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An IoT routing based Local River Field Environment Management solution using Uzbekistan Testbed

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Abstract

Water consumption has grown at more than 2.5 times, comparing the past century. About 2.8 billion people live in river basins with some form of water deficit, because more than 75 % of the river flows are withdrawn for agriculture and other needs [1]. Challenges faced by more and more countries in their struggle for economic and social development are increasingly related to water [2]. This paper proposes a test of an effective local river field environment management solution. And describing a part of a pilot project for the ministry of water resources of Uzbekistan. Current work focused on direct action items of the existing project and describe an IoT routing based solution for local river field environment management solutions. Suggested technological decisions provided by needs and on-site testing results. The paper describes the backbone of IoT routing based river water resources management system.

Key words: IoT Rouing, local river field environment, management solution, hydrological station.

1. Introduction

The future of any management system - becoming "smart". The questions of water management are

extremely important for the regions which are landlocked and their water systems are depending on the neighboring countries. Uzbekistan is a landlocked

country with a unique water providing system first steps of which are dated more than 5 centuries BC. Most of the water reservoirs and water channels are handmade, and still in exploitation. There are just 2 main big rivers which have their origin in the mountains of neighboring countries. The situation is more critical because all water in Uzbekistan is fresh, and peoples use fresh water for technical issues as well. Ineffective way of water usage already destroyed the Aral sea-lake in the last 40-50 years [3]. So the water resource state in the country is in a critical condition. To prevent meaningless water spending and rise an effectivity of water usage Uzbekistan needs an effective and centralized water resource management system.

Since the United Nations Conference of Environment and Development (UNCED) in Rio de Janeiro 1992, the Dublin Principles are included in "Agenda 21". Among the seven water management programs of "Agenda 21", the first is integrated water resources management [4]. The Global Water Partnership [5] (GWP) is an organization that was founded by the World Bank, United Nations Development Program (UNDP), and the Swedish International Development Agency (SIDA) in 1996. Water management methods converging with IoT solutions all over the world is increasing. The International Conference on Water and the Environment held in Dublin 1992, set out four guiding principles associated with water usage [6, 7]. According to these principles many related projects were researched and planned [8, 9]. Also, many research projects are ongoing to develop Smart Water Grid (SWG) technologies and apply the technologies to secure sustainable water supply by connecting water sources and optimizing water treatment methods based on IoT [10].

Uzbekistan also tried to bring the innovative technologies into the water management system, but there was no centralization supporting realization [11]. Most of the project systems are oriented only on local or regional management. Which as a result creating difficulties when different local sites and systems interconnecting with each other. IP based IoT clouds nowadays are just a developing sector in Uzbekistan. And the current solution is fully supporting it.

Korea International Cooperation Agency (KOICA) in 2017 announced the project of creation ICT based integrated water resources management system for Uzbekistan. The Fivetek Co. LTD. Company become responsible for the logical and hardware part development of ICT-based Water Resources Information System in Uzbekistan. Described in the paper researches was created as the solution for the specific regions of Uzbekistan. VTASK, Co. LTD designed the IoT routing system logic. In this paper, the description of organizing technical solutions based IoT technologies, by installing special water resource metering stations on the rivers and channels, is given. Suggested technological decisions provided by needs and on-site tests.

The following sections are describing the proposed IoT solution - hydrological station structure, system description and, communication procedure, described in section 1, experiment results and analysis described in section 2, and conclusion in section 3 respectively.

2. IoT routing based hydrological station.

Conventional condition of the local river field environment monitoring system in Uzbekistan, as well all over the world before the technical upgrade, is shown in Figure 1. Suggested in this work modern solution fully based on the Hydrological station module. Detailed data about Hydrological station work shown in the Figure 2.
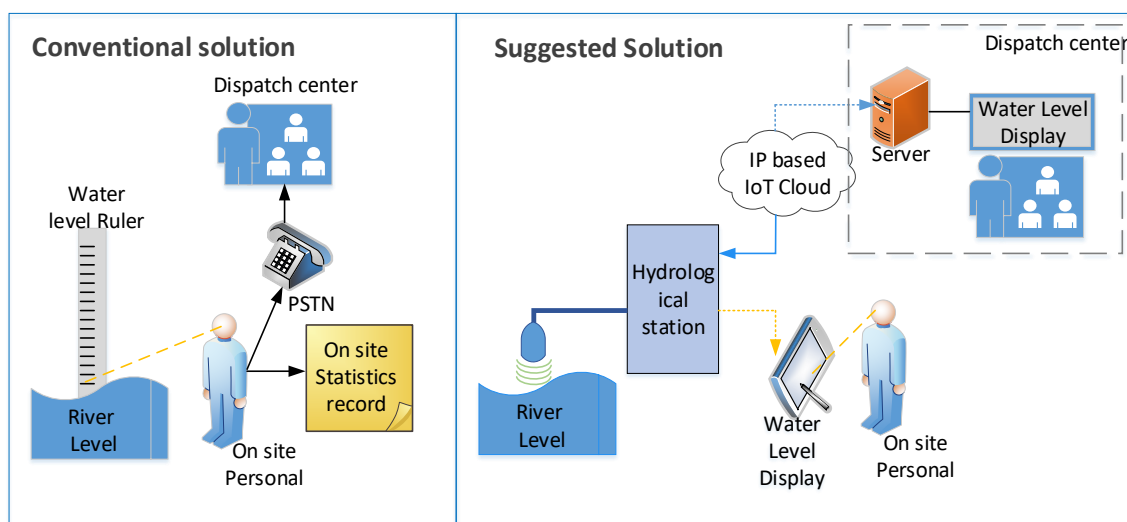
Figure 1. Conventional and Suggested solution

The procedure of Hydrological data harvesting is provided by the Hydrological station on the water control site. Current activities are effective to provide periodically. Each period depends on water resource objects and settings are making individually for each site. Commonly sensor data are collecting continuously but the sending procedure is approximately setting once per hour.
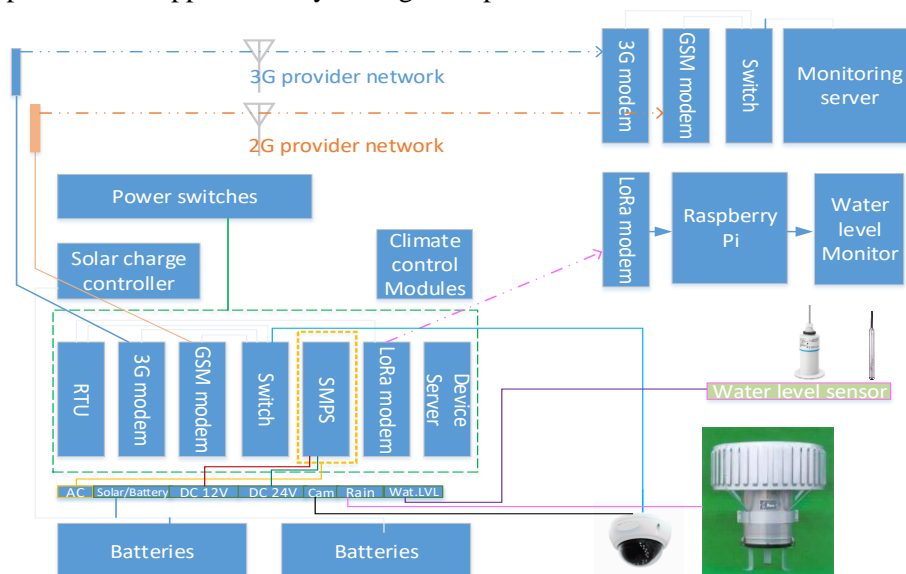
Figure 2. Hydrological Station structure

The Hydrological station is the main device's complex that harvests data about water resource state and transmitting all data to the main monitoring centers: to the main Republic, regional and local. Communication procedures provided by hydrological stations bases on several steps of communication available analyses. Mainly after the RTU module harvest the data from sensors it starts the procedure of data transmitting in two independent ways. One is locally based on the LoRa module connection which transmitting data to the site manager monitor. And second is corporate-level data transmitting. The main controller device in the station is the Remote terminal unit (RTU), a microprocessor-based device that

monitors and controls field devices, such as sensors, that then connect to Supervisory control and data acquisition (SCADA) systems, which is a complex of devices forwarded to control and monitoring [12] The RTU architecture comprises of a CPU, volatile memory and nonvolatile memory for processing and storing pre-loaded programs and harvested data. It communicates with other devices via serial ports or modems with I/O interfaces. It has a backup battery, surge protection against spikes, a real-time clock, and a watchdog timer to ensure that it restarts when operating in the sleep mode [13]. In the current project, each hydrological station has its own RTU, by the time all of them connected to the main Republic monitoring center which is logically SCADA.

The power supply of each Hydrological station is "Green" and based on solar power. Besides some sites, where it is available, are provided by AC 220 power supply. However, Uzbekistan has approximately 276 sunny days per year, so expenses on AC power are reaching the minimum. Each station is working providing data 24/7. For the inner part of the hydrological station, modules use only DC 12V power, including the IP camera supply. Sensor modules are working from DC 24V. The power converting function relies on the SMPS module. While all other modules are directly connected to the battery out of solar charge controller. Inner station communications between modules are organized through TCP/IP switch and RS-232C interfaces. The outer part which is presented by water meter sensors uses 2 wires RS-485 interface. This point is simplified exploitation and increases the reliability of the system.

Communication of the hydrological station and main Republican management center (dispatcher center) is based on the existing cellular network. And provided according to availability and power level of each cellular company in the particular region. If communication is available Hydrological station provides data through the HSDPA network in the format of IP data packets sending. Otherwise, the system uses GSM communication and sending data through encoded SMS messages. Respectively received by modems, and formatted to IP, data transmitted through the IoT routing cloud, after they are decoded and transit to the communication server and file server. Communication issues related to reliability and stability are solved by duplicating communication channels. 3G HSDPA modem is using packet data as a carrier and supplied with VPN function, so all data are protected by direct tunneling technology. In the case of 3G communication become unavailable all hydrological station data are transmitting through 2G SMS service. 3G data transmitting allowing to send real-time video from the camera. Unfortunately, if the data transmitting unavailable IP camera`s functionality is restricted. Also for local monitoring by the local site manager hydrological station has an independent LoRa modem-based monitoring system. These solutions are very cheap at exploitation cost and reliable.

Corporate IP based IoT routing cloud consists of 2 main procedures that depend on each other. In case if HSDPA (3G) communication available, the procedure of VPN tunneling is starting. After VPN connection is established and secured communication available all sensors data are sending through the cellular network in packet data form with the full format, and also captured video from the IP camera is sending to the main control center. The communication procedure repeats until the device gets data to receive confirmation. In case of unavailability of HSDPA communication or fail of VPN tunneling organizing all sensors data are transmitted in the form of short and encoded SMS through 2G (GSM) modem. Here must be pointed out that through SMS service providing captured video or photo data is impossible, so in these cases, this type of data is waiting for a new cycle of communication.

3. Results and Analysis

Depending on the site condition and needs several sensors and their types can be different. The most commonly used sensor is Radar type water level sensors that are installed on the rivers and water channels.

For test execution, the Andijansay channel was chosen. The site condition is provided in Table 1. The main choice is made by communication conditions and the opportunity to check IP camera streaming.

Table1. Andijansay water channel testbed

1.	Name		Andijansay Water Channel	
2.	Coordinates		40.765268, 73.047025	
3.	Max. river depth level (Meter)		3.00	
4.	Min. river depth level (Meter)		0	
5.	Vegetation period		April 10 – September 25	
6.	Downstream water providing		Scheduled	
7.	Water flow method		Self-Flow	
8.	Communication condition 3G	Provider company	Stable	Uz-Mobile
9.	Communication condition 2G	Provider company	Stable	U-Cell
10	IoT Sensors set			
		River depth level sensor type	Radar	
		IP Camera	Yes	
		Rainfall sensor	No	
11	Stationary Power supply, AC		230 V	
12	Solar power supply		Need	

Figure 3 demonstrates a fully operative station on the site of the Andijansay channel. This station is supplied with a radar-based water level sensor, and camera. Station powering is additionally supplied by a solar panel module and can be autonomous.

Figure 3. Hydrological station on river

Local site manager`s room equipped with a Raspberry Pi 3B based monitor and showing water level data received by the LoRa modem. (Figure 4.) Clear, not overloaded, and simplified interface for water level monitoring providing daily routine data and service communication status. Region level main monitoring center equipped with PC and monitoring signage, connected to the corporate secured network through a VPN device. The interface here is based on the web-resource and secured by the regional password as well. Water station status is continuously displayed on the map region. And the operator may operate with all data of each hydrological station as well as can see all sites condition in the region simultaneously.

Figure 4. Local site manager`s monitor

Republic's main monitoring center is placed in Tashkent, capital of Uzbekistan, in the Ministry of water resource building. The test provided all required data to the digital signage set and an operator could control data sets in online mode. (Figure 5.) The current system is supplied by the Autobase application, for testing monitoring system and operates with data sets. Data sets are represented in a form of map markers to make an orientation ability more clear.
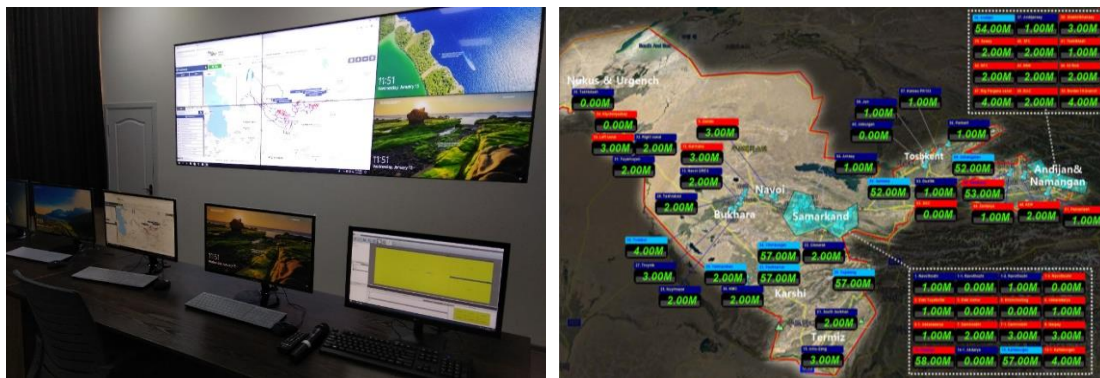

Figure 5. Implemented Autobase monitoring interface

The effectiveness of the work of this system is reached by the on-time control of whole water transporting subsystem. Calculations of water expenses are proceeding automatically and statistically helping to find the unwanted "leakages", as a result define the problem sites of the whole water supporting system. (Figure 6.)
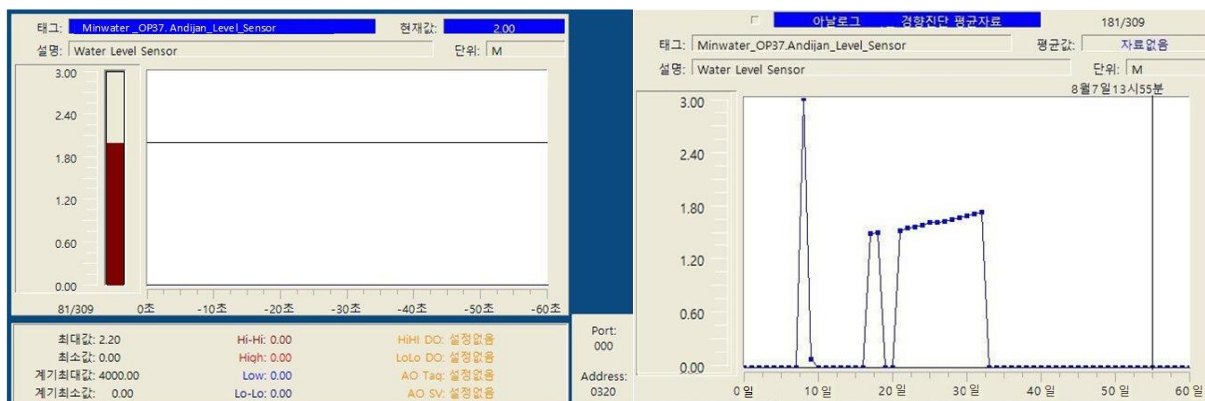

Figure 6. River monitoring data analysis

The statistical condition of each river can be analyzed by a selected time range, "on-line" mode, or during the estimated period. Here on the examples of the provided data the real condition of Andijansay field environment in different modes. The left side figure showing the exact level of water in the Andijansay water channel within 1-minute changes. The right side figure demonstrates test results data, collected within 2 months from the Andijansay water channel - dynamical changes on this figure showing the period of massive watering of the fields in vegetation time when the water in the channel is almost 0, and scheduled channel water providing to downstream.

The test results are matching with scheduled and providing exact data, analyzed from the selected dataset. During the period from the start of 2018 till the end of winter 2021 in Uzbekistan 61 hydrological stations were installed and set fully. Current time all stations are working in the test regime. And providing testing data from sensors to main monitoring centers.

The current solution has some limitations which are related to the geographical positions of each site. Many sites are located in places with low quality of cellular communication coverage, and near neighbor countries borders, where cellular devices are hand-over to the roaming of other countries automatically. The solutions to this issue must be rechecked with the cellular company administrations. Also the lie of the ground in some cases limits of the LoRa modem usage possibilities. So communication situations need more deep study of the terrain and/or search of other solutions of communication.

4. Conclusion

The current project represents an effective and centralized water resource management system. As a pilot project for preventing water over-spending and rise an effectivity of water usage in Uzbekistan, showing exact positive results even in testing mode. The project itself consists of many parts and sections, this article describing only one test site based on Andijansay channel. Objectively project successfully going to the finish. Sites and monitoring centers are in constant communication and gathering data for analyses and control. This kind of projects are making the International relationship between the Republic of Korea and the Republic of Uzbekistan closer, not only in the sphere of business but in the organization common international IoT society, sharing of knowledge and experience in modern communication facilities and technologies. However, the provided solution fully performs assigned functions. Positive results are practically approved.

Acknowledgement

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