Water Monitoring System Embedded with Internet of Things (IoT) Device: A Review

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Abstract. Urbanisation and population growth lead to increased water demand and might affect the water sources. Hence, it is important to manage it effectively. This paper reviews the use of Internet of Things (IoT) device in monitoring water system to conserve and manage the precious resources. The IoT technology is most synonymous with the latest wireless system for data acquisition for real-time monitoring surveillances. The real-time monitoring process involves large distribution of monitoring sensor and network such as computing, wireless sensor network and cloud computing. Traditionally, water quantity and quality reading has been labour intensive and subsequently an expensive process. By application of IoT, human involvement shall be minimized and most procedural decisions in a normal process will be made by algorithms. Developing user-friendly IoT tools will be an excellent contender in real time water monitoring solutions and lead to efficient management.

1. Introduction
Water is a basic necessity either for human or living organisms. Due to rapid development growth, alternative ways in obtaining water supply such as groundwater and surface water will no longer cope with high demand in water supply. This issue is expected to get worsen as many developing countries will be facing water shortage issue. Hence, to avoid water shortage issue during dry period, the current trend is to manage and monitor the accessible natural water supply [1]. Water monitoring technologies have prepared a momentous progress and been accepted since a few decades for water sources and water plant operation as it has potential to eliminate manual monitoring.

Water monitoring is useful in disaster management as an early stage of warning system. In consumer perspectives, water monitoring is a service that often faced with many challenges as it will face a real-time scenario. Water monitoring is necessary in case of flood disaster where it can give early warning alert for evacuation, contingency planning and others to the nearby residents [2]. Water supply are facing new challenges in their actual operation because of inadequate water resources and protection concerning contamination. Hence, there is a need for online water monitoring systems given that present laboratory-based systems are too deliberate to improve effective response and does not afford the level of public protection in real time [3]. Quick detection and response to cases such as contamination is serious due to the possibly severe concerns to human health.
2. Internet of Things (IoT)

IoT is a new innovative conception that has potential to build a smart or intelligent city [4–10]. The system also can reduce human dependency which at the same time can increase productivity [8]. This initiative has been engaged all around the world to develop projects to aid in monitoring ranging from surveillance, healthcare and environment [10–12]. It may possibly not be specifically to those areas, but same concepts are involved [10]. IoT comprises three key components namely sensing hardware, data transmission network and data process capability [13]. It is more innovative from the internet and short-range communication network to attain intelligent identification, exchange information, location, tracking, monitoring network management such as Radio Frequency Identification Devices (RFID), infrared sensor, Global Positioning System (GPS) and laser scanner [3].

Figure 1 shows relationship amid IoT and other networks. There are three significant characteristics of IoT such as broad sense by using RFID, sensors, and dimension code to gather data of objects, the consistent transmission which is sending the exact real-time data of objects over a variation of telecommunications networks and the internet, and intelligent processing by using intelligent computing such as cloud computing and unclear identification to analyse and develop huge total of data and information, for the purpose of carrying out of intelligent control to objects [7]. For calculation and storage, cloud computing is in big scale, low-cost processing unit which based on the Internet Protocol (IP) for connection communication. The water monitoring application includes large distributed of monitoring sensor and a large distribution network [14]. By utilizing the cloud storage, there will be no problem in handling the data storage facility which requires expertise person in ICT background.

![Figure 1. Relationship between IoT and present network](image)

Different monitoring system use different architecture system [15]. The architecture could be different in terms of the component used to build an automated monitoring which are sensor to measure the condition, Arduino UNO (microcontroller) to process the signal from the sensor and transfer to the output display via cloud server, and Wi-Fi shield to link the device to the internet and power supply [5, 13-14, 16-17] (Figure 2). The local wireless monitor unit consists of few wireless data collector namely Wi-Fi router and Wi-Fi gateway [18]. The remote central server is responsible to collect data from wireless sensing system where it collects water data condition [18]. By using Arduino UNO platform, beginners who are unfamiliar with the coding and aimed to get the exact computer programming system would not face any problem. This is because an entire suite of pre-built functions already exists in the platform [17].
Sensor comprises many wireless sensing system are specifically design for water monitoring either for quality or quantity based on a certain water parameter need to be monitored [15]. It is equipped with nodes which are responsible in sensing connected to microcontroller to support interface for water monitoring [13]. Ultrasonic and liquid level sensors are commonly used to detect water level [6, 19]. While for water quality, it depends on what critical parameters to be tested such as potential hydrogen (pH), temperature and turbidity [9, 13, 20]. Besides that, sensing rate is applied to capture the condition of water as to avoid unstable network at the initial stage. A complete sensing scheduling parameters are literate through web-base application from cloud [15]. Cloud server responsible to deliver the computing resources from sensor to data centres through internet basis. This cloud provide service as storage and data analytic tools. There are two types of communication offered and useful in IoT, which are device-to-device and device-to-cloud [16]. Device-to-cloud approach are often used and has become the most developed IoT-based system for data storing and online monitoring. The storage service backup data in database and or analyse data to predict the future state [5, 21]. A web-base application was developed to obtain data from the cloud server where the sensor reading are kept in time-series database (Figure 3) [4]. In developing the system, it needs special attention as it will handle various condition from the sensor. A friendly user interface was then developed to display the sensor status through telecommunication signal and power supply. The system visualizes sensor reading that contain algorithms that analyse data and display alert on the detection of critical event [15].

| Input          | Process               | Output                  |
|----------------|-----------------------|-------------------------|
| 1. Arduino UNO | Cloud server          | Web-base Application    |
| 2. Wi-Fi shield|                       |                         |
| 3. Sensor      |                       |                         |
| 4. Mobile Phone|                       |                         |
| 5. Screw terminal shield |               |                         |

3. Water monitoring system
The rapid development in various sectors has affected the demand for clean water in some areas. It alters the availability, quantity and quality of the water resources, which will affect the entire phase of water supply [1]. Hence, parameters involve in water monitoring should reflect both water quantity and quality [22]. Traditionally this method was obtained manually by going to various locations at different times and collecting water samples. It is then followed by laboratory experiment to analyse the water quality [3, 23-24]. Likewise, a lot of time as well as man power is utilized to monitor water level [12, 25-26].
Such methods are no longer reflected effective as it is lack of actual monitoring information for critical decision and might be a problem if the person-in-charge is suddenly unavailable to conduct monitoring work [3, 9, 12, 23–26]. Monitoring water level, water quality, leakages and the flow of water through different channels are the biggest challenges in water management. IoT is one of the tools that has come to the rescue in all these fields [27].

3.1. Water Quantity
Water quantity monitoring provides a proper management of water usage whether for domestic houses, agricultural or industrial areas. This system helps in contributing towards the conservation of natural resources and maintaining sustainability as water usage pattern will be identified and future management can be planned. Water quantity monitoring system may detect water movement in upward or downward directions indicating the proper water level in the tank [28]. Such system is considered as smart, as it does not only detect and indicate the water quantity but also controls the water level in the tank either not to be empty or not to be full. Sayali Wadkar et al. [19] studied on a result for water management in urban areas with the provision from IoT. They monitored water level in water tank for residential area. Continuous information on the current water level were developed through the sensor placed in the tank. User were able to visualize the water level on smartphone as long as it was connected to the internet. This system helps consumer to predict and plan the usage of water. Water management is also important in managing the optimum use of water resources particularly in urban area, where maintaining record of water quantity is extremely challenging. Tomas Robles et al. [29] used IoT to determine and estimate the quantity of consumed water at particular city in Zaragoza, Spain. This technique helps the water authorities to manage and monitor water flow in more effective manner.

A large amount of water are lost during irrigation process and need proper water utilization to avoid water shortage issue in future. The amount of water used were minimized with the help from remote sensing and irrigation control system to control the amount of water needed for irrigation. Muhammad Ayaz et al. [30] concluded that the use of sustainable IoT-based sensors and communication tools is necessary to maximize crop production. Timothy and Maheshwary [6] recommend a prototype system design with description of necessary tools to improve Internet of Things (IoT) based water level monitoring system for villages in India. In this prototype experiment, Arduino UNO board together with Ethernet shield for Internet connectivity was used. This system enable user to keep track of water source and control the water pump for its necessary task accordingly from remote location in real time.

3.2. Water Quality
There is a need for better development in technology to observe water quality parameters in real time [1]. Selection of parameters are depending on its own purposes either physical, chemical or biological characterization of the water [31-32]. These parameters have their own sensor as it is important to assist a suitable treatment and also avoid contamination [24]. Real-time water quality monitoring has been established as support system to a sustainable water management where it involves the embedded sensor and use the integration of Geographical Information System (GIS) for data acquisition [32]. It has the capability to capture, store, update, analyse and display all forms of geographical information in order to facilitate decision making [33]. Lambrou et al. [3] developed a low cost water quality sensor for real time monitoring in-pipe by using sensor by deploying a light-weight flat measuring probes. The system enabled sensor to make decision and triggered alarms when contamination either physical, chemical or biological event detected in the pipe. The deployment provides information to water consumer, water companies and experts for ideal warning system and further action. Sengupta et al. [34] recommended a low cost system for real time water quality monitoring and controlling using IoT. This system consist of variety of sensors such as the pH sensor, turbidity sensor and temperature sensor which were interfaced with Raspberry Pi through Analog-to-Digital converter (ADC).

Encinas et al. [13] proposed a prototype and proof a idea which concern the monitoring system in the most significant variables in aquaculture water quality based on wireless sensor networks and on the Internet of Things (IoT). Several IoT sensors for water quality were used in ponds to stored the information in cloud and displayed in web-base application. Prasad et al. [10] carried out a study to develop a method to observe seawater quality Fiji islands with the help of IoT and Remote Sensing (RS)
technology. Several water parameters were measured as potential hydrogen (pH), oxidation and reduction potential (ORP), conductivity and temperature. Figure 4 shows the sub-system used to monitor water quality parameter. The system proved that an early warning system was useful to sanitize the ocean if abnormalities arise. The industries such as manufacturing and energy, IoT can be helpful for measuring and monitoring information took and providing real-time analysis for testing water. IoT is also very useful in the field of public utility companies. With the help of sensor devices and water testing meters readings are provided to the end users. Then the end user has the facility to get information and data like total dissolved solids (TDS), biochemical oxygen demand (BOD), chemical oxygen demand (COD), chlorine, bacteria, electrical conductivity [14]. IoT helps to provide accessing the real-time, quantifying the results accurately and the ability to select and solve the problem areas.

Figure 4 Block diagram of system operation [10]

Nikhil et al. [9] developed smart water quality system to observe the water quality in a reservoir (Figure 5). The system assisted in guarding the ecological environment of water resources. It consisted of several invisibly embedded sensors that enable user to remotely monitor the actual condition in monitoring. Sensors are connected wirelessly using Arduino and presented by using IoT. They concluded the smart system was able to minimize the time and cost in sensing water quality in reservoir.

Figure 5. Smart water quality monitoring system in IoT environment [9]

4. Conclusions
This paper reviews IoT usage especially in water monitoring system. It is significant to monitor water in every sources due to the rapid population and decrease of water resources based on high demand. The data provides the real-time monitoring information and consumer will be able to predict the possible action need to be taken. The data also will provide localized water quantity and quality information to the consumer at the point of use and notify the consumer of the availability and suitability of the water for consumption. Some data can be transmitted and stored in virtual datasets in centralized or cloud-
distributed repositories. These datasets can be used by the water service providers to notice and repair hot spots with critical water quality problems (if any).

More researches on the technologies are suggested in order to improve online, integrated and low-cost sensor that will enhance the automatic water monitoring system. It is recommended to develop the system in prototype, affordable and cheaper so that it can be used widely.

5. References

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