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Design and Implementation of Scalable Wireless Sensor Network for Flood Detection and Evasion

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***Abstract*—** Wireless sensor network has materialized as a influential technique for marine applications. Delugeinfluence is one of the substantialtragedies in the ecosphere. More than 50% of overall flood harms occur in Asia. Reasons of floods are natural factors such as heavy rainfall, high tides, low lying areas etc., and human factors such as obstruction of channels or augmentation of drainage channels, unsuitable land consumption, deforestation in headwater provinces, etc. Floods can cause losses of life and destructionof properties. Growing Population results in more urbanization, more rainproof area and less penetration and more flood peak and runoff.The objective of this paper is to develop such a WSN that can be used to monitor tide intensity and build a system that can prevent flood in coastal area. The focus is on the design and implementation of the wireless sensor node and that coordinateswith based base station. In this paper we describe the hardware and software architecture of this sensor network. This papervalidates the probability of using costeffective, flexible, and scalable sensor networks to address critical bottlenecks of the emergency response process.Therefore, a Wireless Sensors Network (WSN) is designed and implemented for monitoring of tide in sea and ocean.The System controls flood gate assembled on drainage system which avoids inundation of sea water in coastal area and the results of implementation are interpreted in this paper.

Keywords-*Wireless Sensor Networks, Flood, Flood disaster management, Tide Intensity, Base Station, Flood Prediction, Remote Sensing.*

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I. INTRODUCTION

Accurate tidal evaluation is an imperative problem for making events in coastal area. Tidal data is vital for the construction of docks and direction finding. In offshore areas, accurate tidal data is helpful for successful and safe operations. The application of Wireless Sensor Networks (WSN) contains a wide variety of scenarios. In most of them, the network is composed of a significant number of nodes deployed in a targeted area in which all nodes are indirectly connected. Further the data exchange is carried by multi-hop communication system.

A major cause of local flooding due to heavy rainfall in many cities is the blocking of drainage facilities with garbage [1].Environmental calamities are essentially unpredictable and arise in very short periods of time. Hence technology has to be developed to capture appropriate signals with minutest monitoring delay.Underwater sensor network (UWSN) is a wireless communication system that consists of battery-powered vessels, sensors nodes and a variety of devices[7].The Extreme Floods are considered to be one of the worst disasters based on environmental conditions. The Floods create a significant impact on human life due to its destructive effect [4].To monitor the environmental parameters the Wireless Sensors Network (WSN) is developed [2].The fundamental differences between UWSN and terrestrial networks are the channel and signal characteristics[7].Wireless sensor is one of the modern technology that can swiftly react to rapid fluctuations of data and send sensed data to a data analysis center in areas where cabling is not possible. Wireless technologies have been developing rapidly in these years.Wireless sensor networks have been developed for a variety of purposes that range from low duty-cycle, low-power environmental monitoring applications [6]. The obvious advantage of wireless transmission is a significant reduction and simplification in wiring and harness [3].The heart of this ubiquitous field is the Wireless Sensor Node. Moreover, the field of microcontroller based embedded technology is innovative and more reliable [2]. Ubiquitous computing is a technology aimed at supporting human activities with a number of computers and sensors that are deeply integrated into our daily lives. Such “smart” and “attentive” services would be realized using users’ context and preferences in the real world [8]. WSN technology has skill of quick capturing, processing and transmission of critical data in real time with high resolution. However, it has its own constraint such as relatively low amount of battery power and low memory availability compared to many existing technologies. It does, though, have the pros of deploying sensors in hostile atmospheres with a bare minimum of maintenance. This fulfills a crucial requisite for any real time monitoring, especially in unsafe or remote scenarios.

The usual practice for data acquisition and monitoring is based on many sensors congregated in one station operating on exterior power supply. This post is left in the water in the place of curiosity and hold onto recording data during some stipulated time, which may last for longer period of time. At the end the stipulated time the station is mend for data transfer, dispensation examination, and to perform predefine set of action.

Wireless communication is essential for scalability because installation and maintenance of a monitoring system with a wired or tethered communication network would be too expensive and complex for hundreds to thousands of nodes [6]. With scalability the network become dynamic in nature which would be desirable for further expansion of network. This facilitates change in network as per requirement of current scenario.Scalability of a wireless sensor network involves the sensors, data acquisition and processing, and wireless communication. A scalable network is one that can be expanded in terms of the number of sensors, complexity of the network topology, data quality e.g., sampling rate, sensor sensitivity, and amount of data while the cost of the expansion installation and operational cost, communication time, processing time, power, and reliabilityis no worse than a linear, or nearly linear, function of the number of sensors [6].

This paper discusses the design and implementation of flood detection and evasion system using WSN system at costal area. The system is built to sense abnormal behavior of tide intensity within sea. The augmented number of incessant depressions in sea has also lead to upsurge in the height and velocity of the sea waves, which can cause increase tides on the sea,

The leftovers of the paper is drafted as follows, Section II describes Background. In Section III Related Work is described. In section IV Implementation is discuss. In Section V Results are shown. Section VI contains Conclusion and Future work.

II. BACKGROUND

The application of wireless sensor networks to the underwater domain has huge potential for monitoring the health of river and marine environments [5].Cities in coastal areas are normally located in low lying areas where drainage is difficult without pumping. High tides or storm surges can hamper flood drainage to the sea and cause prolonged flooding with polluted flood water and health problems in cities. Effects of climate change increase more heavy rainfall, severe and frequent flooding which are more difficult to predict [1].An underwater architecture should consider the characteristics of the network, the underlying channel and environment [7]. A sensor network deployed underwater could monitor physical variables such as water temperature and pressure as well as variables such as conductivity, turbidity and certain pollutants [5]. An underwater architecture should consider the characteristics of the network and make it extendable and flexible enough to accommodate the rapid development of applications and underlying hardware [7].

A. COASTAL FLOOD RISK

Coastal floods can be classified as floods due to local heavy rainfall, floods due to river overbank flow and flood due to high tides or storm surges [1]. Floods in COASTAL areas are also commonly attributable to simultaneous occurrence of rainfall and high tides. If the rainfall is in excess of 200 mm in a day (24 hrs) the floods can occur anytime irrespective of the tides. However, if there is moderate rainfall but the tides are in excess of 4.50 meters at the same time, the area is sure to get flooded. Accordingly, heavy floods are anticipated, if there is excessive rainfall at the time of high tides. Also finally if the drainage density is less may lead to increase COASTAL runoff.

Floods are caused by natural factors or by a combination of natural and human factors. Risk is probability of loss and can be expressed as [1]:

$$\text{Risk} = \text{Hazard} \times \text{Vulnerability} \quad (1)$$

Flood hazard depends on flood magnitudes such as flood depth, velocity and duration. Vulnerability may be defined as the conditions determined by physical, social, economic, and environmental factors which increase the susceptibility of a community to the impact of hazards. When flood waters physically encroach on people and infrastructure, then the vulnerability of people and infrastructure is decisive for the degree of harm and damage

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B. FLOOD HAZARDCONTROLLING IN COASTAL AREAS

A major cause of local flooding due to heavy rainfall in many cities is the blocking of drainage facilities with garbage [1]. Flooding is a routine natural process that occurs when flows exceed the capacity of stream channels to carry them. The adjacent lands, called floodplains, serve an important function. As the water spreads out over the floodplain it slows down, and as a result, both downward erosion in the riverbed and lateral erosion of the riverbanks are reduced. Vegetation on the banks and in the floodplain slows the floodwaters further.

Flood hazards like other natural hazards have their origins in nature. Flood disasters, however, are a consequence of the intrusion of man and his works into an environment that puts them both at risk. The successful application of public policies to the management of flood hazards calls for integrating a number of factors. The three most fundamental of these are: human behavior and the choices people make; natural events and their probabilities; and governmental responsibilities.

III. RELATEDWORK

The role of the designed Flood Monitoring and Evasion System based on WSN is to continuously monitor, detect and report the environment's status to a control unit using relative water level as flood indicators, whose values are gathered by sensors in the sensor field. The flood monitoring and evasion system monitors and compute the status of floods and sends flood notification message to the base station of such zones for necessary action. The system is composed of three major modules which are the sensor module, observation module and the transponder module. The developed system is stout and gives well-timed alert of flood occurrences and controls the flood gate to avoid flood in coastal area.

In proposed system we have develop a wireless sensor node architecture that addresses the node-level requirements that we have set forth. We develop generalized node architecture and evaluate it in depth over a series of instantiations at technology points ranging from off-the-shelf integrations to a full custom range. Threshold values are optimized with the help of heuristics algorithm which is an experience-based technique for problem solving, learning, and discovery that give a solution which is can be optimal. Where the exhaustive search is impractical, heuristic methods are used to speed up the process of finding a satisfactory solution via mental shortcuts to ease the cognitive load of making a decision.

A. CONCEPTUAL FRAMEWORK

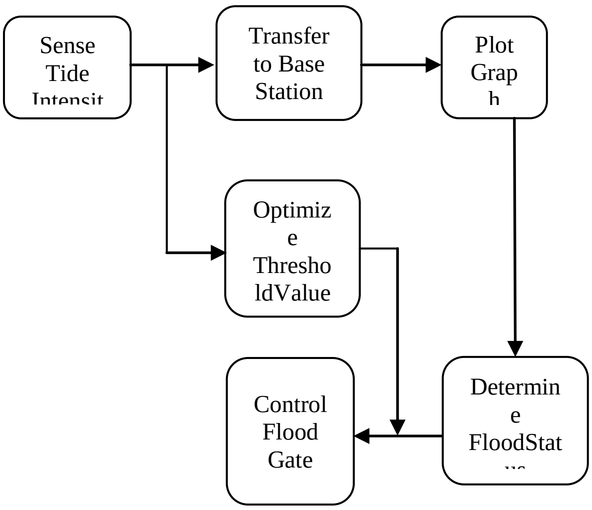

Figure 1: Block Diagram for Flood Detection & Evasion System

Major Functions of proposed system are as follows:-

Sensing & Transmitting Tide Intensity

Above Function will be deployed in water and will sense the water intensity/level. This intensity will be then transmitted to the base station using 433 Mhz Transmitter. The sensed data will be in analog form and it will be transmitted in analog form only.

Plotting Graphs

Above Function will plot simple 2-D graph where the X axis will depicts the time of intensity sensed and the Y- axis will indicate the intensity value.

Optimize Threshold Value

Above function will accept the collective sensed values for each node and applies simple heuristics algorithm; this algorithm will generate a new value which will be treated as a new threshold value. The significance of the threshold value is to determine the operation of servo motor for each node.

To avoid a static value(s) for flood gate and static operation of flood gate controller we are designing the system with heuristics algorithm which will ensure that the system has self-learning mechanism to it.

This process is call self-optimization mechanism which is composed of three distinct phases: Collect; Process and Generate

- Collect: Periodic values are being collected together after the trigger to formulate the optimal values for node.
- Process: All collect values will be segregated into the aforementioned categories to finalize the domain for each value. Depending on the intensity sensed each value will be placed in various categories. After which the heuristics algorithm will be applied on each domain to compute new value.
- Generate: These values are transmitted to the sensor node which will save it as threshold value after which the node will sense the water level and transfer the signal as per the new value.
-

Determining Status of Flood

Once Optimization process is completed, the system can sense individual intensity by means of using the stored procedure. Optimization is the process whereby a new threshold value is computed for individual node which is communicating with the base station and compares with sense value. Further the node will determine the status of flood with currently sensed value.

Controlling Flood Gates based on the received data.

After the Status of Flood is determined the receiver will control the flood gate operation with the help of received data. Depending upon the values it receives the flood gate status will be finalize.

IV. IMPLEMENTATION

A. *HARDWARE*

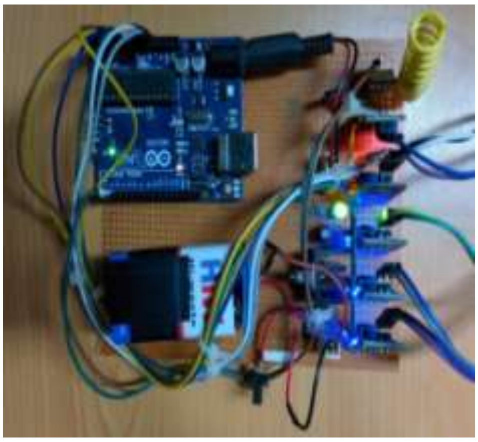

Figure 2(a) Transmitter Module

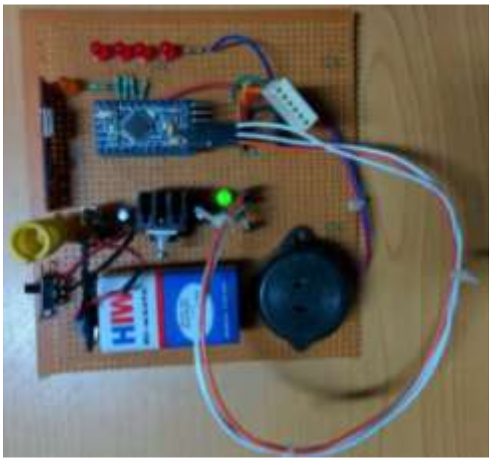

Figure 2(b) Receiver Module

Table 1: Major Components

Sensor	Water Sensor
Microcontroller	Arduino Uno, Mini
Resistor	1KOhm, 10KOhm
Transducer	433 Mhz RF
Indicator	LED
Batteries	9V

Figure 2(a), 2(b), and Table 1 show Flood Detection and Evasion System's hardware components. Hardware components are Arduino Uno, Arduino Mini, 433 Mhz RF Transducers,9V Batteries, Water Sensor, Basic resistors, Voltage converter. The System has been divided into following modules. Redundancy nodes are needed to deploy and the mesh topological structure should be optimized. What's more, the routing-algorithm should be examined to ensurethe communications among nodes [3]. When designing practical sensor network architecture for future ubiquitous computing environment, it is desirable that requirements of the applications be made clear. However, it is so far difficult to envision how such future applications should be like [8].

➢ Power Unit:

The power module contains power management device including two rechargeable batteries. Recharging power source can be supplied by an AC adapter. The module is designed in such a way that the module will meet durability of device by consuming limited power for operation.

➢ Operational Unit:

Some of the Authors had focused their research using intelligent low power sensors that consists of embedded sensor node interfaced with microcontroller which works as a small processing unit [4].The Operational Unit is one which collects the information from various sensor node and further saves this data in database. This sensed intensity will be given for threshold optimizer to optimize current threshold which results in to flexible working of system. The operational unit is consist of Arduino Uno Micro-controller which accepts the data and from Sensor unit and controls flood gate.

➢ Sensor Unit:

Sensor network is a key technology to obtain users' contexts in support of such devices [8].The sensor nodes within each cluster are capable to sense input environmental parameters, among these the most important climatic parameters are humidity level, air pressure and wind speed. These parameters will be very helpful for us in predicting the intensity of upcoming rainfall [4].The heart of Wireless Sensor Network (WSN) is the Sensor Node [2] .The Sensor Unit consists of Arduinouno, 433 Mhz RF Transducer, and basic water sensor which sense current water level and converts it into digital data. This value is sent to operational unit for further process. The sensor module is a module for obtaining information of the real world[8].

➢ Communication Unit:

The Communication unit is entails with 433 Mhz RF Transducer and 9V Battery which act as a communication bridge between Sensor Unit and Operational Unit. The transmission range is within a radius of 100m. On the communication module, a dedicated Microcontroller is used to drive RF transducer.The data could be collected in two ways: (1) with an autonomous robot functioning as a data mule using short range optical communication and (2) using an acoustic communication network with node-to-node routing [5].Designing of DAS, is highly important and tedious job for instrumentation design. Generally, it consists of the blocks such as multiplexer, ADC etc. [2]. However, the proposed architecture has dedicated mechanism to store the data and signals generated by the sensor unit. Transmitting data over these shorter distances reduces the power consumption on each sensor and alleviates the hot spot problem on the sensors near the destination. Moreover, since underwater acoustic

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communication is characterized by low data rates, and optical underwater communication is subject to short ranges, mobility enables a time-efficient and more energy-efficient means to collect and transmit the data [5].

B. SOFTWARE

The work emphasizes the development of sensor node for wireless sensor network. It is an embedded systemhence, for the synchronization of operation the firmware is required [2]. Due to the sensor nodes' reduced physical size and restricted power consumption, software on the sensor nodes hardware must make efficient use of processor and memory while enabling low power communication [8].

Table 2: API

Application API
void Read(void); *//Read current value of sensor.* *void Step (void);* *//To rotates Motor from one level to next or previous.* *void Forward (void);* *//To rotates Motor in Clock wise.* *void Backward (void);* *//To rotates Motor in Anti-clockwise Direction.* *void Door (void);* *//To Determine current state of Flood Gate.*
Communication API
void establish_conn(void); *//Function for Handshaking Signal.* *void set_sen_val();* *//Assign Sensor value by mapping analog value to digital one.*

V. RESULTS AND DISCUSSION

Table 3: Experimental Result.

ID	Sensor1	Sensor2	Sensor3	Sensor4	Sensor5	Mean	Intensity
1	6	5	1	5	3	4	NEGLIGIBLE
2	6	5	1	4	3	3	NEGLIGIBLE
3	6	5	1	4	3	3	NEGLIGIBLE
4	6	5	1	5	3	4	NEGLIGIBLE
5	77	6	1	5	3	18	NEGLIGIBLE
6	70	69	1	4	3	29	MARGINAL
7	70	69	1	4	3	29	MARGINAL
8	68	70	1	5	3	29	MARGINAL
9	68	74	1	5	3	30	MARGINAL
10	69	70	1	5	3	29	MARGINAL
11	67	70	68	44	3	50	CRITICAL
12	67	71	67	44	3	50	CRITICAL
13	68	70	68	44	3	50	CRITICAL
14	68	70	71	46	3	51	CRITICAL
15	66	69	70	69	3	55	CRITICAL
16	67	68	70	68	3	55	CATASTROPHIC
17	67	68	69	68	3	55	CATASTROPHIC
18	66	67	71	69	3	55	CATASTROPHIC
19	65	66	72	70	3	55	CATASTROPHIC
20	62	61	70	69	3	53	CRITICAL
21	61	60	70	69	3	52	CRITICAL
22	60	60	69	69	3	52	CRITICAL
23	58	57	67	67	3	50	CRITICAL
24	59	58	68	67	3	51	CRITICAL
25	58	57	68	67	3	50	CRITICAL
26	57	57	68	67	2	50	CRITICAL
27	58	57	68	68	2	50	CRITICAL
28	58	56	68	68	3	50	CRITICAL
29	56	56	68	67	2	49	CRITICAL
30	56	55	67	67	2	49	CRITICAL
31	7	63	3	8	2	16	NEGLIGIBLE
32	7	63	3	4	2	16	NEGLIGIBLE
33	7	23	2	5	2	8	NEGLIGIBLE

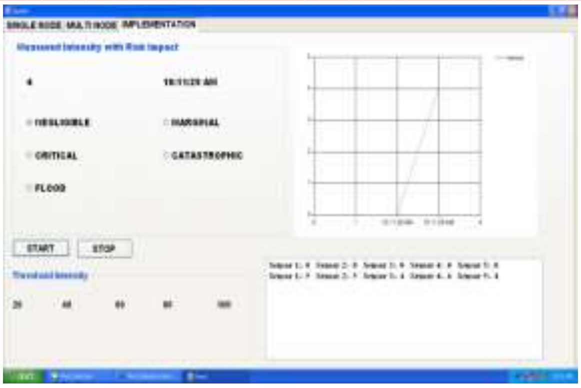

Figure 3(a)Negligible State

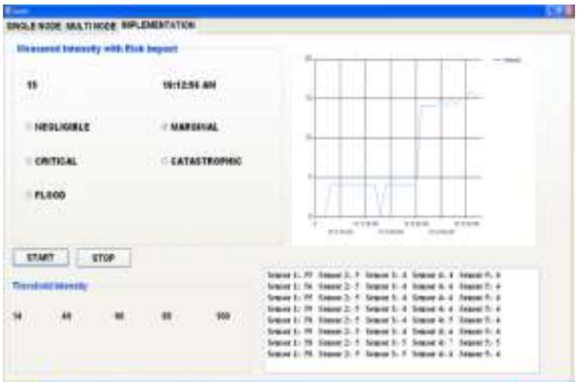

Figure 3(b)Marginal State

VI. CONCLUSIONS AND RECOMMENDATIONS

The main objective of this project work is to develop a real-time flood monitoring and warning system for a selected coastal area. The system employs the use of advance sensing technology in performing real-time monitoring of water information. The developed system is composed of three major components: 1) sensor network, 2) processing and transmitting modules, and 3) database and base station server. The sensor network will be implemented at remote sites, where network infrastructure is not available. The connectivity is done through the wireless tunnels. The sensor network measures water related data while the processing and transmission module is used to transmit measured data to the database and application server. The database and application server is implemented as an application to allow users to view real-time water-related data as well as historical data. The application server is also able to send warnings to the responsible authorities in case of emergency.

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