A pond be smart for flood control

Toshiyuki Moriyama[1], Katsuhiro Morishita[2], Shinobu Izumi[3], Koji Nishiyama[4]
[1]Depertment of Scio-Envronment, Fukuoka Institute of Technology
3-10-1 Wajirohigashi, Higashi-ku, Fukuoka-city, 811-0295, Japan
[2] Department of Architecture and Civil Engineering, Kumamoto National College of Technology,
2627 Hirahama Shinmachi, Yatsuhiro-city, 866-0074, Japan
[3] Department of Informaion, Sojo University ,
4-22-1 Ikeda, Nishi-ku, Kumamoto-city, 860-0082, Japan
[4] Department of Urban and Environmental Engineering, Kyushu University
744 Motooka, Nishi-ku, Fukuoka-city, 819-0395, Japan
Email: [1] moriyama@0disaster.net, [2] *morimori.ynct@gmail.com,*
[3] *izumi@cis.sojo-u.ac.jp*, [4] *nisiyama@civil.kyushu-u.ac.jp*

Abstract: In urbanized area, the risk of flash flood is increasing recenetly. To save residents form this situation, we tried to make a smart raiwater facilites. A pond in Fukuoka Institute of Technplogy named "Otomegaike" is selected for smart rainwater facilites. We installet two sensor node with water level sensors and water qunatity meter and gateway for Internet coonction to the cloud of Amazon Web Service. We plans to control water outlet gate by hand based on diagnose of heavy rainfall with self organized map (SOM).

Keywords- *Smart rainwater facilities; Rainwater grid; Urban river; Flood control; Distributed multi-purpose dam by citizen*

1. Background

Rapid expansion of urban areas in Japan has resulted in widespread destruction of forests and paddy fields, increasing the risk of flash floods during heavy rainfall. While facilities such as dams, levees, rainwater storage facilities, and infiltration facilities are typically used to control flooding, constructing dams or large rainwater storage facilities in certain catchments.

We investigated the adoption of “smart” rainwater tanks, which are tanks capable of sensing water level, monitoring outflow, and which control flow output using pumps. The tanks are connected by a personal area network, making it possible to collect monitoring data and to control the water pumps remotely. Together, these connected tanks make up a rainwater grid system. The Self-Organizing Map (SOM), which represents one of the unsupervised neural network techniques, has been widely used for converting complex nonlinear multi-dimensional features into visually recognizable two-dimensional patterns. And when a self organized map issues a flood warning, a pre-discharge command is sent to the smart tanks in the rainwater grid system, instructing the water tanks to discharge their contents.

We are planning to install this system in the Hii River Basin in Fukuoka, Japan. A total of 106 200 L tanks have already been installed for flood control. The tanks are capable of moderating the peak of a heavy rainfall event and are suitable for experimenting with a grid system. Most households with smart rainwater tanks residents have not yet performed a pre-discharge; instead, the network of 106 tanks will be automatically pre-discharged in the near future. The collected data is stored using a cloud computer system, which can be accessed by the study participants. In this way, participants can understand how the grid works and how much rainwater is captured by the smart rainwater tanks.

At first, we make smart a 110 tons rainwater tank under the ground of housing complex[1][2][3]. A water level sensor, water quantity meter and rain-gage are installed as sensors and data is measured by sensor node. Sensor nodes are consist by Arduino and connected with wireless communication lines. According to request of gateway to internet, measured data are corrected via gateway and transmitted to clouds. Also, an application on the internet cloud diagnose heavy rainfall occurrence based on the prediction with SOM using GPV data served from Japan Meteological Agency and make pre-discharge the rainwater to the river[4][5].

But there was some problems for this first system. We tried to make a better system.

2. Method

First, we encountered an instability of the wireless connection. Especially, when the rainfall was started. We used a Digi Mesh 2.4 with XBee Module, this network protocol is proprietary of the Digi Key. The network topology was reconstructed when starting rainfall disturbs the wilress connection. Our first protocol was assumed as the observed data will collected from sensor node to gateway immediately. But value of counter for water quantity or rain-gauge have not time stamp and after the long disconnect of wireless connection, the value of counter sometimes large number and are given a time stamp at gateway. So large number of counter value is appeared at a time, but it is not real counted data.

Second problem of the previous system is that the power consumption is large and sensor node needs power line, but it

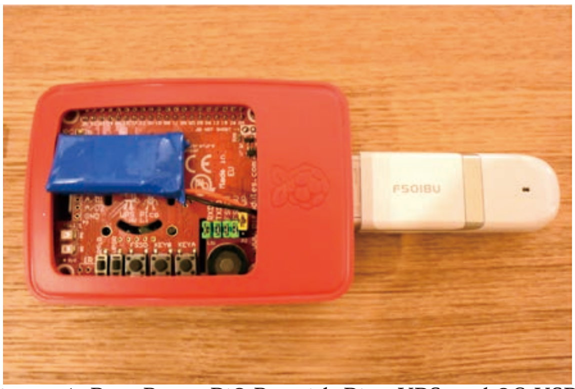

Figure 1. RaspBerry Pi2 B+ with Pico UPS and 3G USB dongle:FS-01BU for Gateway

is too difficult to add more power lines to the garden of the housing complex.

Third problem is web server on the cloud encounters a database error, in spite of Amazon RDS with MySQL database system is used.

To avoid these problems, we adopt these things for new system.

1) Digi mesh 2.4 is changed to broadcast mode, which has no network topology, but sill other node act as router.
2) For new protocol, Observed data is pushed from sensor node to gateway periodically, and sleeps deeply during the rest of the time to save power consumption.
3) Gateway changed form Android tablet to Raspberry Pi with UPS Pico and 3G USB modem shown in Figure 1 . Android is suitable for the client machine, not suitable for server.
4) Database on the cloud is changed to Amazon DynamoDB which NoSQL and possible to scale out.
5) Instead of genie Arduino, we adopt Seeeduino Stalker V3.0. Stalker has Bee socket for XBee module and has Real Time Clock (RTC) shown in Fig.2. This RTC is used for timer interrupt and possible to send logged data with time stamp via XBee, after that forces Stalker to sleep deeply.
6) We made a full range AD conversion shield with FRAM shown in Fig.3. This shield has 8ch 24bit AD converter tip LTC2499, it can measures the water level, air pressure, temperature and so on, and save the measured record with time stamp on the FRAM less power supply.
7) Counter shield is also adopt shown Figure4. This shield can save the counter value with less power and possible to readout the data when the Stalker is wake up from deep sleep.

3. Result

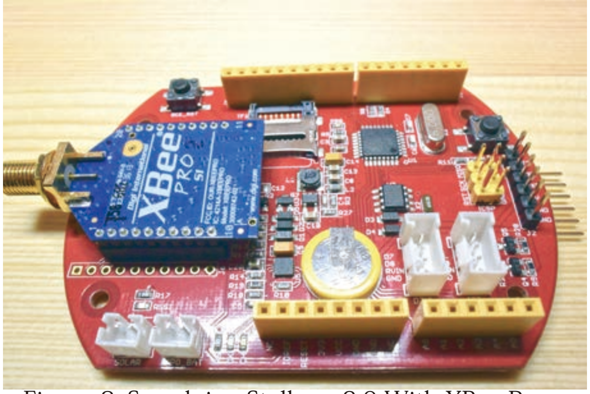

Figure 2. Seeeduino Stalker v3.0 With XBee Pro

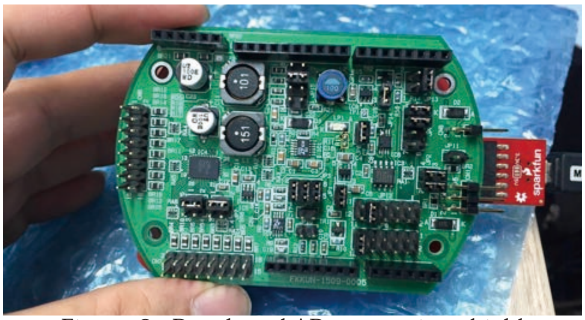

Figure 3. Developed AD conversion shield

Figure 4. Counter shield

For the second verification, we select a pond in Fukuoka Institute of Technology shown in Figure 5. The name of pond is Otomegaike, which means maiden's pond. It has 3,689m^2 of water surface. We install two kind of water level sensors. One is a eTape made by Milton Co. Ltd (Figure 6) and the other is pressure gage for verification of the eTape shown in

Figure 5. Panrama picture of Otomegaike pond

Figure 7. We also install V-notch weir to observe the quantity of outflow from the pond shown in Figure 8 and 9. This weir needs to observe the water level, which also use eTape and water pressure gage. Each data is observed by Stalker every 10 minutes with AD conversion shield, and pushed to gateway which is Raspberry pi 2 with Pico UPS via XBee PAN network. Gathered data is send to AWS EC2 server with http via 3G cellular connection. EC2 server write these data to DynamoDB.

Also, a OpenVPN server is installed on the EC2 server and OpenVPN client are install on the gateway. It is possible to check and control the gateway from other place via VPN connection.

To control the flood, we prepare the diagnose system by using Self Organizing Map. This system learns past 40years GPV data form Japan Meteorogical Agency, and diagnose using online GPV data.

The flood control is planed to dam up the gate about 0.5 m by hand based on heavy raifall diagnose system. It is possible to reserve the water surface 3,689 m^2 with 0.5 m i.e. 1844.5 m^3 water is cutted of the peak of the flood.

The wireless connection of XBee is excellent, because the path between sensor nodes and gateway is good prospect over the pond.

4. Future work

We planned to install rain-gage and clarify the relationship of water level of the pond and outflow of the pond. To combine the data on the cloud from these rainwater reservation facilities or rainwater tanks, it will made up the rainwater grid for flood control by using SOM.

References

[1] Moriyama T., Izumi S., Shimatani Y., Watanabe R., Yamashita S., Minagawa T., Yamashitan T., Concept of Smart Rainwater Tank and Grid for Flood Control, 3rd International Conference on RainWater Harvesting & Management, 2012

[2] Moriyama T., Izumi S., Morishita K., Nishiyama K., et.al., Development of Smart Rainwater Tanks, Proc. of 2013 IAHR Congress, 2013

[3]Moriyama T., Morishita K., Izumi S., Nishiyama K., et.al, Development of Distributed Multi-Purpose Rainwater Stroage

Figure 6. etape for 2m depth (white)

Figure 7. installed eTape, pressure gage and sensor node

Figure 8. V-notch weir with eTape for 30cm depth

Figure 9. Overflowing after the heavy raifall at V-notch weir with eTape

Figure 10. Gateway with Solar panel and Heavy duty battery

System, Proc. of IAHR-APD Congress 2014, 2014

[4]Moriyama T., Morishita K., Izumi S OBSERVATION OF HEAVY RAINFALL USING SMART RAINWATER TANKS,E-proceedings of the 36th IAHR World Congress, 2015

[5]Nishiyama,K. Endo, S., Jinno, K., Uvo C., Olsson J., , Berndtsson,R., Identification of typical synoptic patterns causing heavy rainfall in the rainy season in Japan by a self-organizing map. Atmospheric Research, Elsevier, Vol.83, 185-200, 2007

[6]Nishiyama,K. Diagnosis of climate and weather, Climate Change Modeling, Mitigation, and Adaptation, Chapter 17, ASCE books, American Society of Civil Engineers. , 471-493, 2013