2009 International Conference on Communications and Mobile Computing

An improved Gossiping Data Distribution Technique with Emphasis on Reliability and Resource Constraints

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Abstract— In this paper we present an improved Gossiping data distribution technique with emphasis on the location of nodes called *"LGossiping"* that reliably disseminate information among sensors in a wireless sensor network. Nodes running LGossiping data distribution technique use global positioning system to relay data throughout the network. Each node decides upon position knowledge of the others. This allows each sensor to send its data reliably to one of known neighbors instead of sending data blindly to one of neighbors which may not be near to source node and cause data lost. We outlined SystemC as simulation language and simulate and analyzed Gossiping and LGossiping protocols. In each experiment source node propagate data among nodes with the hope of reaching to sink node. This procedure is called data transmission. We found that LGossiping with transmission radius greater than or equal to 4 (TR>=4) is 30% more reliable than Gossiping for a specific number of experiments. LGossiping is an improvement of Gossiping in terms of reliability. Therefore reliability in this improved method is critical. Moreover, network energy consumption with respect to different TR is considered. We concluded that network energy consumption decreases as the transmission radius increases. As termination, increasing area during the experiment is mentioned. In order to have constant reliability with constant number of nodes in LGossiping method in immense areas, with each $600m^2$ increase of area, transmission radius should increases 1 meter.

Keywords-component; Wireless Sensor Network, Rrouting Techniques, Data Distribution Methods, Gossiping, SystemC, Simulation.

I.INTRODUCTION

Networked sensor systems are seen by observers as important technologies that will experience major deployment in next few years for a plethora of applications. Typical applications include, but are not limited to, data collection, monitoring, surveillance, and medical telemetry [1, 2]. Wireless sensor networks (WSNs) consist of large number of sensor nodes. These tiny nodes consist of sensing, data processing, and communicating components.

The nodes must be distributed in the specified area and the physical location must be declared obviously. The network has to be designed and implemented, and there has to exist flexible mechanisms and applied programs for their efficient and convenient use. In addition to algorithms, hardware and software architecture will significantly impact the effectiveness of WSN. In some applications such as temperature monitoring, combat field surveillance, security and disaster management, reliable data transmission is more important than energy constraints.

Data distribution methods like Flooding and Gossiping have random scheme and send data blindly to other nodes which decreases reliability. Moreover they have implosion, overlap and resource blindness draw backs. *Implosion* caused by duplicated messages sent to the same node, *overlap* occurs when two nodes sensing the same region send similar packets to the same neighbor and *resource blindness* caused by consuming large amount of energy without consideration for the energy constraints [3, 5 and 7]. Gossiping avoids the problem of implosion by just selecting a random node to send the packet rather than broadcasting.

In an improved Gossiping Data Distribution Technique with emphasis on Location-based approach, nodes use global positioning system to relay data through network. Although GPS is not envisioned for all types of sensor networks, it can still be used if stationary nodes with large amount of energy are allowed. In addition, it simplifies the routing protocols and is indispensable when high reliability is considered. Trusted on simulation results contained plots and tables, We proved that LGossiping method in terms of reliability is the best choice among data distribution techniques that are classified as sub group of data centric methods. There are two problems in Flooding method called implosion and overlap. Gossiping and LGossiping avoids the problem of implosion by just selecting random node to send the packet rather than broadcasting.

The three main traditional techniques for analyzing the performance of wired and wireless networks were *analytical methods, computer simulation, and physical measurement*. However, many constraints imposed on sensor networks, such as energy limitation, decentralized collaboration, and fault tolerance necessitate the use of complex algorithms for sensor networks that usually defy analytical methods. Furthermore, few sensor networks have come into existence, for there are still many unresolved research, design and implementation problems, so measurements are virtually impossible. It appears that *simulation* is currently the primary feasible approach to the quantitative analysis of sensor networks. Traditional approaches consist of various simulation tools based on different languages such as C, C++, Java and etc. These simulators have the capability of parallel simulation. However they use 2 different programming languages. Use of these simulators needs programming skills. SystemC is a C++ class library. The language is an attempt at standardization of a C/C++ design methodology, and is supported by the Open SystemC Initiative (OSCI) [6]. Beside other features, SystemC

978-0-7695-3501-2/09 $25.00 © 2009 IEEE
DOI 10.1109/CMC.2009.349

models a system with logic threads running in parallel and there is no need to use two languages for parallelism.

The rest of the paper is organized as the following. More elaborate explanation of data distribution techniques is presented in section II. An improved Gossiping data distribution technique with emphasis on the location of nodes is presented in section III. SystemC-based simulation approach and results and comparisons are discussed in section IV. Finally the whole results are concluded in section V.

II.DATA DISTRIBUTION TECHINIQUES

Depending on the application and architectural issues, diverse routing techniques are considered [3, 7, 8, 9 and 10]. They are classified into four main groups: Data centric protocols, Hierarchical protocols, Location-based protocols, Network flow and QOS aware protocols [3]. In Data centric protocols, sink sends queries and waits for data. Hierarchical protocols take advantage of cluster and cluster head formation. Location-based protocols require location information. Using this information, sink sends queries to particular nodes. In QOS aware protocols, routing is modeled due to network requirements. As instance, if network energy is restricted, the path whose residual energy is the largest will be selected to send the packet rather than sending to path which is very close to resource blindness conditions and may loses the packet.

Flooding and Gossiping and the improved version of Gossiping called LGossiping which will be explained during next section, are classified among data centric protocols. They do not need any routing algorithm and topology maintenance. Therefore they are called data distribution mechanisms.

In Flooding [4] each sensor receiving a data packet broadcasts it to all of its neighbors and this process continues until the packet arrives at the destination or the maximum number of hops for the packet is reached. Gossiping [4] is a slightly enhanced version of flooding where the receiving node sends the packet to a randomly selected neighbor, which picks another random neighbor to forward the packet to and so on. Although flooding is very easy to implement, it has several drawbacks illustrated in figures 1 and 2 redrawn from [5]. Such drawbacks include *implosion* caused by duplicated messages sent to same node, *overlap* when two nodes sensing the same region send similar packets to the same neighbor and *resource blindness* by consuming large amount of energy without consideration for the energy constraints [5].

Gossiping avoids the problem of implosion by just selecting a random node to send the packet rather than broadcasting. However, this cause delays in propagation of data through the nodes.

III.LGOSSIPING DATA DISTRIBUTION METHOD

Because of the implosion and overlap problems highlighted at previous section, we selected Gossiping method for data distribution in WSN. Also, our algorithm is based on location of all nodes in network. So, this new method is called location-based gossiping or *LGossiping*.

In this method, small tiny nodes are dispersed in a specific region. Using GPS, location of each node is determined. Then sink node sends the location information to all nodes in the network. Figure 3 reveals the schematic of network. For our simulation purposes region area is $100m^2$. Source is located at (0, 0) and sink is located at (10, 10). The other nodes are distributed randomly in the specified region.

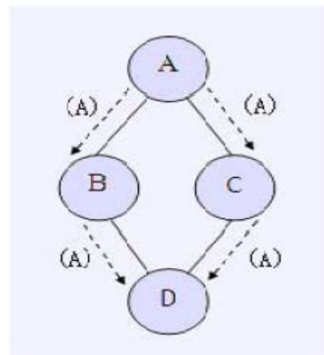

Figure 1: The implosion problem. Node A starts by flooding its data to all of its neighbors. D gets two same copies of data eventually, which is not necessary [5].

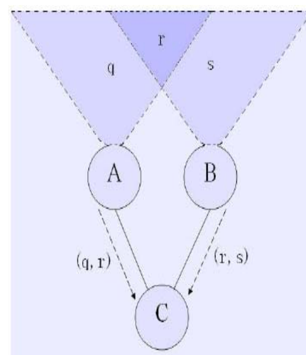

Figure 2: The overlap problems. Two sensors cover an overlapping geographic region and C gets same copy of data for these sensors [5].

In this method, small tiny nodes are dispersed in a specific region. Using GPS, location of each node is determined. Then sink node sends the location information to all nodes in the network. Figure 3 reveals the schematic of network. For our simulation purposes region area is $100m^2$. Source is located at (0, 0) and sink is located at (10, 10). The other nodes are distributed randomly in the specified region.

Nodes have transmission radius and just send data to nodes that exist in their transmission region. Source generates data and finds the nodes located in its acceptable range and sends data to one of its in-range neighbors randomly. Second node, routes received data through network in the same way. The process will be continued up to sink node. Sink is capable of connecting the sensor network to an existing communications infrastructure or to the Internet. Figure 4 shows the schematic of data routing.

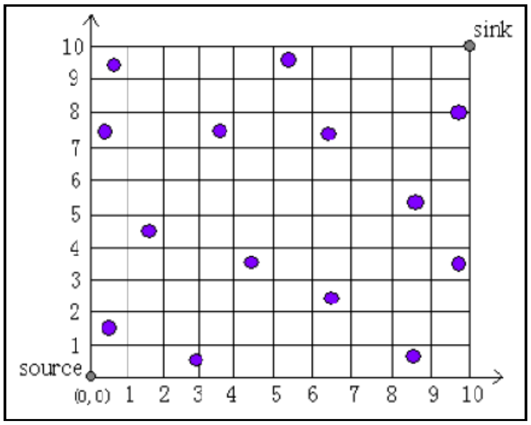

Figure 3: Schematic of Simulation Suppositions

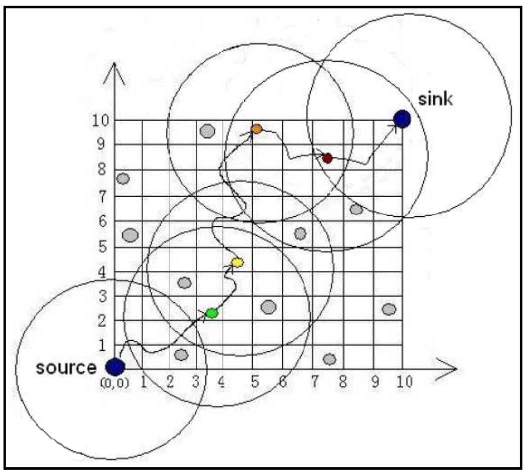

Figure 4: Schematic of Data Routing

We supposed maximum possible hop for data is equal to number of network nodes. If sink didn't receive data after the maximum, data is invalid.

IV. SIMULATION RESULTS AND COMPARISONS

For our purpose, *100* nodes dispersed in a *100m²* area. As stated previously, the simulation codes had been written in SystemC language. Pseudo code is illustrated in figure 5.

Data reliability comparison between these two data distribution methods is useful. Figure 6 shows comparison between LGossiping method with TR=3 and Gossiping Method.

As shown figure 6, when in a single experiment number of passed nodes is equal to 100, it means that sink didn't receive data and data is invalid. According to figure for TR=3 both methods have approximately same results and in 55-65% of all transmissions sink receives data successfully. Table 1 indicates the number of passed nodes in each experiment. In cases with less than 100 passed node, Data is routed successfully and in cases with exact 100 passed nodes, it is vice versa.

```
//set simulation time
//nodes scattered randomly in specified region (area=100m2)
//location of each node is determined
    // (0,0) assigned to source
    m [0][1]=0;
    m [0][2]=0;
    // (10,10) assigned to sink
    m[100][1]=10;
    m[100][2]=10;
    loop for j=1 to 99
       loop for i=1 to 2
          m[j][i]<< (x,y) of nodes
main loop
   //source generates data
        loop for 100 times
              //source finds its neighbors
               if distance of source to nodes<transmission radius
                 store m[j][i] as neighbors to s[k]
              end if
              //select one of the s[k] members randomly
              //send data to destination that is new source
              if destination=sink node
                 successful data transmission process
                           jump to main loop
                    else jump to loop
              end if
       end loop
       wait for 100 nano second
end main loop
```

Figure 5. Pseudo code for simulation procedure

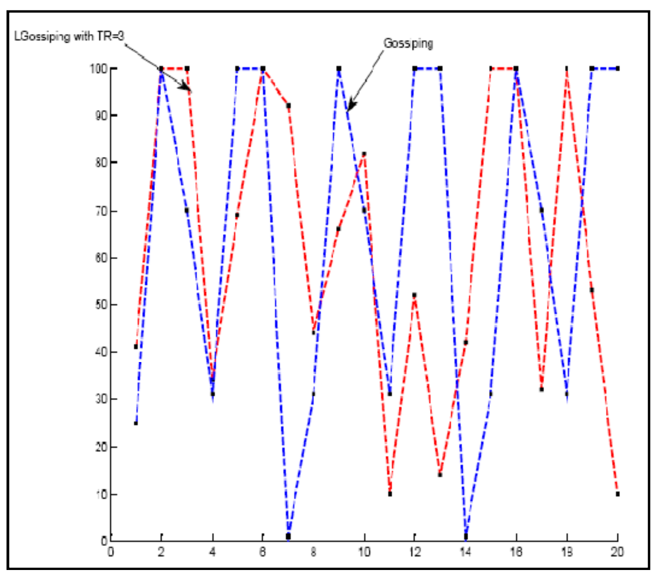

Figure 6: Data Reliability Comparison between LGossiping (TR=3) and Gossiping.

Table1. Detail of Data Transmission Results for TR=3

No of Experiments	Gossiping No of Passed Nodes	LGossiping No of Passed Nodes	Gossiping Data Receive	LGossiping Data Receive
1	25	41	yes	yes
2	100	100	no	no
3	70	100	yes	no
4	31	34	yes	yes
5	100	69	no	yes
6	100	100	no	no
7	1	92	yes	yes
8	31	44	yes	yes
9	100	66	no	yes
10	70	82	yes	yes
11	31	10	yes	yes
12	100	52	no	yes
13	100	14	no	yes
14	1	42	yes	yes
15	31	100	yes	no
16	100	100	no	no
17	70	32	yes	yes
18	31	100	yes	no
19	100	53	no	yes
20	100	100	no	no
Average/Success	11 times	13 times	55%	65%

But for critical situations in which data should be reported continuously this result is not convincing. Therefore Gossiping method is not useful. Because there is no regulating factor in this method and data is routed blindly through neighbors. But in LGossiping increasing the TR will increase the reliability. In order to prove this, we increase the TR to 4 and again draw the data path for both Gossiping and LGossiping. Figure 7 shows comparison between LGossipping with TR=4 and Gossiping.

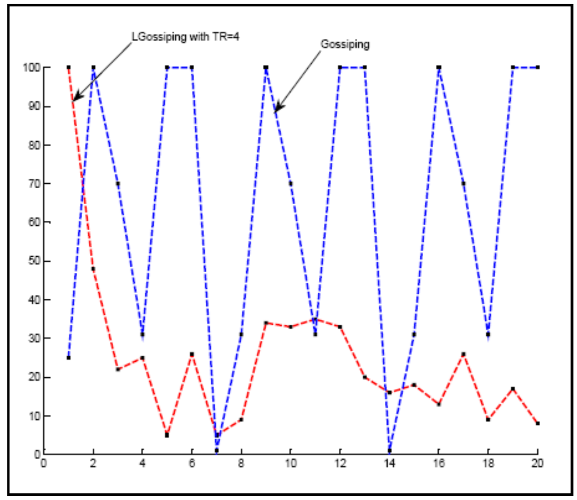

Figure 7: Data Reliability Comparison between LGossiping (TR=4) and Gossiping.

If we trace the red line, we observe that 1 times sink didn't receive data and nodes have just exchanged between data 100 times. But if we trace the blue path, we observe that in 9/20 of all transmissions, data didn't reach to sink node. In LGossiping with TR=4 reliability is 95%. Table 2 shows the detail results for both methods with TR=4.

Table2. Detail of Data Transmission Results for TR=4

No of Experiments	Gossiping No of Passed Nodes	LGossiping No of Passed Nodes	Gossiping Data Receive	LGossiping Data Receive
1	25	100	yes	no
2	100	48	no	yes
3	70	22	yes	yes
4	31	25	yes	yes
5	100	5	no	yes
6	100	26	no	yes
7	1	5	yes	yes
8	31	9	yes	yes
9	100	34	no	yes
10	70	33	yes	yes
11	31	35	yes	no
12	100	33	no	yes
13	100	20	no	yes
14	1	16	yes	yes
15	31	18	yes	yes
16	100	13	no	yes
17	70	26	yes	yes
18	31	9	yes	yes
19	100	17	no	yes
20	100	8	no	yes
Average/Success	11 times	19 times	55%	95%

LGossiping is 40% more reliable than Gossiping, but data reliability by itself is critical when we use WSN for some applications such as vital signals monitoring or temperature monitoring in a forest. We should find the optimum TR for data transmission in LGossiping. Figure 8 shows data receive percent versus Different transmission radius. For transmission radius *(TR =3)* more than *65%* of transmitted data will be received successfully and for TR>4 there is reliability near *100%*. Therefore in order to have reliable data transmission for data dependent circumstances LGossiping method with 100 nodes in each 100 m^2 area and TR>=4 is suggested.

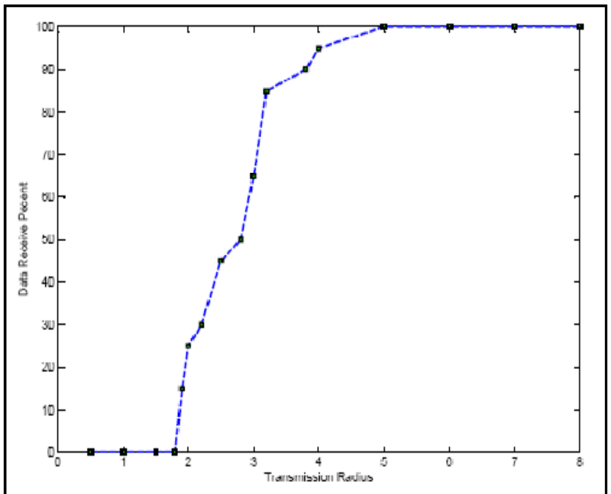

Figure 8: Data receive percent versus transmission radius (Area=$100m^2$)

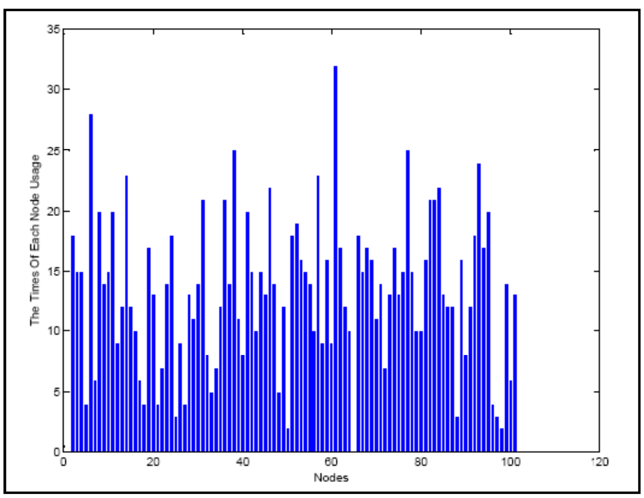

Figure9. The times of each node usage during experiments for TR=3

Besides reliability, resource limitations are considered. It is beneficial to know the rate of the network energy consumption. Due to the fact that, nodes are scattered randomly in the region and randomly located in transmission region of the specific node, number of the nodes' switching is varied. Figure 9 depicts the number of usage for each node during 20 experiments where TR=3. The average number of switching for the whole network nodes is 13 times. Figure 10 illustrates the same graph for TR=4.

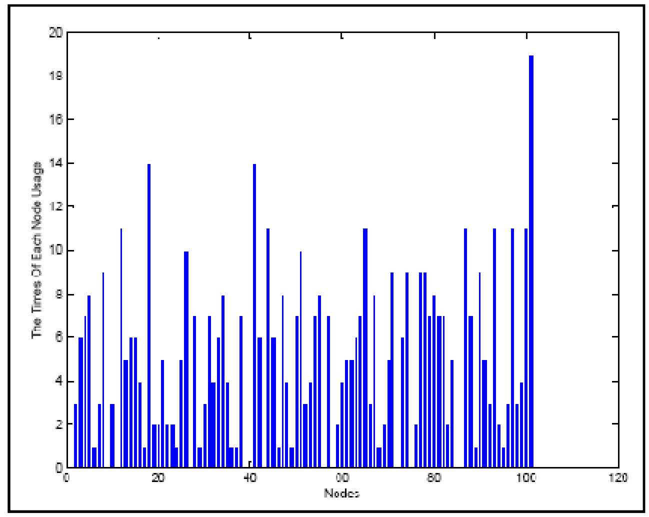

Figure10. The times of each node usage during experiments for TR=4

Here the average number of switching for the whole network is 5 times. In comparing two cases, energy consumption in network with transmission radius equal to 4 is less than the case with TR=3. As conclusion, energy consumption decreases as transmission radius increases. In order to prove this, we considered diverse TR and calculated the average number of node switching's in each situation. The result is illustrated in figure 11. Therefore, again with respect to average switching of the whole network which is firmly related to average energy consumption of the WSN and reliability in data transmission which was discussed a bit earlier, the optimum condition is obtained when TR>=4.

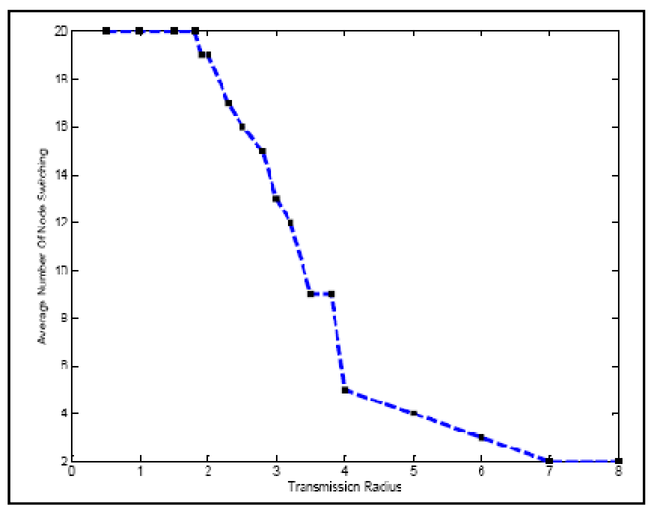

Figure11. The average number of node switching versus different TR.

We suppose that 100 nodes are distributed in larger areas. We increase the area by $100m^2$ steps and repeat the experiment. Figure 12 shows the variation of TR in compare with region area. We observed that according to region, approximately $600m^2$ increases of area causes transmission radius to increase 1m to have the same reliability. Therefore dispersing 100 nodes in larger area needs to increase TR to have reliable data transmission.

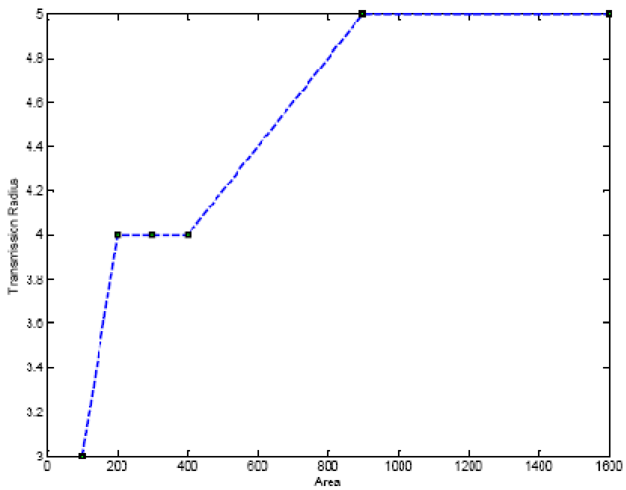

Figure 12. Region area versus transmission radius.

I. CONCLUSION

In this paper we considered data reliability which is critical for applications such as vital signal monitoring and introduced an improved Gossiping data distribution technique with emphasis on location-based approach. We used SystemC to write simulation codes that model a system with logic threads running in parallel. Furthermore coding is more straightforward and line of codes decreases significantly. We showed that reliability in LGossiping method is dependent to transmission radius and energy consumption is related to TR inversely and found that the optimum TR for constant 100 nodes in $100m^2$area is TR>=4. Also we concluded that in order to have high reliability when using 100 nodes in larger areas, transmission radius should increase appropriately.

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