A Model for Flood Prediction and Prevention using Wireless Sensor Network

Indira Priyadarshinee
Dept. of Comp. Sc. & Engg.
Centurion University of Technology &Management, Odisha

Kabita Sahoo
Asst. Professor
Dept. of Comp. Sc. & Engg.
Centurion University of Technology &Management, Odisha

Chandrakant Mallick
Asst. Professor
Dept. of Comp. Sc. & Engg.
Centurion University of Technology &Management, Odisha

ABSTRACT
Flood is a frequently occurring natural disaster in the coastal areas. We, the human beings and our resources are victims of such natural catastrophe. For example, flood. Though flood cannot be totally uprooted by human being still it can be predicted hence major steps can be taken to prevent it. In order to predict & prevent flood structural and non-structural methods are available. In this paper we propose a model to deploy different types of sensors in the river bed forming a Wireless Sensor Network (WSN) for predicting the flood situation and warn the local office & administration regarding the situation and could take preventive steps. WSN is preferred due to its cost effectiveness, faster data transfer and accurate computation of required parameters for flood prediction & prevention. Our model is a simple and cost effective one to predict and prevent flood by regulated flushing of excess amount of water at the barrage. It has an easy computation for managing the barrage water by sensing the upcoming water amount and water speed at some distance in a coordinated manner. The flush rate for draining water is computed before the excess amount of water is reached the barrage causing flood. Hence the computed amount of water is drained out at the barrage to prevent the flood. The wireless sensor network in our model was simulated by using NS2 and the computations made by different sensors are implemented at barrage using MATLAB.

Keywords
Wireless Sensor Networking (WSN), Flood prediction, Sensor, Computational node, Manning's rule.

1. INTRODUCTION
Flood is a kind of natural calamity. In an informal way flood can be combination of flow & odd, means a typical odd flow of surplus water causes flood. According to Australia Government Flood is a general and temporary condition of partial or complete inundation of normally dry land areas from overflow of inland or tidal waters from the unusual and rapid accumulation or runoff of surface waters from any source [1].

The main causes of flood are hydrological condition, metrological condition, geographical condition, planning problem and environmental status due to human activity etc. Hydrological condition arises due to the discharge of heavy rain fall and the enormous water. The hydrological condition is directly and indirectly associated with the metrological condition such as heavy rainfall, cyclone & storm. The geographical condition is also a major factor for flooding condition, for example, altitude of the place. Lower is the altitude of a place; the water flows from the neighboring higher altitude. The planning problem such as poor drainage, high siltation in river, breaching of the embankments, spilling of floodwaters over them, too contribute to flooding situation. The environmental status due to human activity is a significant cause for flooding situation, for example, deforestation, different type of pollution and more buildings construction etc.
Flood is categorized into a number of types such as river flood, coastal flood, urban flood, flash flood and ice jam etc [2]. In developed country like US, Japan etc the flooding problem is minimized significantly & do not affect much due to availability of emergency system and advanced technology. But for developing country like India, Brazil etc the things are opposite to that of developed country. Suffering is a lot during flood in developing and poor country. In Odisha, Flood situation is a troublesome situation which occurs almost every year, to say regularly & washes away the economy of Odisha. Most of the districts are affected by flood. In 2011 and 2013 Odisha has a subsequent flood situation due to heavy rainfall and cyclone Phailin respectively. The economic loss of Odisha for the year 2011 and 2013 is noticeable. From this potential, the struggle and suffering during flood for the developing countries is an urging issue which cannot be discarded simply while assuring a globally applicable solution. Flood detection & prevention is a very expensive process in recent strategy. Current methods are expensive, requires expensive equipment and centralized, computationally difficult flood detection schemes. The flood warning system used in the developed world are costlier and depends on the expert hydrologists who monitor real-time data 24 hours a day and run sophisticated computational Models at a centralized location. These kinds of resources are unaffordable & impractical for poor counties as well as developing country.
Though flooding benefits us by providing fertile soil, more hydroelectricity still flooding is responsible for the loss of precious lives and destruction of crops, food supplies and large amounts of property every year, especially in the poor and developing countries. A lot of effort in terms of structural and nonstructural developing measures [2] is taken which help to minimize the damage. As a network for the prediction model has to be deployed in the rural areas, there is a severe limitation of resources like money, power and skilled man-power.
This motivates us to utilize the work in information communication technology & wireless sensor network to solve problem effectively with minimal cost requirement

and limited computational power along with high reliability and accuracy of both the system and computation.

The previously worked paper on flood prediction using a WSN and other relative papers invigorate us the different ways to predict flood i.e. flood forecast. Those papers discuss about the minimization of the destructive effects of flood on Human being to save the lives and property by using the newly evolved technology i.e. Wireless Sensor Network by adopting. Especially in this proposed work WSN is taken into account for the flood prediction & its effect minimization in an innovative way.

2. BASIC MODELS

Mainly there are two types of models for flood prediction and prevention. Those are

a) Non-WSN System

b) WSN System

2.1 Non-Wsn System

This is a primitive technique of flood prediction. This technique needs trained personnel. As it involves manual procedure so it is expensive. The non-WSN systems reliability fully depends on the skill and experience of the personnel employed. There are automated telemetry systems but these systems are expensive and it requires periodic installation of repeaters and transmitters. Moreover telemetric system follows a centralized computational system which has a number of drawbacks.

2.2 WSN Systems

A wireless sensor network is a group of specialized transducers with a communication infrastructure that uses radio to monitor and record physical or environmental conditions such as temperature, humidity, pressure, wind direction and speed, illumination intensity etc [3].A sensor network consists of multiple detection stations called sensor nodes, each of which is small, lightweight and portable. Every sensor node is equipped with a transducer, microcomputer, transceiver and power source. The transducer generates electrical signals based on sensed physical effects and phenomena. The microcomputer processes and stores the sensor output. The transceiver receives commands from a central computer and transmits data to that computer. The power for each sensor node is derived from a battery [3].WSNs has low power, low cost, multi-hopping systems that are independent of external service providers, can form an extendable network without straight coverage; but have self-adjusting data paths.Three types of models may be designed: Centralized, Distributed or Hybrid.

2.3 Centralized Model

In centralized model computation occurs at the central node only. It needs few number of components required for computation. However, if the central node fails due to single point failure the whole system fails. Another problem associated with this model is simultaneous transmission of measured data from all sensing nodes. This problem can restrict the data available for computation and prediction hence limiting the utilization and correctness of the model. The three main shortcomings of centralized model are:

i) Requirement of sufficient amount of data for computation and prediction.

ii) Complexity of computational algorithm which increases the computational power as well as time.

iii) Reduced system reliability due to unavailability of redundancy checks to provide corrections in the central node during calculations.

2.4 Distributed Model

In distributed model computation takes place at several levels instead of only one computing node as in the previous model. Most of the disadvantages of a centralized system are handled in this model. Here different terminal sensors act together to provide the collected data to bridge nodes, identify internal failures and to adapt to changes in topology. This model also increases the reliability of a system by introducing redundancy as the same calculations are done at different nodes and then matched. However, the model is more costly and suffers from improper communication among the heterogeneous sensors.

2.5 Hybrid Model

As the name indicates, this model consists of both the centralized model and the distributed model. This model combines the advantages of both the systems and simultaneously cancels out the disadvantages of either system. The network hierarchy is same as that of previous model. Computation is done on multiple nodes unlike the centralized method, and yet computation in almost all nodes is not done as in the distributed method. Thus, the cost of deployment and the redundancy and reliability of the system is balanced.

2.6 Related Works

In [4], Seal et al. has given a real time model which is based on an Alarm System that means when the plain area is flooded then the alarm will start blowing. In [5], Basha et al. has showed implementation of the sensor network in Honduras for an early detection of flood & alert the community is done. They have analyzed on the significance on sensor networks in developing countries, sensor networks for flood detection and the available current operational systems for flood detection. In [6], Basha et al. has given a model-based monitoring for early warning flood detection is proposed and implemented. This model prepared in reference to Sacramento Soil Moisture Accounting (SAC-SMA) which is a very efficient model that can detect flood very easily but SAC-SMA is very expensive which could not be affordable for a developing country to be employed for flood detection but this approach is computationally leaner than conventional approaches to flood modeling and prediction, utilizing real-time data from multiple sensor nodes. This counts the advantage of this model over SAC-SMA.In [7], Hughes et al. has described that damage due to flood is correlated to the warning time announced for a flood event. They prepared a hybrid of local and remote sensor network. For example, local computation can be used to provide timely warnings to local stakeholders and a combination of local and remote computation can inform adaptation of the sensor network to maintain optimal performance.In [8], Ahmad et al. has presented a comprehensive study of the flood analysis and prediction using Geographical Information system (GIS) i.e. they are using an Arc GIS simulation tool to identify pre and post disaster flood risk analysis and an Ad hoc wireless Sensor Network Architecture. A model is proposed for flood risk analysis and prediction for calculating the impact of flood damage in disaster hit regions.In [9], Degrossi et al. has proposed a model which is based on Open Geospatial Consortium's (OGC) Sensor Web Enablement (SWE) standards, that collects data to be shared in an interoperable and flexible manner. A Spatial Data Infrastructure (SDI), geospatial software platforms which was used to manage the environmental risks. In [10], Sunkpho et al. has represented two main objectives of the developed system which serve a) as information channel for flooding between the involved authorities and experts to enhance their responsibilities and collaboration and b) as a web based information source for the public, responding to their need for information on water condition and flooding in Nakhon Si Thammarat, a southern province in Thailand.

In [11], Yu et al. has presented a wireless sensor network for real-time forest fire detection method. The forecast forest fires cannot be detected by the satellites fire spreads uncontrollable. The wireless sensor network can detect and forecast forest fire more perfectly and accurately than the traditional satellite-based detection approach. This method is used to minimize the loss of forests, wild animals, and people in the forest fire.

In [12], Stoianov et al. has described a Pipe Net, a system based on wireless sensor networks which detect, localize and quantify bursts and leaks and other anomalies in water transmission pipelines such as blockages or malfunctioning control valves. The system monitors water quality in transmission, distribution water systems and the water level in sewer collectors.

In [13], Anthone et al. has described about an alternative network as a substitute to the usual communication links which are unavailable during major disaster. They proposed an alternative network for maintaining communications capabilities during major natural disasters and other emergency situations by a system that utilizes Short Message Service (SMS) of length upto 7bits over Wireless Mesh Sensor Networks (WMSNs). This technique is relatively simple and inexpensive.

In [14], Jadoon et al. has presented a least cost framework of irrigation control system based on sensor network for efficient water management in Pakistan. The proposed wireless sensor for irrigation control system will monitors four important environmental parameters like moisture, temperature, humidity, soil moisture etc for the efficient management of water.

The model described in [4], [5], [6] and [7] are inexpensive model which could be implemented in flood detection in developing and poor country more accurately. The model in [8], [10] and [12] adapts new technologies in detecting and preventing flood. [11], [12], [13] and [14] showed the accurate and efficient sensing, data transferring, computation and decision making capability of wireless sensor network (WSN) in different field.

A number of models are proposed and also implemented but the necessity of another model arises when we consider about flood depending upon the flushing style at the barrage [22]. At the time of flooding large volume of discharged water is accumulated at barrage. When the water holding capacity of the barrage exceeds more than the normal level, the excess volume is flushed out. When the excess volume of water is flushed at a sudden then the water flows to the basin of river and floods the plain area.So if a model could predict the upcoming amount of volume and the time to reach the barrage, it can be ready to receive the excess volume without being over flooded. Barrage can flush out the water in a well and stipulated manner so that flooding due to flush out of excess volume of water suddenly will not occur.Deploying the wireless sensor network, a cost effective model is conceived which could be used by developing or poor country, this adds to the advantages of the proposed model.

3. PROPOSED WORK

In this section we are discussing about the components in our proposed work, the architecture and different challenges.

3.1 Sensing Sensor node

The Sensing node senses and collects the data relevant for calculations. It is used to sense water level, water speed etc. The data collected by these sensors are used by the local computational node. In our proposed model we are using three types of sensor.

3.2 Water level sensor

The sensor used for measurement of fluid levels is called a level sensor. This level sensor is used to measure the water level in river is called a water level sensor. A variety of water level sensors are available, for example, ultrasonic continuous level instrument [15] which is operated on the basic time-of-flight principle using sound waves to determine water level. Ultrasonic Level sensors comprises of two elements; such as a high efficiency transducer and, an associated electronic transceiver. Complete return trip time between transmitted ultrasonic pulse and reflected echo is measured to determine the fluid level. The frequency range for ultrasonic methods is in the range of 15 to 200 kHz. The water level sensor is compact, low cost, low power, easy to use and can take an accurate reading in less than a second.

3.3 Water speed sensor

The sensor node for measuring speed of the water speed is called a water speed sensor. Here we are considering an ultrasonic flow meter. An **ultrasonic flow meter** [16] is a type of flow meter. This measures the velocity of a fluid using ultrasound. Using ultrasonic transducers, the flow meter can measure the average velocity along the path of an emitted beam of ultrasound, by averaging the difference in measured transit time between the pulses of ultrasound propagating into and against the direction of the flow or by measuring the frequency shift from the Doppler effects. Ultrasonic flow meters are affected by the acoustic properties of the fluid and can be impacted by temperature, density, viscosity and suspended particulates depending on the exact flow meter [17]. The Doppler Effect Ultrasonic Flow meter use reflected ultrasonic sound to measure the fluid velocity. By measuring the frequency shift between the ultrasonic frequency source, the receiver, and the fluid carrier, the relative motion is measured. The resulting frequency shift is named the *Doppler Effect*.

Mathematically, the fluid velocity can be expressed as

$$v = c\,(f_r - f_t) / 2\, f_t \cos\Phi$$

where f_r = received frequency
f_t = transmission frequency
v = fluid flow velocity
Φ = the relative angle between the transmitted ultrasonic beam and the fluid flow
c = the velocity of sound in the fluid

3.4 Intermediate node

To minimize the effect of a node failure while connecting the computational nodes to the managing computational node the intermediate node is used.

3.5 Computational node

The computational nodes possess CPUs required to implement the computational part of model. The computational node receives transfers and computes the data to measure specific value. There are two type of computational node in the proposed model. Those are described in 4.2.1 and 4.2.2.

3.6 Local Computational Node

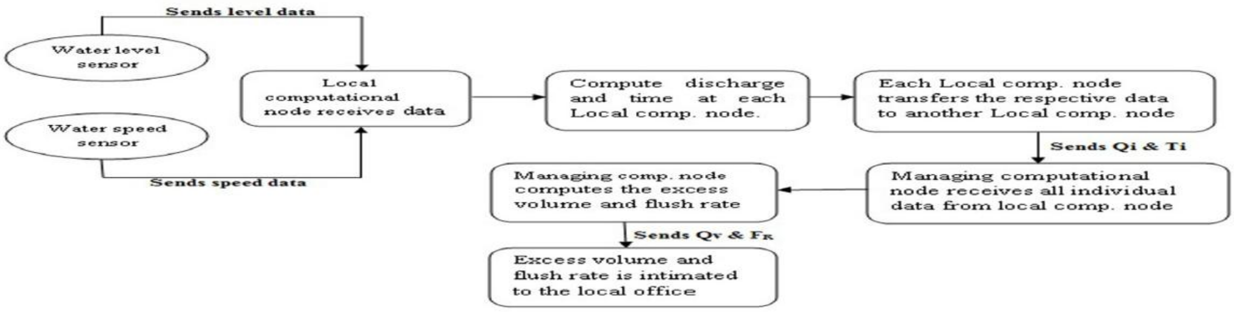
The local computational node or local node is deployed locally at given distance from the barrage. This node is associated with two another sensor nodes i.e. water level sensor and water speed sensor. These three components combinedly called as cluster. The local node receives data from the respective sensor, processes those data, computes the amount of discharge, time of reaching of that amount of water to another local computational node and sends the data to another local node.

3.7 Managing Computational Node

The managing computational node is deployed near the barrage. It receives all the data (discharge amount and time of reach). It processes the data and finds the rate of flush of water volume.

The proposed model on Wireless Sensor Network (WSN)

system architecture for flood prediction and prevention consists of three types of sensor nodes, two types of



computational nodes. The three types of sensor nodes are water level sensor, water speed sensor and intermediate nodes. The two types of sensor nodes and local computational node are unitedly result a cluster. A number of clusters across the river basin upto the barrage are deployed depending on the suitability of placing the clusters.A managing computational node is placed near the barrage along with a water level sensor.

4. CHALLENGES IN PREVENTING FLOOD AND ITS RESOLUTION

Parameters: F_l=Fixed level of water,

F_s =Fixed speed of water, where F_L & F_S are stored in the database of the respective sensing node.

R_l=Current water level,

R_s =Current water speed

1. Challenge 1

If $((R_l > F_l) \& (R_s > F_s))$

In this situation water level as well as water speed goes on increasing simultaneously.

Solvent: The excess amount of water is computed frequently rapidly and the rate of flush is computed.

2. Challenge 2

If $((R_l > F_l) \& (R_s = F_s))$

Here current of water (water speed) is normal but the water level goes on increasing. This results in accumulation of excess amount of water at Barrage ultimately it lead to flood.

Solvent: The excess amount of water is computed and should be released to escape the flooding situation.

3. Challenge 3

If $((R_l = F_l) \& (R_s > F_s))$

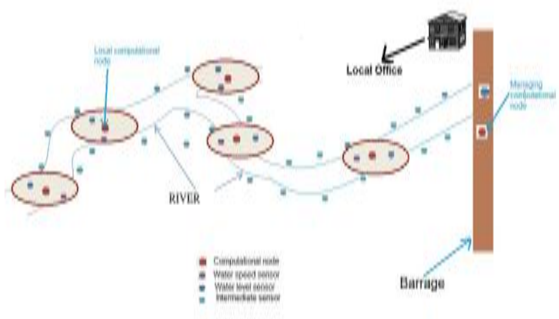


Fig 1: The proposed model Architecture

In this situation water level is normal but speed of water is high. The high speed of water is hardest to control. This challenge will be dealt as the future work

5. OUR PREDICTION MODEL

5.1 Work Flow of Proposed Approach

With a dynamic data collection, prediction and prevention are made using our suggested algorithm and the results are communicated to the local office which will flush out the required amount of water from the barrage.

In this approach the sensing node reads the data like water level and water speed sensor. The read data is transferred to local computational node in the respective cluster. The local computational node processes the data and computes the amount of discharge and the time required to reach the barrage. These computed data will be send to another local computational node. In his way all the data of respective cluster will reach to the managing

5.1.1 System Interrupt

Unlike event or query driven interrupts which are both external events, system interrupt is internal. System interrupt is generated by a computational node corruption or loss of data during any phase of the communication process-data sensing or recording, transmission, accumulation or calculation. The office node or computational nodes send a request to the sensor nodes to take another readings (or set of readings) whenever it detects an error by using a system interrupt.

computational node. In managing computational node, these data will be processed and flush rate is computed which will be communicated to the local office. Depending on the amount of surplus water computed, the water is flushed with the help of the local office.

The instants at which sensors read data are decided by any one or more of these four parameters [4]:

5.1.2 Time Reset

Time is the most frequently and commonly used parameter. The system will reset automatically after every one hour interval.

5.1.3 Event

Event refers to sudden change in a data reading which may affect the desired result. The state of water level and water speed is taken as the event. Basing on these two values we are transferring the data to local computational node. An event driven data makes a reliable prediction and prevention of data before the flood occurs.

5.1.4 Query

This parameter is useful to an administrator, when he/she wants to see the immediate level and get an instantaneous prediction even when it's not time to take a reading. A hardware interrupt is used to get the instant query driven data. Hardware interrupt is quite similar to the event driven case but the only difference is the interrupt, which is provided by a human instead of natural parameters.

5.2 Algorithms

5.2.1 NEC Algorithm (for energy conservation)

The energy consumption is described in [18] and [19]. Energy consumption in a proper manner is important to improve the battery life of sensor nodes. So we have proposed an algorithm to efficiently use the battery hence increase the battery life. The algorithm is given as follows.

Parameters: F_l=Fixed level of water.

F_s =Fixed speed of water, where F_l & F_s are stored in the database of the respective sensing node.

R_s =Current water speed.

R_l=Current water level.

Step 1

If (($R_l > F_l$) or ($R_s > F_s$))

{ set $F_l = R_l$;

set $F_s = R_s$;

send R_l to the local computational node;

send R_s to the local computational node;}

Step 2

Reset the sensor node to its fix value after 1 hour.

Whenever either of the two conditions is true, the sensor node will start sensing the data and send the sensed data to its respective local computational node otherwise not. After sensing the data it will reset its fixed water level or fixed water speed with the currently read water level & currently read water speed respectively.

The advantages of this NEC Algorithm are that, it will not start sending the data till the above condition will not arise. So there will be no unnecessary consumption of energy.

5.2.2 Flood Detection Algorithm (FDA)

This FDA algorithm is mainly applied to the resolve the flooding condition by predicting the excess water discharge. Here we denote the different components as follows.

Table 1. Notation table

Component	Notation
Water level sensing node	wl_sn
Water speed sensing node	ws_sens
Local computational node	lc_node
Managing computational node	mc_node
Fixed level of water	F_l
Fixed speed of water	F_s
Current water level	R_l
Current water speed	R_s
Fixed water volume between two node	F_v
Fixed Barrage water volume	F_b
Current Barrage water volume	B_v
Hydraulic mean radius(A/P)	R
Area of cross-section	A
Wetted Parameter (using R_l of two node)	P
Slope of the energy line between two point	S_f
Roughness coefficient	N
Discharge/Volume	Q
Distance between two nodes	D
Time of reaching the excess volume from one node to another	T
Sum of all T of each node	T_t
Excess Volume	Q_v
Sum of Excess Volume at each node	Q_t
Flush Rate	F_R

The Local computational database table (L_Table) is shown in Table2.

Table 2. L_Table

# Node _id	# F_l	# F_s	#R	#A	#P	#S_f	#n	#D
…… ….	… ….	… …..	… … …	… … ….	… ….	… … …	… …	… …

The Managing computational database table (M_Table) ia given in Table3.

Table 3. M_Table

#Node_id	$\#F_l$	$\#F_v$	$\#Q_v$	$\#Q_t$	#T	$\#T_t$
………..	….	…..	…..	……	……	……

//Sensing Node (wl_sens and ws_sens)

1. Set the level and speed in wl_sens and ws_sens with F_l and F_s respectively
2. Sense R_l and R_s.
3. Check for the condition whether (($R_l > F_l$) or ($R_s > F_s$))
4. Go for NEC Algorithm.

 if condition=true

 $F_l = R_l$;

 $F_s = R_s$;

5. Send R_l and R_s to respective lc_node.

//Local node computation (lc_node)

6. Receive R_l and R_s.
7. Read other value D, n, A, R, S_f from L_Table.
8. Compute volume

$$Q = \frac{1}{n} A R^{1/3} S_f^{1/2} \quad \text{// using Manning's rule [20]}$$

9. Compute T

$$T = \frac{D}{R_s} \quad \text{// using Kinematics rule [21]}$$

10. Send Q and T to mc_node.

//Managing node computation (mc_node)

11. Receive Q and T of each node.
12. Store it in M_Table.
13. Compute Q_v

$$Q_v = Q - F_v$$

14. Compute Q_t

$$Q_t = \sum_{i=1}^{n} Q_{ti}$$

15. Compute T_t

$$T_t = \sum_{i=1}^{n} T_{ti}$$

16. if ($F_b = B_v$)

{

$$F_R = \frac{Q_t}{T_t}; \quad \text{//Compute } F_R$$

} else if ($F_b < B_v$)

{

Z = (Q_t-F_b)+B_v;

$$F_R = \frac{Z}{T_t}; \}$$

else if ($F_b > B_v$)

{

X = (F_b+Q_t)-B_v;

$$F_R = \frac{X}{T_t}; \}$$

17. Send F_R to local office.

6. SIMULATION

Our simulation was performed in NS2 and MATLAB environment.

6.1 Simulation in NS2

NS2 is a Network Simulation tool. Here we checked the flow of data in WSN. The simulation parameters are defined in the Table4.

In this section, we checked the packet flow from sensing node to local computational node and local computational node to managing node.

The process flow of data from sensor node upto managing computational node is shown in the Fig.3 and Fig.4.
Here 50 nodes are created which include the water level sensor, water speed sensor, local computational node, managing computational node. The sensor nodes sense the data and send it to local computational node. The managing computational node receives all data from each local computational node. The managing computational node computes the flush rate.

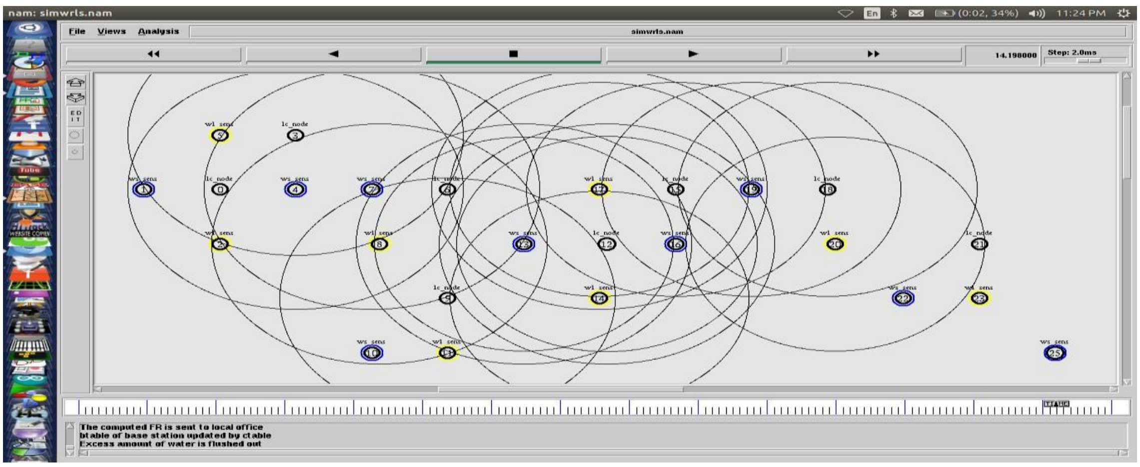


Fig.3 Sensor Node Deployment

Table 4. Simulation Parameter

Area	10000m X 10000m
Nodes	50
Packet size	512bytes
Transmission protocol	UDP
Simulation time	100sec
Traffic Type	CBR
Antenna Model	Omni directional area
Routing Protocol	AODV
Queue Type	Drop Tail
Propagation Model	Two Ray Ground
Initial energy	100joules

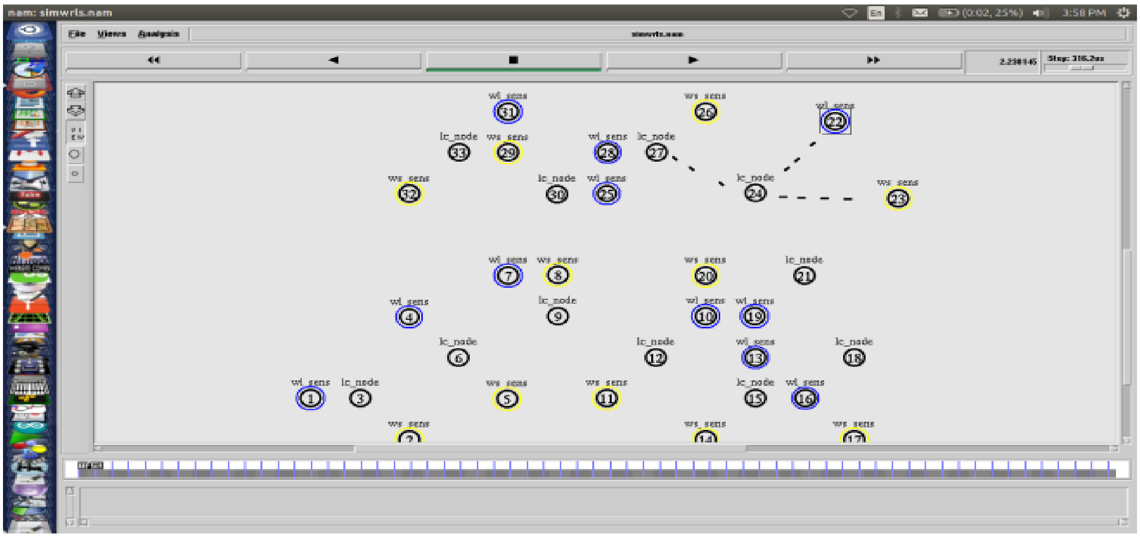


Fig.4 Data Transfer from one node to another

6.2 Simulation in MATLAB

In MATLAB we simulated the computational part of managing computational node by taking the random data in a particular range.

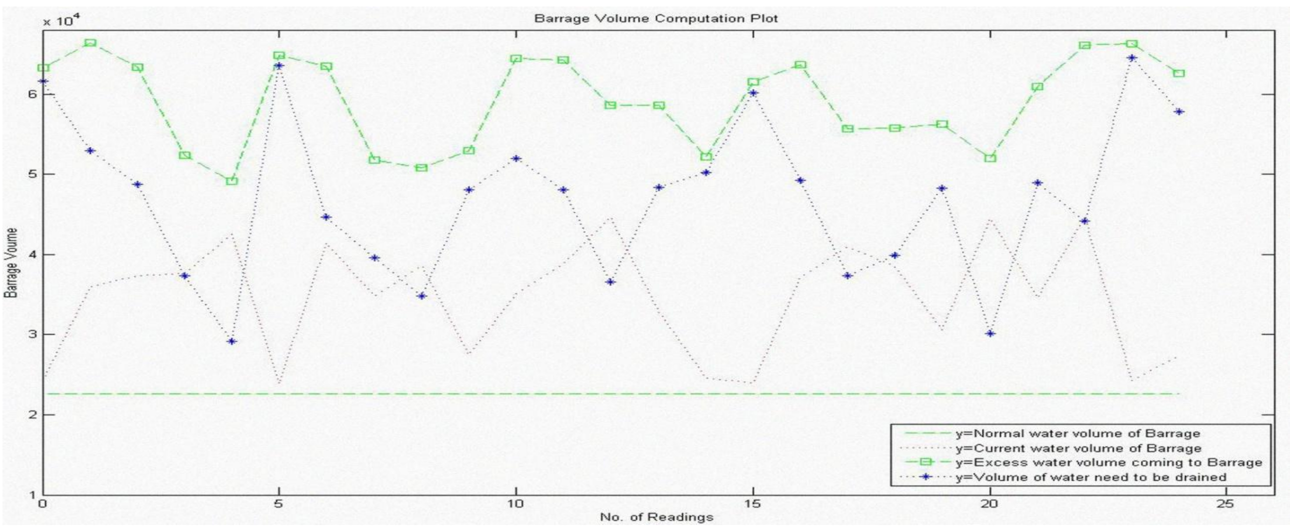


Fig.5 Plot of Water Volume

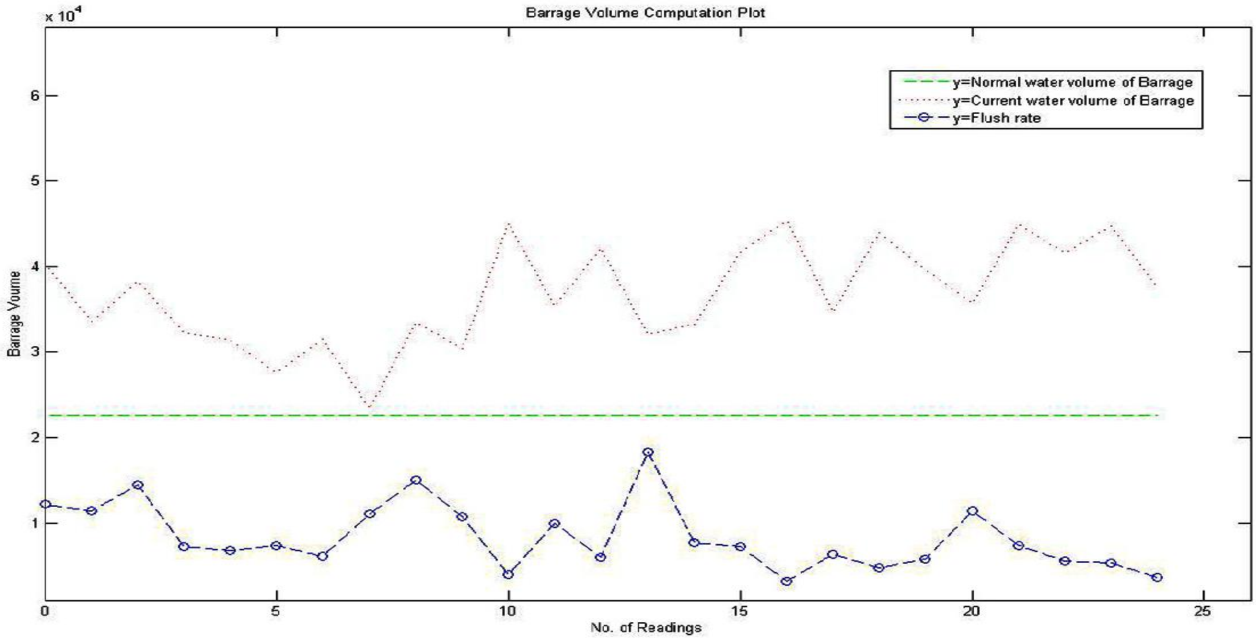


Fig.6 Plot of Flush Rate

Here we have plotted (Fig.5 & Fig.6) the water volume by taking the barrage volume in Y-axis and different successive readings noted as states in X-axis. The normal barrage volume, current water volume at Barrage, excess amount of water coming to the Barrage and the Volume of water that is need to be drained are plotted in Fig.5.The normal water volume, current water volume and flush rate

is plotted in Fig.6 The surplus volume of water computed by using FD Algorithm is flushed to maintain the normal water volume at barrage.
Hence we could sense and compute the accurate data to manage the water volume at barrage to avoid flood.

7. CONCLUSION & FUTURE WORK

The proposed model is an efficient model which helps in preventing flood due to the draining of excess water from barrage at a time. In this model the water from barrage is flushed in a controlled manner so that flood in the plain area is avoided.

The wireless sensor network (WSN) uses less resource like money, power and skilled manpower. This model is useful to deploy it in the developing and poor country. Hence we could minimize or stop the effect of flood, save the valuable resources that were affected by flood and empower the economy as well as resources of the country.The advantage of this model is that it uses minimum number of parameters and adopting an efficient NEC algorithm for optimized power consumption by increasing the sensor node life.

Future work involves performing field tests. Here we will observe the reading process communication process between the nodes and the real-time implementation of the distributed FD algorithm in situ.

In any adversary condition like any node failure due to any reason, how the intermediate node will take an active part will be shown in future.

The time of discharge to reach another node is computed by kinematics rule, considering only two parameter i.e. velocity and distance. For more accurate computation we would consider another parameter i.e. acceleration in our future work.

8. REFERENCES

[1] Flooddefinitionhttp://www.ga.gov.au/scientifictopics /hazards/flood/basics/what

[2] Type of flood, SAARC Disaster Management Centre. http://saarc-sdmc.nic.in/pdf/flood.pdf

[3] Everette Adams. *Preparatory Definitions for Understanding Target Localization in Wireless Sensor Networks*. IJEIT. Volume 2, Issue 11, May 2013

[4] Victor Seal, Arnab Raha, Shovan Maity, Souvik Kr Mitra, Amitava Mukherjee and Mrinal Kanti Naskar. *A simple flood forecasting scheme using wireless sensor networks.* International Journal of Ad hoc, Sensor & Ubiquitous Computing (IJASUC) Vol.3, No.1, February 2012

[5] Basha, Elizabeth, and Daniela Rus. "Design of early warning flood detection systems for developing countries." *Information and Communication Technologies and Development (ICTD) 2007. International Conference on*. IEEE, 2007.

[6] Basha, Elizabeth A., Sai Ravela, and Daniela Rus. "Model-based monitoring for early warning flood detection." *Proceedings of the 6th ACM conference on Embedded network sensor systems*. ACM, 5-7 November 2008.

[7] Danny Hughes, Phil Greenwood, Gordon Blair, Geoff Coulson, Florian Pappenberger, Paul Smith and Keith Beven. *An Intelligent and Adaptable Grid-based Flood Monitoring and Warning System (DRAFT).*UK eScience All Hands Meeting 5th, 2006

[8] Naveed Ahmad, Mureed Hussain, Naveed Riaz, Fazli Subhani, Sajjad Haider, Khurram.S.Alamgir, Fahad Shinwari. *Flood Prediction and Disaster Risk Analysis using GIS based Wireless Sensor Networks, A Review*.Journal of Basic and Applied Scientific Research. ISSN 2090-4304, 2013

[9] Lívia C. Degrossi, Guilherme G. do Amaral, Eduardo S. M. de Vasconcelos, João P. de Albuquerque, Jó Ueyama.*Using Wireless Sensor Networks in the Sensor Web for Flood Monitoring in Brazil*. Proceedings of the 10th International ISCRAM Conference. May 2013

[10] Jirapon Sunkpho and Chaiwat Ootamakorn. Songklanakarin J. Sci. *Real-time flood monitoring and warning system.* Vol.33 (2), 227-235, Mar. -Apr. 2011

[11] Yu, Liyang, Neng Wang, and Xiaoqiao Meng. "Real-time forest fire detection with wireless sensor networks." *Wireless Communications, Networking and Mobile Computing, 2005. Proceedings. 2005 International Conference on*. Vol. 2. IEEE, 2005.

[12] Ivan Stoianov, Lama Nachman, Sam Madden. *PIPENET: A Wireless Sensor Network for Pipeline Monitoring.* IPSN'07, April 25-27, 2007.

[13] Vinicio Anthone, Satoru Oishi. A *wireless mesh sensor network framework for river flood detection which can be used as an emergency communications network in case of disaster.* 11thInternational Conference on Hydroinformatics HIC 2014

[14] Sultanullah Jadoon, Salman Faiz Solehria, Mubashir Qayum1. *A Proposed Least Cost Framework of Irrigation Control System Based on Sensor Network for Efficient Water Management in Pakistan.* International Journal of Basic & Applied Sciences IJBAS-IJENS Vol: 11 No: 02. April, 2011

[15] Ultrasonic level sensor http://www.engineersgarage.com/articles/what-is-level-sensor?page=4

[16] Ultrasonic flow sensor http://en.wikipedia.org/wiki/Ultrasonic_flow_meter

[17] Ultrasonic flow meter http://www.engineeringtoolbox.com/ultrasonic-doppler-flow-meter-d_495.html

[18] F. Shebli, I. Dayoub and J.M. Rouvaen. *Minimizing energy consumption within wireless sensors networks.* Ubiquitous Computing and Communication Journal ,2007

[19] M.N.Halgamuge, M. Zukerman, and K. Ramamohanarao, H.L.vu. *An estimation of sensor energy consumption*. Progress in Electromagnetics Research B, Vol. 12, 259–295, 2009

[20] K.C. Patra. *Hydrology & Water resources Engineering*. 2nd edition .Alpha Science Intl Ltd 12 August, 2008

[21] A.K. Mohanty. *Fluid Mechanics*.Prentice-Hall of India Private Limited, Second edition 2004.

[22] Indira Priyadarshinee, Kabita Sahoo, Chandrakant Mallick. *Flood Prediction and Prevention through Wireless Sensor Networking (WSN): A Survey.* International Journal of Computer Applications Vol 113 No. 9, March 2015.