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An Efficient and Robust Spanning tree Topology to Minimize Power Consumption and Data Loss in Wireless Sensor networks

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---**ABSTRACT**---

Efficiency and Robustness to minimize power consumption and data loss in the presence of adverse conditions are desirable for the distributed applications like Wireless sensor networks(WSN). This notion is important for today's large complex high performance systems like wireless sensor networks because they are subject to frequent disruptions due to resource contention, such disruptions are inherently unpredictable. In this paper, a methodology for constructing a spanning tree overlay network that is capable to minimize both power consumption and data loss. In this work the construction technique employ Bellman-Ford algorithm to a weighted formula for hop count and path weight that changes the relative importance as the distance from the root node changes. This results in trees that perform for a wide variety of metrics to the problem of power consumption and data loss.

Keywords – Wireless Sensor networks, distributed computing, Power consumption, Data loss, Efficiency, Robustness.

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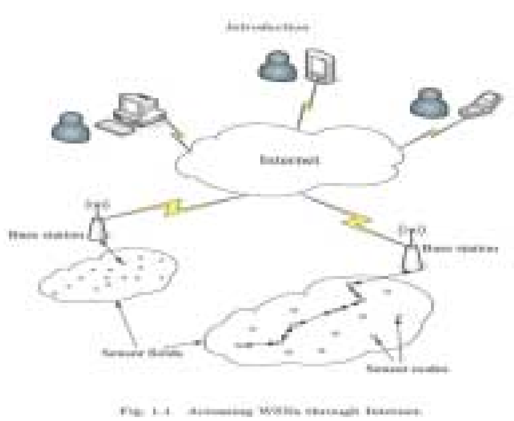
1. Introduction

Sensing is a technique used to gather information about a physical object or process, including the occurrence of events (i.e., changes in state such as a drop in temperature or pressure). An object performing such a sensing task is called a *sensor*. When many sensors cooperatively monitor large physical environments, they form a *wireless sensor network* [1,2,12,20,24]..



A sensor node should be able to operate until either its *mission time* has passed or the battery can be replaced. The length of the mission time depends on the type of application, for example, scientists monitoring glacial movements may need sensors that can operate for several years while a sensor in a Battlefield scenario may only be needed for a few hours or days. As a consequence, the first and often most important design challenge for a WSN is energy efficiency. This requirement permeates every aspect of sensor node and network design. Data loss and Network Congestion in the presence of adverse operating conditions is desirable for the large scale distributed applications.

1.1 Applications for wireless sensor networks

Industrial Control

Industrial facilities consist of a set of relatively large physical plants where long cables need to be installed to transfer the state of the plant to the control room (valves, temperature, pressure...) which is centralized in most facilities. Significant cost savings can be achieved when these cables are replaced by inexpensive wireless communication. Because most of the information being communicated is state information, it only changes relatively slowly, therefore in normal operation traffic is very low but when it is required to send new state information, the network must be very reliable. Exactly this could be guaranteed by a wireless sensor network where every node has many neighbors so that many different routing paths would exist from source to destination[6].

Asset Tracking and Supply Chain Management

There is a huge amount of interest in wireless sensor networks for applications in asset tracking and supply management due to the possible very high volumes required for these applications. Let me give two practical examples from the industry. Each item of inventory in a factory warehouse has a tag attached to it. Stick-on sensors, discreetly attached to walls, or embedded indoors and ceilings, track the location history and use of items.

The sensor network can automatically locate items, report on those needing servicing, analyze long-term correlations between workflow and wear, and report unexpected large-scale movements of items or significant changes in inventory levels. Some systems today (for example, those based on bar codes) provide inventory tracking; full sensor-net based systems will eliminate manual scanning and provide more data than a simply bar code such as location information or the like. Better decisions can be made by wireless sensor

Networks placed along the supply chain because they enable everyone in the business to make better decisions due to the additional available information.

Environmental Sensing

Many valuable applications can be found in agriculture where sensor networks could be fitted with a near infinite variety of chemical and biological sensors. A simple but very useful application is the control of irrigation. In large farms and ranches that may cover several square kilometers only portions of the area may get some rain sporadically. Knowing which areas of the field need irrigation can direct the irrigation system to precisely irrigate those areas. Such an application is ideal for wireless sensor networks since data rate over the network is very low and delay of several minutes or hours could be tolerated.[12].

Health Monitoring

With the development of biological sensors, health monitoring is expected to grow quickly. The development of these sensors might experience a breakthrough if conventional CMOS integrated circuits can be combined with biological sensors. Applications in this area can be the monitoring of the blood sugar and blood pressure, heart pulses and respiration rate. Some sensors might just be wearable and attached externally others might be implanted to allow the monitoring of the person. In a first stage these sensor networks might find their application area on big farms where sensors will be attached to the animals. The sensor information might be used for location information or for determining the need for treatments to prevent parasites.

Interactive Museum

In modern and attractive museums the interaction with the visitor is very important. Wireless sensor nodes that every visitor would get as an entry ticket combined with the sensors placed within the museum would allow a better interaction through localized services and information.

Traffic Control

Another idea think could be very interesting, is the use of sensor networks for traffic control. With more and more congestion on the roads today, traffic management becomes a very important issue, especially in Europe where the density of cars is very high and where it is difficult to build new roads due to the lack of space. Imagine that every vehicle in a large city has one or more attached sensors. These sensors are capable of detecting their location; vehicle sizes, speeds and densities; road conditions and so on. As vehicles pass each other, they exchange information. This information can be used by drivers to plan alternate routes,

Estimated trip times, and be warned of dangerous driving conditions.

Challenges and Constraints

General constraints are Energy consumption, Data loss and security the constraint most often associated with sensor network design is that sensor nodes operate with limited energy budgets. Typically, they are powered through batteries, which must be either replaced or recharged (e.g., using solar power) when depleted. For some nodes, neither option is appropriate, that is, they will simply be discarded once their energy source is depleted. Whether the battery can be recharged or not significantly affects the strategy applied to energy consumption. For no rechargeable batteries, a sensor node should be able to operate until either its *mission time* has passed or the battery can be replaced. The length of the mission time depends on the type of application, for example, scientists monitoring glacial movements may need sensors that can operate for several years while a sensor in a Battlefield scenario may only be needed for a few hours or days. As a consequence, the first and often most important design challenge for a WSN is energy efficiency [2]. This requirement permeates every aspect of sensor node and network design. Data loss and Network Congestion in the presence of adverse operating conditions is desirable for the large scale distributed applications. This notion is important for today's [3] large, complex high-performance distributed computing systems because they are subject to frequent disruptions due to resource contention.

About Spanning Tree Topology

Distributed applications like sensor networks are subject to frequent disruptions due to resource contention and failure. Such disruptions are inherently unpredictable and, therefore, Efficiency is required for the distributed operating environment. In this work, describe and evaluate an efficient spanning topology for applications that operate on a spanning tree overlay network. Unlike previous work that is adaptive or reactive in nature, take a proactive approach. The topology itself is able to simultaneously withstand disturbances and exhibit good performance. In this work both centralized and distributed algorithms taken to construct the topology, and then demonstrate its effectiveness through analysis and simulation of two classes of distributed applications: Data collection in sensor networks and data dissemination in divisible load scheduling. The results show that the spanning trees of this work achieve a desirable trade-off for two opposing metrics where traditional forms of spanning trees do not. In particular, the trees generated by these algorithms exhibit both resilience to data loss and low power consumption for sensor networks. When used as the overlay network for divisible load scheduling, they display the capability to withstand to link congestion and low values for the make span of the schedule [4,19,21,25].

The design and implementation of distributed computing systems has historically been carried out with performance being the dominant goal. Typically, the objective is to optimize a criterion such as response time, make span, or hit rate. Furthermore, the performance metrics are usually viewed from an individual perspective and may not correspond to the social optima. In order to realize the benefits from such performance-oriented designs, the distributed environment in which the application is deployed must be somewhat predictable. That is, calculation of the optimal schedule often requires accurate and a priori knowledge of system load,

Communication latencies, and execution times of individual tasks. With the current trend toward large-scale, geographically separated systems with shared computational resources, the assumption of exact knowledge of system parameters is unrealistic. Hence, there is a need to incorporate Efficiency into the design of distributed systems. Efficient systems perform well across a wide range of operating conditions and exhibit graceful degradation under anomalous conditions. In this work, presented a technique for improving the Efficiency of a distributed system for applications that operate on a spanning tree overlay network. Spanning trees are widely used in communication networks as a means to disseminate information from one node to all other nodes and/or to collect information at a single designated node. The defining characteristic of spanning tree topology when compared to other types of commonly seen spanning trees is that the resulting trees perform well for multiple, conflicting metrics; the trees are Efficient.

The importance of Efficiency in the design of complex and distributed systems is well-established. Biological systems naturally form efficient topologies that are resilient to attack. Social networks exhibit the small-a can be viewed as a form of Efficiency since information reaches every person in the network very quickly, despite the fact that some people will not pass on the information. More pertinent to distributed computing systems to maintain performance despite the presence of various perturbations. This should be a fundamental concept in the design of distributed systems. Particularly when network bandwidth and computational resources are shared, Efficiency is a desirable system property because communication delays and execution times are inherently difficult to predict. Nonetheless, some choice in the design of the system, e.g., the topology of an overlay network, then influences the system's response to various disturbances. There is often a trade-off for incorporating Efficiency into a system and work is no exception in this regard. However, will show that the price paid in performance loss is well worth that gained when the operating environment is unpredictable.

In this section, compare and contrast related work in the areas of system design and scheduling, and then discuss in Section the application model for which our technique is appropriate and present both centralized and distributed algorithms for constructing the efficient topology. The form of the resulting spanning tree is compared to other spanning trees that are commonly found in the literature. Through analysis and simulation, and then evaluate the effectiveness of the technique on two different distributed applications. Considered an application to sensor networks wherein data is forwarded up the tree and collected at a single node. The results show that the trees effected by algorithm admit near-optimal resilience to node failures (I prove the optimal case) and, at the same time, are very efficient with respect to power consumption. Presented an application to divisible load scheduling in which work originates at a single node and is distributed over a spanning tree network for the purpose of minimizing the make span via parallel execution. The focus of this particular application is not optimality of the schedule per se, but rather it is to show that technique can be used to easily construct efficient solutions that achieve a desired trade-off: low execution times and Efficiency to network congestion.

2. Systems Analysis

2.1 Existing System

The most commonly seen forms of spanning trees are the following[20,21]:

Shortest paths: The distance in edge weights of the path from each node to the root node is minimum. Such a tree is efficiently constructed by Dijkstra's algorithm designate this method as SP.

Fewest hops: The distance in number of hops along the path from each node to the root node is minimum. This method is equivalent to SP when all edge weights are equal and, therefore, Dijkstra's algorithm may be employed to designate this method by FH[17].

Minimum weight: The total sum of edge weights is minimum. Such a tree can be constructed by either Kruskal's algorithm or by Prim's algorithm and does not take into consideration the location of the root node. designate this method as MST.

Shortest Path	**Fewest Hops**	**Minimum Weight**
In Shortest Path data loss is high because here consider the edge weight only. So the nodes are added depth	Fewest Hops minimizes the expected value of the amount of data loss when a link or node fails. However it is not the best choice for other performance metrics such as power consumption in sensor networks.	MST produces trees that are very deep and "skinny". This is natural since the only criterion is the edge weight and the location of the root node is not taken in to consideration.

2.2 Proposed System

Efficient and Robust Tree: Here, constructed proposed system of efficient and robust spanning tree topology. Here, take computational-complexity model for construct an efficient spanning tree topology. Efficient spanning trees achieve a desirable trade-off for two opposing metrics where traditional forms of spanning trees do not.

In this tree topology, seek a method to construct spanning trees that effect good tradeoffs: trees that are relatively immune to data loss when nodes or links fail and yet are able to maintain good performance. Indeed, this is the very notion of Efficiency. Through analysis and simulation, will show that the spanning trees that perform best for different, and even opposing, metrics are constructed by considering a weighted combination of hop count and path weight as follows:

$$\lambda \times hopcount + (1-\lambda) \times pathweight, \quad (1)$$

where $0 \leq \lambda < 1$. If more importance is placed on hop count, then the tree will tend to be fat and shallow. Alternatively, more importance on path weight means that the tree will be skinny and deep. The type of tree that performs best depends on the metric of interest. In order to construct trees that perform well under a wide variety of metrics, attempt to make the tree fat near the root and skinny further away from the root. The intuition (with respect to data collection in sensor networks) is that, the further a message has to travel to reach the root node, the more likely it is to encounter a failed parent somewhere along the way. After a message has traveled a certain distance, the network has already "invested" resources (i.e., power and bandwidth) to get the message that far. When a message gets close to the root node, want to give it the best possible chance to make it the rest of the way so that its payload will be recorded. The weight λ is really a function of a node's depth in the tree. When an edge (*i, j*) is being considered for inclusion in the tree and *i* is the new vertex not already in the tree, then

$$\lambda_i = 1 - \lambda_i / \varepsilon_i \quad (2)$$

where λ_i is the hop count of node *i* from the root and ε_i is the eccentricity of the root node. The eccentricity of a node is the largest of the shortest paths from that node to all other nodes. measure eccentricity in number of hops, not path weight. Another way to think about it is that (My measure of) eccentricity is the depth of the deepest leaf in the SP tree. However, note that the eccentricity of a node is a characteristic of the underlying graph; it is not a property of the overlay network. Using this measure of eccentricity in (2) ensures that $0 \le \lambda_i < 1$ for all i. It also effects values for λ_i that are close to one when selecting nodes that are near the root and values close to zero when selecting nodes that are further from the root. They give the desired relative importance of hop count versus path weight in (1).now present two algorithms for constructing an efficient spanning tree: a centralized version and a fully distributed version[17].

2.3 Advantages in the Proposed System

- Minimize the congestion between nodes.
- The type of tree that performs best depends on the metric of interest. In order to construct trees that perform well under a wide variety of metrics, attempt to make the tree fat near the root and skinny further away from the root.
- I have proposed a source based heuristic which does not create overhead at destinations or intermediate nodes.
- My heuristic is applicable to both centralized and distributed overlay networks.

2.4 Normally connected some systems

This is used to construct a topology Structure[12,21]. This will be show how the systems are connected between them.

Here, will use server-socket technology to construct this kind of topology. This is sample topology used to make tree topology

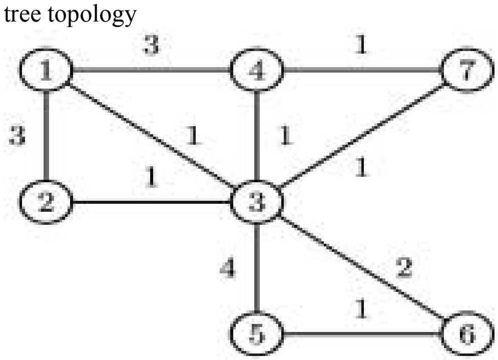


Fig (2) : Normal Topology

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Spanning Tree Topologies

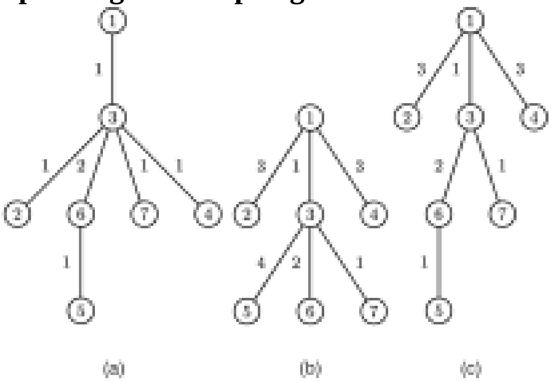

Fig (3) : (a) Shortest Path Topology (b) Fewest Hop
(c) Efficient& Robust

2.5 Creation of Efficient and Robust spanning topology

In this creating the efficient spanning tree topology choose a distributed algorithm to achieve the minimization of both power consumption and data loss through a weighted combination of hop count and path weight as follows:

λ_i × hop count + (1- λ_i)×path weight
where $0 \leq \lambda_i < 1$

If more importance is placed on the hop count, expected amount of data loss is minimum when a node or link fails but, power consumption is maximum and if more importance is given on path weight power consumption is minimum but data loss is maximum when node or link fails . Here attempt to make the tree fat near the root and skinny further away from the root. Here , the weight λ is function of a node's depth in the tree. When an edge (i,j) is being considered for inclusion in the tree and is the new vertex not already in the tree, then,

λ_i = 1- hi/ λ_i
where hi is the hop count of node from the root.
λ1 is the eccentricity of the root node.

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Algorithm: BELLMAN-FORD
Input: A weighted, directed graph G = (V,E,w); a source vertex s.
Output: A shortest-paths spanning tree T rooted at s.
    for each vertex v ∈ V do
        d[v] ← ∞
        π[v] ← NIL
    d[s] ← 0
    for i ← 1 to n − 1 do
        for each (u,v) ∈ E do
            if d[v] > d[u] + w(u,v) then
                d[v] ← d[u] + w(u,v)
                π[v] ← u
    for each (u,v) ∈ E do
        if d[v] > d[u] + w(u,v) then
            Output "A negative cycle exists."
            Exit
    T ← ∅
    for v ∈ V − s do
        T ← T ∪ {(π[v],v)}
```

2.6 Distributed algorithm

Let xi be node I's estimate distance from the root node, either in path weight or number of hops.

Let zij be the weight on the link between nodes i and j
Then, the kth iteration of the algorithm has the form

$$x_i^k = \min_{j \in A(i)} (z_{ij} + x_j^{k-1}), \qquad i = 2, \ldots, n,$$
$$x_1 = 0,$$

Where A(i) is the neighborhood of node i
The algorithm terminates when

$x_i^k = x_i^{k-1}$ for all i. A node may only proceed to the next iteration after it has received the updates of the previous iteration from all its neighbor nodes.

The algorithm will terminate most m* iterations.

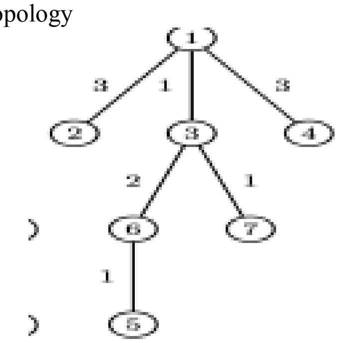
$$m^* = \max_{i=2,\ldots,n} m_i \leq n-1$$

and mi is the number of edges contained in the shortest path from I to 1. Thus the worst case scenario is n-1 edges.

Upon the termination of the algorithm each node in the known position-
Its parents and distance to the root edge in both the weights and hops.
Each node I reads its list of neighbors and choose a parent j based on

$$\min_{j \in A(i)} \{\lambda_i \times (1 + h_j) + (1 - \lambda_i) \times (z_{ij} + d_j)\},$$

Here converting the normal topology into efficient spanning topology



2.7 Power consumption

Let be the number of nodes in the sub tree rooted at node i and z_{ij} be the weight on the link from node i to its parent node j. Then, the total network power P required to collect a single data observation is

$$P = \sum_{i \in V(T)} m_i \times z_{i,j}.$$

2.8 Expected Data loss

Consider a tree T with vertex set V (T) and edge set E(T). Let mi be the number of nodes in the sub tree rooted at node i (including node i itself) and let qi be the probability that node i will fail. Then, the expected value of data loss L given that

$$\sum_{i \in V(T)} m_i \times q_i ,$$

Where

$$\sum_{i \in V(T)} q_i = 1.$$

Here, assumed all nodes have an equal probability of

failure,

The expected data loss is

$$\frac{1}{n-1} \sum_{i \in V(T)} m_i ,$$

3. Application

India is facing environmental disaster with Costal erosion like Tsunami and Cyclone needed very much WSN technology. Computations for these purses are difficult. Fuzzy control systems are helpful with the small data collected with WSN. For instance, If depression over the sea is more and height of ware is high and velocity of wave is very high then erosion is more. With the collection of small data from WSN using Fuzzy Logic[4, 13] will be helpful and cost reduction to forecast Environmental disaster.

4. Conclusion

Efficiency and Robustness in power consumption and Data loss is an important property for Sensor Networks. These systems are subject to resource contention and, hence, node failures and transmission delays are common enough to warrant their consideration in system design. This is especially true when the application designer has some control over the manner in which data is routed and computations are performed, such as the choice of topology for an overlay network. In this work using Bellman-Ford algorithm presented a methodology for constructing a spanning tree overlay network that exhibits Efficiency to network disturbances. The construction technique employs a weighted formula for hop count and path weight that changes the relative importance as the distance from the root node changes. This results in trees that perform well for a wide variety of metrics. When compared to the most common forms of spanning trees, efficient trees are closest in appearance to fewest-hops spanning trees. Applications like Mobile Computing[18], Fuzzy Control System[4] shall be studied for this work as further work

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