WSN-Based Water Channelization: An Approach of Smart Water

Hrusikesh Panda, Hitesh Mohapatra and Amiya Kumar Rath

Abstract The existing water monitoring system of India is incapable to regulate the excessive water flow which leads to potential water wastage. The overpopulation, unrestrictive water supply, irregular monitoring, and lack of awareness are the major hurdles for the deployment of smart water system (SWS) in India. In this state of the art, we present a simulation-based work to monitor the water flow in accordance with the demand for water by several regions. In our experiment, we have designed a protocol which regulates water flow according to the priority value. The proposed **p**riority-based **w**ater **d**istribution (PWD) protocol executes through two phases. The initial phase assigns priority values to the geographical belts like an emergency belt (EB), residential belt (RB), and industrial belt (IB) by the utility center (UC). In the second phase, we install a *sensor-based smart valve* which is regulated by the UC corresponding to the priority values of several belts. This novice method is addressing one of the open challenges of smart water grid (SWG), i.e., data analytics over wireless communications.

Keywords Smart water · Water management · Wireless sensor network · Water distribution network · Water grid

1 Introduction

Priority basis water supply is an important issue which is being faced worldwide. The resources such as electricity, natural gas, and water need to be managed carefully to ensure future use and sustainability [1]. SWS is a new paradigm with ICT convergence for future generations [2]. The ICT-based SWS is expected to be helpful to the human to deal with various contexts such as scarcity of water, maintaining water quality, and proper distribution of water according to the command and demand of the situation [3]. In order to improve the quality of life, reduce the effects of human activities and the way in which people utilize water new

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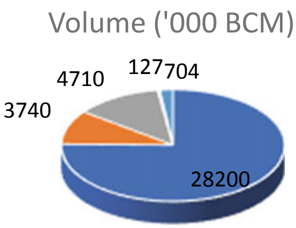
technologies are being searched [4, 5]. People living in developed and underdeveloped countries are facing problems like non-availability of clean water and water at right time. To meet the demand for clean water by the growing population and urbanization has become a challenge at present [6]. During the process of addressing this issue, it invites many parallel challenges such as cost of management, water transmission, storage, distribution, and billing for consumption of water. The lifestyle of the people is changing rapidly. At the same time, the capacity of the people to pay has also increased. These attributes have certain negative effects on the use of water [7] (Fig. 1).

The term SWS does not have any generic or worldwide accepted definition, and hence, the definition of SWS is always dependent on the situation and the country structure. Every country and cities define the term SWS as per their own conditions and adopt a scientific and technological solution to focus on its different parts. According to the population index of 2018, India stands at the second position after China. As the population of India is proliferating, the water foundation should be prepared to take care of expanding water demand by considering the resource constraint as a factor. Secondly, to ensure good quality of water for clients round the clock, the conditioning of involved assets in water supply must be maintained. Parallelly, India is marching toward a developed country with the support of industrialization. The demand for water supply from both the sectors, i.e., RB and IB, invites many challenges for proper channelization and customer satisfaction.

2 Literature Review

The remote communication infrastructure and 24/7 sensing make WSN as a reliable tool for SWS. The WSN-based condition assessment retrieves more dynamic and real-time data. The existing water supply is controlled by a valve which is human operated. The intervention of human is an operation creates the problem of delay, mismanagement, and dependency. Hence, the better understanding of WSN with the existing water supply system allows us to plan, design, manage, and operate SWS efficiently [7]. The implementation of WSN also extended to monitor the water



ITEM	VOLUME ('000 BCM)
Polar Ice and Glaciers	28200
Ground Water< 800 m deep	3740
800 - 4000 m deep	4710
Lakes and Rivers	127
Others (soil moisture and atmospheric vapors)	704

Fig. 1 Water availability status *Source* http://cwc.gov.in

quality in lakes and sea (Ex.MOBESEN Project) [8]. The WSN concepts also have been used for gauging the ion concentration level in the water through selective field effect transistors (ISFETs) and blind source separation (BSS) algorithm [9].

2.1 Residential

The water channelization process is increasingly drawing attention on the deployment and usage of SWS. The existing literature on smart water recognized several benefits over the traditional water supply system [10, 11]. The SWS provides the benefits of managing huge demand for water supply, water utilities, water billing, and water quality monitoring [12, 13]. As per the existing statistics, the per capita water consumption in India is estimated to 180 L and is distributed among various categories like personal hygiene (70 L), toilet flushing (40 L), dishes (25 L), laundry (20 L), drinking and preparation of food (15 L), and others (10 L) [14, 15]. However, the study says the average water consumption is nonlinear than linear. It seems the lack of importance of knowledge on usage of water in homes leads to heavy water wastage [16]. This field of study majorly focuses on the behavior and knowledge level of the end user. The term knowledge defines how, when, and by whom the water needs to be consumed for efficient water management [17, 18]. The lack of an efficient model needs intersection of sensor networking to operate on data basis.

2.2 Industrial

As per the water consumption statistics, industry stood second in the rank on water usage. The main source of water for the industrial sector is surface water and groundwater. The cost of supplying water is mainly decided by the administrator and by the government since the improper use of water becomes a normal practice [19]. Since the water supplied by the municipal water sources is not sufficient, ultimately industries are dependent on groundwater. (According to the ministry of water resources) [20].

2.3 Emergency

The effect of global warming largely influences on average rainfall. The irregular monsoon rains in most parts of India causes heavy rainfall with floods (Report by NDRF). After a natural calamity, constant supply of water for a long time is very necessary as per the situation concern. A new water supply system to facilitate disaster-resilient communities can be delivered from a traditional water distribution system by accommodating with WSN [19].

3 Proposed Work

In this section, we introduce a novice framework for water channelization monitoring. According to our proposed method, we divide the deployment geographical map into three specific zones such as IB, RB, and EB [20]. We have executed the simulation in Sambalpur district as our case study [21].

In each zone, we have deployed a fixed number of static sensor nodes which are responsible for data collection and transmission. Every SN is identified by SN_{id}. The traditional WSN architecture says that the SNs form clusters to maximize the lifetime of the network, where the cluster head (CH) monitors individual clusters. The CH is responsible for data aggregation and forwarding same to the base station (BS). In our proposed network, the UC acts as a base station which regulates the channelization task according to the data received from SNs.

PWD Algorithm

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Inputs;
Vp, Zid = 1,2,3;
Number of zones = Zid ;
Water Channelization Graph = Gw ;
Initialization;
SNi = 1, 2, 3, ...,n ;
FORM : Cluster ;
MAP: SNid › → Zid;
READ: Vp by SN ;
REPORT: SN → BS;
INSTALL: SVs ;
READ: Vp by BS ;
Channelize: Water Supply ;
while Vp ==  1 do
Redirect Water Supply ;
if Vp ≠ 1 then
Delay Amount of Time ;
else
Stop Water Supply ;
end
end
Repeat: Step 4 with Time instance Ti
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3.1 Motivation

The motivation of work begins with a report produced by Associated Chambers of Commerce and Industry of India (ASSOCHAAM). This report revealed that the gap between supply and demand of water being nearly 1300 million liters. It is noted by PH division of Odisha that the state suffers a daily loss of nearly 150 million liters of drinking water because of non-uniform distribution of water among various regional belts. Secondly, the traditional water distribution network is operated through human intervention [22]. The lack of awareness among people regarding water scarcity leads to potential water waste [23, 24].

3.2 Methodology

Based on the specification and design requirement, the flow diagram is shown in Fig. 2. This flow diagram defines the overall functions to be performed by the system. This system contains three belts which are represented by SNs in the simulation environment. The distribution management unit is deployed with smart sensors which are operating on the basis of decisions taken by UC. The SNs or individual units of sensor network periodically report their status to the BS. Here, the status defines the priority value (V_p) of several zones according to their demands where V_P. When the priority value becomes 1 the UC redirects the water supply towards that zones subsequently to others according to their priority values. In Fig. 3, we have illustrated the flow diagram of the proposed model.

3.3 Results and Analysis

This paper mainly focuses to present the remote sensing-based water channelization system, only by considering few static SNs. This piece of work is simulated in Cupcarbon (SCI-WSN) simulator. Here, we assumed the UC availed with 24/7 water availability, the SNs are static in nature, as the SNs are domestically deployed there provided with time to time energy backup, and the SNs are in the coverage zone of sink node. Initially, the SNs are mapped with specific zones. Then, according to the command and demand of the situation, the V_p of several belts is updated with the time instance t_i. On the basis of data aggregated with the sink node or BS, the UC is taking decisions regarding channelization of water to a specific zone. Figure 5 illustrates the mapping of SNs with the zones (Z_{id}). The deployment of sensor node (SN) is illustrated in Fig. 4.

In the case of traditional water distribution network (WDN), the water gets supplied non-uniformly among several zones which leads to huge customer dissatisfaction. In Sambalpur zone, during the summer season, the water supply to the

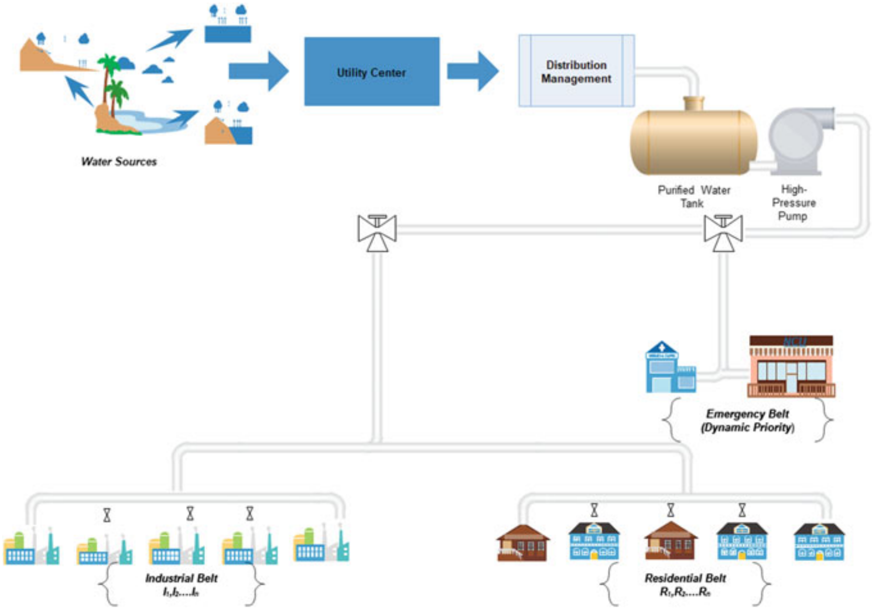

Fig. 2 Model of PWD system

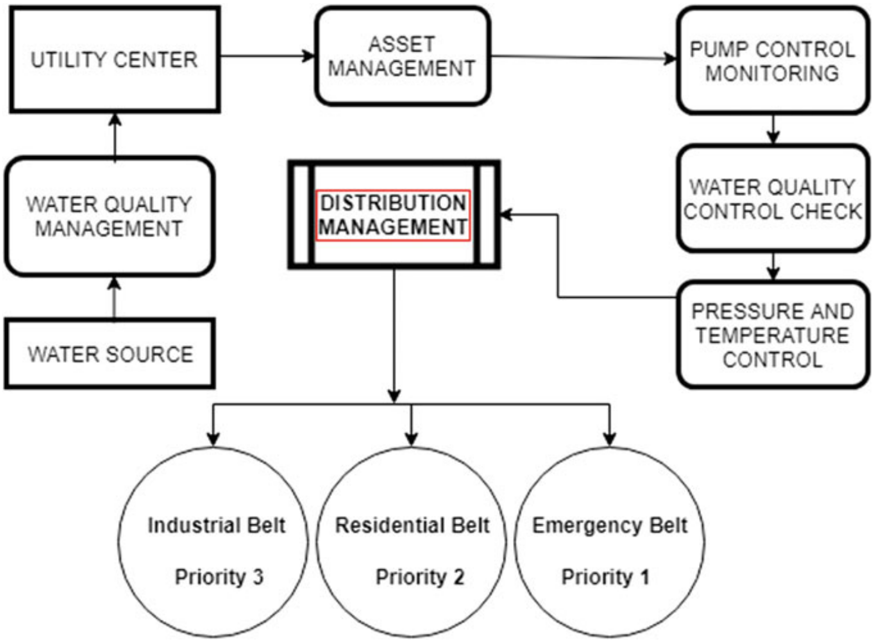

Fig. 3 DFD of proposed model

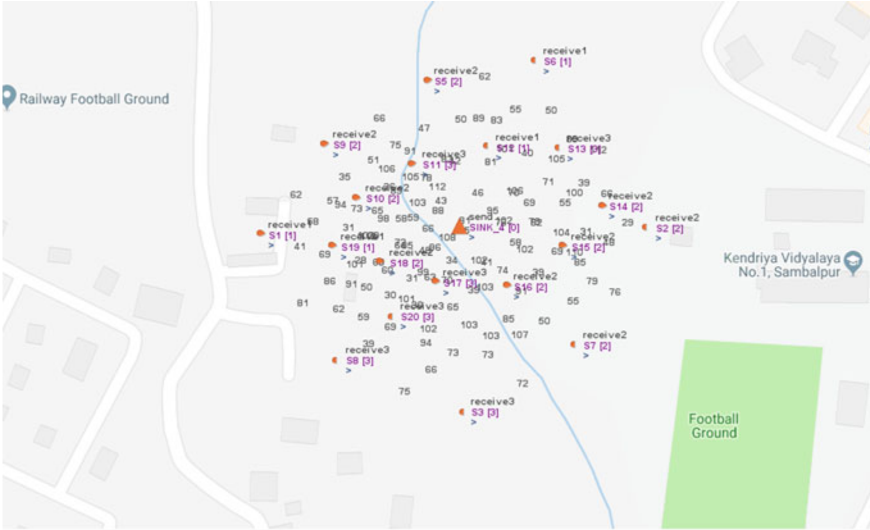

Fig. 4 Node deployment

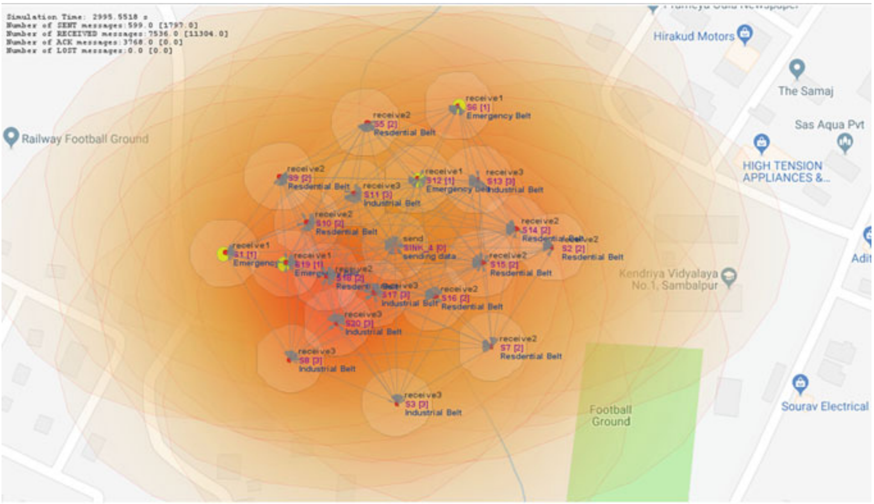

Fig. 5 Mapping phase

urban areas lasts for 13-15 min at maximum. Somehow, the existing WDN fails to reach up to the customer's expectation level. The result of such mismanagement costs in terms of revenue generation, customer satisfaction, and artificial scarcity of water. In Fig. 6, we have illustrated the uniform water supply to various zones according to the assigned time. In this figure, the Y-axis represents water resource

Fig. 6 Optimized water supply scheduling

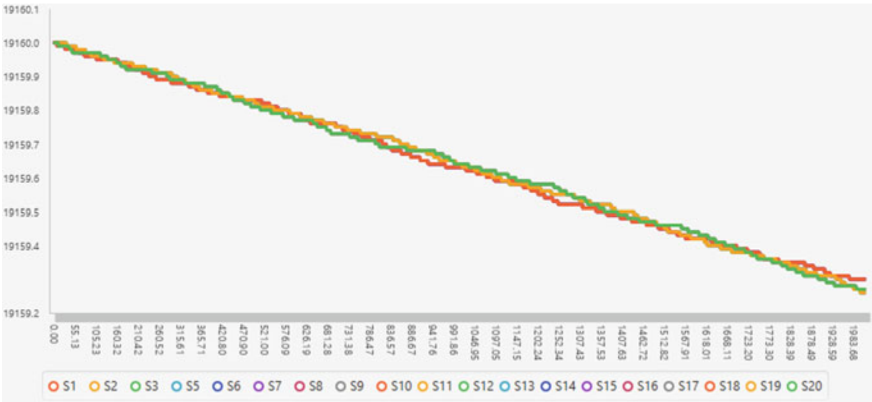

Fig. 7 Uniform water resource consumption

consumption rate, whereas the X-axis represents the SNs. Through our simulation, we have concluded that, when the water supply among various zones are uniform in nature, the sustainability os smart water lasts for long time and we can efficiently manage the water resource by avoiding surplus water supply to a specific zone. In Fig. 7, we present the uniform nonlinear water consumption rate.

4 Conclusion

In this state of the art, we have presented a WSN-based remote water channelization model. The water is a non-renewable resource; so, efficient resource management is needed. This model is implemented logically with SCI-WSN simulator where we have considered the district Sambalpur, Odisha, India as our area of study. The proposed system reduces human intervention as a controller for water channelization. The sensor-based smart valve is an automatic water channelizer. This piece of work can be extended by applying dynamic water demand from several zones.

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