Comparative Study of Symmetrical and Asymmetrical Network Parameters in Smart Grid Infrastructure

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ABSTRACT
In this paper, a comparative study of symmetric and asymmetric network for smart grid is proposed. In smart grid different nodes may be present with different capabilities, such as depending upon manufacturer, sensitivity of different nodes may changes. This significantly keeps impacts on the range of the parent node. Random nature of the infrastructure may changes the power capabilities to send the information to the parent node. This needs the power which is directly proportional to the physical distance between respective nodes. RPL (Routing Protocol for Low Power and Lossy Network) is proposed for the LLN (Low Power and Lossy Network) network which closely resemblance the infrastructure of smart grid. It's independent on the physical layer parameters and useful in the Cognitive Radio aspect. For symmetric nodes we compute the bidirectional links and node can directly communicate with its parent node without any extra overhead, however in asymmetric nature node needs to discover the multiple paths and may increase the overhead. In this paper we proposed different parameter which keeps significant impact on asymmetric network for smart grid.

Keywords
Symmetric Network, Asymmetric Network, Smart grid, LLN network (Low Power and Lossy Network), Bidirectional links.

1. INTRODUCTION
Recently WSN (Wireless Sensor Network) has become the one of the most interesting communication technology since it can deploy without communication infrastructure. Often wide range of application utilizes the unlicensed ISM (Industrial, scientific and Medical) spectrum band for their application. In practice, the precious and limited unlicensed radio spectrums are shared by many wireless application including Bluetooth and ZigBee. Confluence of Wireless Sensor Network (WSN) technology into smart grid causes the spectrum scarcity in unlicensed band. This gives opportunity to the many researchers to investigate dynamic spectrum allocation policy through deployment of Cognitive Radio [1], [2]. The basic idea in dynamic spectrum utilization is to let people use licensed frequencies, provided they can guarantee interference perceived by the primary license holders will be minimal [3]. In smart grid, several node might exist at utility such as smart meter, thermostats etc. Low cost, low power wireless smart meters, which are one kind of the sensors, have been recognized as one of the most cost efficient way to collect meter data by wireless communication. In normal WSN all the nodes, utilized for sensing and measurement of the information have uniform capacities of transmitting power and sensitivity. This network can be called as the symmetric network. In the symmetric network due to same forward and reverse links there is no need to calculate the forward and reverse path for the exchange of packets. Asymmetric network is the network where some of the nodes have different capabilities of transmitting power, also different vendors manufactures the devices with different sensitivity. Here we cannot panelized the network with bidirectional discovery of the route; it increases the overhead and reduces the energy of the node. Since in smart grid spectrum sensing function to all the nodes is not the practical approach, we perform the sensing through only PAN coordinator. ZigBee/802.15.4 standard [4] is widely used currently for low rate wireless PAN deployment and we assume 802.15.4 data rates when we refer to WSN in unlicensed band. In smart grid using the WSN leads towards the efficient utilization of spectrum and reduces the overhead. In this paper we compare different parameters and its impact on the energy utilize by the node while dealing with the symmetric and asymmetric network.

2. RPL (ROUTING PROTOCOL FOR LOW POWER AND LOSSY NETWORK) FRAMEWORK
In smart grid different nodes with limited processing power, memory and energy are present. These nodes are interconnected and send the information towards the coordinator by lossy links, typically supporting only low data rates that are usually unstable with relatively low packet delivery rates. Such kind of the network supports point to point or point to multipoint direction. RPL operation requires bi-directional links. RPL does not rely on any particular features of a specific link layer technology. In RPL, network information is maintained by the one or more directed acyclic graphs (DAG). A directed acyclic graph has the property that all edges are oriented in such a way that no cycles exist [5]. For smart grid we are considering the coordinator base scenario, coordinator will act as the DAG ROOT and no edges will come out from this. The coordinator in the AMI will act as a gateway node. The rank of the nodes along any path to the coordinator should be monotonically decreasing in order to avoid any routing loop. In order to construct a DAG, coordinator issue a control massage called DAG information object (DIO). DIO will exchange the information related to the DAGID and DAGROOT [6]. Here node calculates its rank to determine the position in the network relative to the others. Any new device want to join the network first it listens the DIO from the coordinator and after being validate it calculate its own rank using OCP and fixes parent using the DIO. Suppose any device which wakes up after sleeping or it was powered off then it directly listen the DIO, according to its predefined credentials it calculates rank and assigns parent. In order to support the traffic from coordinator to the nodes, nodes issues the control massage called Destination Advertisement Object (DAO). DAO massage consist the list

of nodes through which it travels and compute the reverse path in the network.

3. NETWORK DESIGN ISSUES

In smart grid different nodes with different capabilities may exist. Since RPL does not rely on any particular features of a specific link layer technology, we must keep an eye on the different parameters which significantly keeps the impact on the smart grid communication. A network may run multiple instances of RPL concurrently. Each such instance may serve different and potentially antagonistic constraints or performance criteria. In order to be useful in a wide range of LLN application, RPL separates packet processing and forwarding from the routing optimization objective. In RPL, bidirectional links are present and depending upon the capabilities of nodes, it discovers the network symmetry. Nodes construct and maintain the network with the help of DIO, optimized according to the Objective Function. Rank of the node goes on decreasing while its move away from the coordinator and it increases while it approaches to the coordinator. Different node contains the info tuples [7]. RPL plays useful part in the smart grid due to types of traffic it supports, RPL supports point to point, point to multi point and multi point to point. In network one DAG structure rooted at the coordinator node. According to the routing matrices, nodes calculate its rank. A routing metric is a quantitative value that is used to evaluate the path cost. [6]**.** The initial value of ETX of any link is set to be 1.0. In this coordinator node has the lowest rank among all the nodes present in the network. Depending on the rank it increases as it passes through the nodes and contains the information of nodes through which it passes. Coordinator forms the network and is the head of the network. It performs the role of network manager and collects all the data generated, regarding rank and free channel in the spectrum sensing. For spectrum sensing we consider the external sensing architecture**.** Coordinator forms the DAG and all the edges are calculated considering the coordinator as parent node. The network information stored at each node consist the information related neighbor list, parent list, ETX of the link from coordinator. Rank computation is calculated using

R_i =R (p (i)).X (I, p (i)) +1.0. [7]

3.1 Symmetric Network Formation

In symmetric network Fig. 1, all nodes are Power Amplifier (PA) enable. Node first checks if the DIO sender is in the parent list, according to that node computes its own temporary rank or updates the sender entry in the parent list. If DIO sender is in the parent list, node computes its temporary rank comparing with the senders rank. If sender is default parent then node compares temporary rank with current rank, according to the rank it reselects the parent. If DIO sender is not in the parent list then node computes the current rank. Depending upon the current rank and threshold, node forwards the DIO with current rank or discards the DIO. [6]

3.2 Asymmetric Network Formation

In asymmetric network Fig. 2, since network asymmetry node i and node j may reach each other depending upon the PA enable or disable. If DIO sender is PA enable then ETX between the node will increases and comparing with the threshold set Parent node will reselect. If DIO sender is PA disable then ETX between nodes will decreases and depending upon the neighbor best parent node will be selected.

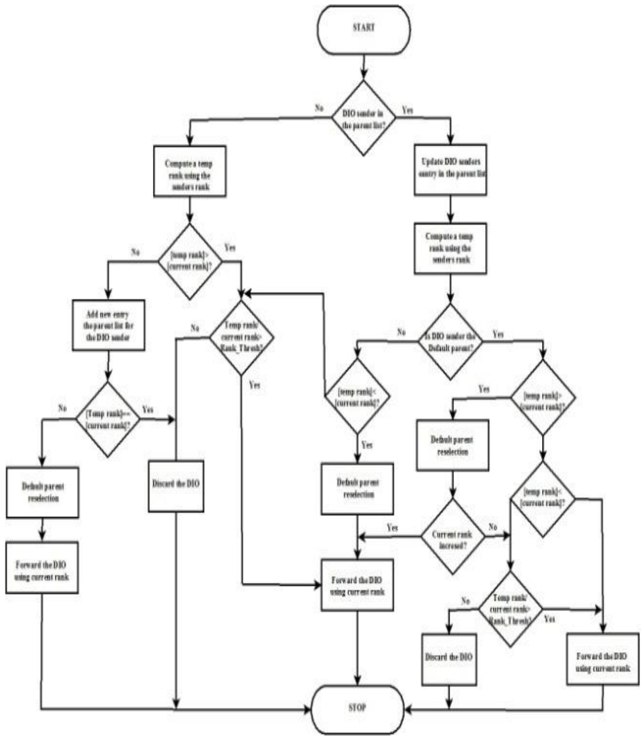

Fig 1: Symmetric Network Formation

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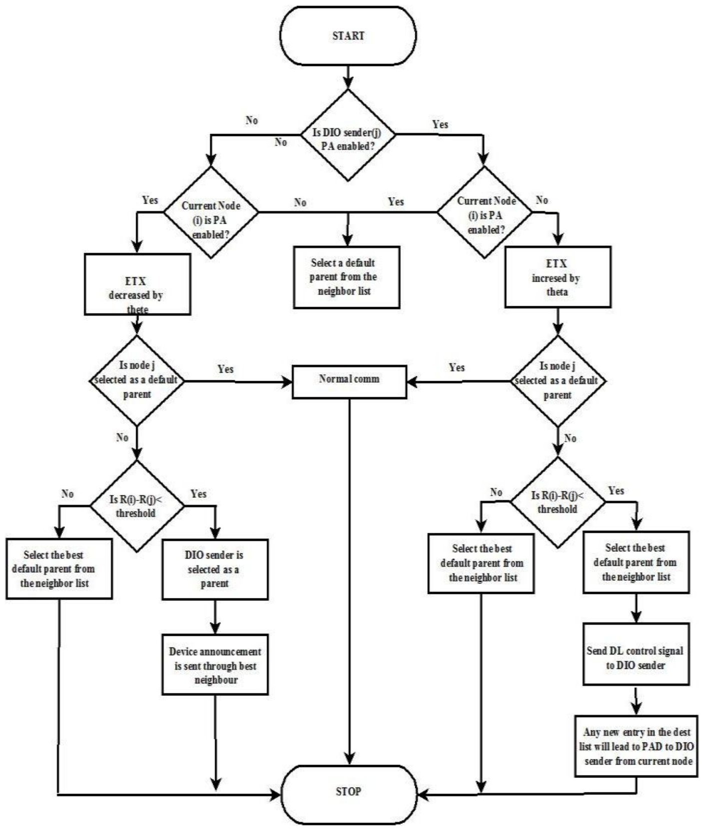

Fig 2: Asymmetric Network Formation

4. SIMULATION AND RESULT

For simulation we used Matlab 2011b (7.13.0.546). The simulations have been performed for a smart grid infrastructure comprising of 50 nodes. These nodes are fixed and randomly place into 40x40 sq. meters area. Asymmetry in the network increases as the probability of a node being PA enabled increases here we taken the probability for PA enable nodes for asymmetry is 0.4. For symmetric networks, this probability is zero.
Parameters:
Po=1dBm; Pa=10dBm (asymmetric power);
Fm=10; loss exponent=4

4.1. Number of Links

In Fig. 3 & 4, comparing the symmetrical and asymmetrical network in smart grid, number of links is higher when the asymmetry in the network increases because communication ranges decrease.

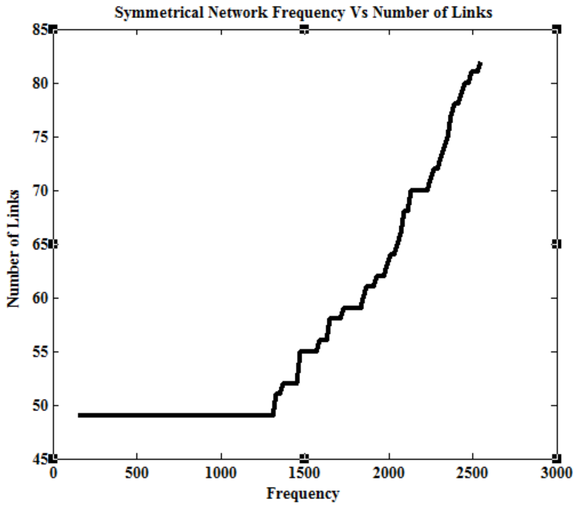

Fig 3: Symmetric Network Frequency Vs Links

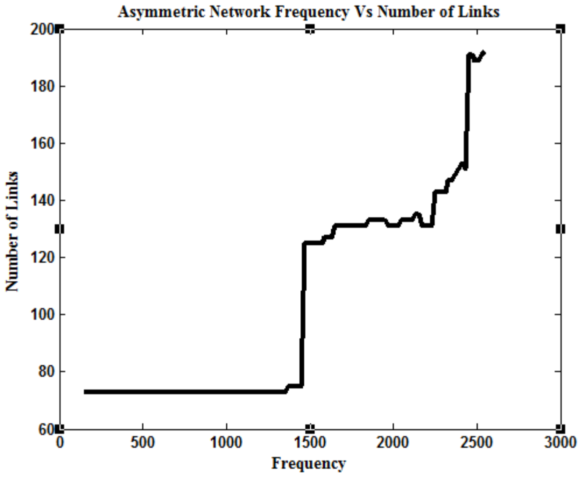

Fig 4: Asymmetric Network Frequency Vs Links

4.2. Number of Packets

In Fig. 4 & 5, number of packets is higher when the asymmetry in the network increases. This is because of the increase in number of links and updates in packet with asymmetry. Number of packets increases with frequency since the number of links increases with frequency.

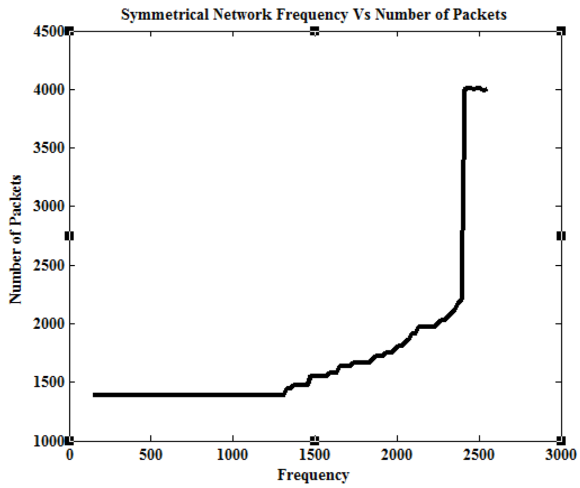

Fig 5: Symmetric Network Frequency Vs Packets

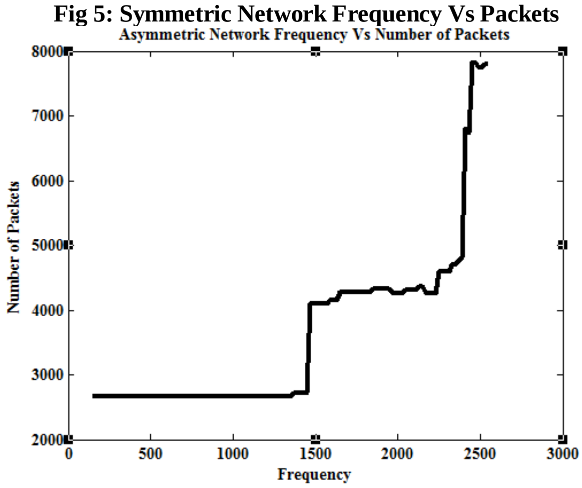

Fig 6: Asymmetric Network Frequency Vs Packets

4.3. Energy Consumed

In Fig 7 & 8, Energy consumed is higher when the asymmetry in the network increases, this is because of the increase in number of links, packet updates, and increase in number of nodes which are PA enabled. Energy consumed increases with frequency, since the number of links increases with frequency. In symmetric network number of packet, number of links is less as compared to the asymmetric network.

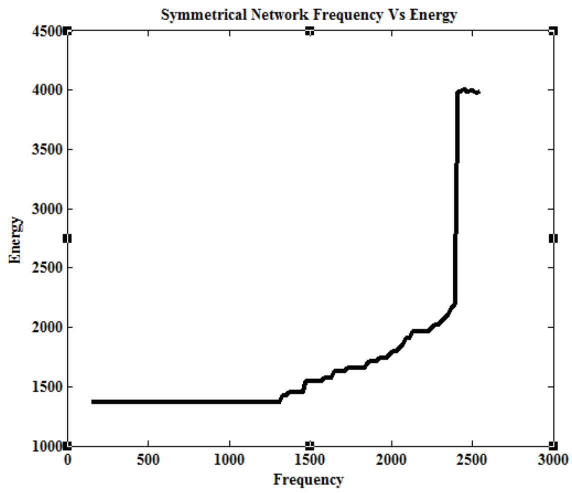

Fig 7: Symmetric Network Frequency Vs Energy

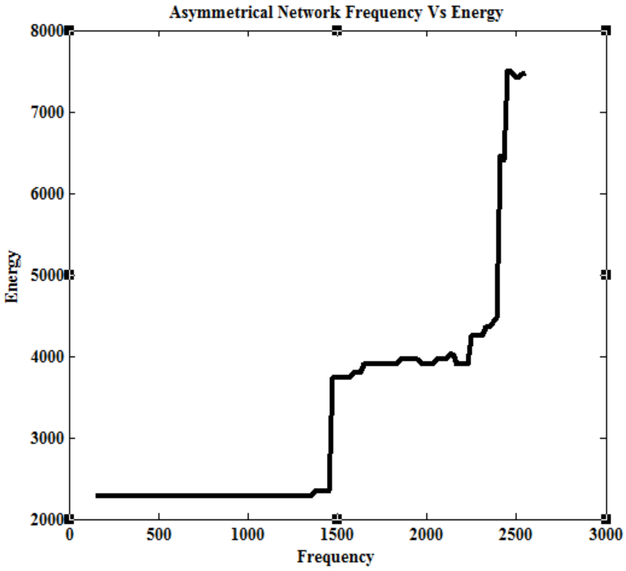

Fig 8: Asymmetric Network Frequency Vs Energy consume

5. CONCLUSION

After careful analysis, Smart Grid capacities produce the asymmetry in the WSN network. We can accept the asymmetry when it is in initial stages, however if it goes on increasing we cannot underestimate the effect of asymmetry on network due to limited resources in the WSN. We can solve the overhead problem with the help of modified approach [7]. We analyze energy consumed by the node, in the initial stage, asymmetry is acceptable however as it increases we have to consider the effect of asymmetry in the network due to limited power handling capacity of the node, on expense of more number of packets, links and energy, compared to symmetric approach we can solve the asymmetry issue in the smart grid infrastructure using WSN. We come to conclusion that number of packets, number of links and energy are the important parameters which must be consider while developing the smart grid infrastructure.

6. REFERENCES

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