now more devices than ever gathering all sorts of data, such as temperature, humidity, CO2 levels, the movement of packages, and the flow of people in populated areas. This even includes physiological data such as heart rate and pedometer data collected by smart watches and other wearable terminals. A data-driven society (or cyber physical system: CPS) is one that creates new added value by integrating this real-world data with data exchanged between people in cyberspace via social network services (SNSs) and the like.

In a data-driven society, services are typically provided on information terminals such as modern-day smart phones and smart watches. These information terminals are principally used by humans. On the other hand, a network robot differs from an ordinary information terminal in that its embodiment gives it a strong affinity to humans and can thus provide services that work on humans from the network robot side. This is the meaning of “information terminal”. The ability to keep an active dialogue going through the use of eye contact and backchanneling is a major difference from conventional information terminals such as smart phones. As mentioned in the previous section, Pepper is
an excellent information terminal because it can download robot apps, but it also exhibits the characteristics of an information terminal in that it displays its own emotions and other information on a display device attached to its chest.

A nursing service that makes use of this information terminal characteristic has already been started. For details, see Shintaro Watanabe’s article “Implementation and application of robot information processing functions — Using Communication Robots for Elderly Care Support Services” (p. 10) and the article “Using Androids to Provide Communication Support for the Elderly” by Nishio et al. (p. 14).

The use of multiple robots linked with signage for the purpose of advertising has also been attempted. For example, consider Toshiba’s ApriPoco™ and ApriPetit™. As Figure 1 shows, ApriPoco™ (lower left) recognizes passers-by and calls out to them. At the same time, it transmits the recognized age and gender of the passers-by to ApriPetit™ (upper right) and to the digital signage shown in the center. The digital signage displays adverts suited to the age and gender, and in concert with these adverts, ApriPetit™ catches the attention of passers-by and describes the advert. This is an example of collaboration between networking and information delivery.

2.3 The increasing risk and reducing scale of overseas production

Although progress has been made in networking, autonomy and information terminals, it does not follow that the robot market has suddenly become invigorated. While the Japanese yen was getting stronger against other currencies, the manufacturing base was transferred abroad where labor costs were lower. However, in recent years there has not only been high wage growth in developing countries, but their currencies have also been rising against the yen and there have been various risks such as floods, infectious diseases and the outflow of human resources.

The increase in risks such as these has conversely spurred on the production of robots. The transfer of manufacturing overseas has also had the large merit of simplifying production lines, resulting in an increase in scenes where robots can do useful work. With robots, people are freed from the risks of rising labor costs and the outflow of human resources. Even in fields where production robots are usually separated from people from a safety point of view, the deregulation of December 2013 made it possible to have helper robots that can work together with people. Thus, in order to transition from the mass production of products to small-scale production using equipment such as 3D printers, a simple change of control in the cloud can spur the development of network robots that can adapt without changes in training or production lines.

3. International standardization strategy

Various forms of standardization are needed to make it easy for robots to cooperate via a network. The organizations that are involved in standardization related to network robots are ITU-T, ISO, IEC, OMG (Object Management Group), OGC (Open Geospatial Consortium), and the IEEE. Figure 2 lists the details of the standardization efforts by these organizations.

ITU-T SG16 is studying a network robot platform (UNR-PF: Ubiquitous Network Robot Platform) that allows robots to cooperate (see “A Platform to Support Network Robots” by Koji Kamei, p. 6), OMG and ISO/TC211 are studying the use of positional information (RLS: Robotic Localization Service), OGC are studying indoor maps, and OMG are studying RT middleware and interactions between robots and humans (RoIS: Robotic Interaction Service).

ITU, ISO, IEC and OGC are organizations that produce de jure standards, with voting in country units. OMG is a standardization forum whose members attain voting rights by paying a membership fee. The IEEE is an academic society that works on standards for wireless communication and the like, such
as 802.11, and gives all its members the right to vote, including students. Activities that have passed through these standardization organizations that have completely different standardization systems are performed centered around the network robot forum (NRF). The NRF was integrated into the next-generation robot development network on 1st July 2014, and is now active as iRoobo (http://iroobo.jp/).

As in other standardization efforts, China and South Korea are active participants, and from the viewpoint of "autonomy, information terminals and networking", standardization should be strategically promoted together with IoT.

4. Resolving ELSI

For robots to provide services that cause no problems in social activities, there are a variety of ethical, legal and other aspects to consider. These are called ELSI (Ethical, Legal and Social Issues).

According to lawyers, when analyzing conversations between elderly dementia patients and robots at nursing facilities via the cloud, there are issues such as the possibility of the elderly person’s consent being legally invalidated, and who would be a suitable person to accept this consent.

It is also necessary to consider autonomy.

The National Highway Traffic Safety Administration (NHTSA) classifies the automation of automobiles into the following levels:

Level 1: Automation restricted to a partial function
Level 2: Automation of complex functions, e.g., adaptive cruise control (ACC)
Level 3: In specific environments and traffic conditions, performing limited automation to stop the driver from operating the car.
Level 4: Complete automation

The autonomy of robots can also be considered on similar levels. For example, level 3 could correspond to operating an autonomous robot or car by remote control, or taking control of a robot or car when switching over to a human at a particular timing would not go well. To reduce risks, it is essential that all users are aware of and accept such risks, and are trained what to do in an emergency. An important issue is how to recognize danger and consider usage patterns that strike the best balance with convenience instead of banning anything deemed to be risky [6].

*Aldebaran, the Pepper name and logo are registered trademarks of Aldebaran Robotics SAS in France and other countries.

References