River Monitoring System

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Due to the frequent heavy rains and torrential downpours seen in recent years, it has become important to provide support for more appropriate and safe flood-related activities at small-and-medium-sized rivers while at the same time reduce the burden on organizations/people involved with disaster preparations and flood fighting activities. OKI has developed a river monitoring system aimed at solving problems of flood-fighting activities at small-and-medium-sized rivers.

This article describes the current situation and challenges of river monitoring that served as a backdrop for the development of a river monitoring system followed by the functional overview and installation example of OKI's system.

Background of Development

According to the damage costs by river type in the Ministry of Land, Infrastructure, Transport and Tourism's "Flood Statistical Survey[1]," the annual average damage caused by river flooding was calculated to be about 248 billion yen between 2008 and 2012. Of these, about 10% were large class-A rivers under direct control of the national management while small-and-medium-sized class-A rivers, class-B rivers, secondary rivers and ordinary rivers under prefectural/municipal management accounted for nearly 90%. Hence, flood measures for small-and-medium-sized rivers are keys to mitigating damage.

Civil engineering work to strengthen embankments, construct flood control dams and develop water reservoirs is an important measure. However, at the same time, quickly providing local governments and residents with information that will serve as action criteria for safe, timely evacuation and enhancing knowledge through data accumulation to promote the overall optimization of flood-fighting activities are also necessary to mitigate damage. To accomplish this, collection and utilization of water level/rainfall data is vital.

The Revised Flood Protection Law of 2005 called for the specification of water level notification rivers and special warning water levels. The Law requires the Minister of Land, Infrastructure, Transport and Tourism or prefectural governors to establish a special warning water level (water level that exceeds the warning level and requires special attention for occurrence of flood disasters) that will be a guideline for recommending evacuation from major small-and-medium-sized rivers (water level notification rivers). When the water level reaches the prescribed level, concerned prefectural governors and flood-prevention administrators (municipal mayors) are to be notified and information passed to residents. Therefore, each municipality has placed emphasis on collecting data of river water levels, making appropriate evacuation decisions quickly based on the collected data and communicating the information to residents.

Unfortunately, very few small-and-medium-sized rivers are equipped with systems that collect real-time water level data due to budget constraints. This is the same for locations designated as flood-prone areas, and data collection is still accomplished visually onsite at majority of the small-and-medium-sized rivers. Growing anxiety of residents over the frequent flooding that has occurred in recent years has heightened the interest for implementation of a low-cost river monitoring system especially in flood-prone municipalities.

Conventional Monitoring Systems

Large rivers are widely maintained with systems that provide real-time visual data of water levels and rainfall. These systems utilize optical fibers laid along national highways and river embankments to collect/provide data obtained from water level gauges, rainfall gauges and surveillance cameras. The data is open to the public and is accessible via PCs or mobile devices. In fact, municipalities and residents have been accessing the "River Disaster Prevention Information" website operated by the National Land with Water Information Data Management Center under entrustment of the national government to obtain real-time data of water levels (6,726 stations) and rainfall (10,051 stations). Use

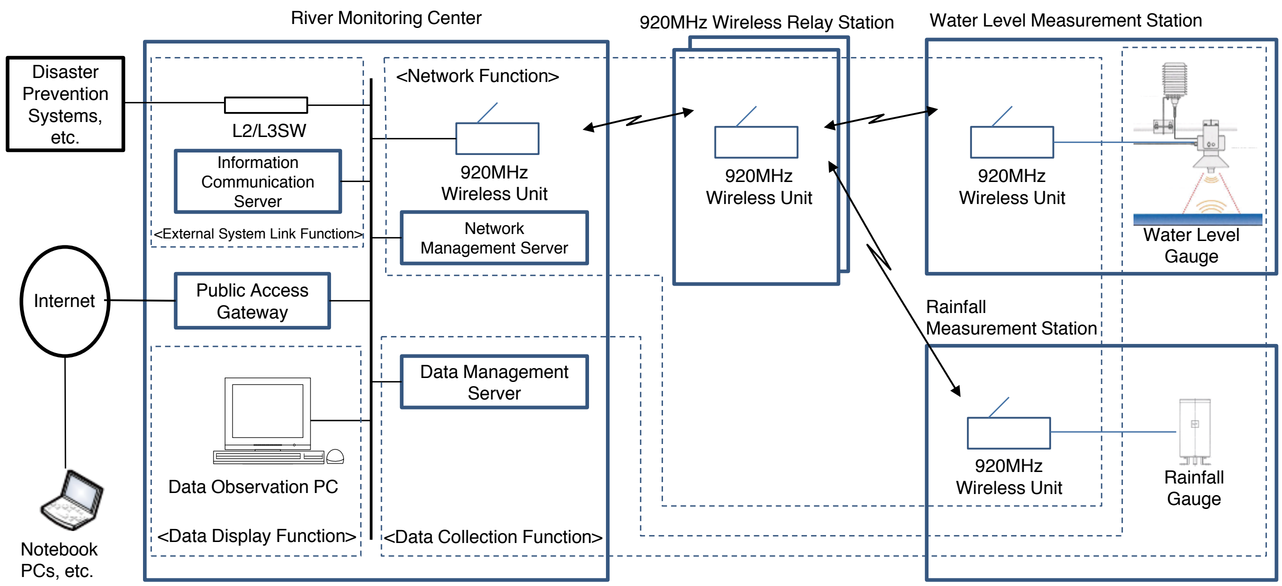

Figure 1. Configuration of River Monitoring System

of the website is increasing yearly and regarded as valid source of information in understanding threat situations enabling users to decide on evacuation and disaster response actions.

OKI's River Monitoring System

OKI's system is targeted at small-and-medium-sized rivers. Even if the river lacks communication infrastructure, the system costs less to deploy and operate than conventional systems. Furthermore, changing or adding observation points is relatively easy. Overview of OKI's river monitoring system is introduced below.

The system consists of four major functional units. They are "network function," "data collection function," "data display function" and "external system link function." **Figure 1** shows the main configuration of the system, and function of each unit is described below.

(1) Network Function

Since the volume of water level and rainfall data collected from the observation points is small, large capacity transmission is unnecessary. From this fact, to link the observation points with the river monitoring center, emphasis was placed on a communication infrastructure that was easily configurable, disaster resistive and relatively low in cost. The result was the adoption of OKI's own 920MHz wireless multi-hop network system. Wireless units are installed at the river monitoring center (master station) and observation points (slave stations). If the monitoring center and observation points are too far apart, one or more relay stations are set up enabling the network to be constructed using only wireless communication.

In the adopted 920MHz wireless multi-hop network system, the network management server centrally manages all communication paths within the network. A path can be rerouted if certain sections of the path are cut off due to failure during a disaster. Rerouting is accomplished in a short period, and data loss should not occur in most cases. For maintenance, it is possible to update the control data and firmware remotely. External views of the wireless units are shown in **Photo 1** and specifications are given in **Table 1**.

Photo 1. External Views of 920MHz Wireless Units

Table 1. 920MHz Wireless Unit Specifications

Item		Specifications
Wireless Interface	Frequency	920MHz band (ARIB STD-T108 compliant: 922.3~928.1MHz)
	PHY/MAC Standards	PHY: IEEE802.15.4g MAC: IEEE802.15.4
	Maximum Output Signal	20mW
	Transmission Rate	100kbps maximum (varies by environment)
	Transmission Distance	Approximately 1km (varies by environment)
	Modulation Scheme	GFSK
External Interface	Physical Interface	RS-485x1 or RS-232Cx1 Micro USBx1
	Upper Connection	RS-485 or micro USB
RS-485 Compatible Protocol		Modbus RTU, others
Network Standard		Compatible with 6LoWPAN, IPv6/RPL, etc.
Power Source		DC5V: Micro USB, proprietary power connector AC100V: AC adapter connection
Operation Environment		Main Unit: -20~+60
Maximum Power Consumption		Less than 1W
External Dimensions		115x56x24mm (excluding protruding parts, mounting plate, antenna)

(2) Data Collection Function

Function is made up of water level/rainfall gauges at the observation points and data management server at the river monitoring center.

The rainfall gauge used is a conventional and inexpensive product that is readily available whereas, the water level gauge is an "ultrasonic water level gauge" (manufactured by Shizuoka Oki Electric), which provides stable and accurate measurements.

(3) Data Display Function

The display function is implemented with almost the same functionality as the river monitoring system for large rivers. In addition to displaying water level/rainfall in table and graph form, lines are displayed on the graph that indicate various reference levels such as flood-fighting team standby level, flood watch level, evacuation decision level and flood warning level. This enables real-time comparison of the current water level against the different reference levels.

When a river becomes swollen, drainage pumps located at tributary junctions are operated. The decision to start or stop the pumps is based on the internal and external water levels. Considering this fact, the display of both the internal and external water levels at the same location was made possible. **Figure 2** shows an example of the display.

(4) External System Link Function

The various types of information collected in the data management server can be transferred via the information communication server to other systems including the disaster prevention system. This function widens the effective use of the river monitoring information.

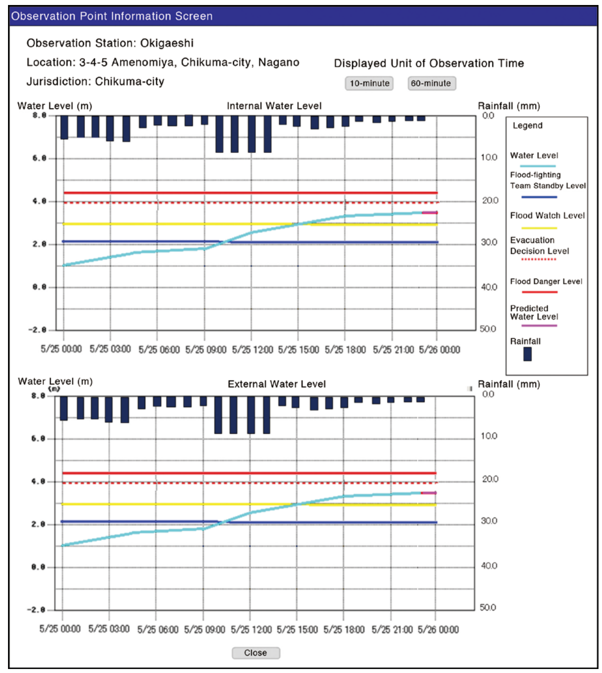

Figure 2. Display Example

Installation Example

OKI's river monitoring system was adopted for the mobile-wireless testbed of JOSE[2], a large-scale open testbed headed by the National Institute of Information and Communications Technology (NICT). The system was installed at the Sawayama River in Chikuma-city. The configuration of the installed system is shown in **Figure 3**.

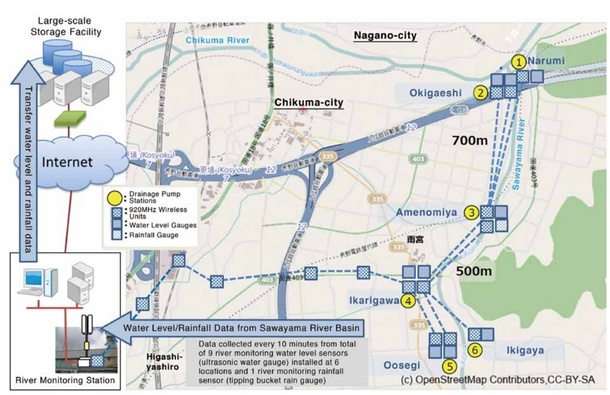

Figure 3. Configuration of System Installed at Sawayama River, Chikuma-city

Description of the installed equipment is given below.

(1) River Monitoring

River monitoring center was established at the Chikuma-city River Monitoring Station and observation points were set up at six different locations along the Sawayama River mainly at drainage pump stations (internal water level gauges installed at all six stations, external water level gauges installed at three stations and rainfall gauge installed at one location).

(2) 920MHz Wireless Multi-hop Network

One wireless unit was installed at the Chikuma-city River Monitoring Station, ten units at observation points and five units as relay stations for a total of sixteen. The maximum number of hops from the observation points to the river monitoring center is eight. Transmission has been stable with almost zero data loss caused by retransmission or other countermeasures. To reduce cost, the wireless units were attached to existing pillars such as those used for municipal disaster radio communication.

Future Efforts

Adequate support against the rapid rise in small-and-medium-sized river levels is not possible with only the real-time collection/display of the occurring phenomenon. In order to allow a more rapid decision-making on evacuation orders and other actions, what the water level will be after a few hours needs to be predicted. Until now, measurement installations have been undeveloped. Therefore, at this stage, data and knowledge of small-and-medium-sized rivers is lacking and more time may be required to establish a prediction method. Furthermore, situation varies greatly for each small-and-medium-sized river located throughout the country due to differences in surrounding environment and climate. This and many other issues remain to be resolved before a widely effective prediction system can be realized. Additionally, just the same as the systems before it, the prediction system will be stalked with budget constraints. However, accumulating small-and-medium-sized river data and increasing knowledge is imperative in reducing human suffering and economic damage caused by floods, thus the significance of the prediction system is large.

Analysis and verification of the data obtained from the mobile-wireless testbed in Chikuma-city will be continued and knowledge will accumulated to strive for the development of an effective prediction system. The use of publicized water level and rainfall data from measuring equipment already setup by the nation, prefectures and municipalities will be carefully considered. As for rainfall data, which is indispensable for predicting water level, coordination is planned with prediction data from the Meteorological Agency and the weather service companies.

Work will be coordinated with recent countermeasure activities against local heavy rain taking place at various small-and-medium-sized rivers as part of OKI's effort to speed up the realization of the prediction system. ◆◆

■ References

1) [General Contact Site for Government Statistics (e-Stat)]
http://www.e-stat.go.jp/SG1/estat/GL08020103.do?_toGL08020103_&listID=000001118306&requestSender=search
(Latest revision: March 26, 2014)
2012 Flood Statistics Research, Statistics Table "Damage by River Type," Asset Damage Costs by River Type for the Past 20 Years (2005 cost value) (Table-37)
2) Large-scale Open Testbed JOSE
http://www.nict.go.jp/nrh/nwgn/jose.html

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TIPS

【Glossary】

Class-A river

River pertaining to a water system (class-A water system) that is particularly important to the nation's land conservation and economy. Designated and managed by the Minister of Land, Infrastructure, Transport and Tourism, but certain rivers are managed by prefectural governors.

Class-B river

River pertaining to a water system other than a class-A water system. Designated and managed by prefectural governors.

Secondary river

River other than a class-A or class-B river. Designated and managed by municipal mayors correspondingly applying class-B river laws.