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Online Pollution Level Measurement for Water Quality Monitoring System Using Internet of Things

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***Abstract*—Several studies related to water quality assessment using the water quality index uses several water quality indices, including the water quality index (WQI), water pollution index (WPI), and river habitat Survey (RHS). Water pollution control is needed to achieve an ideal level of environmental health. To achieve this, online and real-time monitoring is required as part of water pollution control. One of the technologies that support real-time monitoring of water quality is the Internet of Things technology. Wireless sensor network technology becomes part of the Internet of Things makes it possible for online data acquisition from several node stations that are spread in monitoring locations. This paper purpose the implementation of Internet of Things development using wireless sensor network and IaaS cloud computing service to display the real-time water quality data acquisition. From the result of implementing the system, a system can perform continuously to monitor the water pollution level. The proposed framework can develop a wireless network sensor with limitless number of nodes and has extensive scalability.**

Keywords—online level pollution level measurement, water quality monitoring system, internet of things (IoT), river habitat survey (RHS)

I. Introduction

Several studies related to water quality assessment using the water quality index uses several water quality indices, including water quality index (WQI) [1], water pollution index (WPI) [2], and river habitat survey (RHS) [2]. Usually, parameters used in monitoring water quality include pH [3], temperature, turbidity [4], and total dissolved solids (TDS).

Acidity (pH) is one of the crucial things in determining the water quality of water. The pH generally increases due to polluted waters [5]. pH indicates how acidic or basic a substance is, H refers to the number of hydrogen ions and hydrogen ions present in substances; these hydrogen ions affect the nature of a substance. The lower the number of hydrogen ions means the more acidic substances. The higher the number of hydrogen ions means the less acidic substances. The pH scale has a value between 1-14, and neutral pH is at a pH level of 7 [6]. Temperature is critical because it influences water chemistry. The rate of chemical reactions generally increases at higher temperatures [7]. The temperature has a significant influence on biological activity and growth. Temperature also regulates the types of organisms that can live in rivers and lakes. Turbidity is a measure of the turbidity/clarity of the water. Turbidity is caused by suspended solids, especially soil particles (sand, mud, clay), microscopic plants and animals suspended in the water column.

Low levels of turbidity can indicate health. Meanwhile, higher turbidity levels often provide higher levels of viruses, parasites, and some bacteria because they can sometimes stick to dirt in the water [7]. Total dissolved solids (TDS) are the term used to describe the inorganic salts and small amounts of organic matter present in solution in water. The principal constituents are calcium, magnesium, sodium, potassium cations and carbonate, hydrogen carbonate, chloride, sulfate, and nitrate anions. Water with TDS concentration below 1000 mg/litre can usually be consumed, although acceptance may vary depending on the circumstances. However, the presence of high TDS levels in water may not be desirable because of the taste. Water with a low TDS concentration is also not suitable for consumption [8].

Online data acquisitions have become a significant issue [9,10], especially in water pollution monitoring [11,12]. The traditional way, measuring and detecting water quality is done manually where water samples are taken and sent for examination to the laboratory. This process requires a longer time, higher costs, and requires human resources [13]. This method does not provide real-time data. The application of an online monitoring system can continuously monitor water quality to control water pollution conditions. Computer network-based automation can improve work effectiveness in measurement in processing. Computer-based systems are more precise and faster in execution, so it is suitable for measurements that require high response speed [14].

One of the technologies that support real-time monitoring of water quality is IoT technology. The Internet of Things (IoT) will consist of billions of devices that can sense, communicate, calculate, and have the potential to act [15]; Data originating from IoT devices will flow continuously as data streams for further processing. The wireless sensor network is a sensing network for physical environmental parameters and performs real-time data streams as part of IoT technology [16]. A wireless sensor network consists of a network consisting of several sensor nodes built into a processor. This sensor node processes raw data and then sends the data for further processing [16]. This paper aims to use database replication for online monitoring of a wireless sensor system. Database replication is made replication of the data and synchronizes with the server database on a network server [17]. The information can be used as a reference to handling water pollution.

II. METHODOLOGY

A. Internet of Things

Internet of Things (IoT) is a structure in which objects, people are provided with an exclusive identity and the ability to transmit data over a network without requiring human-to-human performance as a source to destination or human-to-computer interaction. IoT-based physical objects are interconnected with sensors, actuators, and data centres to collect, process, and store acquired data. The data collected is then used for analysis and decision making by the Base Station [18]. The use of the Internet of Things (IoT) is becoming increasingly common in agribusiness [19], health [20], environment [18], and disaster [21]. IoT can connect billions or trillions of IP-owned objects over the internet, so there is a critical need for a flexible layered architecture. The collected data is then analysed to take specific actions based on the services required. IoT sensors can be intelligent sensors, actuators, or sensing devices used [22].

B. Wireless Sensor System

A wireless sensor network (WSN) is a wireless network used to communicate between sensors and form a system used to monitor physical environmental parameters. This network system can access systems and data remotely without having to go to the monitoring area [23,24]. The use of wireless sensor networks is also widely applied in other fields including smart home [25], health [25], industry [25], energy [26], transportation [27], plantation [28], cultivation [28], agriculture [28], environment [6], sports [29], supervision of building construction [30], fire disasters [31], landslides [32], and materials dangerous gas leaks [32].

Wireless sensor networks are also used as data acquisition devices that generate data quickly and in real-time big data systems. Figure 1 shows the basic structure of a big data system using WSN as a sub-system for data acquisition.

The sensor node sends data to the sink node. Data is collected into a temporary database, which will later be sent to the central database and reprocessed through the significant data analysis process [33].

There are two formations in the wireless sensor system network, the first formation is centralized, and the second is a distributed formation. These two formations are shown in Figure 2. In addition to these formations, wireless sensor networks can also be classified into four categories in handling sensors in the process. monitoring, namely single node-single sensor, single node - multi-sensor [34], multi-node - single sensor [35] and multi-node - multi-sensor [36]. Both the monitoring data are presented in the online form [36] or not [37]. Not all wireless sensor network implementations have database facilities as data storage systems [38]. Some are displaying real-time data, but the data is not stored in a database [39].

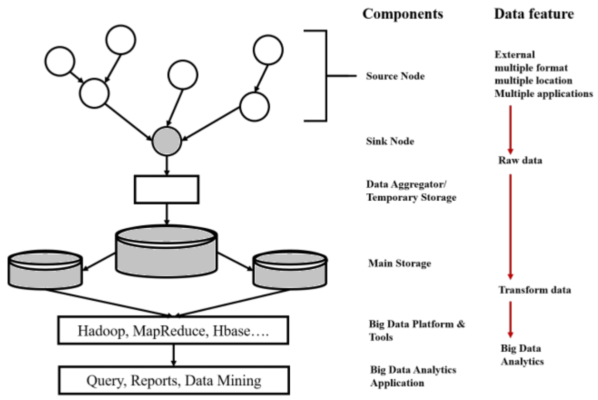

Fig. 1. Big data using wireless sensor network [33].

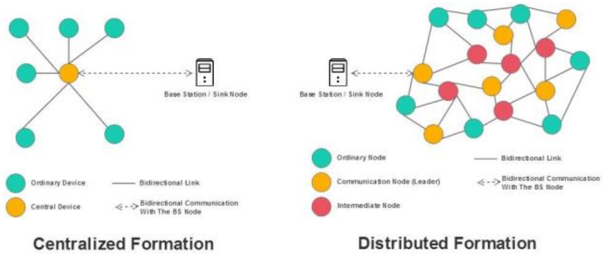

Fig. 2. Wireless sensor network formation [40].

C. Database Replication Concept

The database replication method is a technique for storing the same data in multiple storage devices. Database replication involves duplicating multiple data from the same database and sharing data or changing database designs between databases in different locations [41]. In developing water quality monitoring systems, the concept of database replication is applied to node stations and online servers. This method can improve the consistency between data received by online servers and data at node stations [6]. Figure 3 shows the concept of database replication.

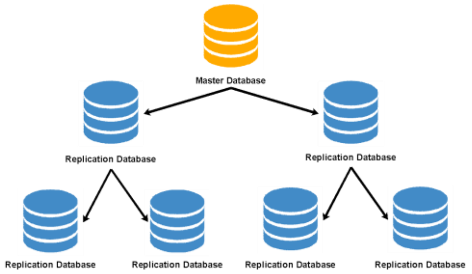

Fig. 3. Cascading database replication.

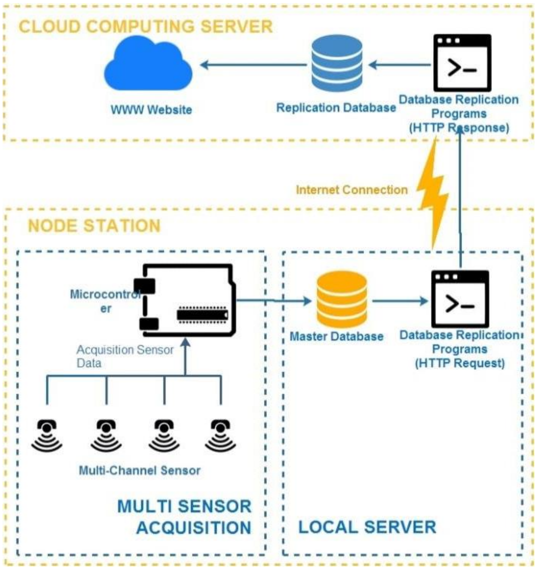

Fig. 4. Multi-sensor each node station sending data using HTTP Request and HTTP Response.

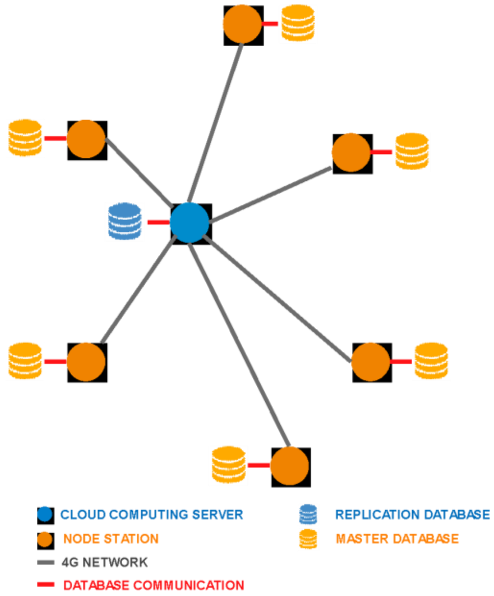

Fig. 5. Adaptation of database replication methods and centralized formation.

D. Data Acquisition Design

The system is built with a multi-node - multi-sensor concept with each node using pH, temperature, turbidity, and total dissolved solids sensor shown in Figure 4. The sensor manufacturer has calibrated each sensor, every sensor measures data on the water in the water container, the measurement results by the sensor probe are then sent to the signal converter to produce then data stored in the microcontroller database. This system also adopts the database replication method that is used to transmit data. This method also has another function: to maintain data availability when the data communication network is disrupted and maintain data consistency. In applying the water quality monitoring system using a centralized formation, each node station synchronizes data with the cloud computing services. The adaptation of database replication methods and centralized formation is shown in Figure 5, and the design of the node station and water container is shown in Figure 6.

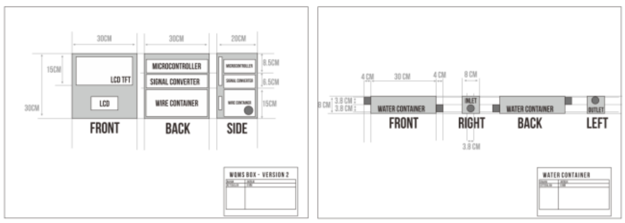

Fig. 6. Node station and water container design.

Fig. 7. Implementation of node station.

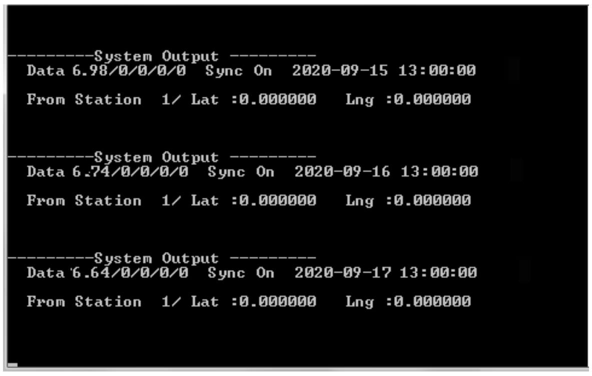

Fig. 8. Synchronize data from node station to cloud computing server.

III. Online Monitoring of Water Quality Monitoring System

Implementing the online water quality monitoring system is applied to using HTTP requests and HTTP responses to send data from the master database at the Station node in Figure 7 (on the local database) to the replication database (on the cloud computing server), shown in Figure 8. The microcontroller collects data from sensors and saves the data into a local database as a master database. Cloud computer servers use Infrastructure as a Service (IaaS) services in processing data, and acquisition data continue to be displayed in the HTTP website, shown in Figure 9 so that it can be easily accessed and monitored data from sensor data acquisition by each station node in real-time.

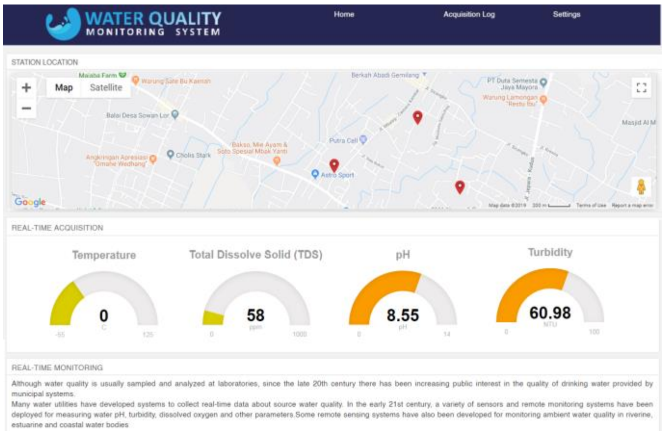

Fig. 9. Realtime monitoring of water quality monitoring system.

IV. Conclusion

From the result of the implementation of online pollution level measurement for the water quality monitoring system using the Internet of Things, the system can continuously perform online acquisition data with the centralized formation of the wireless sensor network. Furthermore, an adaptation of the database replication allows the database to build multiple data acquisition from multiple node stations with high availability and consistent data. In the network disrupted, the sensor still processing data acquisition to store on a local database and send it into cloud computing services when the network is back online. The proposed framework can develop a wireless network sensor with limitless number of nodes and has extensive scalability.

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