A Water Leak Detection Service Based on Sensors and ICT Solutions

FUKUSHIMA Kei, MARUTA Yuuji, IZUMI Kazuo, ITO Yusuke, YOSHIZAWA Ayumi, TANAKA Toshiaki

Abstract

Japanese infrastructures built in the high-growth period have recently been challenged by deterioration due to aging and various issues have occurred. As a result of the current water supply situation, NEC started a Water Leak Detection service in September 2014 for monitoring water pipe leaks on a permanent basis. This service detects water leaks in key underground water pipe infrastructures, and informs the waterworks departments of their precise locations. In contrast to traditional water leak detection procedures, with which human operators find water leaks by detecting sound, this service protects the city water supply by employing a leak monitoring technology instead of using auditory detection methods. Bearing in mind that water leakage is a global issue that has already grown to become a critical issue in many areas, this innovative leak monitoring solution is applicable worldwide. This paper introduces this technology and discusses features of the service and its future perspectives.

Keywords

deterioration of infrastructures, waterworks, water leak detection, vibration sensor, Google Maps, monitoring, cloud computing, M2M, big data, smart water

1. Introduction

Leakage from water pipes is posing a serious problem for the water supply industry that has to supply purified water at high cost to the consumers. Water pipes are usually buried underground, the piping distance can be extremely long, and it is not rare that a pipe is used for as long a period as more than forty years. Since the pipes are buried, they are difficult to monitor either visually or by using cameras. Even when a water leak incident is clearly indicated by the difference between the supply and consumption quantities, it is difficult to identify the actual location of the leak. The water leak survey method most often used at present consists of patient work performed by trained human operators, who find the water leaks by detecting sounds by using a special leak detector placed at the ground level (**Fig. 1**). This method often fails to detect a leak unless it is one that results from a serious incident.

The Water Leak Detection service that NEC has developed recently can be an effective for resolving the above issues. The service installs sensors at arbitrary intervals on water pipes in order to capture vibrations caused by a water leak, sends the acquired data to the cloud computer via wireless networks or public switched telephone networks (PTSN) and identifies the leak location with high precision based on the results of data analysis. The users of this system such as the water suppliers can identify the accurate leak generation situation on the web screen and thereby minimize the damage resulting from leaks.

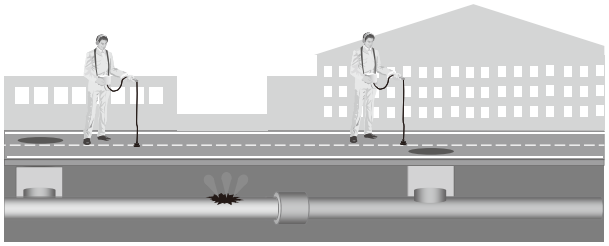

Fig. 1 Traditional water leak survey method.

There are reasons that such a system has not existed before in spite of its simple arrangement. These are the difficulty in precise identification of the leak location using the sensing technology alone, and particularly, the high costs and labor to be invested compared to the expected efficiency. What made us focus attention on water leak detection was the development by the NEC Group of a world leading compact vibration sensor device. However, it was not easy for us to resolve the

above issues, until eventually we were able to start up the service.

After trials and errors such as demonstrations using actual water pipes, we succeeded in making the service a highly practical product by adopting the following guidelines.

(1) To concentrate the leak analyses and other services in the NEC cloud computing and provide them as a Water Leak Detection Service thereby reducing the amount of work and equipment-investment burden on the users.
(2) To collaborate with Gutermann AG of Switzerland who has the world's most advanced technology and achievement in the field of leak location identification using vibration sensors.
(3) To prepare a service system that permits users to realize the benefits of the introduction even with the minimum configuration and one that can be extended or modified flexibly according to budget, even after introduction.

An overview of the Water Leak Detection Service is given in the following section.

2. Outline of the Water Leak Detection Service

Fig. 2 shows the features of this service.

2.1 Sensor Loggers

The small cylindrical body of each sensor logger (**Photo**) consists of packaged: vibration sensor, memory, battery, logic, wireless device and antenna. It has a powerful magnet at the bottom so that it may be attached and detached freely to a metallic section of the water pipe equipment, such as to a fire hydrant or water stop valve in a manhole. The battery is capable of continuous use for five years (variable depending on the operating conditions). The sensor loggers are installed at intervals of about 200 meters in existing manholes. They communicate with a network device, as described below, via a specified low power radio that does not need a license.

2.2 Network Device

- **Relay equipment (for permanent collection)**
  A repeater is a device for collecting information from the sensor logger that is installed on a public utilities pole or similar facility within some tens of meters of

Photo Sensor logger.

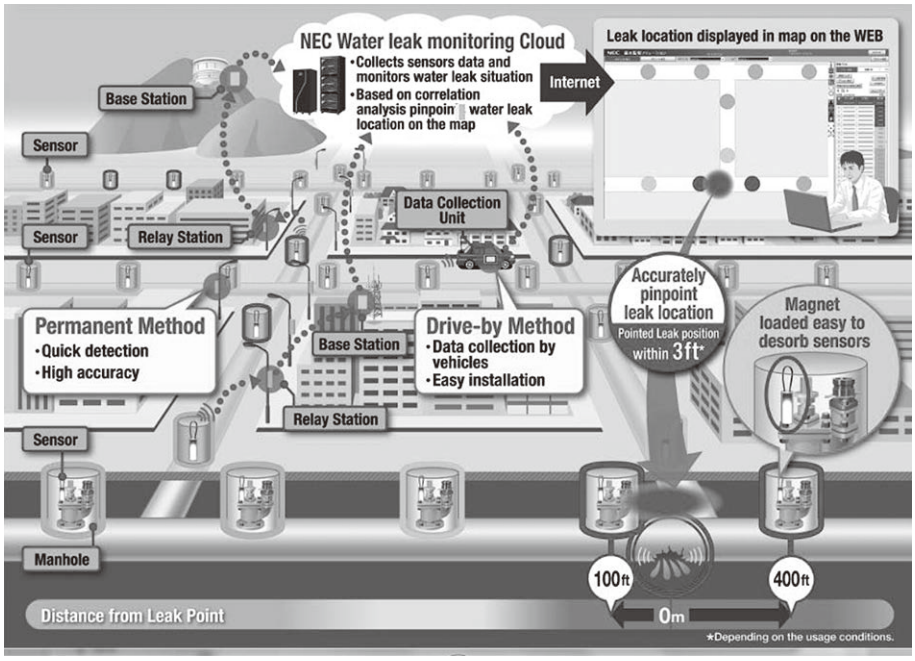

Fig. 2 Overview of the Water Leak Detection Service.

each sensor logger. In a similar manner to the sensor logger a battery is incorporated so that it may be used continuously for a long period without maintenance.

- **Base stations (for permanent collection)**
  The base station is the communication device for gathering information from the repeater. It uses a specified license-free low power radio for communication for approximately 0.5 to 1 km distance in line of sight from each repeater installation location. The data is then communicated to the NEC cloud computer via the PTSN, etc.
- **Data collector (for drive-by collection)**
  In addition to the permanent data collection function, data from the sensor loggers may also be collected using a data collector that can be installed easily on a vehicle. With this method, data is collected by a drive-by vehicle so that permanent collection equipment is not necessary.

2.3 NEC Water Cloud

The NEC Water Cloud has been developed to implement the Water Leak Detection Service. The NEC Water Cloud is composed of the Water Leak Analysis Engine, which combines the unique expertise of Gutermann and the Water Leak Service Application that implements the NEC-original analyses and services based on the results obtained with the Leak Analysis Engine.

(1) Water Leak Analysis Engine

The Water Leak Analysis Engine that monitors water leaks is routinely based in combination with the sensor loggers and expresses the certainty of a water leak detection by each sensor logger via a unique index called the Water Leak Score. When a score exceeds a certain level, the engine detects the possibility of a water leak near to the sensor logger and starts a detailed analysis of the data. The detailed analysis consists of a "correlation analysis" between multiple sensors around the location where a leak is suspected, which makes it possible to pinpoint the leak precisely with an accuracy of about 1 meter. There has traditionally been an approach to install vibration sensors and detect water leaks in their proximities, but it requires the additional work of opening the manhole of the suspected location and the attachment of a special water leak detector in order to identify the precise water leak point. The service proposed herein does not need such work and features the possibility of doing everything by office based operations.

(2) Water Leak Service Application

The NEC Water Cloud provides various functions so that the water leak score obtained with the Water Leak Analysis Engine can be utilized at maximum to support user operations (**Fig. 3**).

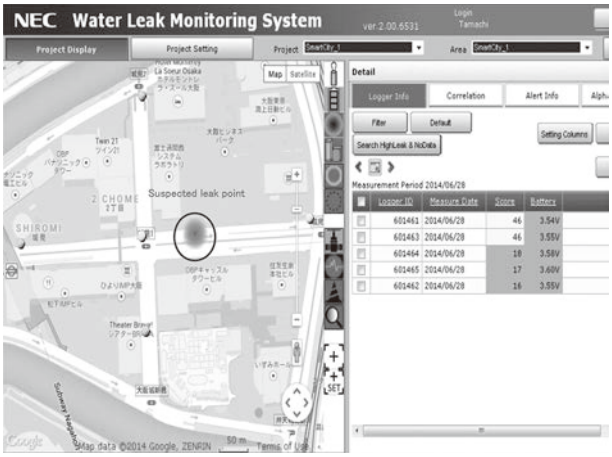

Fig. 3 Display of cloud computing for water leak detection cloud display.

These functions are listed below.

1) Displaying the locations and the statuses of the sensor loggers on Google Maps (the location information is set by GPS measurement at the time of installation)
2) Data compatibility with the mapping systems of the various waterworks departments
3) Alarms for various leak situations
4) Daily score logging of abnormal points, searches based on various conditions
5) Compilation of leak reports
6) Traceability of leak generation points, etc.

In routine use, the display is conveniently interconnected with alarm functions as well as with various maps including the Google Maps. The sensor logger icons are displayed in green, yellow and red according to their leak scores so that the degree of leak suspicion can be confirmed visually. In the actual operation, the staff check the service displays every morning in performing meticulous maintenance and thereby enable significant improvements in business operation efficiency.

We believe that in the future, it will be possible to convert the status of each installation position into a numerical value based on the various data collected by the service and use the service for purposes other than for water leak detection. For example, it will support efficient water business operations by deciding the priority of a piping updating plan that would require a large investment. It will do this by defining the deterioration trend of each factor, such as the degree of pipe ageing, construction material and ground properties. With regard to the possible application extensions of the technology discussed above, we also expect that the efficiency of the water supply industry can be improved by applying NEC's big data analysis technology for dealing with globally accumulated data.

3. Results of Field Demonstration

In the period from September 2013 to March 2014, we made a demonstrative test on actual water pipes jointly with KASIX Corporation, local information processing company, and under collaboration from the Gas and Water Supply Bureau of the City of Kashiwazaki (Niigata Prefecture).

As a result of assessment using about twenty sensor loggers under various test conditions, we succeeded in detecting four water leak cases with position errors of less than 1 meter. Some issues were noticed in relation with the operability, but they have already been noticed as the points to be improved in the commercial version.

4. Future Perspectives

It is well known that the Japanese water management is excellent at the global level and the national average water leak rate of 5% is much lower than other countries where the leak rate often exceeds 20%. Nevertheless, since most waterworks were installed in the high growth period after WWII, the ratio of decrepit pipes used over 40 years is sure to increase rapidly in the future, while investment of high expenses for water pipe updating cannot be expected because of depopulation. It is therefore indispensable to manage the installed water pipes more efficiently than before by utilizing the force of ICT, and we at NEC are determined to contribute to the water management in this direction.

Since the problem of water leaks is more serious in countries other than Japan, the needs for the service as described above are expected to be very high in overseas countries. The problems related to water supply are not only those in developing countries, but they are also severe in areas where old water supply systems are ageing such as Europe and North America.

The newly constructed NEC Water Cloud was designed assuming the worldwide deployment from the beginning, and has already received favorable responses in pre-sale activities in North America. We are planning to concentrate the achievements, including the collaboration with Gutermann AG and the results of joint study into the smart water management with the Imperial College London, on the cloud platform so that we can provide internationally substantial services in the field of water management.

5. Acknowledgment

We would like to express our gratitude toward the Gas and Water Supply Bureau of the City of Kashiwazaki for giving the opportunity of demonstration that was very precious for the product development as well as for publication of this paper, as well as to KASIX for cooperation in the demonstration test.

* Google Maps is a trademark and/or a registered trademark of Google Inc.

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