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Smart Sensor Node of WSNs for River Water Pollution Monitoring System

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Abstract — Development of economic has impact by many industries operating along the river then create the pollution by industry waste as well as effected to river water. This research aims to develop a system to monitor river water quality in many parameters that safe for human as well as for ecosystem live in the river. Wireless Sensor Networks (WSNs) used in this design because of advances WSNs system, a sensor node attached to many sensors such as water temperature, pH, dissolved oxygen (DO) and electricity conductivity. The river water monitoring system designed be able to monitor water level and flow rate for environmental and flooding alert. A sensor node customizes designed to fulfill water quality standard as well added others sensor for flooding alert, data collected by sensor node forward to WSNs sink node which embedded with a microcontroller unit and memory as local database before sending to backend system. Monitoring at backend system shows by some displays in order to easy monitoring by representative institution or local authority as well action will be taken if some case happen or abnormality reported by monitoring system. Prototype of WSNs node have been designed and tested, the results shows sensor node be able to detect polluted water parameter and water level as well flow rate. Furthermore, sensor node will be testing at actual site which is one of the river in Riau Province in Indonesia.

Keywords—Water Pollution, Monitoring, River, WSNs

I. INTRODUCTION

In some countries river still an important part for daily activities especially in developing country. Along the river community using for many kind of activities such as transportation, floating home, and some area they using river water for daily usage such as for washing, shower and even for cooking without filtration system. Economic enhancement effected by many company operating and many company operating along the river for easy in transportation as well others consideration. Riau Province in Indonesia has 6 rivers and one of them the river as deepest river in Indonesia. Many industries operating along the river caused wwater pollution because of the waste from industry operation and unclean environmental. Polluted water very dangerous for the community when use it for daily activities, polluted water may contain many kind of parameter such as water pH, dissolved oxygen (DO), temperature, electricity conductivity, etc.

The traditional method to monitor water quality has been done by doing laboratory based testing of collected water samples. Though this method able to conduct in a complete laboratory testing range including physical, biological, and chemical parameters, but very hard to do and it is not practical for measuring at several points along the river [1-3]. Additionally, laboratory based test by doing several sample could take up to several days to achieve the results and for some parameters may show less accuracy because the sample water changing in sampling. Recently, real-time sensors for environmental monitoring system are beginning to gain popularity due to rapid advancement in sensor technology, especially in WSNs technology that could apply in many kind of application. The continuous collection of water quality data as well as real-time monitoring system can be used to monitor the state of a river ecosystem, establish trends and determine specifics related to event detection [4-6].

Water pollutant monitoring system have been done in previous research by doing or sensing water quality but the parameter of water quality monitoring is limited to a few and most of them monitor basic parameter of water as discussed [7-9]. There is some solution water pollutant monitoring system used multi sensor and limited to basic parameter of water, the use of local host for data collection has limited access to monitoring system as elaborate by researchers in [10-12]. Analysis of water quality by image processing and remote sensor for long distance monitoring has less accuracy for some cases, the long distance monitoring maximum accuracy more them 10 meter and only analysis according image changing as discussed in the article [13, 14]. The use of robotic in water quality monitoring system has the advantages for mobile system and deep river or ocean but the cost is very expensive and required skill to operating the system, some research has been done for this robotic water quality monitoring system but less effective for fixed system and some cases as discussed in [15-17].

This research aims to develop a new sensor node for WSNs system with ability to sense multi parameters of water pollutant based on water quality parameter at one of the river in Riau Province Indonesia. Beside monitoring of water pollutant in real-time based, the system adds on with river water level sensor and river flow rate sensor to monitoring water level as the environmental in Riau high risk for flooding if rain intensity is high or in raining season. The research gain to knowledge as well and

contribute new invention for water quality monitoring system by data collection including design a new sensor that be able to collect accurate data. A new method of communication system from sensor nodes to WSNs gateway through WSN sink for effective data transmission and sharing is one of aims in this research. With the local or remote data monitoring center, a complete monitoring interface implemented to carry out historical data queries, real-time data and network state display, data analysis and alarming for non-normal status.

II. SENSOR NODE DESIGN FOR WATER MONITORING

The design of sensor node for WSNs system application on river water monitoring system based on early data collected by analysis river water samples. Based of sample results then design a smart node sensor for WSN system to approach pollution parameters and material contamination to the river water. Figure 1 shows a scene from a part of river in Riau Province Indonesia, the community using river and river water as daily activities such as for transportation, shower, washing and even for cooking.



Fig. 1. A scene from a river in Riau Province Indonesia

Actual condition of river and river water in Riau Province Indonesia very bad and high risk to the ecosystem along the river as well as for the human and community that using river water for daily activities. Figure 2 shows an actual condition of polluted river by contamination of material or chemical from industry operating beside the river as shows in circle bottom left, while a few kids swimming and playing in the river as shows at top right of the figure 2. Based on visual observing and water samples analysis, there are some

parameters indicator of water quality required to monitoring such as temperature, pH, dissolved oxygen (DO) and electrical conductivity. The water river monitoring designed as not only for water polluted monitoring, furthermore to make sensor node as smart sensor then additional sensor for measuring water flow rate and river water level is added. Additional of water level measurement and water flow rate sensor is related to the indicator of flooding. Most of river located in Riau very high risk for flooding especially during raining season, then as alert for the community of the flooding and the sensor node attached with water level monitoring. Flooding alert system is very important to remind community when water level in dangerous level.



Fig. 2. Water polluted by chemical of industry operating along river

Smart sensor node of WSNs designed consist of 6 parameters as indicator to measure water pollutant and river water status alert. Table 1 shows the complete measurement indicator with range of sensor as well as the accuracy.

TABLE 1. SENSOR NODE DESIGN SPECIFICATION

Parameter	Range	Accuracy	Method
Temperature	0 to 16 °C	± 0.5 °C	Thermistor
DO	0 to 20 mg/L	± 0.5 mg/L	Polarography
pH	0 to 14	± 0.1	Glass Electrode
Salinity	0 to 50	± 0.5	Conductivity Measurement
Flow rate	0 to 10 m ³ /s	± 0.1	Flow sensor
Water level	-5 to 10 m	± 0.1	Level meter

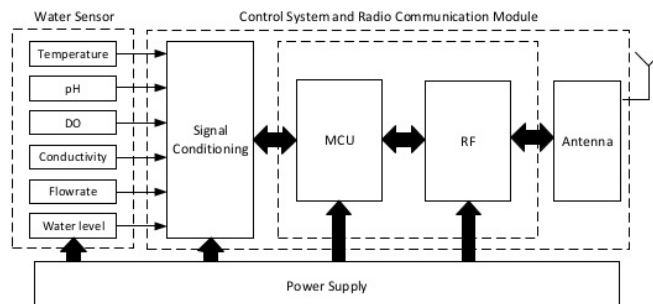


Fig. 3. Block diagram of smart sensor node for WSNs system

Smart sensor node of WSNs designed consist of 6 parameters as indicator. Figure 3 shows a block diagram of smart sensor node for WSNs system in order to detection river water pollutant index. Sensor node attached with 6 sensors based on water pollutant index as water flooding indicator which is water level sensor and flow rate sensor. Every data collected by sensor unit will stored in local database to analyze, then all the data will forward to data center at the backend system.

III. RIVER WATER POLLUTANT MONITORING SYSTEM

To collect common polluted water parameters, some sensors related to polluted water installed such as water temperature, pH, electrical conductivity and dissolved oxygen. This paper design and develop a novel of water pollution monitoring system based on WSNs. The system possesses typical WSNs structure with a novel design of sensor nodes, which is easy configured as an arbitrary parameter or multi-parameter monitoring networks. Comparing with the traditional water monitoring system, it has the following merits. The sensor nodes are attached with multiple sensors and low power with independent power supply through solar panel system. The monitoring parameters are flexible; the sensor network on the monitored area is self-organization; the capacity of network is big and the node distribution can be much denser. All the information will share to the community, a display of information about water quality will install at community center and all the people know the information including river water level thought alarm system as the alert system.

A. WSNs Sensing System

A set of sensing system with all the sensors to detect how much river water get contamination installed at the river side, this method to get actual data from the water flow on the river. Figure 4 shows illustrated a sensor node installed on the river with independent power supply system from solar, sensor node normally installed located very far from the city area thus normal power supply may difficult to install, then a solar power system setup to supply to the sensor node with backup battery. The sensor node installed including river water flow rate and water level that distribute in many locations along the river to achieve accurate and real time data [18].

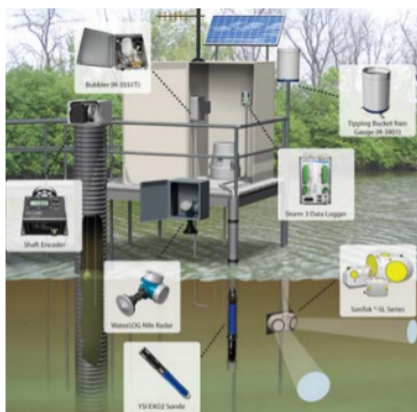


Fig. 4. WSNs node installed at the river side to detect water pollution

The raw data collected from every sensors contribute large quantity, in the sensor node has limited data storage and the large data effected to the slow response while sending data to sink node (gateway). Multiple sensor will impact to sensor node performance as well, thus in this method an intelligent sensor node designed to achieve quick response when abnormal detection on river water monitoring. Introducing of algorithm to the sensor node and some data filtering to avoid waste data, then the sensor node become intelligent and smart in detection river water pollution.

B. WSNs Sink Node and Communication System

In order to achieve accurate monitoring data from the sensor node installed and because of the river quite long more than 50 km, thus a few sensor nodes have to install. The average distance between node is different based on early data collected by survey the geographic of the river as well as quantity of the industry operating along the river. Furthermore, community village and some others activities have contributed river water pollution, then in this case to achieve more accurate data the average node distance require to install as closer as possible for example less than 1 km. Figure 5 show a scenario of network topology for the sensing system with n number of sensor node, then every sensor node have their own sink node for collecting data in local host before forwarding to monitoring center (backend system). In this case Fourth Generation (4G) network proposed for sink node communication to data center for faster communication and real-time monitoring, as currently most of area covered by 4G network.

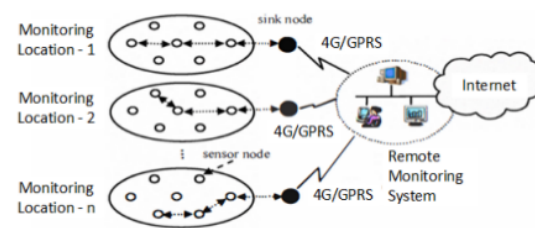


Fig. 5. Sensor node communication to sink and backend system

Real-time data is required to obtain fast response of indication of river water get polluted by chemical or other materials.

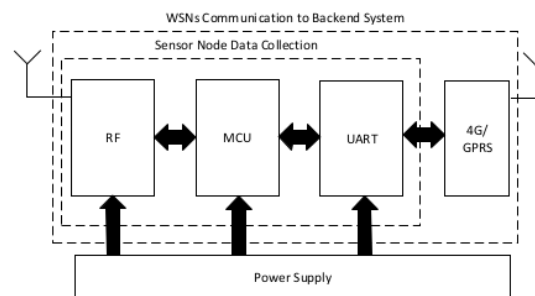


Fig. 6. Block diagram of sink node to communicate to sensor node

Figure 6 shows a block diagram of a WSNs sink node as gateway to communicate between sensor node for data collection to monitoring center. In this designed sensing node be able to serve up to 50 sensor nodes then all the information stored in the buffer before forward to backend system. Many way of wireless communication system to transfer data from sink node monitoring system but in this case 4G wireless network used in this application for faster data transfer because of sink node location very far away to data center. Dedicated wireless communication system is applicable to use but required line of sight (LOS) and high cost involve to setup.

IV. SIMULATION RESULTS AND DISCUSSION

Results of simulation is done in the laboratory testing, the results use for initial data before the actual sensor installed in actual sensor, furthermore initial results very useful to check whether proposed sensor model and type is good and applicable to use in sensor node based on design parameter set. Some of results data compar² to sensor data sheet and literature as reference [5]. Results of the temperature sensor tested compare to thermometer as shows in Figure 7, The thermometer temperature measurement compare to temperature sensor assembly. The average difference between the temperature sensor to thermometer is min 0.071 °C and maximum 1 °C.

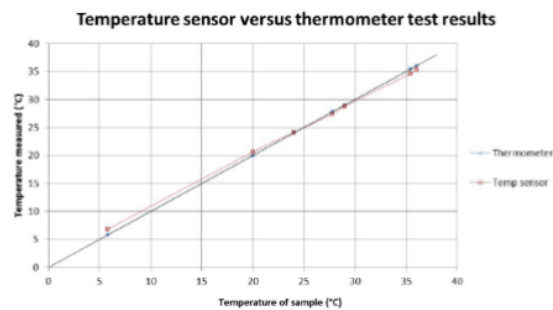


Fig. 7. Temperature sensor results vs thermometer

The conductivity is ² the of parameter to measure in water pollutant index, based on a 2-electrode method design. The sensor expected to get accuracy at least 15%. The initial test conducted to observe the accuracy of the signal conditioning circuit, Figure 8 shows the signal conditioning test results compare to the theoretically simulated conductivity.

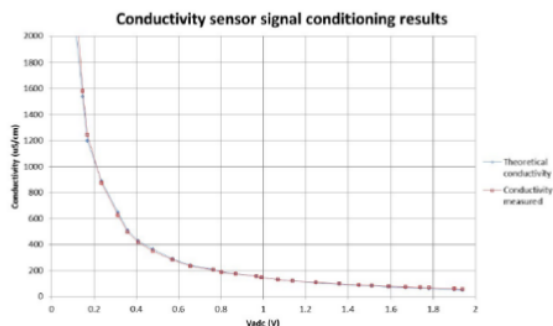


Fig. 8. Electrical conductivity test results for sensor node

Water pH is very important to check ² quality of the river water, the sensor use for sensor node based on the glass electrode with electrode design. ² The pH sensor design with specification and accuracy at least 0.4 pH. Two classifications of tests conducted to observe the accuracy of the installed pH sensor. Figure 9 shows pH sensor tested between measurement and theoretical analysis as initial results for this sensor node application.

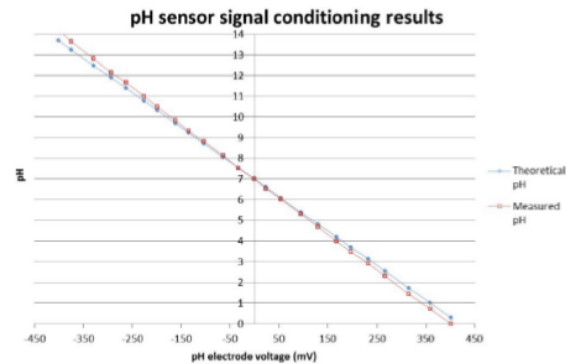


Fig. 9. Water pH sensor test between theoretical and measurement

Water flow sensor is used to measure flow rate of the river, because flow rate of liquid related to the pressure and the deepest of the river. The flow rate sensor selected based on the river deep and width to design a flow meter. The signal receive from the sensor analyze bit by bit and convert to the unit then a value of river water flow rate will obtain. The signal conditioning received from sensor mostly based on the amplitude of the voltage pulses. Figure 10 shows an initial test of water flow rate and measurement results.

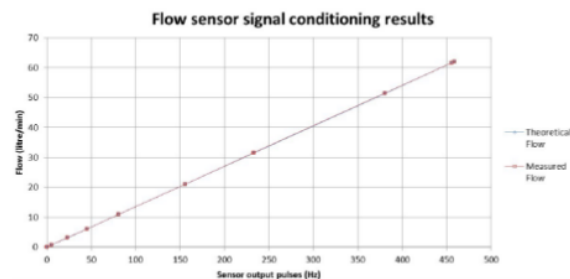


Fig. 10. Water flow rate sensor testing compare to theoretical

Based on initial test in the laboratory and measurement of all the sensors, achieve good results and good agreement between theoretical and measurement results. Further installation and test to the actual site is required to check and measure in actual site condition with real environment.

V. CONCLUSION

The design of smart sensor for WSNs node have been proposed with multiple sensors to accommodate all the parameters in the polluted water in the river. Based on initial laboratory sample test of river water, there are many parameters and chemical involve to the polluted water, thus various sensor such as water temperature to detect

industry through they are waste and chemical. Water pH is one of the parameter need to monitor as well as water DO. Electricity conductivity is measure in order to detect waste from industry or unclean environmental that contain chemical. Furthermore, to make sensor node is beneficial for the community a set of sensor which is water level sensor and water flow rate installed in the sensor node to measure river water status as alert for the flooding. Measurement results has good agreement compare to the theoretical analysis for all the sensors, then sensor node apply and ready to deploy in actual site to test with actual environment. Finally, to make sensor node become smart, then sensor node embeds which an algorithm to check only any abnormal or changing data with significant then update the data to WSN sink node, this method applies to avoid dump and waste data keep in the sink node as well as for the data communication.

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