



Energy Aware Target Coverage Protocol for WSN

Priyanka Pandey¹, Raghvendra Kumar², Prasant Kumar Pattnaik³

¹Department of Computer Science and Engineering, Takshshila Institute of Engineering and Technology, Jabalpur, M.P., India

²Department of Computer Science and Engineering, Lakshmi Narain College of Technology, Jabalpur, M.P., India

³School of Computer Engineering, Kalinga Institute of Industrial Technology University, Bhubaneswar, Odisha, India

Email address:

pandeypriyanka906@gmail.com (P. Pandey), Raghvendraagrawal7@gmail.com (R. Kumar), pattnaikprasantfcs@kiit.ac.in (P. K. Pattnaik)

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Abstract: In this paper, concentrate on scheduling sensors between sleep and active modes to maximize network life time while maintaining target coverage and consuming minimum energy. In this work, we try to develop an Energy Aware Target Coverage Protocol in which we have considered that if a target is with in the receiving / transmitting range of two or more sensors nodes, then only one of the sensor node may be initiated to cover the specific target while the other sensor nodes of that receiving / transmitting range may not require to participate, which help to minimize participation of sensor nodes to cover the specific targets, there by consuming minimum energy. Our result analysis brings a considerable amount of energy saving without affecting the coverage problem.

Keywords: Wireless Sensor Network, Target Coverage, Energy Aware Protocols, Sensor Nodes

1. Introduction

An important issue of wireless sensor networks is energy conservation. Energy constrained wireless sensor networks are usable as long as they can communicate sensed data. Sensing and communications consume energy, there for judicious energy management and sensor scheduling can effectively extend network lifetime. To cover a set of targets with known locations when ground access in there remote area is prohibited, one solution is to deploy the sensor remotely, from an aircraft. The lack of precise sensor placement is compensated by a large sensor population deployed in the drop zone that would improve the probability of target coverage. The data collected from the sensors is sent to a central node (e.g. cluster head) for processing.

Most existing works concentrate on scheduling sensors between sleep and active modes to maximize network lifetime while maintaining target coverage and consuming minimum energy. In this work, we try to develop an Energy Aware Target Coverage Protocol where we have considered that if a target is with in the receiving / transmitting range of two or more sensors nodes, then only one of the sensor node may be initiated to cover the specific target while the other sensor nodes of that receiving / transmitting range may not require to participate, which help to minimize participation of sensor nodes to cover the specific targets here by consuming minimum energy. Our result analysis brings a considerable

amount of energy saving without affecting the coverage problem.

The increased demands for mobility and flexibility in our daily life are demand that lead the development from wired LANs to wire less LANs (WLANs). Today a wired LAN can of high bit rates to meet the requirements of bandwidth consuming services like video conferences, streaming video etc. With this in mind a user of a WLAN will have high demands on the system and will not accept too much degradation in performance to achieve mobility and flexibility. This will in turn put high demands on the design of WLAN so the future. During the last few years Wireless mesh networking has become increasing sand the preferred mechanism to provide coverage to campuses, small towns, etc. In Wireless mesh network a subset of the wireless nodes are connected to the wired backbone and provide connectivity to the other nodes in the network through multi hopping over the wireless links. As a natural extension to WLANs, the medium access mechanism of choice for these networks is the CSMA / CA based IEEE802.11 distributed MAC protocol. While IEEE802.11 MAC protocol was designed for and provides are as on able performance in a single hop network, It results in severe performance degradation in a multi-hop setting. In a single hop 802.11 network, all nodes contend for the channel with equal opportunity and act as greedy as possible to increase their one hop through put which directly results in increase of the

network aggregate throughput. In a multi hop network, however, the greedy behavior of the nodes may result in service degradation as the packets transmitted by a source might not reach their final destination due to network congestion. In a congested network packets might be dropped in an intermediate node. Such a behavior will result in waste of the system resources used to deliver the packets to the intermediate node. A congestion control scheme insures that the nodes place only as many packets on the wireless channel as can be delivered to the final destination. End-to-end schemes like TCP are the preferred solution in the Internet due to their scalability characteristics. In a wireless mesh network, however, a hop-by-hop congestion control scheme can be more appropriate as such a network does not have the scalability problems of the large-scale Internet. A layer to hop by hop solution reacts more quickly to congestion and is effective regardless of the traffic type.

Security of the nodes and data in a network are also required to be of high standard and is a big issue in MANET. Due to dynamic behavior of the nodes, security becomes a necessity in such a network to be considered at the top. The technology of Mobile Ad-hoc Networking is somewhat synonymous with Mobile Packet Radio Networking, Mobile Mesh Networking and Mobile, Multi hop, Wireless Networking. There is current and future need for dynamic ad-hoc networking technology. The emerging field of mobile and computing, with its current emphasis on mobile IP operation, should gradually broad require highly adaptive mobile networking technology to effectively manage multi hop, ad-hoc network clusters which can operate autonomously or, more than likely, be attached at some point (s) to the fixed Internet. MANET can be established extremely flexibly without any fixed base station in battle fields, military applications, and other emergency and disaster situation. Some applications of MANET technology could include industrial and commercial application involving cooperative mobile data exchange. In addition, mesh based mobile networks can be operated as robust, inexpensive alternatives or enhancements to cell-based mobile network infrastructures. There are real so existing and future military networking requirements for robust, IP-compliant data services within mobile wireless communication networks many of these networks consist of highly dynamic autonomous topology segments. Also, the developing technologies of "wearable" computing and communications may provide applications for MANET technology. When properly combined with satellite-based information delivery, MANET technology can provide an extremely flexible method for establishing communications for fire safety and rescue operations or other scenarios requiring rapidly-deployable communications with survivable, efficient dynamic networking. There are like other applications for MANET technology which are not presently realized or envisioned by the authors. It is simply put, improved IP-based networking technology for dynamic, autonomous wireless networks.

1.1. Wireless Local Area Network

A wireless local area network (WLAN) links two or more devices using some wireless distribution method and usually providing a connection through an access point to the wider internet. This gives users the mobility to move around within a local coverage area still be connected to the network. A wireless LAN is based on a cellular architecture where the system is sub divided into cells, where each cell is controlled by a Base station.

1.2. Wireless LAN Standards

Those are currently being explored in the field of communications technology are:

1. IEEE 802.11
 - a 802.11a
 - b 802.11b
 - c 802.11g
 - d 802.11e etc.
2. HIPERLAN/2
3. Bluetooth
4. Home RF

1.3. Wireless Mesh Network (WMN)

WMNs, generally described, consist of two types of nodes: mesh router and mesh clients. The difference between a conventional router and a mesh router, a part from the mesh functionality, is that the latter can achieve the same coverage with lower transmission power through multi-hop communications. As regards to mesh clients, they also have necessary mesh function and can thus behave as a router. On the other hand, gateway or bridge functions do not exist in these nodes. Additionally, mesh clients have only one wireless interface.

1.4. Mobile Ad-Hoc Networks

Wireless Ad-hoc network, with shared wireless channel to transmit messages, faces complicated wireless transmission environment, which will bring in a series of new problems, especially with routing, congestion being one of the problems. Generally speaking, for wireless Ad-hoc network, the calculation of the congestion control of one certain link should not just be based on the congestion of the link itself, instead, it should respond according to the general congestion message that interrupt the link. Therefore, to solve the routing congestion which might come up with the Ad-hoc network, the following issues should be taken into consideration:

1. The intrinsic properties of wireless multiple-hop links
2. The time varying of network topology
3. Dynamic end users

More and more advancements in wireless communication technologies and availability of less expensive, small, portable computing devices led to mobile computing and its applications. A "mobile ad-hoc network" (MANET) consists of mobile nodes connected by wireless links. The union of

which forms an arbitrary graph. The nodes are free to move randomly thus, the network topology may change rapidly and unpredictably. During the last few years Wireless mesh networking has become increasingly ubiquitous and the preferred mechanism to provide coverage to campuses, small towns, etc. In Wireless mesh networks a subset of the wireless nodes are connected to the wired backbone and provide connectivity to the other nodes in the network through multi hopping over the wireless links. As a natural extension to WLANs, the medium access mechanism of choice for these networks is the CSMA/CA based IEEE 802.11 distributed MAC protocol. While IEEE 802.11 MAC protocol was designed for and provides as on able performance in a single hop network, it results in severe performance degradation multi hop setting. In a single hop 802.11 network, all nodes contend for the channel with equal opportunity and act as greedy as possible to increase their one hop throughput which directly results in increase of the network aggregate throughput. In a multi-hop network, however, the greedy behavior of the nodes may result in service degradation as the packet transmitted by a source might not reach their final destination due to network congestion. In a congested network packets might be dropped in an intermediate node. Such a behavior will result in waste of the system resources used to deliver the packet to the intermediate node. A congestion control scheme insures that the nodes place only as many packets on the wireless channel as can be delivered to the final destination. End-to-end schemes like TCP are the preferred solution in the Internet due to their scalability characteristics. In a wireless mesh network, however, a hop-by-hop congestion control scheme can be more appropriate as such a network does not have the scalability problems of the large-scale Internet. A layer 2 hop by hop solution reacts more quickly to congestion and is effective regardless so the traffic type. The idea of Ad-hoc Networking is gaining popularity with the recent proliferation of mobile computers like laptop and palmtops. Minimal configuration, absence of infrastructure and quick deployment make Ad-hoc Networks convenient for emergency operations. Since host mobility causes frequent and unpredictable topological changes, the formation and maintenance of Ad-hoc Network is not only a challenging task and a wired networks.

Ad-hoc Routing Protocols are classified into Proactive and Reactive type. Proactive routing protocols use the periodic update of information to know about the current topology while the reactive routing protocols create a route to a destination on demand basis. Few of the proactive protocols are DSDV, WRP, and DBF etc. while DSR, AODV, and ABR are few examples of reactive protocols. Even though no protocol is superior to the other, but the previous studies indicate that in general reactive protocols exhibit better performance than proactive protocols. A wireless sensor networks (WSNs) is a formation of number of nodes (even hundred of it) that communicates with each other to perform sensing process. Normally each node equip with a battery to power it up, a main board with a chip and memory that act as

a CPU for the nodes. Each node has sensing capabilities thus to able sense the environment information (temperature, earthquake and etc) and process the information to be send through the network. Node can be hundred and each of the nodes connects each other to form a network communication. All the nodes will be monitor and control by a base station or sink which responsible to receive all information sensed by the nodes. In recent years, wireless sensor networks have been applied into real time application such as environment monitoring, health monitoring and military where the data in this application is considered as critical.

2. Related Work

Sensor nodes have size, weight and cost restrictions, with direct impact on resource availability. They have limited battery resources, processing and communication capabilities. As replacing the battery is not feasible in many applications, low power consumption is one of the most important requirements of a sensor network. Various power efficient schemes have been proposed in literature, not only at the hardware and architectural design, but also when designing algorithms and protocols at all layers of the network architecture.

In sensor target coverage problem, the goal is to have each target or point in the physical space of interest within the sensing range of at least one sensor. Given m targets with known location and energy constrained wireless sensor network with n sensors randomly deployed in the targets' vicinity, schedule the sensor nodes activity such that all the targets are continuously observed and network life time is maximized.

Cardei and Du address the target coverage problem where disjoint sensor sets are model disjoint set covers, such that every cover completely monitors all the target points. The sensor nodes are divided into disjoint sets, such that every set can individually perform the coverage tasks. These sets are then activated successively, and while the current sensor set is active, all other nodes are in the sleep mode. The goal of this approach is to determine a maximum number of disjoint sets, as this has a direct impact on conserving sensor energy resources as well as on prolonging the network life time.

Cardei, Thai, Li and Wu [1] proposed an efficient method to extend the sensor network life time by organizing the sensors into a maximal number of non-disjoint set covers that are activated successively, with sensor nodes allowed to participate in multiple sets. Only the sensor nodes from the current active set are responsible for monitoring all targets and for transmitting the collected data, while all other nodes are in a low-energy sleep mode. By allowing sensor nodes to participate in multiple sets, the network life time increase as compared to existing work.

3. Proposed Work

We propose that in the formation of non-disjoint set covers of sensor nodes to cover the specific targets, if a target is

within the sensing range of two or more sensor nodes, then only one of the sensor nodes may be initiated to monitor the specific target while the other sensor nodes of that sensing range may not be required to participate, as shown in Figure1. This prevents unnecessary wastage of the energy as each sensor node consumes a specific amount of energy to continuously sense a target.

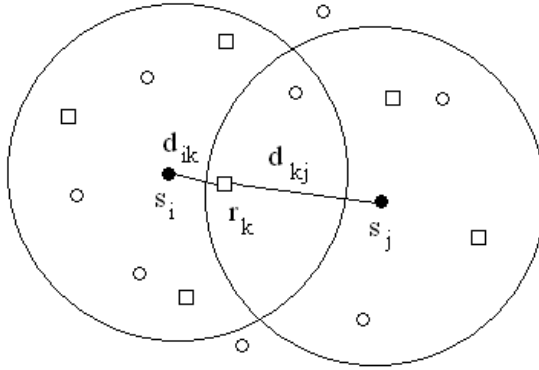


Figure 1. Coverage of a target by sensor nodes based on shortest Euclidean distance between them.

Algorithm: Algorithm for Coverage of targets by sensor nodes based on shortest Euclidean distance between the sensor nodes and the targets.

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for i ← 1 to n
  do for j ← 1 to n
    do for k ← 1 to m
      do if ( dik ≤ Wi ) && ( dkj ≤ Wj )
        find t ← min( dik, dkj )
        st = si ∪ rk
        if ( t = i )
          sj = sj - rk
        else if ( t = j )
          si = si - rk

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Consider as scenario in which there are five number of targets (r_1, r_2, r_3, r_4, r_5) which are being covered by a set of six sensor nodes ($s_1, s_2, s_3, s_4, s_5, s_6$) with the sensor-target coverage relationship known as: $s_1 = \{r_1, r_5\}$, $s_2 = \{r_1, r_2\}$, $s_3 = \{r_2, r_3\}$, $s_4 = \{r_3, r_4\}$, $s_5 = \{r_4, r_5\}$, $s_6 = \{r_1, r_2, r_3, r_4, r_5\}$ and the Euclidean distance assume as how n in Table 1. Here each sensor node's sensing range is assumed to be 41 unit of distance.

Table 1. Assumed Euclidean distance between the sensor nodes and the targets.

$d_{11}=32$	$d_{12}=63$	$d_{13}=75$	$d_{14}=61$	$d_{15}=40$
$d_{21}=38$	$d_{22}=22$	$d_{23}=67$	$d_{24}=91$	$d_{25}=88$
$d_{31}=71$	$d_{32}=37$	$d_{33}=24$	$d_{34}=64$	$d_{35}=79$
$d_{41}=93$	$d_{42}=80$	$d_{43}=36$	$d_{44}=30$	$d_{45}=56$
$d_{51}=98$	$d_{52}=105$	$d_{53}=76$	$d_{54}=36$	$d_{55}=37$
$d_{61}=37$	$d_{62}=37$	$d_{63}=37$	$d_{64}=37$	$d_{65}=37$

According to the work in [1], the sensor nodes get organized to six non-disjoint set covers to monitor the targets for a maximum duration (assuming that a sensor node covers the target if the Euclidean distance between the sensor node and the target is smaller or equal to the sensing range of the node) : $SC_1 = \{s_6\}$, $SC_2 = \{s_2, s_3, s_5\}$, $SC_3 = \{s_2, s_4, s_5\}$, $SC_4 = \{s_1, s_3, s_4\}$, $SC_5 = \{s_1, s_2, s_4\}$, $SC_6 = \{s_1, s_3, s_5\}$. Energy

In Figure 1, target r_k is within the sensing range of sensor nodes s_i and s_j (denoted by W_i and W_j respectively). It may be possible to assign one of these nodes to cover the target based on the shortest Euclidean distance between the sensor node and the target, i.e. if ($d_{ik} \leq d_{kj}$), then $s_i = \{r_k\}$ else $s_j = \{r_k\}$ as shown in algorithm.

s_i, s_j - sensors

r_k - target

d_{ik} - distance between sensor i and target k

d_{kj} - distance between sensor j and target k

consumed by a sensor node to cover a particular target in each set cover is represented by a unique rectangular box as shown in the Figure 2. Here, if each sensor node consumes X unit of energy to keep track of a target, the total energy consumed by all the sensor nodes is $35 \times$ units of energy.

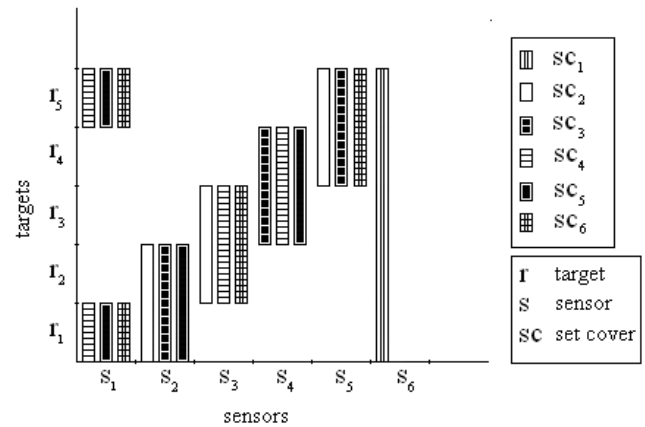


Figure 2. Coverage of targets by sensor nodes in different set covers according to work in [1].

However we propose that the targets, which are within the sensing range of more than one sensor node, may be covered by only one of these nodes having the minimum distance to the target. For instance in set cover SC_2 , r_2 is covered by s_2 and s_3 . So here r_2 now would be covered only by s_2 due to the shortest distance between them. Rest calculation is done similarly as shown in Figure 3. Here, the total energy consumed by all the sensor nodes is $30 \times$ units of energy, thus a saving of $5 \times$ units of energy. This method in certain situations may result in load balancing between the sensor nodes. In this paper the protocol for smooth management of the Target Coverage Scenario where the energy consumption is lower as compared to the existing protocol.

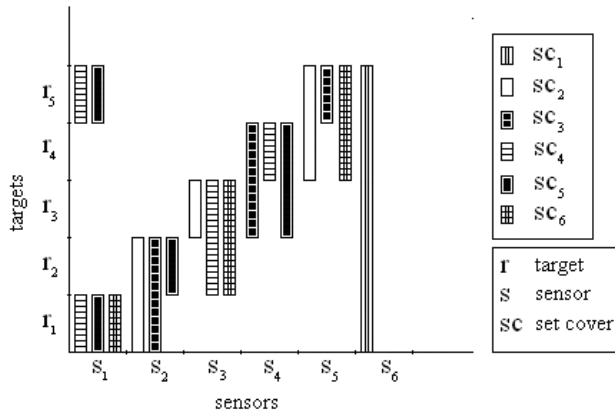


Figure 3. Coverage of targets by sensor nodes in different set covers.

4. Conclusion

Coverage of the specific targets is an important concern in Wireless Sensor Network. In this paper discussed the basic Target Coverage Problem and some related work to energy efficient coverage of the specified targets taking into consideration maximization of network life time and minimum participation of the sensor nodes while performing the coverage task. Energy is the scarcest resource of the sensor nodes. So, taking into consideration the judicious management of the energy resources of the sensor nodes, in this paper shows the results in saving of a considerable amount of the energy of the nodes by eliminating the simultaneous activation of redundant sensor nodes while monitoring as pecific target.

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