Energy Optimization in Wireless Sensor Networks

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Abstract
Wireless Sensor Nodes are generally having less memory and low battery life. Due to this constraint, we need a strong algorithm by which we can reduce the energy consumption. The main energy is utilized during sending of the data. Some part of energy is utilized in processing the data. In this paper, we will give another approach for reduced energy consumption. We will consider the cost of sending as well as processing. So, we will use short distance path as well as compression of the data to reduce the power consumption. Finally we will simulate this scenario by making a small simulator for 4 nodes.

Keywords—*Wireless Sensor Network, Energy optimization, compression, efficiency*

I. INTRODUCTION

From recent years, it is found that the area of wireless network and mobile computing is evolved rapidly. When we compare Wireless network with wired networks, we have benefit with wireless networks as they are capable of scaling easily, rapidly deployable and most importantly cost effective. Sensor nodes are low-power devices that is having inbuilt functionality of sensing, small amount of computing and wireless communication. It is expected that the cost of producing the sensor node is negligible. A simple transceiver is equipped to transmit and receive measurements from neighbours. The microcontroller performs the data processing task and is responsible for data functionality in sensor node. These sensor nodes are generally used to sense light, temperature, sound, position, vibration, pressure, stress etc. We can define wireless sensor network as aggregating different sensor nodes into computation and dedicated communication infrastructures. Wireless Sensor Networks (WSNs) are new era of networking system. It deals with scale and density, which is very hard in the ideal environments. Sensor networks are made with the intention of monitoring the physical world. So, they are often deployed in uncontrolled and natural environments. Wireless sensor networks must be designed to operate while unthread (no external power), unattended (no manual configuration or management), intermittently connected (radios may be turned off for substantial periods of time to conserve power), and uncontrolled environment [1].

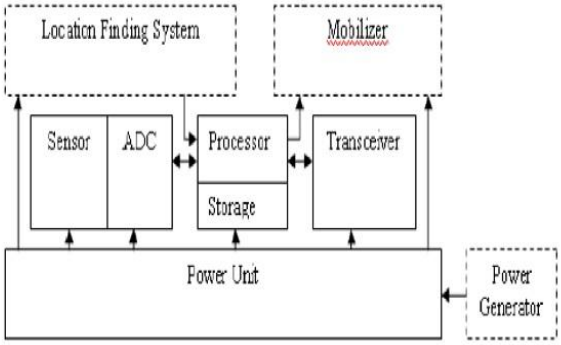

Figure 1 : Components of sensor node [1]

The following figure shows the typical sensor node which is very small like coin and with limited power and memory.

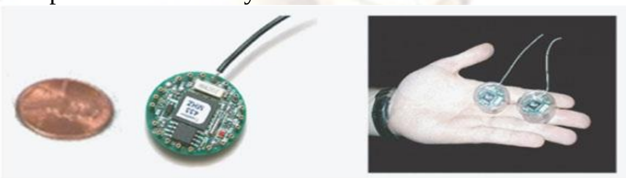
Figure2: Typical sensor node

WSNs are made up of integrate general-purpose computing with heterogeneous sensing nodes and wireless communication and low power sensor. The power unit is one of the most important components of a sensor node [2].A WSN can limit the radio frequency channel, due to, that is to say, unstable links, limit of physical protection of each sensor node, actual of each nodes connection, variation topology in addition dangerousness about routing security is high by activity spite nodes. The restrictions in the hardware of the sensor nodes, makes it difficult to guarantee the maintenance of security because of its vulnerability.[3][4].A WSN is consists of spatially distributed autonomous sensors together monitor physical or environmental conditions. A sensor network normally makes a wireless ad-hoc network, that is, each sensor is deployed with a multi-hop routing algorithm. The network does not have any already existing infrastructure, such as routers in wired networks or access points in managed (infrastructure) wireless networks.

II. RELATED WORK

The challenges in deployment of WSNs are as follows [14-16][17][18]:

1. The WSNs are used for not only collecting environmental information but it also used for changing the environment information.
2. The resources are limited and memory is less. It should manage all the complex functionality using different topologies.
3. There are many uncertainties in WSNs. They can affect the functionality of WSN.
4. One of the big challenges of WSN is to make the node as self-organizing and self-optimizing.
5. There can be a large number of WSN nodes but network must have limited number of nodes that guarantee the desired WSN service.
6. WSN operates in the real world. So, it must have real-time features as per need.
7. WSNs are not safe because it uses free band. So, there must be some security for managing original data.

There are lot of techniques and protocols available for optimizing energy used by sensor nodes. The categories are mainly categorized into following types.

1. MAC layer techniques
2. Network layer approaches
3. Transmission control approaches
4. Automatic approaches

A. MAC layer approaches

The main portion of the node's energy is spent on radio transmission and on listening the medium for message [5]. MAC protocols manage communication and regulate the shared medium such that performance is improved. For example, Zigbee technology uses MAC protocol for less energy consumption. The TDMA MAC protocol is based upon cross layer optimization based upon Physical layers and MAC [13].

B. Network layer (Routing) approaches

The main objective of WSNs application is to gather the data from nodes and transfer the data to sink in energy efficient way using proper routing protocol. REACA , EARQ, MMSPEED, Energy Efficient Broadcast Problem (EEBP) and Green Wave Sleep Scheduling (GWSS) are some of the algorithm used for less energy consumption at network layer [6-9].

C. Transmission Control approaches

There are many Transmission Power Control (TPC) approaches available. Its main goal is to reduce the energy consumption and improve the channel capacity. TPC solutions work with single transmission power for whole network.One of the algorithm is Power Control Algorithm with Back Listing (PCBL), in this algorithm, each node transmit the packet with different transmission power levels to find optimal transmission power based on Packet Reception Ratio (PRR) [10]. Local Mean Algorithm(LMA) and Equal Transmission Power (ETP) are other approaches used at this layer.

D. Automatic approaches

Autonomic computing was introduced by IBM in 2001 to describe the systems that are self-manageable [11].The main properties with are [12]:
Self- configuration: It concern with system's ability to configure by itself for achieving high level goals.
Self-optimization: It concern with the change in system pro-actively to optimize the performance or quality of service.

III. PROPOSED APPROACH

There are many approaches available to optimize the energy as discussed in previous work section. Our approach comes under the category of Network layer (Routing) approaches. The proposed approach is basically divided into 2 steps. First step deals with the routing part and second step deals with the compression-decompression part. Both the steps when combined, can give better result and benefits of reliability and also less energy consumption. Our main objective is to reduce the energy consumed by the sensor node to have good battery life and also provide reliability of data. Each step is explained in details in following sub-sections.

Step1: Routing based upon the cost

The routing plays important role in design of Wireless networks because the data transfer path is most important to save energy. If the data follow the wrong path then it waste the energy of the nodes which comes on that path as well as waste the time. So, we can consider the network as a graph where each node are sensor nodes and the cost of the edge is cost for transferring data from 1 node to another. It can be anything like distance or energy consumption. Here, we will use Floyd-Warshall algorithm to find the shortest distance between node and destination via intermediate nodes. So, the route will be shortest route and the data can be transferred on that path so that less energy will be utilized. In case, when the battery life of the node which comes in shortest path is completed then the distance will become infinite. So, another shortest route will be calculated based upon the existing scenario. It will increase the flexibility and reliability of the data. Floyd-Warshall algorithm is as follows :

```
let dist be a |V| × |V| array of minimum distances initialized to ∞ (infinity)
for each vertex v
   dist[v][v] ← 0
for each edge (u,v)
   dist[u][v] ← w(u,v)  // the weight of the edge (u,v)
for k from 1 to |V|
   for i from 1 to |V|
      for j from 1 to |V|
         if dist[i][k] + dist[k][j] < dist[i][j] then
            dist[i][j] ← dist[i][k] + dist[k][j]
```

Algorithm 1: Floyd Warshall Algorithm [19]

```
let dist be a |V| × |V| array of minimum distances initialized to ∞ (infinity)
let next be a |V| × |V| array of vertex indices initialized to null

procedure FloydWarshallWithPathReconstruction ()
   for each vertex v
      dist[v][v] ← 0
   for each edge (u,v)
      dist[u][v] ← w(u,v)  // the weight of the edge (u,v)
   for k from 1 to |V|
      for i from 1 to |V|
         for j from 1 to |V|
            if dist[i][k] + dist[k][j] < dist[i][j] then
               dist[i][j] ← dist[i][k] + dist[k][j]
               next[i][j] ← k

function Path (i, j)
   if dist[i][j] = ∞ then
     return "no path"
   var intermediate ← next[i][j]
   if intermediate = null then
     return " "   // the direct edge from i to j gives the shortest path
   else
     return Path(i, intermediate) + intermediate + Path(intermediate, j)
```

Algorithm 2: Floyd Warshall Algorithm for Path Reconstruction [19]

After calculating shortest path, we can go for transmission of data. Now we can save more energy by sending data via shortest path. But we also require that it should take less energy for transmission of data. To reduce the energy utilized during transmission can be reduced by using compression-decompression. It is discussed in the step2.

Step2: Compression- Decompression

Before sending the data, we can compress it to save the energy of the transmitting node as well as intermediate nodes. It can be achieved by using binary transfer. For example, there are 4 nodes and they capture the temperature of the region and send it to sink node via shortest path. In this case, we can have 2 bits to represent each nodes (node 1 : 00, node 2: 01, node 3: 10 and node 4 : 11). If we take it as integer then it will take 2 bytes of size. Now, if we want to send the temperature captured by the node, we can convert the value in binary. As the node is a physical device, it cannot stay in temperature more than 64 degree Celsius. If the temperature goes beyond the 60 degree, we can say it as fire in that region. To represent the temperature, we need 6 bits of size (2^{6} = 64). Total we require 8 bits (2+6). It is of 1 byte data. So, the data is compressed from 4 byte to 1 byte and we can transfer this information to destination sink. It will save energy of intermediate nodes also. On other side, destination sink will check first 2 bits to check which node sent the data and remaining 6 bits for checking the temperature of that region. It is part of decompression process.

IV. IMPLEMENTATION

Above 2 steps process can be achieved by creating a simulator. The simulator's work will be divided into above mentioned 2 steps. It can be implemented using c# language in .NET technology. The design of the simulator can be as shown in figure 2.

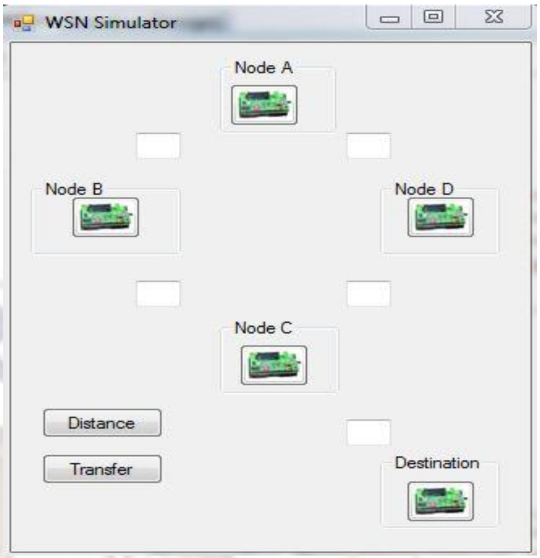

Figure 2: Implementation

In above figure, each nodes (Node A, Node B, Node C and Node D) are capable of capturing temperature (in this simulator, it will generate random temperature). Each textbox will take input as cost between nodes. Distance button will calculate the shortest path from each node to destination node via intermediate node. While the transfer button will do the functionality of step2 mentioned above. It will transfer the data from individual node to destination node via shortest path.

V. CONCLUSIONS

From the above discussion, we can conclude that the two step procedure proposed in this paper will save 75% of energy of each node (In case of 4 nodes) in step 2 only.It can be shown as follows:

Before Compression:-

Data for transfer : 2 bytes for storing the address of node + 2 bytes to store the temperature = 4 bytes

After Compression:-

Data for transfer : 2 bits for identity of node + 6 bits for temperature = 8 bits = 1 byte.

Energy saved = 4 byte - 1 byte = 3 byte = 75%Also, we can save some amount of energy in step1. When we combine both the steps, it will save too much energy. One more benefit from the step1 is that it can work for the case when one of the nodes from the route is dead. In that case, it can reconstruct the path.

VI. FUTURE WORK

In our case, we have studied the algorithms for 4 nodes, we can enhance the implementation for more than 4 nodes as well. We can have more other approaches which can be more cost effective. Also we can use some other algorithms for compression and decompression. But we must keep in mind that compression and Decompression also requires energy to process it. So, the algorithm must be less complex so that more energy is not wasted on processing the data compared to sending the data. We can have modification in hardware to have some more efficient technique. We can take energy available in the nodes which comes along with the path as 1 parameter for comparison.

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