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Iaas level Internet of Things based Aquaculture Data Monitoring System with Network Topology Analysis

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Abstract:
In this paper we have design an internet of things system for pure water aquaculture applications. Initially the IoT system routing topology is analyzed using network simulator to improve the quality of service by extracting the performance indices parameters. Eventually the IoT system is implemented practically using sensor nodes, internet gateways and application interfaces. Overall the system can monitor the parameters like temperature, PH, dissolved oxygen, light and nitrite which are primarily required in aquaculture application. The present aquaculture industry demands these type of water quality monitoring system, which helps the farmers to take smart decisions to increase the yield. The application of the aquaculture system is developed using infrastructure as a service cloud computing. The network topology routing analysis is done on number of nodes required over 5km x 5km area for high quality of service.

Keywords: *IoT, WSN, network routing, quality of service, sensors, aquaculture, network simulator.*

I. Introduction

The internet of things is unique technology which is emerged in to different fields like agriculture, medical, military, and industry[1-3]. Among these agriculture IoT is the potential research area which is attracting more researchers[4-5]. And aquaculture is the one of the most sensitive domain in agriculture, so by adopting IoT technology in aquaculture we can improve the shrimps and fisheries yield, it is the major motivation of many researches [6].

Temperature, PH, dissolved oxygen, salinity, sulphide, biological oxygen demand(BOD),chemical oxygen demand (COD), nitrate, nitrite, ratio of phyto and zooplankton are the priory parameters in aquaculture[7]. Periodical monitoring of these parameters using IoT system help the farmers to take smart decisions which helps to improve the yield. In IoT offering the good quality of the service with high security is one of the major research challenge. Prior to the implementation doing network level analysis helps to improve the quality of service[8]. By using proper user login credentials we can provide high security to the IoT system[9].

In IoT system design communication technology plays an important role. The communication technology may be wired or wireless, the wired communication technologies like RS485,HART, ProfiBus are generally used in IoT for transducer interface. The wireless communication technologies like Wi-Fi, Zigbee, 6LoWPAN are used in IoT for data uploading into the cloud (bigdata). From any communication technology the novel and sturdy IoT system design expecting high transmission rate, high coverage, low latency, large number of connections, high reliability, high security. Markov discrete time M/M/1 queuing modeling is preferable modeling the parameter like energy consumption, delay, throughput, path loss, wireless link channel, non-isotropic transmission.

The paper is organized as follows: in section II, we investigate the related work on aquaculture IoT systems, section III describes the network level

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analysis. implementation work is presented and discussed in section IV and followed by conclusions in section V.

II. Related Work

As Internet of Things (IoT)applications are emerging, in the next decade the world economy is greatly influenced by these advanced applications. Prior to the IoT technology, wireless data collection is done using RF ID, WSN, smart objects. From the last decade IoT technology showing a great potential in the area of physical data collection and monitor with high security. With its flexibility and sturdy nature IoT technology is recommended by researchers in health, manufacturing, security, agriculture applications. In the area of agriculture internet of things is termed as agriculture internet of things (AIoT).

Aquaculture is one of the domain in agriculture, which is offers more profits to the farmers. But the aquaculture cultivation and final yield more and more depends on the atmospheric conditions. So, monitoring primary parameters like temperature dissolved oxygen, PH, luminance and nitrite levels is essential. The internet of things(IoT) technology already proved its potential in the aspect of data monitoring applications[10].

The IoT system implementation involves the perception layer, network layer and application layer aspects. Prior to the implementation doing network level routing analysis helps to improve the IoT system quality of the system. Throughput, power consumption, delay and path loss are the basic IoT system performance deciding parameters.

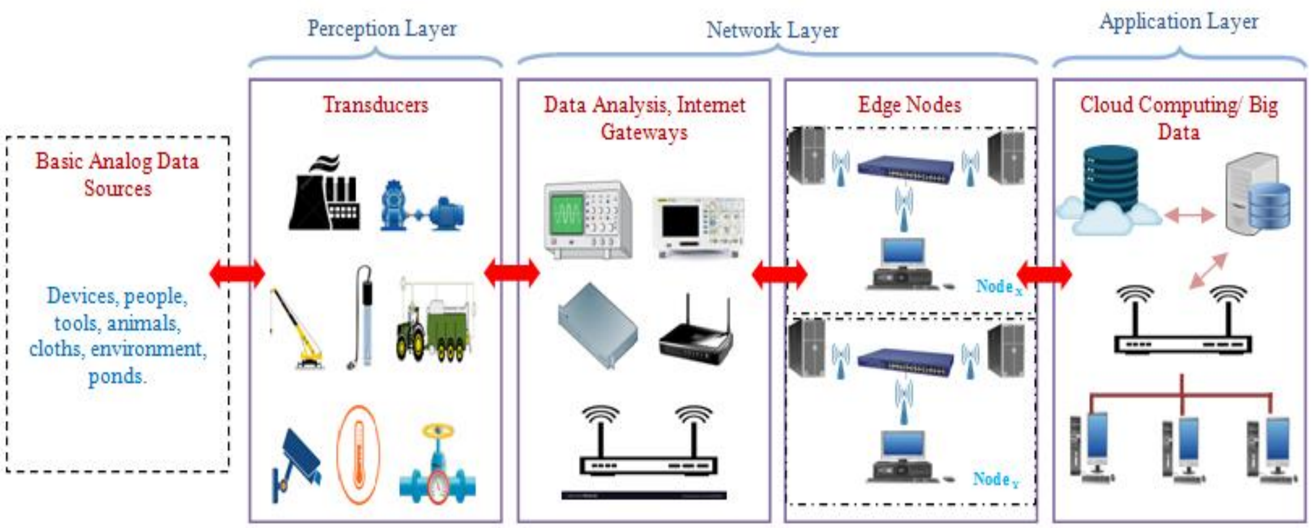

Fig. 1. Basic architecture of Aquaculture internet of thing (AIoT)

TABLE I. Pure water Aquaculture basic parameters

Parameter	Units	Description	Measurement Rate Weekly/yearly	Range	Effect
Temperature	^{o}C, (or) ^{o}F	Max. & Min.	Weekly once	20-35^{o}C	• Controls the biochemical s rate of reaction. • Controls the

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					biochemicals rate of reaction
Ph	Constant	Alkaline/Acid balance	One to three times a week	6-8	• (4-6)Slow growth and poor feed consumption . • 9-11 Slow growth, poor feed consumption and lethal to shrimp over a long period of time
DO	ppm	Oxygen dissolved in the water	One to three times a week	Must be above 4 ppm	• affects feed consumption, metabolism, environmental conditions, solubility and availability of nutrients.
Ammonia	ppm	Toxic waste product	Based on requirement	Must be Less than 1 ppm	• Toxic • Very low level, toxic to small fish • Poor growth & gill deformities
Turbidity / Suspended Solids/Hardness	ppm	Toxic waste product	Yearly once	Must be above 40 ppm	• Since turbidity limits light penetration. it limits photosynthetic activity in the bottom layer. • High turbidity can cause temperature

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					and DO stratification in shrimp ponds
Total ammonia nitrogen	ppm	Toxic waste product	Based on requirement	---	• It depends on the temperature and PH level
Nitrite	ppm	Toxic by-product	Based on requirement	Must be Less than 1 ppm	• Fish will be asphyxiated • Chocolate brown blood
Nitrate	ppm	---	Based on requirement	---	• Promote algal growth • Algal growth promote zooplankton • Both types are the first foods of aquaculture animals
BOD(Biochemical oxygen demand)	ppm	---	Based on requirement	Must be Less than 10 ppm	• High turbidity can cause temperature and DO stratification in shrimp ponds
COD(Chemical Oxygen demand)	ppm	---	Based on requirement	Must be Less than 70 ppm	• High turbidity can cause temperature and DO stratification in shrimp ponds

III. Network level Analysis

Prior to the implementation the aquaculture IoT system is simulated using network simulator which helps to improve the quality of the service. In network level simulation, we have primarily concentrated on the network routing topologies and number of nodes require for the considered geometrical area of 5km x 5km.

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For the topology we have extracted the parameters like throughput, delay, path loss and packets received. The topology nodes, net devices, applications are described using C++ programming language and simulated using NS3 tool. The topology animation view is extracted using Netanim. Overall five sensors are interfaced with each sensor node and one access point is assigned to a group of fine sensor nodes. All the sensor nodes are transmitting the data to the sink node i.e., server node.

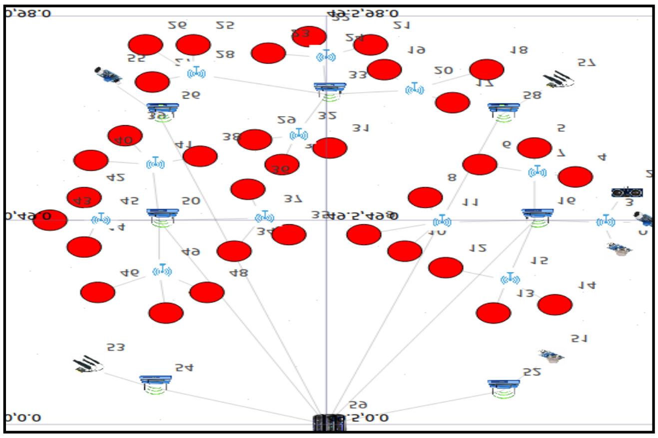

Fig. 2. Aquaculture IoT network topology.

For the topology in the area 5km x 5km, overall it requires 98 sensor nodes to monitor the data of 98 ponds.

All the sensor nodes are connected toserver through internet via access points. The topology is offering average throughput of 200 kbps, delay 40ms, energy consumption 55% and path loss of 94%.
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TABLE II. Simulation Results

Parameter	Sensor
Average throughput	200 kbps
Delay	40 ms
Energy consumption	55%
Path loss	94%

IV. Implementation of Aquaculture IOT

The network level topology analysis revealed that the nember of sensor nodes required over the geometrical area. With that experiance eventually we have implimented an auaculture IoT system with each sensor node is designed with reaspberry pi by interfacing temperature, PH, dissolved oxygen, light, ammonia, and nitrite/nitrate sensors.

The experiment was conducted by connecting five sensor nodes to the server through one access point.

Table III. List of sensors connected to each sensor node

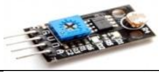
Parameter	**Sensor**	**Analog /Digital**	**Sensitivity/ Accuracy**
Temperature	DS18B20 	Digital	+- 0.5C from -10C to +85C
PH		Analog	± 0.1pH
DO		Analog	0.04mg/lit
Light		Digital/ Analog	0.5lux
Ammonia		Analog	0.05ppm
Nitrite/ni		Analog	-54 ± 5

Fig. 3. Aquaculture IoT application user authentication page.

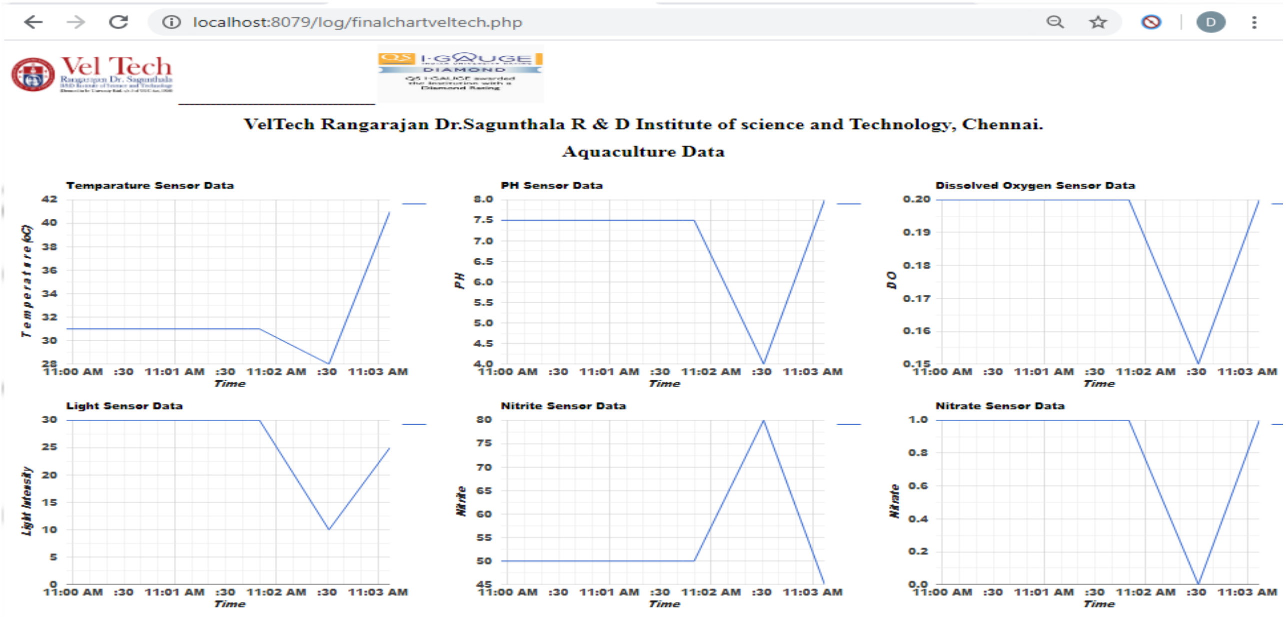


Fig. 4. Aquaculture IoT application data monitoring page.

TABLE IV. Comparison of presents work with literature

Parameter	**Reference [11]**	**Reference [12]**	**Reference [13]**	**Present work**
Parameters	Temperature, PH, electrical conductivity, water color.	Temperature, PH, Dissolved oxygen.	Dissolved oxygen, PH, Temperature, ammonia, Salinity, Nitrates,	Temperature, PH, Dissolved Oxygen, Light, Nitrite, Nitrate.
Protocols	MTP	---	---	HTTP
Network topology analysis	No	No	No	Yes
Board/ controller	Arduino	---	Raspberry pi	Raspberry pi
Access point	LTE	---	Wi-Fi	LTE
Database	MySQL	----	---	MySQL

V. CONCLUSION

In this paper we have design an internet of things system for aquaculture applications. The IoT system routing topology is analyzed using network simulator to improve the quality of the system by extracting the performance indices parameters. Eventually the IoT system is implemented practically using sensor nodes, internet gateways and application. Overall the system can monitor the parameters like temperature, PH, DO, light, nitrite, nitrate.

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