IoT Device and Service Platforms Development and Realizing IoT Business

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Abstract

IoT - the Internet of Things - is "the next big thing" and it's already here. Revolving around the incorporation of sensors in physical objects or "things", or sensing the event or changes of environment. And then using cloud-based applications to analyze and leverage the data collected by those sensors in real time to create new values, IoT is rapidly accelerating worldwide. As a major player in communications and database technologies, NEC is well positioned to capitalize on this trend and promote its development. The company has developed and reorganized its core technologies and system technologies to create the foundation for a powerful new IoT platform. These systems are already having an impact in the healthcare field, which has conventionally been difficult to turn into a service, as well as in the physical distribution industry, which is involved in the transportation of goods. To this point, the biggest impact by far has been in the M2M market where mechanisms to quickly configure systems by more efficiently using existing infrastructures and networks are now beginning to be deployed.

Keywords

IoT, M2M, healthcare, wearable

1. Introduction

Today, there is a lot of buzz surrounding the Internet of Things (IoT), in which data-gathering sensors embedded in everyday things and objects transmit data via the Internet to cloud-based computers which analyze the data to create new value. The key to making this all work is instant connection between the sensors, which act as the contact points with the real world where the targeted things exist, and the cloud platforms, which utilize the data obtained from those sensors efficiently and effectively.

This paper introduces the cloud platform technology and embedded system devices or sensors developed by NEC to provide the infrastructure necessary to make the world of IoT a reality.

1.1 The Growing Buzz around IoT

The increasing excitement that surrounds IoT is being driven not only by the extraordinary advances in technology we have seen over the past decade - most obviously the rapid evolution of the communication environment as exemplified by the ubiquity of Wi-Fi, smartphones, and various sensing technologies - but also by the expanding potential for new applications capable of solving a wide range of problems faced by society today.

Many industries that play key roles in modern society such as energy, manufacturing, and healthcare face increasing demands to create new value, while at the same time being under pressure to increase efficiency, reduce cost, and enhance international competitiveness (**Fig. 1**).

Efforts to solve such problems eventually reach a limit -

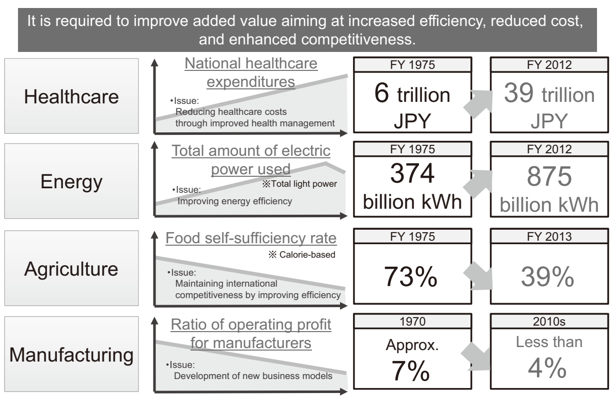


Fig. 1 Examples of social issues.

both quantitatively and qualitatively - when those efforts are made by people alone. This is what makes IoT so exciting; it promises to make everything - from automobiles to airports - “smart.” With data-gathering sensors embedded in physical objects transmitting data to cloud-based computers able to use that data to visualize scenarios, predict the future, provide feedback, and suggest alternatives - all automatically with as little human intervention as possible (**Fig. 2**).

One area where progress is already substantial is in the field of machine-to-machine (M2M) communications as the ability to monitor the operating conditions of machines from a distance and to increase the efficiency of maintenance tasks delivers immediate value to businesses. The rate of adoption is picking up rapidly as companies must introduce these capabilities merely to stay competitive. So far, however, this technology has only been adopted by those industries that already have the necessary preconditions in place: 1) certain computer functions and 2) means of connection with external networks. In other words, the targets have been companies such as those in the industrial machinery industry which already use ICT systems.

The IoT will change all this. Information about things and humans that have never been connected to ICT will be collected and utilized by new technology like wearable devices - smartwatches and activity trackers are early examples of this technology. The possibility of embedding sensors in just about everything promises potentially explosive expansion of the IoT market (**Fig. 3**).

1.2 The Value of IoT in Inter-industry Markets

In many industries today, corporate efforts are no longer restricted to one’s own company. Cooperation between diverse business categories - or the trend toward inter-industry - is becoming more and more prevalent across a wide range of industrial categories. By energizing collaboration between companies that transcends the existing frameworks of business categories, these efforts are focusing on creation of new values and creation of new businesses (**Fig. 4**).

In markets that are becoming inter-industry-oriented, the role played by IoT is growing in importance. In the field of healthcare, for example, the IoT environment has gradually become extensive enough that it is now possible to conceive of new services in various business categories based on human biological information that can be obtained from IoT. Today many companies are accelerating their utilization investigations into IoT, aiming at creation of new healthcare and lifecare services and new businesses, such as prevention and early detection of disease and health promotion while still healthy, in addition to conventional medical care (**Fig. 5**).

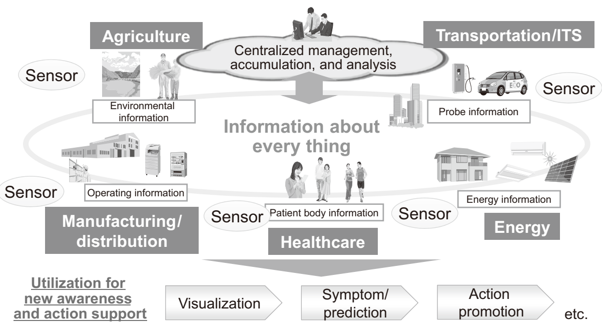


Fig. 2 Examples of values created by IoT.

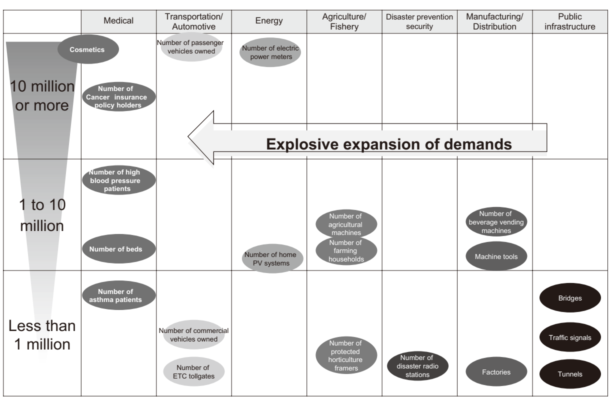
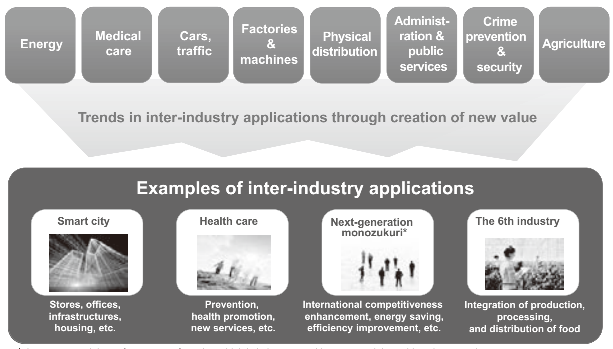


Fig. 3 Conceptual chart showing the level of IoT.



* Japanese word that refers to manufacturing which is in harmony with nature and that adds value to society.

Fig. 4 Trends in inter-industry-oriented applications.

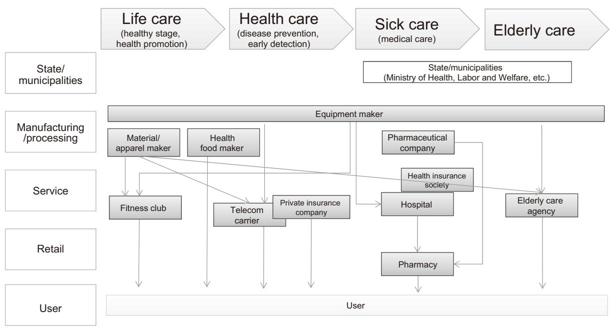


Fig. 5 Inter-industry-oriented applications in healthcare.

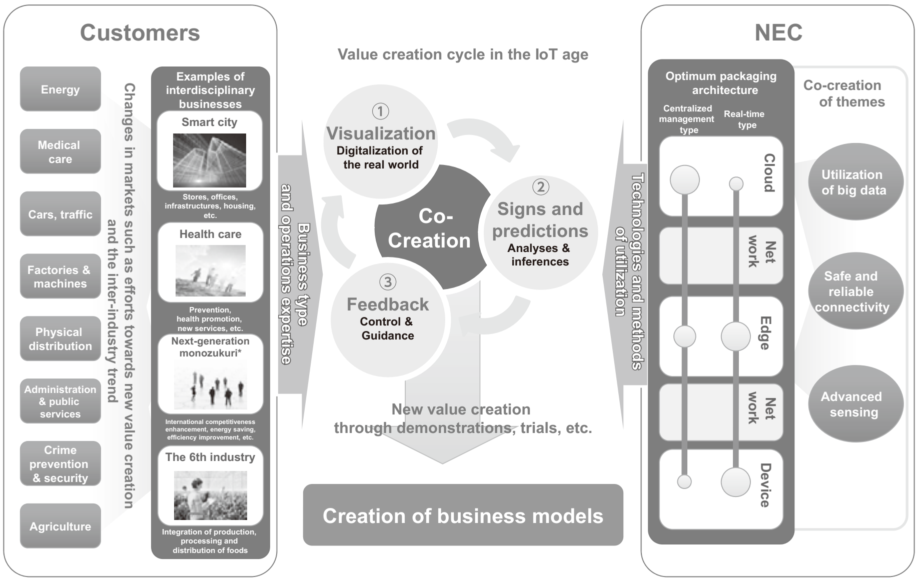


Fig. 6 Value creation cycle in the IoT era.

1.3 Creating Business Models in the IoT Era

To create new social values utilizing IoT and at the same time to create business models to achieve those values, it is important that the hypothetical verification of provided values be carried out in cooperation with clients from the conceptual stage - not simply by proceeding with development by strictly observing the required quality, cost, and delivery time based on the specifications provided by the customers, as is the case in the conventional system integration business. This is because the customers themselves often don't have a clear picture of what their final services and systems will be and don't know what devices to use.

For this reason, it is important that the hypothetical verification cycle be put into operation at an early stage in cooperation with customers and partner companies through validation trials, while proposals for customer values are actively made on a hypothetical basis. In other words, it is important that the approach be shifted to the co-creation of business models (**Fig. 6**).

At NEC, the cycle of co-creation of values through hypothetical verification has been transformed into a service execution platform ranging from devices to clouds - enabling development of efficient IoT systems.

2. IoT Cloud Platform

The requirements for a cloud platform to promote creation of new businesses through co-creation of value utilizing IoT include: connection to diverse devices, handling of large volumes of data, and flexible combination of application by loose coupling. At NEC, we achieve these requirements by implementing our original design to build a cloud platform that utilizes Open Source Software (OSS), which is always evolving to meet market needs (**Fig. 7**).

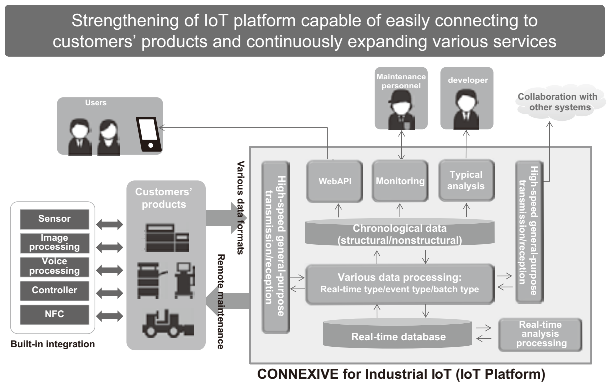


Fig. 7 Cloud platform for IoT.

2.1 Connection to Various Devices

Data formats, interfaces, and data processing systems differ depending on the sensor and device. In a cloud platform, networking between various devices is made easier and standardization of subsequent processing is achieved by incorporating a mechanism to receive and convert data in real time (**Fig. 8**).

Specifically, the cloud platform is provided with a reception interface that uses MQTT and HTTP as its main protocols. Utilizing these protocols, the sensor and device can transmit the data. The data itself is sometimes stored in a different place before being collected on the cloud platform. In this case, the

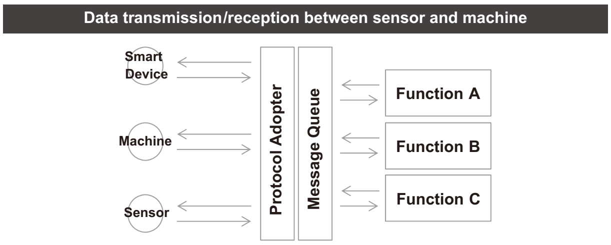


Fig. 8 High-speed general-purpose transmission/reception function.

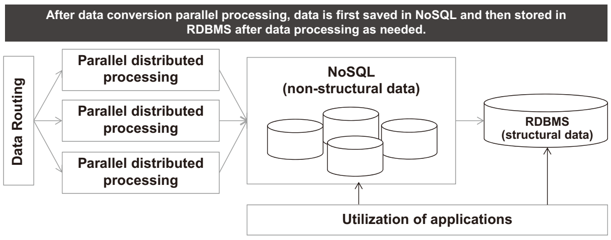


Fig. 9 Flow of data processing treatment (non-structural to structural).

collection of large volumes of data can be executed at higher speed by incorporating an agent that utilizes high-speed parallel transfer technology. The internal process that operates after the data has been gathered is independent of the receiving protocol. This makes it possible to perform the same data processing no matter what the form of reception.

2.2 Bundling of Large-volume Data

While challenging the value creation approach, the types of connected sensors and devices and the volume of collected data is steadily increasing. This makes scalability an essential feature of a cloud platform, enabling it to be expanded or modified as required.

The cloud platform achieves parallel distributed processing by utilizing message queues for the distribution of data reception and processing. Data is processed using parallel distributed processing, which performs functional implementation in three steps: processing single received data, processing combination of received data and other data, and processing accumulated chronological data after a certain period of time. Data is stored and maintained using NoSQL - which makes it easier to use non-structural data like a document-type database. Since a data store compatible with the application is required for the data layer, unstructured data is first stored in NoSQL and then switched to the data store after data processing as needed (**Fig. 9**).

This structure helps significantly reduce the design processes required for data storage and achieves an environment which makes it possible to concentrate on the extraction of meaning from the data.

2.3 Flexible Combination of Applications Based on Loose Coupling

Once value has been confirmed through actual verification on a hypothetical basis, applications that match the respective phases will be necessary. The required applications change as follows: an analysis tool to extract the value from the collected data for the initial phase; an application to use the data in a standardized form for the business validation phase; and a system to facilitate collaboration between the data and various players in the business expansion phase.

The cloud platform incorporates a mechanism that allows it to efficiently provide the required combination of applications as required. Applications are becoming more and more multi-layered as they are installed smart devices and multiple cloud systems. It is expected that function-specific clouds such as data accumulation, data analysis, and customer contact will emerge in the future and they will help complete the multi-cloud environment where data-centered collaboration will be achieved.

When the cycle of visualization of scenarios, prediction of the future, and feedback of new actions is automated under this environment, the primary data distribution method will not be the “pull” type, in which the application in use extracts data periodically; rather, it will be the “push” type, in which the data is sent to the required application at the required time. Using the “push” type method ensures that the required data will be made available when required, accelerating the data utilization cycle and optimizing the timing.

Let’s take a smart device application as an example. The data required for the application is obtained by using the “pull” type API, and the user is able to use it. On the other hand, a notification enables the user to be aware of data reception at the right time, so if that’s the case, the “push” type data distribution is more suitable.

NEC thinks that it is important to use both communication systems where appropriate. That’s why we provide a cloud environment that makes it possible to select the “pull” or “push” type from an application (**Fig. 10**).

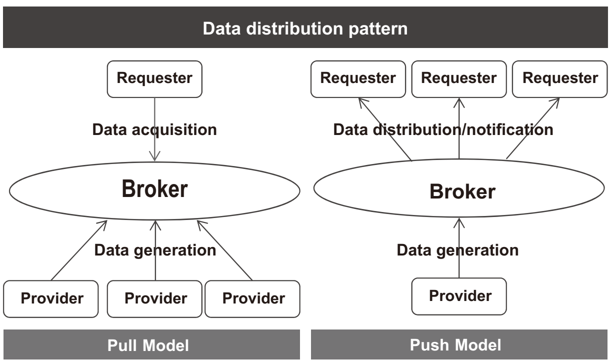


Fig. 10 Data distribution pattern (“pull” type/“push” type).

3. IoT Device Configuration

When looking at a market as new as IoT, NEC believes that there will be many cases where intermediate devices will be replaced with smartphones and tablets in line with current trends in ICT technology. To complement these changes, an architecture is required that concentrates numerous core technologies and processes on the cloud side or sensor/device side (**Fig. 11**).

3.1 Stack Configurations of IoT Devices

In order to create this architecture, we conducted R&D using algorithms - as differentiation technology - to process the data obtained from a sensor, as well as to control software that drives the sensor. We concentrated on the development of a sensor node provided with an appropriate microcomputer, communication function, and sensor and defined it as a wireless (public wireless, Wi-Fi, and BLE) sensor node (**Fig. 12**).

Wireless sensor nodes like this are equipped with an agent to connect to the cloud side and a security function to safely send various sensor data to the cloud. As for the microcomputer, the ARM microcomputer frequently used in the embedding market is used for low cost nodes and small data types. A higher-performance microcomputer is used for large-size data such as images. This allows the system to efficiently handle a wide variety of data.

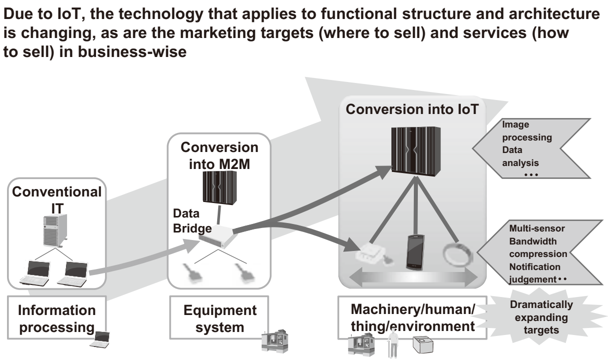


Fig. 11 Device trends in the IoT era.

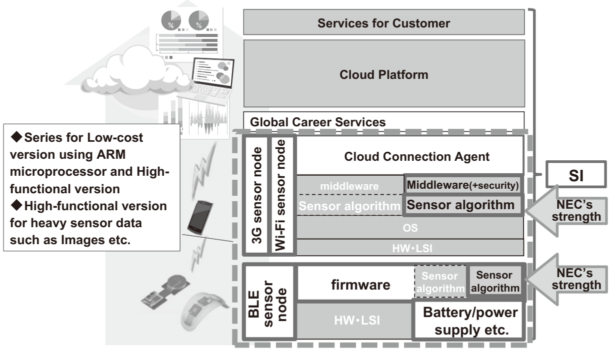


Fig. 12 NEC's IoT device stack configuration.

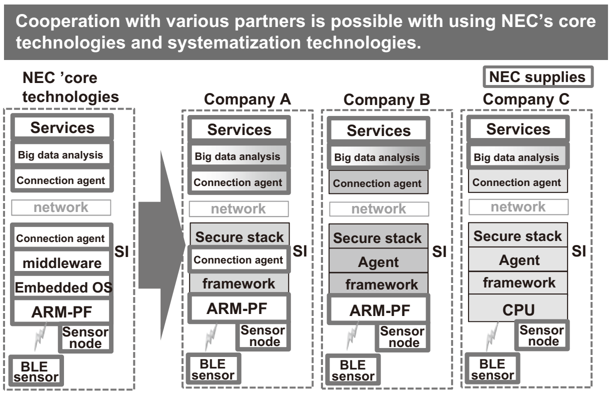


Fig. 13 NEC's IoT devices and how they facilitate cooperation with partners.

3.2 Building Relationships with Partners

In the solution set of the IoT devices and clouds, cooperation with partners in various core technologies will make it possible to utilize IoT in an even wider range of markets. For this reason, all the system stacks including the clouds are modularized to facilitate cooperation with the partners. This makes it possible to build and offer solid system solutions tailored to market needs (**Fig. 13**).

To facilitate cooperation with partners, NEC provides various interfaces and is conducting R&D while advocating standardization for the future.

3.3 IoT Device Technology

Now let's take a look at the technology incorporated in the wireless sensor node. In addition to wireless capability, various sensors of a minimally required level (for acceleration, LED, temperature, and humidity) are incorporated. These sensors are integrated on a 20-mm square circuit board. This module configuration made it possible to accurately adapt to various devices required for the IoT market as well as to the "humans," and "things" that those devices will be incorporated in or and mounted on (**Fig. 14** and **Fig. 15**).

Moreover, due to the flexible implementation technology derived from the R&D conducted at the NEC Monozukuri Innovation Division, NEC's IoT devices can now be easily incorporated and mounted not only on devices and things that have plane surfaces but also on humans and things that have curved surfaces. In addition to the conventionally applicable wrist band and watch type devices, our IoT devices now can be incorporated and mounted on clothes as well as in various containers and cases. Now an IoT truly is possible.

Another characteristic of the IoT market is that the potential fields of application are virtually unlimited. This is due to the fact that sensors are not only being incorporated in people and things, but also are being applied in an ever expanding range of industries. For this reason, a sensor section that can be adapted to the needs of different industries has been built into the IoT device since the initial stage of its design (**Fig. 16**).

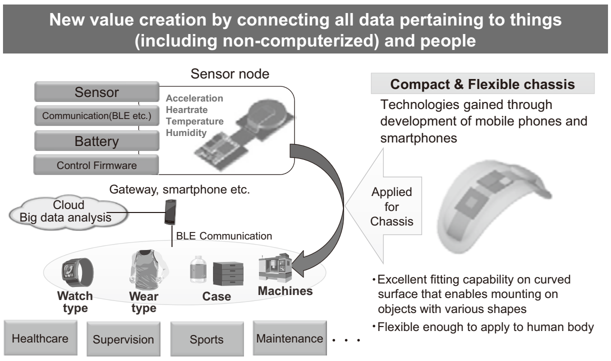


Fig. 14 Features of NEC's IoT device technology.

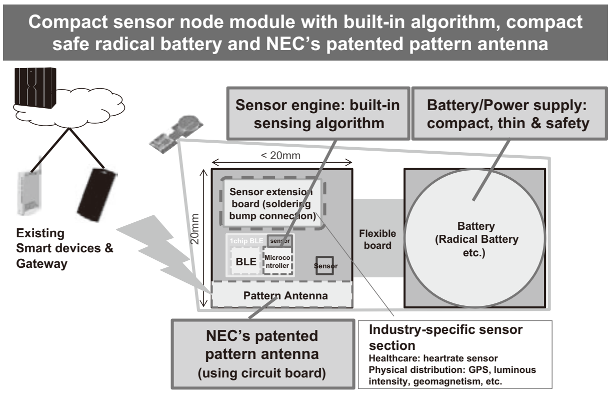


Fig. 15 Advantages of NEC's IoT devices.

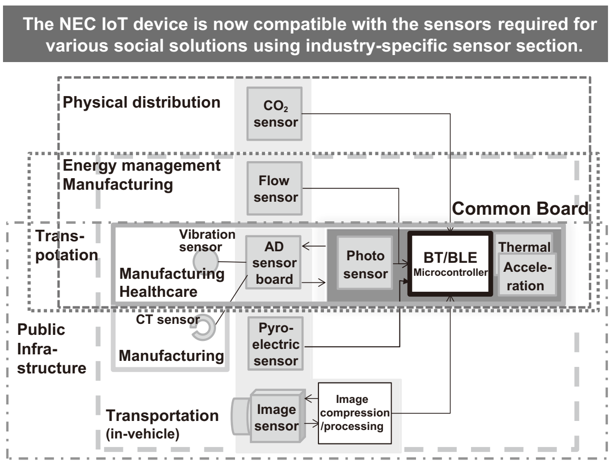


Fig. 16 NEC IoT device's expandability for various industries.

Through extensive study of the various social solutions that would need IoT, the sensors and sensor environments that would be required have been sorted out. To enable these to be incorporated while ensuring both high efficiency and expandability, the design has been divided into a common main board and user section for addition of custom sensors. In actual cases, it is very unlikely that all the mountable sensors will be mounted at the same time. The mounting formats as well as the interfaces that would allow various sensors to be mounted in combination were all defined when the circuit board was designed. This has made it possible to configure IoT devices that are compatible with a wide range of applications.

4. Conclusion

NEC is committed to promoting the growth of IoT by providing its customers with end-to-end systems compatible with the differing requirements of various markets, while continuing to conduct R&D aimed at expanding the IoT and the IoT market in the years to come.

* ARM is a registered trademark of ARM Limited (or its subsidiaries) in the EU and other countries.

* Wi-Fi is a registered trademark of Wi-Fi Alliance.

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