

NEW PRODUCT DEVELOPMENTS BY A NEW COMBINATION OF EXISTING TECHNOLOGIES AND OPEN INNOVATION STRATEGY: A CASE STUDY OF BATTERYLESS AUTO ALERT FIRE EXTINGUISHERS

Hiroshi Yamamoto, Keio University
Satoshi Tomita, Rikkyo University
Yoshiyasu Takefuji, Keio University

ABSTRACT

This is a proposal for the world's first prototype system of batteryless smart fire extinguisher and it was implemented such that the water flow can produce electricity while extinguishing fires. This is a real successful case by combining the existing technology according to the concepts of "New Combination" and "Open Innovation". Generated electronic power is used for broadcasting the location from the fire extinguisher and sensed data to receivers or sending the signal directly to cloud. Because the proposed system has no batteries, battery maintenance is not required at all. During severe environmental circumstances including power outages and dead batteries, the proposed fire extinguisher functions for messaging the fire department about the detailed fire location. In our experiment, the message can be sent to the cloud through the proposed system while electric power is being generated from the water flow. The proposed system is an innovative product developed with low cost and rapid prototyping by using off-the-shelf parts and open source modules, and proposes a solution to the problem that a fire alert should be called rapidly. It is quite a successful case study and leads to the academic contribution toward studies in open innovation and management of technology.

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KEYWORDS: New Combination, New Product Development, Open Innovation, IoT (Internet of Things), Auto Alert System

INTRODUCTION

In order to cope with fires, we must not only inform the minute location to the fire department as we should, but also extinguish the fire as soon as possible. Without communicating with the fire department, we may be able to achieve early extinction of a fire with the proposed system.

In existing systems, they require electric power or batteries for messaging the fire department. During a power outage and/or if the battery is dead, the existing systems cannot function as intended. Furthermore, in the existing systems, battery maintenance is a cumbersome task. In the proposed system, battery maintenance is not required.

Without GPU technology and open-source framework, we have never achieved the AI advances these days.

In this paper, we have created an innovative prototype using the existing technology. The proposed system is a batteryless fire extinguisher with automated alert capability. It is based on the followings: 1. an energy harvesting technology for achieving batteryless system, 2. low power wide area networking (LPWAN) technology for low power and long distance networking, and 3. cloud technology for the automated alert

system.

LITERATURE REVIEW

In existing systems, the messaging capability includes the age of the fire extinguisher, the time of fire, and the fire location, which are all informed to the fire department. In the IoT Maker Challenge, Guillaume Chabas has proposed an idea of the connected fire extinguisher (Kube, 2015). His idea needs batteries for proper operations. Mark Jarman and Brendan McSheffrey have developed wireless sensors network for fire extinguisher monitoring (en-Gauge Technologies, Inc., 2007). However, they also require power or batteries for possible operations.

It is indispensable to embed messaging capability to the fire department in the existing smart fire extinguishers. The fire evacuation alarm is extremely important to save lives. During a power outage and/or with dead batteries, in the existing fire extinguishers systems, this expected functionality cannot be achieved (Chubb Fire & Security Pty Ltd t/a Quell, 2015).

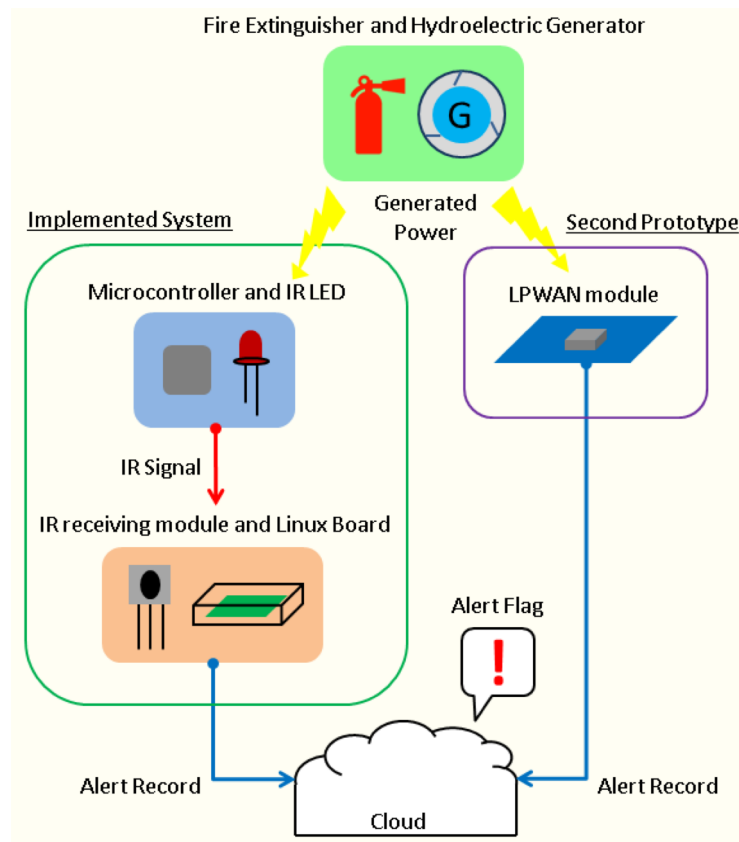
The proposed system does not require any power to message to the fire department. Additionally, the system is designed by compound of open source hardware which is low rates and simple development.

Schumpeter (1912) said new knowledge is created by new combinations of already existing knowledge and Chesbrough (2003) said the strategy of Open Innovation is so useful and significant for new product developments in these days. Additionally, Takefuji and Shoji (2017) explained the function, usage, and history of open source hardware. These are prior important literatures for this research.

DATA AND METHODOLOGY

In this study, we developed a self-reporting system on a fire extinguisher which is powered by a small hydraulic power generator driven by the water flow exerted from the fire extinguisher, and is powered without a battery. The implemented system and the second prototype system are shown in Figure 1.

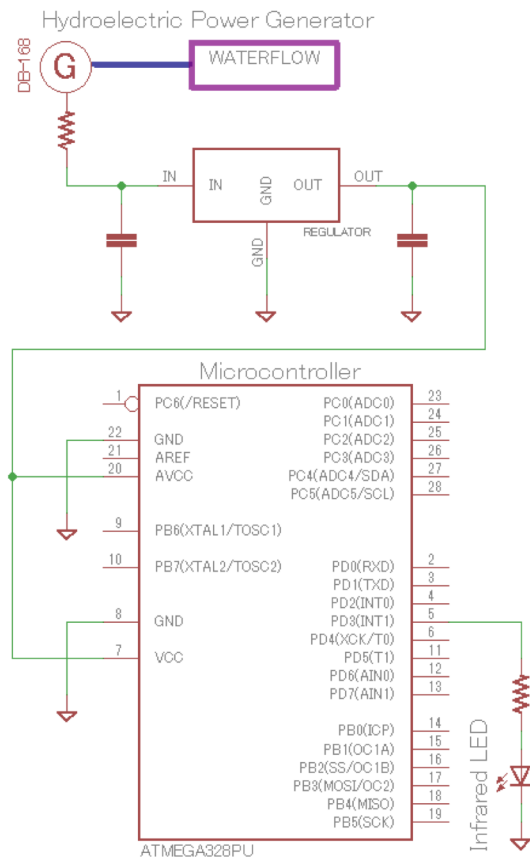
Fig. 1. Diagram of the implemented system and the second prototype



First, the fire extinguishers used in the experiment were those for fire prevention training (ST10A, manufactured by Morita Holdings Corporation) which were filled with 3.0 L of water and air pressure of 0.9 MPa. This is a fire extinguisher capable of exerting the same pressure as a commonly used fire extinguisher.

Next, the transmitter consists of a small hydroelectric generator, microcontroller, and high brightness infrared Light Emitting Diode (LED). The circuit diagram of the transmitter is shown in Figure 2 below.

Figure 2: Circuit diagram of the hydroelectric generator and infrared transmitter with the fire extinguisher.



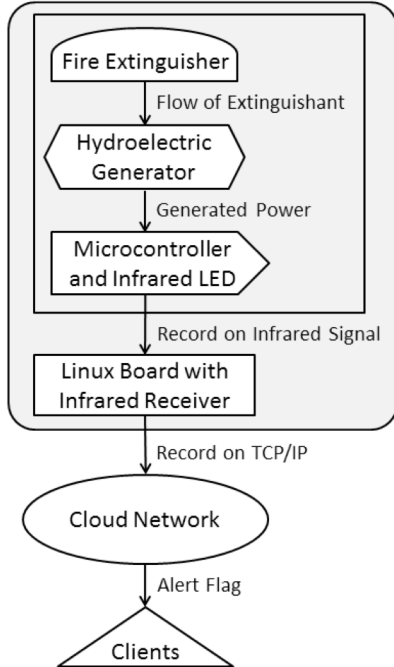
The implemented system is detailed:

1. A hydroelectric generator produces a maximum output of 5V, 150 mA.
2. A Raspberry Pi 2B (Linux board), equipped with an infrared receiver module is used as the receiver. The infrared LED was adopted because it consumes less power.
3. When the fire extinguisher is in use, the pressure at which the fire extinguishant is discharged is converted into electric power by the hydroelectric power generator. This powers the microcontroller using firmware provided by Arduino, an open-source electronics platform, which sends an infrared signal. The signal is received by a receiver installed in the vicinity.
4. When receiving the infrared signal, the receiving device creates a record that summarizes the ID of the fire extinguisher that sent the infrared signal, the date and time when the signal was received, and the information on the location of where the receiving device is installed.
5. The receiving device is connected to the Internet, and uploads the record to the cloud network. The system connected to the cloud network identifies the time and location of the fire occurrence by signals from the fire extinguisher and reports it to the fire department, and so forth.

Figure 3 shows the block diagram of the implemented system.

Figure 3: Block diagram of implemented system (the first prototype).

【Alarm Transmission System with Fire Extinguisher】



By adopting energy harvesting methods in such a mechanism, this idea of a high-performance fire extinguisher is a world's first. By the automatic power generation from the water flow of the fire extinguisher's discharge, we have built a smart fire extinguisher that can give alarm notifications as well.

Although the first prototype proposed here can realize the batteryless implementation of the transmitting device, the receiving device still requires a power infrastructure.

For the second prototype, it uses 'low power, wide area (LPWA)' network module, which is a low power and low cost communication system such as SIGFOX, a French system recently introduced to Japan, as opposed to an infrared system to transmit signals from the transmitting device directly to the cloud network in order to upload information.

Figure 4 shows the complete-batteryless Internet of Things (IoT) device without the receiving device. Our hydroelectric generator can provide sufficient and enough electric power to the IoT device.

Figure 4: Block diagram of second prototype system
 【Alarm Transmission System with Fire Extinguisher】

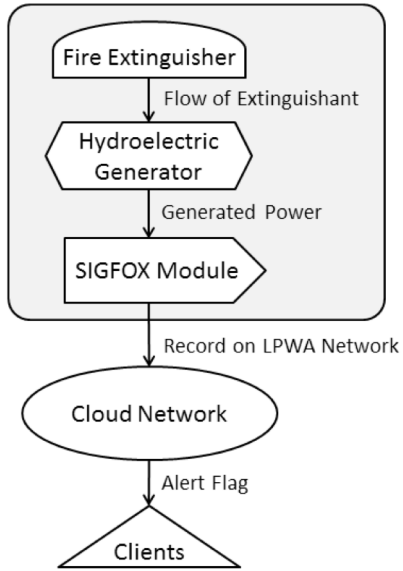
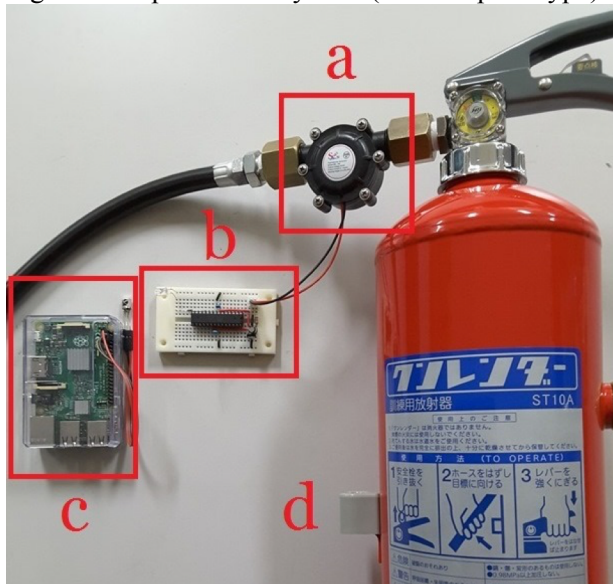


Fig. 5 shows the first prototype system. The system is composed of a hydroelectric generator, an infrared transmitter, a Linux board, and a fire extinguisher.

Figure 5: Implemented system (the first prototype)



- a Hydroelectric Generator
- b Infrared Transmitter composed of microcontroller and infrared LED
- c Linux Board (Raspberry Pi 2B) and IR Receiver
- d Fire Extinguisher (Morita ST10A)

RESULTS AND DISCUSSION

We actually conducted experiments in Japan in December 2016 using the proposed system and devices as shown in the previous section.

When the extinguishant is discharged from the fire extinguisher capable of discharging the internal contents (water in this experiment) at the same time and at the same pressure as a common fire extinguisher, electricity, 0.5 Watt is generated by the water flow. There is a small hydroelectric power generator attached to the fire extinguisher that conducts energy harvesting. With that power, we attempted to drive the infrared signal transmitter and upload alert information to the cloud network.

As a result, it was possible to generate power by discharging the contents continuously for 10 seconds, and to operate the transmitting device. We were also able to receive the infrared signal at the receiver 3 meters away.

Even without a continuous discharge of only 10 seconds, which is a standard determined by law for fire extinguishers in Japan, we were able to check alarm information sent from a batteryless fire extinguisher on the cloud network.

We also confirmed that the second prototype system described in the above section functioned as intended.

As a result, energy harvesting was conducted by the hydraulic power of the extinguishant discharge, and we were able to post a warning flag automatically on the cloud network.

In this experiment, fire extinguishers with the same performance as fire extinguishers commonly used were utilized, so it is sufficiently practical.

CONCLUDING COMMENTS

In this research, we built the new system by using off-the-shelf hardware parts and open source software modules. This research hasn't shown any original technology except for the new innovative product idea. The proposed system is the world's first prototype implemented with low cost.

As this paper has shown, a small hydroelectric power generator attached to a fire extinguisher generates electricity using hydraulic power from the discharged extinguishant. This electric power is used to drive the infrared Linux board such as Raspberry Pi and the transmitter that uploads alert information to the cloud network. Until presently, similar systems and devices requiring a power infrastructure or batteries existed, but for this experiment no electric power infrastructure was necessary.

Now that batteryless has been achieved, fire extinguishers can be freely installed at any location, and problems with dead batteries are irrelevant so maintenance is no longer necessary. Furthermore, it works without issue even in severe environmental circumstances or a power outage.

According to Japanese law, fire extinguishers are regulated to continue discharge for more than 10 seconds, and most common fire extinguishers can only be in continuous use for 10 seconds. It was necessary to flag the alarm in the cloud network within this limited time, which was left as is a very difficult task.

However, this problem was solved by the system and device proposed in this research. Hence, this

batteryless automatic alert transfer system by fire extinguishers is a world first.

This issue is not specific to Japan. It is a worldwide one, and the device proposed in this paper makes a very important contribution to world firefighting.

Recently R&D activities in the manufacturing and IT industries are growing more mature and competitive. Also, it is getting more difficult for companies including large ones listed in Tokyo Stock Market to innovate new products only by taking closed innovation strategy, which limits R&D activities inside their companies or only makes use of their present hold technologies. In actuality, companies must pay high cost and long term for their R&D of new innovative products if they are standing on the strategy of closed innovation. This imposes a limitation for their invention of new products and exploring their new business opportunities.

Namely in new product developments, closed innovation which uses only owned technologies has high costs and technical limitations in order to develop new products. Conversely, open innovation which acquires existing technologies and combines them reaches low cost and high speed development capability.

Therefore, present companies should use or acquire the existing technologies, off-the-shelf parts, or open source modules outside their organization by the strategy of open innovation. It must lead to new product developments with low cost and rapid prototyping respectively. At that time the open source modules as documented in this paper should be used.

This trend is related to the concept and theory by Schumpeter in the early 19th century, that new knowledge is created by new combinations of already existing knowledge. We can understand that the concept of “New Combination” is a functional theory even today, although the new combination of existing technologies is not a fresh concept. The auto alert system proposed in this paper is exactly the real typical case of Schumpeter’s theory.

Consequently, the proposed system in the paper implied that a new innovative system or product that was invented from combining existing technologies as a typical case study. It has an academic contribution to studies in management of technology, R&D activities, and open innovation.

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BIOGRAPHY

Hiroshi Yamamoto received his Master's Degree at the graduate school of media and governance, Keio University in 2008. He is presently a Ph.D. candidate in the same research field. Along with the guidance of Dr. Yoshiyasu Takefuji in the research lab, he focused on IoT research. At the same time, he established a business for IoT system development, and focuses on system design and development. He can be reached at yama@sfc.keio.ac.jp .

Satoshi Tomita is a professor at the Graduate School of Business Administration, Rikkyo University, who teaches Strategy for Technological Solutions. He received his Ph.D. in Media and Governance from Keio University. He is also the President & CEO of TC Consulting Co., Ltd., which provides consulting services of business development primarily in the IoT field. He can be reached at tomita@rikkyo.ac.jp or tomita@tcconsulting.co.jp .

Yoshiyasu Takefuji is a tenured professor at the Faculty of Environment and Information Studies at Keio University. His research interests focus on neural computing, security, IoT and machine learning. http://neuro.sfc.keio.ac.jp/staffs/takefuji/yoshi_biography.html
He can be reached at Keio University, 5322 Endo, Fujisawa, 2520882 JAPAN, takefuji@sfc.keio.ac.jp .