



## Application of Connected Dominating Set (CDS) in Wireless Sensor Networks – Water Management System(WMS)

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**Abstract:** Wireless Sensor Channel is unreliable in nature, and number of obstacle can prevent transmission of packet from a receiver to a sender. One of the important obstacles is interference because of many devices. If two or more transmitters transmit on the same channel their signal overlap, they may interrupt each other's signal. This needs to be solved by retransmission, which will increase the time and energy. Therefore, new network architecture, named as Connected Sensor Dominating System (CSDS), has been proposed. Considering that the Connected Dominating Sets (CDSs) are commonly used to support data collection and network communication in wireless networks, and thus we will also investigate the CDS construction problem in Sensor Devices. Such technology extremely expands the scope of the IoT applications. In a typical CSDS network, the only dominating nodes are equipped with any sensor devices which connect other nodes. In this paper, the problem of constructing CDS in a CSDS network is formally used in Water Management System (WMS).

**Keywords:** Dominating Set; Connected Dominating Set; IoT; Wireless Sensor

### I. INTRODUCTION

Graph theory has been widely used to study and model various applications, in different areas. In chemistry, graph theory has been used in the study of molecules, construction of bonds and the study of atoms. In sociology, it is used to explore diffusion mechanisms. In conservation efforts where a vertex represents regions where certain species exist and the edges represent migration path or movement between the regions. It is also used in the study of breeding patterns, tracking the spread of disease, parasites and in the study of impact of migration that affect other species. Graph theoretical concepts are widely used in Operations Research. It has wide number of applications in modeling transport networks, activity networks, theory of games and to solve large number of combinatorial problems. The most popular and successful applications of networks in operations research is the planning and scheduling of large complicated projects.

Wireless Sensor Networks (WSNs) have attracted recent research attention due to wide range of network communications applications they support. In WSNs, all nodes are energy constrained. It includes a number of wireless nodes which can be divided into three parts: data management centre, data collection, and based-station. There is no fixed or predefined infrastructure in these networks. A kind of broadcasting in sensor networks is normally

flooding-based, where each node retransmits the broadcasting message that it receives. It raises energy consumption because packet retransmission is needed when interference occurs.

A Connected Dominating Set (CDS) is a subset of nodes that is able to perform data communication tasks and to serve nodes that are not in the communication. A CDS can be selected as a communication layer, and only the nodes in the CDS transmit data. It is greatly reducing the transmission of redundant information, simplifying the topology of the network, saving the energy for information gathering and filtering, routing and forwarding information required.

In recent years, wireless sensor networks (WSNs) have wide range of applications in various fields. A WSN comprises of independent sensor nodes that sense and transfer physical information to the sink. Cheap and small sized sensor nodes cannot be equipped with a large battery source. As these sensors have limited energy, it restricts the sensors to use limited memory, limited transmission power and perform limited computations to increase the lifetime of sensor. Network and data link layers in a sensor node play a vital role in the WSN communication. The energy problem is usually solved by the sensor node by changing its state.



Water is an essential resource for all life on the planet. Of the water resources on earth only three percent of it is fresh and two-third of the fresh water is locked up in ice and glaciers. As time advances, water is becoming scarcer and having access to clean, safe, drinking water is limited among countries. Nowadays, only 0.08 percent of the world's fresh water is exploited by human that increases the demand of water. The remaining small percentage of fresh water should be optimized from natural resources which have been a continuous difficult process in various parts of the world.

Unlike other utility energy water does not have any alternative source and thus it is a scarce product. Consumption of water needs to take care to save the scarce resources. Pure water production is an unpredictable and till date there is no solution. Well renovation, rain water harvesting and ground water refresh had played a vital role in water conservation. Groundwater will run out soon since population of the earth has been increasing rapidly. Hence water conservation must be the responsibility of every individual in the world.

IoT plays a major role to conserve water through its sensor devices. These scarce devices are used to identify the excess usage of water and leakage problems. These devices need to be fixed and has to communicate to get the actual information. Hence in this paper in order to optimize the usage of these devices, dominating set is used to identify the CSDS and thus minimizes the number of devices used which will increase the clarity in communication.

## II. DOMINATING SET

### A. Dominating Set

Let  $G = (V, E)$  be a simple connected graph of order  $n$ . For any vertex  $v \in V$ , the open neighborhood of  $v$  is the set  $N(v) = \{u \in V / uv \in E\}$  and the closed neighborhood of  $v$  is the set  $N[v] = N(v) \cup \{v\}$ . For a set  $S \subseteq V$ , the open neighborhood of  $S$  is and the closed neighborhood of  $S$  is  $N[S] = N(S) \cup S$ . The maximum degree of the graph  $G$  is denoted by  $\Delta(G)$  and the minimum degree is denoted by  $\delta(G)$ . [7] A set  $S$  of vertices in a graph  $G$  is said to be a dominating set if every vertex  $v \in V$  is either an element of  $S$  or is adjacent to an element of  $S$ . A set  $S$  of vertices in a graph  $G$  is said to be a total dominating set if every vertex  $v \in V$  is adjacent to an element of  $S$ . A total dominating set  $S$  of  $G$  is called a connected total dominating set if the induced subgraph  $\langle S \rangle$

is connected. The minimum cardinality of a connected total dominating set of  $G$  is called the connected total domination number and is denoted by  $\gamma_{ct}(G)$ .

### B. Dominating Set in Computer Networks

The information between the nodes is well routed using the dominating set nodes between the computer and communication networks. A wireless network is a type of computer network that uses wireless data transmission by connecting the wireless network nodes. Cell-phone network, mobile Ad-hoc network, wireless sensor network etc. are some of the examples of Wireless Sensor Network.

### C. Dominating Set in Wireless Sensor Network

The mobile devices in wireless mode are connected using the less self configurable infrastructure network Mobile Ad Hoc Network (MANET). In Mobile Ad Hoc networks for routing and broadcasting the information the dominating set theory has been used. To provide different communication primitives such as routing, broadcasting etc. a Connected Dominating Set (CDS) is widely used for MANETs.

"The connected dominating set is defined as a subset of nodes in a wireless network such that each node in the network is either present in the set or as a neighbor of some node in the set and the induced graph with the nodes in the set is connected". [4] discussed that the activity related status data will be communicated consistently and shared among drivers through VANETs keeping in mind the end goal to enhance driving security and solace. Along these lines, Vehicular specially appointed systems (VANETs) require safeguarding and secure information correspondences. Without the security and protection ensures, the aggressors could track their intrigued vehicles by gathering and breaking down their movement messages. A mysterious message confirmation is a basic prerequisite of VANETs. To conquer this issue, a protection safeguarding confirmation convention with expert traceability utilizing elliptic bend based chameleon hashing is proposed. Contrasted and existing plans Privacy saving confirmation utilizing Hash Message verification code, this approach has the accompanying better elements: common and unknown validation for vehicle-to-vehicle and vehicle-to-roadside



interchanges, vehicle unlinkability, specialist following capacity and high computational effectiveness.

### III. WIRELESS SENSOR NETWORKS IN IoT

#### A. IoT Applications

One of the highly developed automation and analytics system is IoT (Internet of Things) using which we can exploit sensing, artificial intelligence, machine learning and big data to distribute whole systems for a service. When applied to industry these systems allow greater transparency, control, and performance.

They enhance data collection, automation, operations, and much more through smart devices and powerful enabling technology. IoT systems have applications across industries through their unique flexibility and ability to be suitable in any environment.

One of the greatest challenges in the engineering of buildings remains management of environment and conditions due to many factors at work. These factors include building materials, climate, building use, and more. Managing energy costs receives the most attention, but conditioning also impacts the durability and state of the structure.

The structure design and managing existing structures can be improved by IoT through more accurate and complete data on buildings. It provides important engineering information to know how fine a material performs as insulation in a particular design and environment.

#### B. Smart Homes using IoT

IoT is a buzz word which will play an important role in creating Smart Home. This will help us to switch on air conditioning before reaching home or switch off lights even after we have left home, to unlock the doors for temporary admission even when we are not at residence. IoT helps to make our life easy and suitable for us. Smart Home has become the innovatory of success in the housing and it is predicted that it will be as common as Smart Mobiles. Smart Home Companies like Ring, Nest, Exobee will help to make our life smarter and unexpected luxury life using IoT.

#### C. Need for Water Management System (WMS)

Utility companies are scrambling to meet the demand of human energy since they are consuming more energy every year. By 2040 the demand for energy increases by 37% which will lead to scarcity of energy. The IoT is making energy use more efficient, which should help relieve some of the stress on energy demand. Among the Utility companies, in the last few years smart meters become the top IoT devices. To manage energy flow into buildings these devices are attached to the buildings and finally connected to a energy grid. IoT helps the energy industry such as water, electric, gas and oil.

#### D. Sensors in WMS

Temperature, water quality, pressure, consumption are tracked by the Smart Sensor devices. The data is sent to the water utility company which is analyzed using the software and transform in a customer centric easy format. This helps to compare the consumption throughout the city and also compare with the previous month utility of the same customer. Water leak detectors help to identify the leaking pipe in a specific house of a building which helps to repair the same to save the water. Several companies like Fibaro, Samsung, Honeywell, Sensaphone, Insteopn, started manufacturing smart water sensor devices and water leak detection devices.

### IV. PROPOSED ARCHITECTURE

#### A. Connected Dominating Set(CDS)

A Dominating Set DS is a subset of nodes such that each node is either in DS or has a neighbor in DS. A Connected Dominating Set CDS is a connected DS, that is, there is a path between any two nodes in CDS that does not use nodes that are not in CDS. A CDS is a good choice for a backbone. It might be favourable to have few nodes in the CDS. This is known as the Minimum CDS problem.

#### B. Dominating Set in WMS

Water Management System needs to be done using sensor devices in the places where water leakage and use of water is more. In an apartment, lot of houses will be there and device usage will be more. To reduce the usage of





sensor devices CSDS is used. Various parameters used for identifying Dominating set is

1. Heavy usage of water
2. Usage of Old pipes
3. Main pipe inlet inside the house
4. All Water tank outlet
5. Other Criteria

These parameters helps to find the DS and sensor devices were fixed in the places of dominating set. Initially these 5 parameters were used to minimize the device fixation. Houses are represented as nodes and by considering anyone of the above parameters, the edges are drawn between the nodes. The number of sensor nodes where the devices need to be fixed is more which leads to lot of interferences. In order to avoid this we need to reduce the nodes. By Connected Dominating Set we can identify Dominating nodes through the above mentioned parameters. These CSDS will communicate to other nodes and helps to get clear communication.

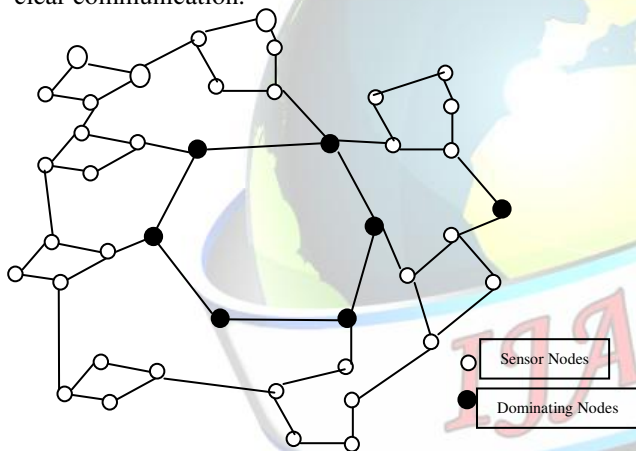


Fig 4.1 Sensor Nodes after CDS

#### C. Advantages of CDS in WMS

Water is the scarce resources which need to be saved. The main advantage of CDS in WMS helps to reduce the usage of sensor devices which in turn increases the capacity of devices and reduces the overlap of sensor communication signals. Thus this will improve the efficiency of communicating sensor devices and give a clear understanding to make correct decision in water saving.

#### V. CONCLUSION

Water management impacts on several key matters of human lives and several scenarios, such as cities, natural areas, agriculture, etc. In this paper, an initiative for defining reference architecture for water management based on integrating IoT capabilities to achieve a scalable and feasible industrial system have been presented. This Connecting Dominating Set Architecture will reduce the number of usage of sensor devices and helps to improve the performance of the devices.

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