Wildlife Damage Management Using ICT: Visualization of Data Over a Sensor Network

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1. Introduction

The city of Shiojiri is near the geographic center of Nagano Prefecture at the southern end of the Matsumoto Basin. Rich in historical associations, the area is surrounded by the Northern Alps to the west and the Central Alps to the south. Shiojiri has an average year-round temperature of 11.9C˚, 26,000 households and total population of 67,000, and is committed to urban development under the slogan "the good life in a garden city with eyes to the future."

Favorably situated to move inland traffic from the Pacific coast on one side of Japan to the Sea of Japan on the other, Shiojiri flourished as a post town along the ancient Nakasendo route stretching from Kyoto to Tokyo. Today, as in centuries past, Shiojiri has evolved into a transportation hub with well-developed infrastructure: crisscrossed by JR (Japan Railways) lines, with the Nagao Expressway and other highways, and easy access to the Shinshu Matsumoto Airport.

Scenic beauty is unsurpassed, but the area falls within the Itoigawa-Shizuoka tectonic fault zone, which makes the area somewhat vulnerable to seismic activity.

2. Information-driven policy and wildlife damage management using ICT

Shiojiri began its transition to an information-based society in 1984 with the introduction of general-purpose business computers and first tentative steps to develop an autonomous system infrastructure. Since then, investment has continued to focus on information-driven initiatives and networks supporting IT to upgrade and develop Shiojiri as a convenient and congenial place to live.

About the time development of citizen data and administrative systems were completed, work began on the development of network—*e.g.*, the Internet—and server-based systems. More recently, efforts have focused on migrating from these earlier systems to smart systems that minimize impacts on the environment. Investment has thus continued to focus on a smart information-driven society that contributes to Shiojiri as a garden city in harmony with the natural environment.

The Shiojiri "Disaster Mitigation Project using Sensor Network" is based on the "2012 MIC-subsidized ICT-based Smart City Project," that was evaluated during a two-year pilot project. The Shiojiri project is supported by an ad hoc wireless network interconnected with a optical fiber communications infrastructure. The ad hoc network collects data directly from various sensors deployed throughout the community and stores the data on a server (see Figure 1). The sensor data can be accessed via the web from a Wi-Fi hotspot or can be downloaded as email and viewed on a personal handheld device such as a smart phone or a cell phone. Primary goals of the project were to determine if there were enough sensors to make specific administrative decisions, and to see how quickly local citizens in the community could be notified of the sensor-based information.

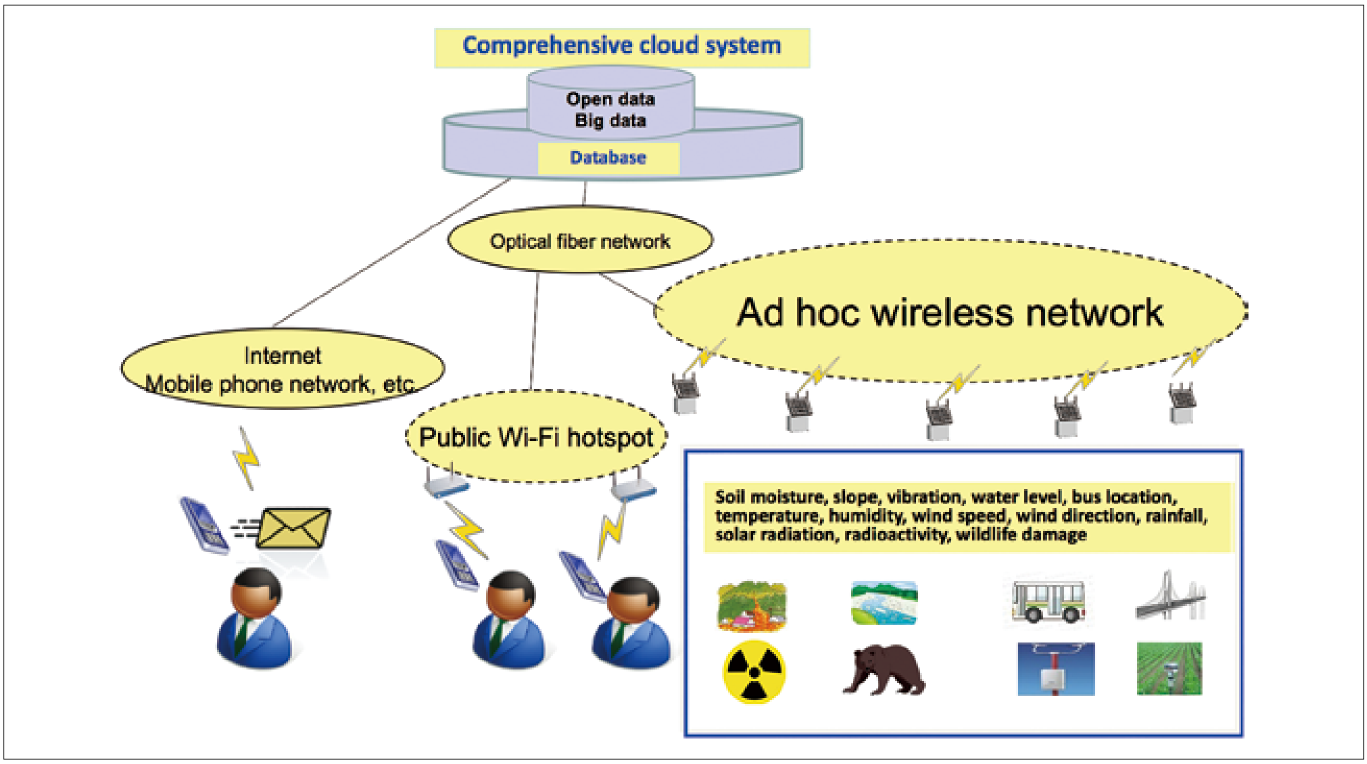
One initiative, for which we received the Special Regional Information Award from the MIC in 2014, was the "Wildlife Damage Sensor" that helps manage and deter wildlife from damaging crops. This system is designed to detect and capture wildlife in the Kitaono Ueda district of Shiojiri, a hilly and mountainous area where cultivated fields are immediately adjacent to forest lands. Until recently, we saw a sharp increase in damage

Table: History of Shiojiri's information-driven policy

1984	Introduction of general-purpose business computers, and construction of autonomous system infrastructure and City Hall LAN.
1996	Rollout of *Shiojiri Internet Service* for Shiojiri residents.
1999	Opened information base *Shiojiri Information Plaza*, implemented municipal public optical fiber network, and completed groundwork for Shiojiri ICT infrastructure (Inspired by Ministry of Posts and Telecommunications projects: *Project to Create an Invigorated Multimedia Society* and *Regional Intranet Infrastructure Project*).
2004	Signed partnership agreement with Shinshu University to collaborate on various research projects.
2007	Built first ad hoc wireless network with radio propagation range and radio repeaters for regional children tracking system using sensor tags employed by "Ministry of Internal Affairs and Communications (MIC) funded project of improved regional children tracking system of 2006." Constructed sensor platform that collects data very cost-efficiently from sensors deployed throughout the city plus several highly useful applications that use the sensor data in collaboration with Shinshu, Shizuoka, and Okayama Universities.
2012 2013	Won adoption of "Disaster Mitigation Project using Sensor Network" as implementation of "2012 MIC-subsidized ICT-based Smart City Project," and pilot project was conducted over 2 years.

Note: Ministry of Posts and Telecommunications (MPT) was merged to newly established Ministry of Internal Affairs and Communications (MIC) in 2001

■ **Figure 1: Diagram of Disaster Mitigation Project using Sensor Network (2012 MIC-subsidized ICT-based Smart City Project)**



■ **Photo 1: Wildlife detection sensor**

■ **Photo 2: Trap and capture sensor**

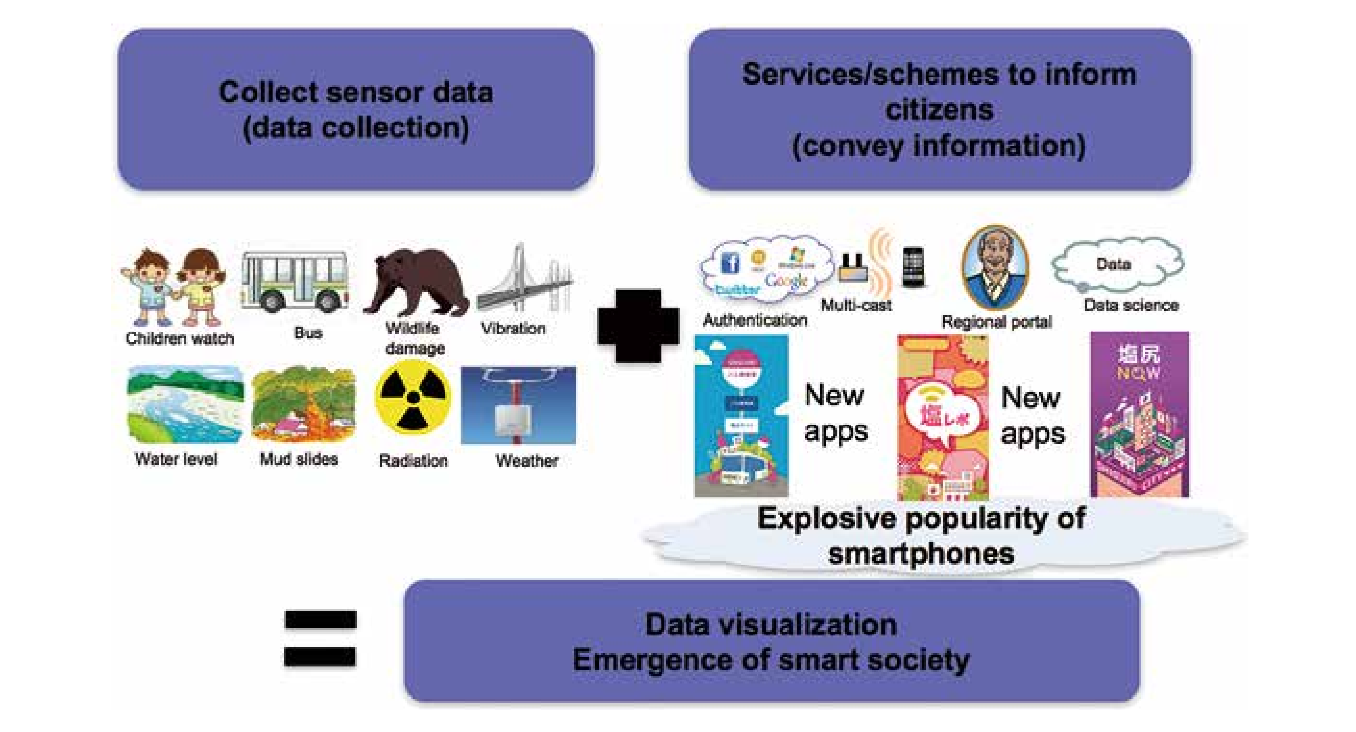
to potato crops and wet-rice paddies caused by wildlife in this area, and this project was conducted to see if IC technology might be useful in deterring wildlife or mitigating the damage to crops caused by wildlife. Two types of sensors are used by the system. First is a *wildlife detection sensor* shown in Photo 1 that detects infrared emitted from animals, then triggers a loud alarm or flashing lights to scare off the animal while at the same time sending an email notification to the local farmer or hunting club detailing the time and exact location of the intrusion. The second type of sensor is a *trap and capture sensor* shown in Photo 2 installed at places where animals are known to visit that sends an email notification to the local farmer or hunting club when an animal is caught. The wildlife damage control system has had a very beneficial impact. Before the system, farmers were becoming discouraged and disappointed when they came out the next day and found their crops trampled or eaten. The system now enables farmers to pinpoint the exact time and place that animals are getting into their fields, and the whole community is involved in doing something to eradicate the problem. With its proximity to forest land, the Kitaono

Ueda district has been especially vulnerable with as much as 85% of crop land damaged by wildlife, but the damage has been completely eliminated by implementing this simple system. Some of the farmers who were ready to call it quits due to the unending damage to their crops have had their confidence restored and are extremely happy with the results of the trial.

3. Indirect effects: use of Sensor Network and *Visualization of Information*

In addition to the "Wildlife Damage Sensor," we also demonstrated a number of other sensor applications over Shiojiri's "Disaster Mitigation Project by Sensor Network."

■ Figure 2: Visualization of Data



- Soil moisture sensors that detect moisture content of the soil at 20cm increments to anticipate mudslides.
- Tilt sensors that detect annual shifts in hillside slope in millimeter increments to anticipate mudslides.
- Vibration sensors that measure vibrations in bridges and other public structures to detect broken bolts and other structural problems.
- Water level sensors that measure the water level of lakes and rivers.
- Location sensors that measure the location of buses on circular routes through the city every 30 seconds.
- Weather sensors that measure temperature, humidity, wind speed, wind direction, rainfall, solar radiation, and radioactivity.

By collecting data from these various sensors over Shiojiri's optical network and ad hoc wireless network and storing the data in the cloud, we demonstrated that the system worked extremely well in everyday circumstances as well as in emergencies and disasters. The system gets valuable data into the hands of those who need the information quickly and efficiently. We also found that the system and sensors were more effective if the sensor data could be converted to a *visual* format.

We learned a number of valuable insights from the project.

■ Better to build the communications infrastructure for flexible adaptation rather than robust endurance to withstand disasters, for a major disaster will knock out any infrastructure no matter how robust.

- Costly infrastructure that is expensive to set up and maintain is limited, so better to build a simple communication infrastructure that can be expanded or adapted autonomously as needed.
- Setting up separate radio repeaters is simplistic and not very reliable, but a reliable and highly flexible infrastructure can be implemented by combining many of these simplistic structures.
- Optimum arrangement for disseminating sensor data is to store and maintain the data (bus route operational status, soil moisture data, water level data, wildlife damage data, and so on) at a data center, and distribute the information to users via the Internet.

■ On-going development initiatives (revitalizing local industries)

- A town or community can begin revitalizing its local industry by developing mobile applications, embedded software, sensor devices, and other equipment to work in conjunction with a network information infrastructure.

4. Future directions

This project was primarily focused on accessing sensor data over an ad hoc network, but we envision an explosive increase in the number and type of sensors used in combination with wireless devices in the years ahead as anticipated by the Internet of things (IoT). This will open the way to all kinds of beneficial services such as tracking young children and the elderly, providing security at greenhouses, or security for tractors and other farm equipment, and countless other services.

Meanwhile, research continues on the development of new sensors as a fundamental technology at Shinshu University, Shizuoka University, Okayama University, Seiko Epson Corporation, and at the Shiojiri Incubation Plaza (SIP), a development base for small and medium-sized Shiojiri businesses. Some of these new sensor technologies now under development include a pH sensor for grape cultivation, a greenhouse hydroponic cultivation nutrient sensor, a home garden moisture sensor, a frost sensor, and a tension sensor for inside tunnels. Certainly these sensors prove useful in the IoT era that is now unfolding.

Turning to education, we are starting to expose children to technology at an earlier age by introducing technical subjects in the classroom and open-source language Ruby to elementary and middle school students.

It is clear that sensors will play an increasingly important role and will be the focus of increased research and development in the years ahead. Shiojiri is leading in this development by pursuing successive challenges to make the city a vigorous and congenial place to live. Shiojiri is moving aggressively to develop embedded software which is at the heart of the municipal optical fiber ICT infrastructure and Shiojiri Incubation Plaza (SIP), pursuing new business development such as inauguration of the Shinshu OSS Promotion Consortium organized around the Shiojiri Industry Promotion Corporation for developing application software and open source software, exploiting dynamic general-purpose programming languages such as Ruby, moving quickly to get new technologies out of the laboratory and into the marketplace through process management and by cultivating human resources through on-the-job training, by rolling out projects to rejuvenate the manufacturing sector, and numerous other initiatives.

5. Conclusions

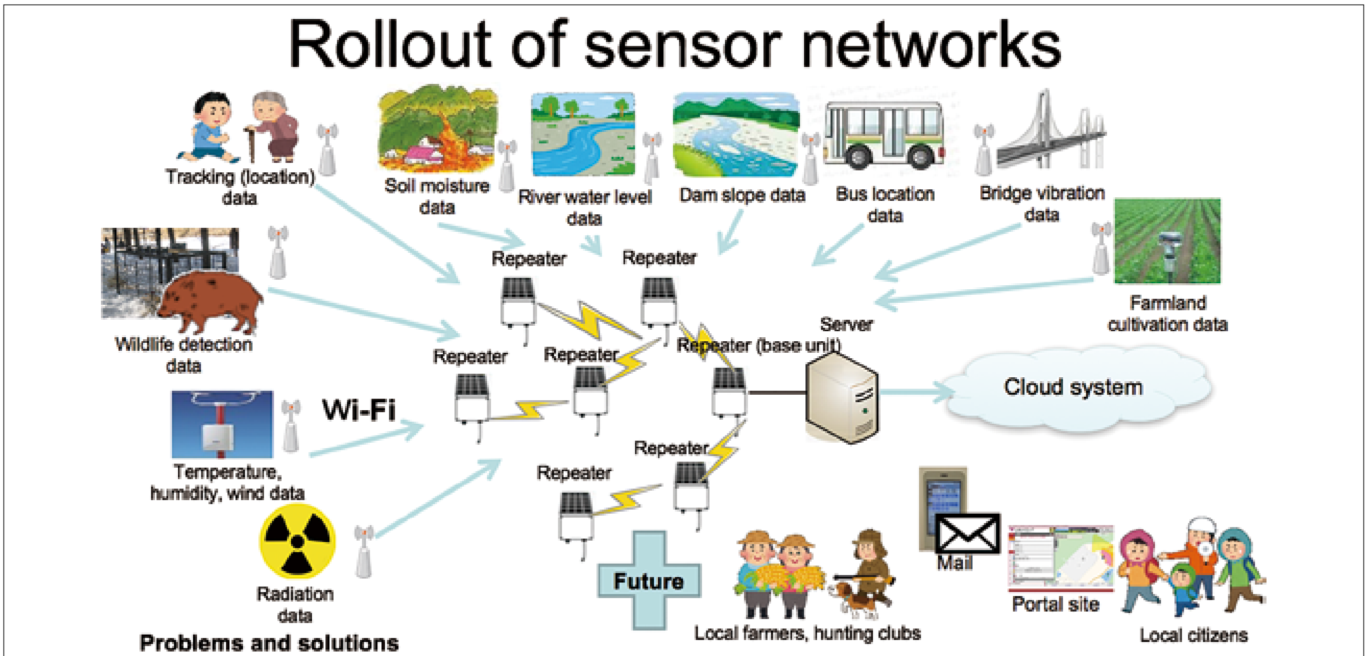
With the emergence of an information-driven society at the national level as well as the local level, we have witnessed the deployment of an extensive ICT infrastructure over the past decade. Japan now has one of the highest broadband penetration rates in the world, and ICT infrastructure is largely in place throughout the country. In terms of how information is utilized, there has been a marked shift away from open systems toward the cloud and other platforms which has made information far easier to access and has greatly increased the number of people using data. We are also seeing a rapid shift away from personal computers to mobile terminals (mobile phones and smart phones).

We have been hearing about the advent of the *local era* for some time now, but this will require greater autonomy for local governments and successful local management. This means that local governments must be able to secure financial resources without being dependent on the central government and have access to a fair allocation of people, things, and money derived from the strategic thinking of the modern era—in other words, the advent of the local era is closely linked to the revitalization of local communities. We can't afford to fail in this strategic pursuit.

Shiojiri's ICT policy has won the admiration of the international community, and Shiojiri was named one of the world's top 21 intelligent communities by the Intelligent Community Forum in 2015.

We have also taken the initiative to share the lessons and issues and insights learned through this project with the international community. For example, we delivered a presentation at the recent anniversary ITU WSIS + 10 event, transferred our wireless network technology to Himalayan mountain villages in Nepal, and collaborated in developing an e-agriculture application and other technologies for a Myanmar rural community redevelopment plan. It is this sort of activity that will spark revitalization of local government and local communities, and we are committed to stay the course until revitalization is achieved.

Figure 3: From Sensor Networks to Internet of Things (IoT)



Public demand for IoT will lead to greater use of electricity, gas, water, sewers, and other utilities, as well as further refinement of *Smart City Project* initiatives through collaboration with Shinshu University and the University of Tokyo, and eventual rollout of more advanced IoT technologies and security technologies into local communities.