UBIQUITOUSWARE: Value Creation by Proprietary Algorithms

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The Internet of Things (IoT) has great potential for creating product differentiation in business solutions and services in a wide variety of fields. However, a great deal of work would be required to individually develop devices that match each and every business and the applications that use those devices. Fujitsu has developed an IoT package called FUJITSU IoT Solution UBIQUITOUSWARE with the aim of making effective and efficient use of IoT, which offers many diverse possibilities. UBIQUITOUSWARE is composed of a core module, which can be easily incorporated into devices making up a customer's system, and algorithms for analyzing sensor-collected data, which can be straightforwardly applied to business applications. This paper describes the features of UBIQUITOUSWARE and the proprietary algorithms of Fujitsu's Human Centric Engine, which provides the basis for UBIQUITOUSWARE.

1. Introduction

The Internet of Things (IoT) offers great business potential due to its capacity to link information from people, things, and the environment that creates new value. It is predicted that about 50 billion things will be connected to the network by 2020.[1)]

Expectations for the IoT are also growing rapidly among Fujitsu customers, who see the IoT as a means of visualizing and converting into events the states of people, things, and the environment for more efficient management, launching original solutions in new fields, etc. The content of such business activities will be highly diverse. However, there are limitations to individually developing IoT devices using sensor algorithms for each and every need, which differ from customer to customer, and the business applications that use those devices. Doing so would also enhance the risk of duplicate development.

Fujitsu has developed FUJITSU IoT Solution UBIQUITOUSWARE as an IoT package for addressing these issues. This paper describes UBIQUITOUSWARE products (IoT devices and solutions) and the two key components of UBIQUITOUSWARE: the core module and algorithms for analyzing sensor-collected data.

2. UBIQUITOUSWARE product lineup

UBIQUITOUSWARE is mainly composed of a core module, which can be easily embedded in a customer's existing devices and systems, and algorithms for analyzing sensor-collected data, which can be straightforwardly applied to business applications. The UBIQUITOUSWARE package also provides IoT devices and solutions together with embedded modules that will support a variety of usage scenarios (**Figure 1**), all of which enable a customer to rapidly construct an IoT system and launch solutions.

2.1 IoT devices

1) Vital-sign sensing band

This device estimates the wearer's heat stress using temperature, humidity, movement, and pulse readings. It can also detect whether the wearer tumbles by using barometer readings and changes in acceleration.

2) Location badge/tag

These devices use Bluetooth Low Energy (BLE) beacons to perform positioning in places where GPS is difficult to use such as indoor settings. They can also use Pedestrian Dead Reckoning (PDR) technology using an accelerometer, a gyroscope, and a magnetometer to detect location and motion tracking with high accuracy

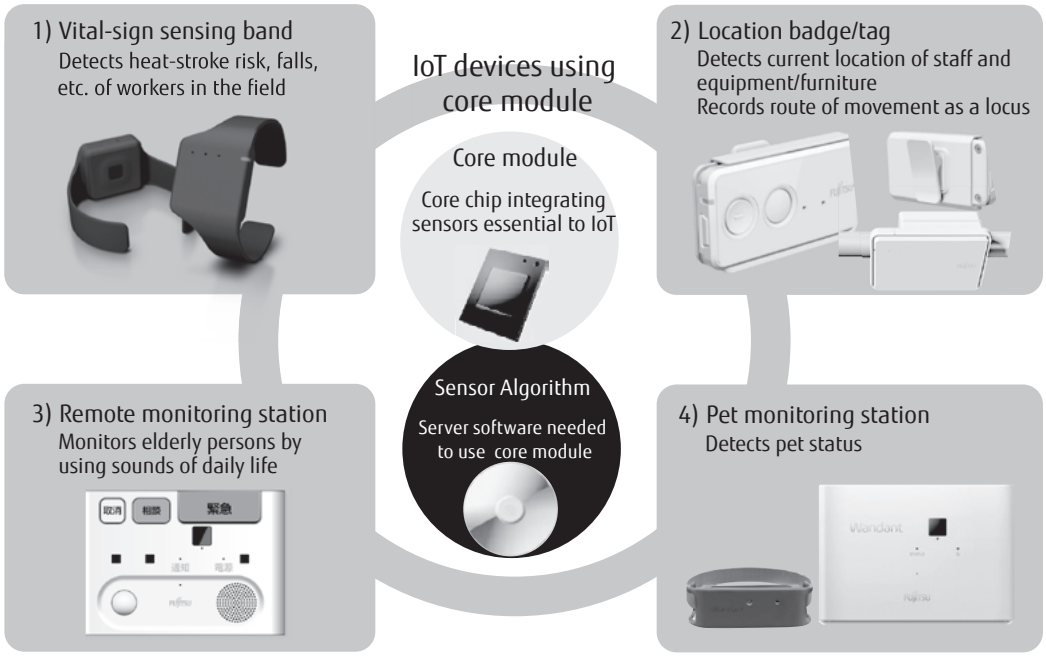

Figure 1
UBIQUITOUSWARE concept.

at low cost for both indoor and outdoor scenarios. Badges can also be used to assess the wearer's posture and determine whether the wearer tumbles.

3) Remote monitoring station

This device uses sounds of daily life (talking, coughing, snoring, etc.) and human movement to analyze changes in condition of his/her daily life. It can estimate the thermal environment surrounding a person using temperature and humidity sensors.

4) Pet monitoring station

This device can capture images of a pet alone at home and can automatically notify the pet's owner of any changes in activity through a pet-activity-log analysis algorithm. It can also issue alerts in the event of changing temperature or humidity conditions.

2.2 Solutions

Here we introduce three key solutions provided by UBIQUITOUSWARE (**Figure 2**).

1) Safety/Labor management solution

This solution enables safety measures to be implemented for workers at construction sites, manufacturing plants, and other operations in the field and enables visualization of on-site conditions. With these capabilities, supervisors can respond quickly to signs of heat stroke and to accidents.

2) Optimizing business solution

This solution can detect the location of sales staff in a commercial establishment, nurses and medical instruments in a medical-care facility, etc. in real time with high accuracy. Such location information can be used to reduce costs by optimizing the placement of staff and the operation of instruments.

3) Senior care service solution

This solution uses an algorithm to extract and identify abnormal states in everyday life. It also enables monitoring of a person's current state and health condition by his/her family even if living far away, the local government, operators of welfare facilities, etc. This results in early detection of abnormalities in the life of elderly people living alone or in care facilities.

In the above ways, UBIQUITOUSWARE makes it easy to construct a great variety of IoT solutions using products that can support various types of usage scenarios. In the following section, we describe proprietary elemental technologies that support UBIQUITOUSWARE.

3. Core module features

Fujitsu smartphones incorporate the Human Centric Engine (HCE)[2], which is designed to bring users

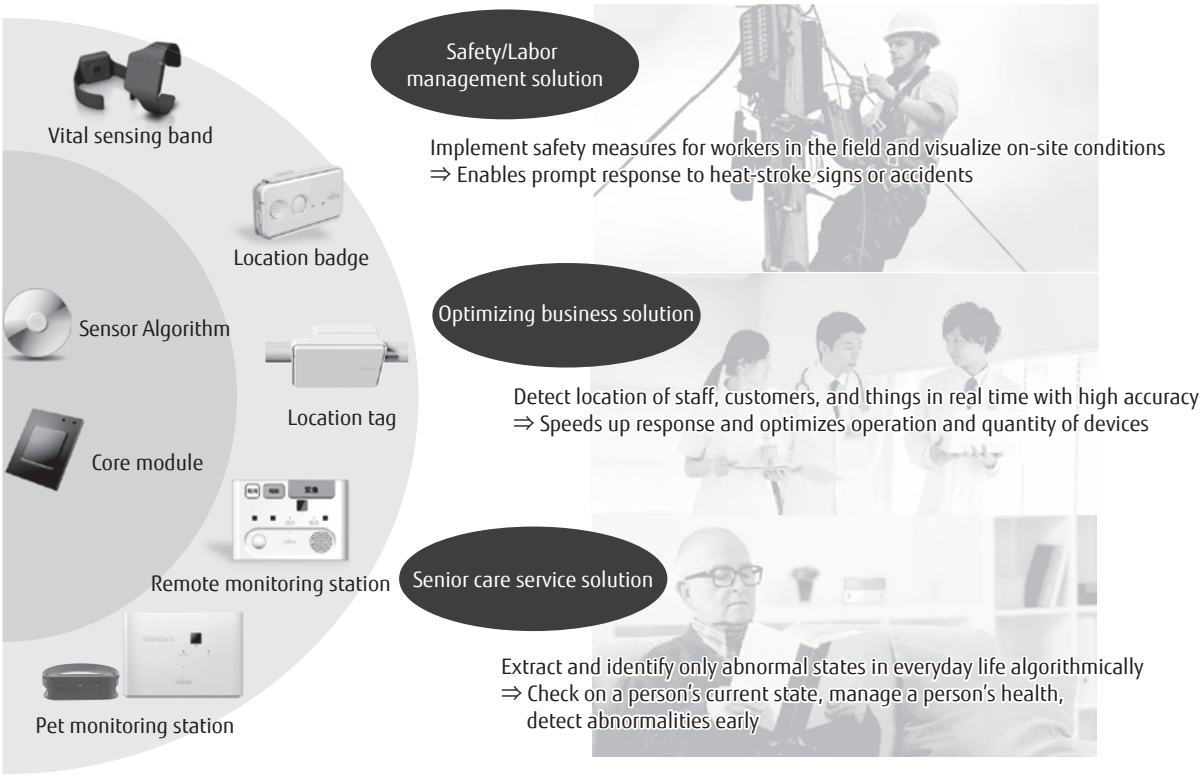

Figure 2
Solutions provided by UBIQUITOUSWARE.

comfort and peace in their heart. This HCE can also be applied to UBIQUITOUSWARE to sense a person's behavior and surrounding environment and provide analyzed data to the IoT-device user. The following describes HCE algorithms achieved in the UBIQUITOUSWARE core module.

1) Motion sensing algorithms

In addition to the algorithms incorporated in Fujitsu smartphones such as ones for a pedometer, activity meter, and movement-classifier, the core module also features algorithms for detecting tumbles and falls for monitoring solutions for workers in the field and elderly people.

In tumble detection, the algorithm detects whether the device wearer tumbles and if that person cannot move after tumbling by detecting the person's actions and posture. In fall detection, the algorithm additionally judges whether a fall occurs from a high place. For example, the algorithm can detect accidents such as falling from a ladder by detecting whether the device wearer falls from a high place and he/she cannot move by himself/herself.

2) Location sensing algorithms

The location sensing algorithm detects the position and the location of people and things in both indoor and outdoor settings. It uses GPS for outdoor positioning and BLE beacons for indoor positioning. However, the power consumption of UBIQUITOUSWARE must be minimized to enable the regular use of GPS for positioning. Moreover, a sufficient number of BLE beacons are required to provide complete indoor coverage, which can be costly.

It is therefore necessary to operate GPS-based positioning intermittently to save battery power and to widen the interval between BLE beacons to lower costs, but this results in a drop in positioning accuracy. To solve this problem, the location sensing algorithm applies PDR technology using a person's walking behavior (walking speed and direction) to supplement positioning between the positions obtained by intermittently operated GPS positioning and between BLE beacons installed at relatively wide intervals. It thereby achieves high accuracy while simultaneously lowering power consumption and costs.

3) Vital-sign sensing algorithms

The vital-sign sensing band device of UBIQUITOUSWARE incorporates a pulse sensor and temperature/humidity sensors, which can be used to determine the wearer's state of health, detect abnormal conditions, and drive an algorithm for making health-related predictions.

Recent years have seen a dramatic increase in heat-stroke patients. In Japan, 58,729 heat-stroke patients were transported by ambulance in 2013 alone.[3] In view of this crisis, UBIQUITOUSWARE can estimate the original heat index based on the Wet Bulb Globe Temperature (WBGT) from the readings of temperature/humidity sensors. This index can be used to assess the risk of heat stroke and issue a notification that divides that risk into five levels.

Algorithms for making physical-load and thermal-stress estimations are also included. These use not only environmental readings but also pulse and activity readings to estimate the load currently being applied to the wearer of the vital-sign sensing band.

4) Sonic sensing algorithms

Remote monitoring solutions for the elderly include the use of cameras for checking on the well-being of an elderly person at home. Many users, however, dislike themselves being monitored by camera. There has been little user resistance, however, to sound-based monitoring. Detecting the sounds of everyday life at home can determine whether the elderly person being monitored is living life as usual. For example, detecting the sound of TV indicates that he/she is watching TV, which provides information on one of his/her daily activities. In addition, detecting coughing sounds can indicate the health status of the elderly person, and detecting snoring or irregular breathing during sleep can provide information on that person's sleeping conditions.

5) Optical sensing algorithms

The monitoring solution for the elderly can check on the state of an elderly person by camera monitoring as an option. However, as described above, many users are resistant to the idea of having themselves and their daily life monitored by camera. With this in mind, we have developed an algorithm that checks for indoor human movement using a pyroelectric infrared sensor that can detect the movement of a heat source.

The sonic and optical sensing algorithms were implemented in a remote monitoring station in March 2016.

4. Features of server software

UBIQUITOUSWARE makes use of server software to store the measurement results of its diverse algorithms on a cloud platform and perform compound or time-series analysis to create additional value.

One example of such value is an algorithm that can learn what normal behavior is for something and issue a notification whenever that behavior departs from the norm. Such an algorithm could be used to learn how long an inspector spends in a frequently visited area for inspection work. If it is much longer than usual, it can be inferred that an abnormality is occurring and if it is much shorter than usual, it can be inferred that some part of the inspection process in that area can be left out.

The platform used to collect sensor data for storage on servers is the FUJITSU Cloud Service IoT Platform (hereafter, IoT platform) a service that facilitates efficient use of IoT data (**Figure 3**). Server-software algorithm control provides two analysis functions: a real-time analysis function and a learning-and-analysis function. These can be executed in parallel through thread partitioning within the process.

1) Real-time analysis function

This function receives an instantaneous event from the IoT platform through real-time processing, converts the event into corresponding data through algorithm processing, and passes that data to the algorithm library module.

The data resulting from real-time analysis are then converted into JavaScript Object Notation (JSON) format, which simplifies reading and writing at the time of application development, and collected on the IoT platform.

2) Learning-and-analysis function

This function periodically obtains sensor data stored on the IoT platform through periodic execution processing, converts the results of learning, collecting and converting algorithm library modules into JSON format, the same as in real-time analysis, and sends the converted data back to the IoT platform.

As described above, we are further enhancing the value of UBIQUITOUSWARE by using a real-time analysis function and a learning-and-analysis function

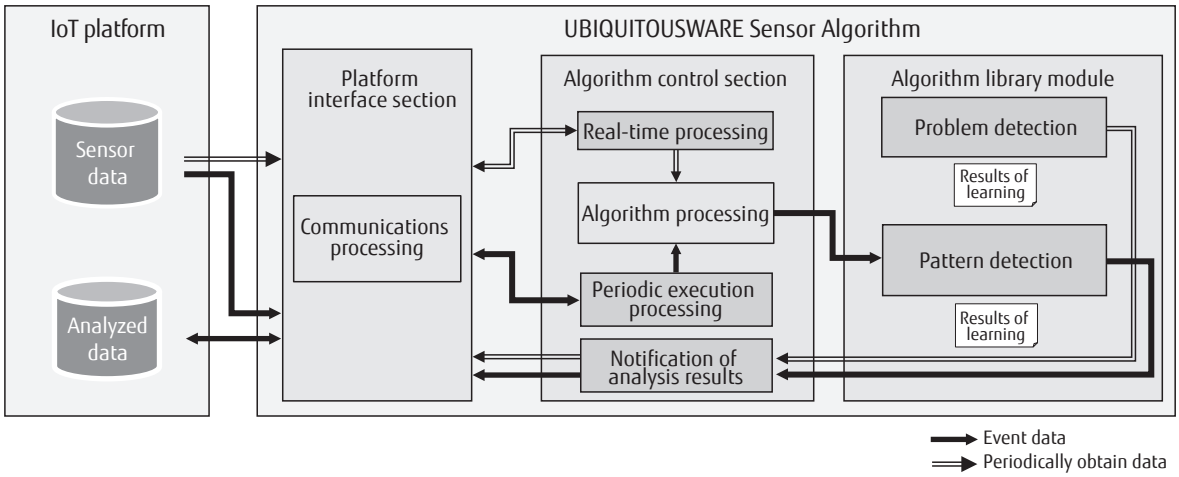

Figure 3
IoT Platform and UBIQUITOUSWARE Sensor Algorithm.

to process proprietary algorithms that add and extend HCE technology originally developed for Fujitsu smartphones.

5. Conclusion

A variety of business applications are being explored for IoT, which has great potential for providing first-mover advantage. In this IoT market, UBIQUITOUSWARE can give form to new business ideas quickly and become a useful tool for customers and business owners.

Fujitsu plans to provide an extensive lineup of UBIQUITOUSWARE products as key components in total solutions that can be used in diverse types of businesses and fields. It will support many types of IoT businesses to create a society that can provide a safe and secure life for everyone.

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