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Survey on Optimization of The Energy Consumption and Load Balancing in Wireless Sensor Network

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ABSTRACT

In era Internet of Thing (IoT), Wireless Sensor Network (WSN) is the most important device involved in communication networks between two or more nodes [1]. The growth of communication in the network may cause the performance of delivering packets to become slower or it could be loss packets during transmission time. There are many factors need to be considered in order to decrease the packet loss such as energy consumption, memory space, load balancing, network lifetime, etc. The main focus in this paper is to identify the most problematic issues that happen in the Wireless Sensor Network which is focus on balance heavy traffic load and the energy consumption on the network system. Some comparison will be recognized based on several reviewed research paper and will show the strength and limitation on Wireless Sensor Network communication.

Key words - Energy Consumption, Load Balancing, Node, Network Lifetime, Packet Loss, Wireless Sensor Networks.

1. INTRODUCTION

Technologies Internet of Thing nowadays towards into the Industry 4.0, also known as a smart industry or Fourth Industrial Revolution (4IR). It is involving with some group of sensors, communication hardware, embedded software, Cloud Computing Service and the manufacturing that related with electronic system to share, monitoring, collection, recorded, communication, also as a transportation data [2].

Wireless Sensor Network is one of the innovative technologies of the Internet of Things that make all the equipment or device can communicate with each other [3]. It is getting more attention from various media site, either it from companies, entrepreneurs, government, military and also civil society. Many devices have been created to meet demand target for advanced technology goes smoothly and well organized.

In Wireless Sensor Network, data generated in a network with consist lot of sensor nodes, all these nodes monitored by the central entity as a special node call as Sink Node or Base Station (BS) shown in Figure 1, where all nodes interact with each other used a frequency signal of radio. BS collects all the data and process it and send the available data to the consumer via the Internet [5]. Meanwhile, based on energy consumption concept, energy will increase due to the incensement of communication distance. The data that close to the sink should be pass to other nodes. This will make energy drain faster and lead to the creation of whole energy around the sink. As an outcome, the whole network indicates early death caused by the creation of an energy hole. This sentence is supported by several authors [6]-[9].

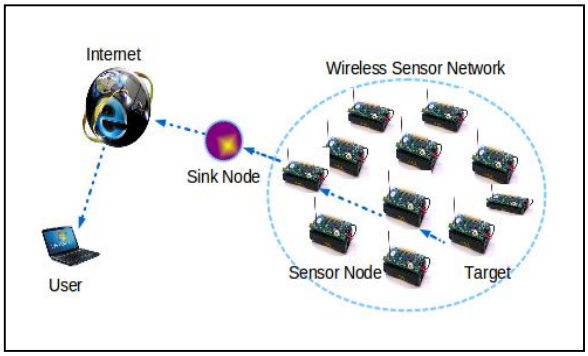

Figure 1: The Wireless Sensor Network [4]

The biggest technology growth in the scope of Wireless Sensor Networks will build a group or thousands of connections between nodes in the communication system. These issues will lead to the creation of some factor towards on failure of WSN. There are several factors of weakness in WSN such as high energy consumption, congestion traffic, unbalance load, slow data processing, compressing techniques, cross-layer design, communication arrangement, thousands of nodes creation, etc [10]. All of these may be caused by heat, electromagnetic interference, equipment problem, multi-path effect, human error, dust, noise, and fading, which make WSNs limited to give the consumer the best performance service [11].

The following issues in the proposed survey paper follow as: In section 2, Related work of Wireless Sensor Network will be presented. Taxonomy of existing work on Wireless Sensor Network will be reviewed in section 3., strength and

limitation in section 4 and Section 5 will present the conclusion and future research.

2. RELATED WORK

This survey paper will identify most of the strength and weakness of the Wireless Sensor Network. But before that, all the related to WSN need to study first.

In a Wireless Sensor Network, the ability of transmission and receiver relies on node energy and make energy usage have a limited lifetime. The drain of energy may cause a loss of network data in the transmission line [7]. Some existing approaches said that most sensor nodes used power by a limited energy source such as a battery that means it not easy to continue to sustain the lifetime expectancy.

There are several approaches technique have been done by some author to implement the weaknesses in the communication network. As in [9], their proposed energy-aware balanced energy consuming and hole alleviating algorithm (EA_BECHA) to minimize the data drop ratio to increase the throughput. The difference with [6] and [12], where both adopt the same technique that is the sleep-wake schedule algorithm to save and minimized the maximum energy on sensor nodes. However, there are also have another way to solve the problem on high energy consumption such as part energy control technique (PECT) which setting the node energy based on path energy consumption to propose by [2], energy balance routing protocol (EBRP) propose by [13] to protect the low energy node through a compact energy area for sent nodes to the sink.

As mention in energy consumption section above, unbalance load also can cause a problem of the premature deaths in earlier than other nodes. Unbalance traffic load may happen when used more one sensor nodes in the transmission range. Which mean all the nodes will focus at the same point at the same time. This will cause of creation hole around the node sink or base station where the hole occurred because of extreme heat concentrated there.

Previous research has shown by change the range of intermediate network nodes at different distances to the sink for bypass the high load region will make energy usage can be distributed and can continue to extend the lifetime [14]. The author has proposed a minimal-energy part, balanced communication on nodes, and ultimately lead to failure network on premature nodes. Same as [12], the author used to create balance dynamic change for traffic load to find a route with an available channel to sink nodes. Although some researchers approach another solution which is presented a Dynamic Hyper Round Policy (DHRP) schedules which cluster static task to split a time to fix length rounds at the beginning of the performance. The schedule is to obtain a load balancing of network lifetime [15]. Almost similar to the DHRP approach, in [1] use cluster algorithms to cluster the size of routing to increase network lifetime. In [16], presents a Low power and Lossy network (LLN) routing to control the heavy dynamic load which designs a low throughput network.

All of this case study can be concluded that both energy consumption and balance traffic load the most significant to each other in order to implement a Wireless Sensor Network. Both have the same issues and the same structure that need to be modify become more stable.

3. TAXONOMY OF COMPARATIVE ISSUES IN WSN

Based on the previous Section 2, all the review paper can be classification into several criteria with differences entity. Table.1 shows that frequent issues occur in Wireless Sensor Network. Instead, there are many ways that can be addressed to fix related issues. There is comparative work, strength, limitation of some literature reviews as shown in Table 1.

Table 1: Taxonomy of Existing Work

Author, Year	Ref	Contribution	Comparison Criteria				
			Control Issues	Algorithm / Classifier used	Method/ Tools	Strength	Limitation
J. Zhang, X. Feng, and Z. Lui, 2018	[1]	• Analyzing load distribution model and energy consumption. • The cluster size of nodes to balance energy consumption. • Cluster head by selected energy and distance in each cluster.	• Load Balance • Energy Efficient • Cluster Nodes	• GCA • ACT • ER-HEED • RUHEED	Simulation	• Minimize energy consumption. • Balance energy of cluster head. • Minimize overhead communication.	• High energy consumption. • Unbalance energy cluster. • Unbalance load distribution.
F. Tubiello et al., 2018	[2]	• Decreases the WSN efficiency to increase energy consumption. • Reduce energy consumption in transmission data. • Increase the lifetime	• Energy Efficient • Lifetime Network	• DPR • EEOR • PECT • QPth • RSSI	Simulator	• Reduce energy consumption. • Increase lifetime nodes. • Increase packet retransmission.	• High Packet loss. • High energy consumption. • Limited memory capacity.

Author, Year	Ref	Contribution	Comparison Criteria				
			Control Issues	**Algorithm / Classifier used**	**Method/ Tools**	**Strength**	**Limitation**
		network.					
S. Kaur and R. Goel, 2016	[5]	• Clustering protocol energy-efficient communication protocol where energy conservation needs. • Selection node for cluster head, ▪ Responsible to collect sensed data from own cluster. • Aggregate the data to the base station or sink.	• Energy Efficient • Cluster Nodes	• LEACH • EEHC • EECP • DEEC • G-DEEC • M-GEAR • GBC	Review Paper	• Cluster algorithm to perform energy stability. • Better utilization and stability lifetime.	• Energy unstable on a cluster node. • Short lifetime.
C. Zhan, Y. Zeng, and R. Zhang, 2018	[6]	• Sensor Nodes wake-up schedule and UAV's trajectory to achieve reliable and energy-efficient. • Minimize energy consumption for all SN's • Design mixed-integer non-convex. • Compare benchmark scheme with static data.	• Energy Efficient • Load Balance.	• UAV-Enabled	CVX – a Software tool	• Minimized the maximum energy. consumption • Wake-up schedule stable and efficient.	• Strike a balancing on the direct link and interference link. • High Energy Consumption.
I. Khan, and D. Singh, 2018	[7]	• Analysis of selection probability and energy balance of node path. • Determine the energy node: ▪ Selected the maximum distance and energy. • Consider the shorted path, direction, energy adjustment for the selected node. • Filter algorithm: ▪ Eliminate the path node by used dynamic selected and balancing the energy. • To prove network lifetime, stability and accuracy need to perform in data analysis.	• Energy Efficient • Distance Nodes	• EBDA	MATLAB	• Optimizes energy network also probability nodes. • Improve lifetime node.	• Low accuracies and data rate during the pre-operation. • Unbalance Load Energy. • Fast drain energy on node transmission.
J. Ren et al., 2016	[8]	• Estimation of energy consumption, load balancing, and sensor nodes lifetime. • A lifetime of dead nodes • Estimate error in less than 5% rate. • Studies on the energy hole of temporal and spatial also provided theoretical mitigate energy hole.	• Load Balance. • Energy Efficient • Life Node.	• FNDT • ANDT	OMNET++	• Reduce error rate energy hole to < 5% • Improve network lifetime	• Short energy lifetime on the node. • Creation energy hole. • Unbalance energy consumption.

Author, Year	Ref	Contribution	Comparison Criteria				
			Control Issues	Algorithm / Classifier used	Method/ Tools	Strength	Limitation
N. Jan et al., 2017	[9]	• Balancing the load of the network. • Enhance throughput ▪ The packet drop ratio is minimized. ▪ To efficiently the utilizing of the energy the lifetime has been prolog.	• Load Balance • Energy Efficient	• WSNEHA • EA-BECHA	Simulation	• Minimized load and energy hole level. • Maximize the packet delivery. • Energy constraint in the transmission process.	• High bandwidth. • High residual energy.
M. Faheem, and V.C. Gungor, 2017	[11]	• Dynamic cluster algorithm: ▪ Balance traffic load and energy consumption. • BMO clustering routing: ▪ Balance energy on cluster head. • Propose protocol to reduce end to end delay. • Improve throughput, memory, packet delivery, and remaining energy.	• Load Balance. • Energy Efficient • Cluster Routing. • Routing Protocol	• BMO • EQRP	EstiNet9.0	• Balance data traffic. • Maximize energy efficient. • Control packet loss. • Maximum lifetime energy.	• Imbalance energy consumption. • Nonuniform node distribution. • Data path loop. • Packet loss. • High delay.
X. Li et al., 2017	[12]	• Change time an identified using SVM to balance the traffic. • Maximum traffic load: ▪ Used DGA to obtain a good traffic balance level. • Deploy the cluster head node. • Sleep-wake schedule to control energy consumption.	• Load Balance • Energy Efficient • Cluster Node	• SDSS • CHN • SHTGT	Simulation	• Control energy consumption used the sleep-wake technique. • Minimized heavy load.	• High energy consumption. • Unbalance traffic load.
F. Ren et al., 2011	[13]	• Energy balance data gathering routing algorithm. • Construct an independent virtual field. • Protect the low energy nodes for residual energy.	• Energy Efficient • Load Balance	• EBRP • RSSI • CLP	Tiny-OS	• Stable energy consumption. • Maximized network lifetime. • Minimized heavy load.	• Low energy lifetime. • High energy consumption. • Unbalance energy node. • Lack of dynamic time-varying potential field.
K. Lui, and C. Wang, 2017	[14]	• Minimize energy consumption path. • Balance load of nodes. • Improve the network lifetime.	• Load Balance • Energy Efficient	• ORECA • ROL • MORA • EARP	NS-2	• Minimize energy consumption • Balance communication of nodes	• High energy consumption. • Limited lifetime battery. • High delay process. • Overhead of the route.
P. Neamatoll	[15]	• Cluster task - schedules load balancing.	• Load Balance.	• DHRP • RBP	MATLAB	• Maximized the network	• Overhead due to clustering.

Author, Year	Ref	Contribution	Comparison Criteria				
			Control Issues	Algorithm / Classifier used	Method/ Tools	Strength	Limitation
ahi et al., 2018		• Eliminates the unnecessary by re-cluster. • Control throughput network lifetime. • Enhance the cluster task by online and offline algorithms.	• Energy Efficient • Life Node.			lifetime. • Balance energy efficient. • Reduce energy consumption.	• Wasted energy resource.
S. Taghizadeh, H. Bobarshad, and H. Elbiaze, 2018	[16]	• Modify of RPL: ▪ Make high -speed sensor data stream. • Increase the lifetime network. • Able to balance load and energy level in the network system.	• Lifetime Network • Load Balance • Energy Efficient	• CAOF • CARF • RPL routing • ETX metric • CLRPL	Cooja-Contiki	• Balance energy level • Maximize lifetime network • Maximize the power of the upstream parent chain.	• High traffic load. • Low throughput Network. • High energy consumption.
A. Sachan, S. Nigam, and A. Bajpai, 2018	[17]	• Clustering the sensor network area. • Used a virtual antenna technique. • Design energy resource in a communication network.	• Energy consumption • Lifetime control	• LEACH • V-MIMO	Simulator	• Boost energy efficient. • Increase the lifetime network. • Increase Performance Network.	• High energy consumption. • Limited lifetime. • Overhead of data transmission.
Y. Cheng, D. Yang, and H. Zhou, 2018	[18]	• Two metric such as miss packed deadline and ratio packet loss need to be considered to remove from AP's. • Make sure that station can be selected by optimal AP's.	• Load Balance • Packet Loss • Network performance	• Det-LB • RLF • MMF • DLBA	NS-3	• Control packet loss performance. • Improve network performance.	• Overloaded AP's. • Unbalance Access points. • Fixed deadline • Unbalance load.

The overall from the fifteen review papers in Table 1 shows most of 93.33% of fifteen paper issues due to energy consumption and 73.33% due to load balancing. Refer to the percentage of the overall paper, can be concluded most of the issues are due to energy consumption and unbalance energy nodes. Where most are affected to maximum the network lifetime and minimize the packet loss performance. Hence, the best performance is come from the minimum energy consumption and reduce traffic during the transmission time. There is a litter bit explanation on both issues in the next subtopic.

3.1. Energy Consumption

Energy consumption is the quantity of energy or power used on electronic devices. Where the longer the device is in used, it will increase energy consumption. This issue does not affect to the wired device but its effects on the device that used a battery to support the lifetime. It is because a device that used a battery have limitation support. As mention in section 2, energy consumption is one of the important things that need to be considered to make process perfectly work in Wireless Sensor Network communication. Without enough energy, some data or process cannot be transfer or perform smoothly by a given time.

To make sure lifetime network stay longest, many contributions can be made to achieve the solution for these issues. As a state in Table 1, some of the authors propose to minimize the heavy load [12], [13] balance the energy-efficient [15] and used a sleep mode schedule to save the battery power [6].

3.2. Load Balancing

In detail explanation, load balancing is the method used to control the flow of the data or packet in the transmission line. The packet needs to be transferred from the sender to the receiver without having any problem. Distance is the main factor in this issue that needs to be measured. Short distance with many data transfer will lead to unbalance traffic.

In balancing the load, it is related to energy consumption, were to control the traffic load in the transmission line, the device needs enough power to transfer data without any delay. Some delay it causes by not enough energy to supply the power to the device. Traffic also can come from the many data have been sending into the transmission line at the same

time. This issues also has been mention in section 2. All these also can control the packet lost performance as in [18] said in their paper. Both of these issues need to be studied in-deeply to resolve all possible problems.

4. STRENGTH AND LIMITATION OF WSN

There are several listed of strength and limitation in Wireless Sensor Network can be identified based on previous paper as shown in Table 1. The following subtopics are an explanation of the strengths and limitations of Wireless sensor networks.

4.1. Strength of WSN

The strength of the Wireless Sensor Network as identified in Table 1 refer to the terms of functionality, control system, how the management, and the concept idea. The strength of the Wireless Sensor Network are:

- **Independent**:
  Stand-alone sensor and device become easy to control and manage. Especially when it used in a large of the location area. Where it can operate by itself without using any other support life system.
- **Flexible**:
  The sensor can be placed and remove at any in location range to separate the signal to another nodes sensor.
- **Scalability**:
  Scalable to change the performance from time to time by itself. Especially on manage the traffic load during transmission time. Where the sensor needs to accommodate more nodes while the network is increased.
- **Capability**:
  Able to choose the shortest part direction of the connection to fast delivery and avoid a packet loss.

4.2 Limitation of WSN

The limitation listed in Table 1 is referred to as terms of speed, capacity, battery issue, and distraction. The following are the explanation regarding the characteristics are pointed below:

- **Capacity**:
  The sensor has limited storage where it used to install all the real-time data inside the device. That why nowadays technology combines with the cloud service to manage the data in the Wireless Sensor Network.

- **Battery Issue**:
  Limited power support makes the life of the sensor depends on the life of the battery. Many functions install in the device makes the sensor used more power to operate.
- **Low Speed**:
  The sensor has limited coverage signal to make some location unable to reach the signal.
- **Distraction**:
  Due to the fact that many sensors have been built nowadays make the sensor device located everywhere, these make signal will be interrupted by other wireless devices.

5. CONCLUSION

In Wireless Sensor Network, energy consumption is one of the important issues need to be stressed it out. From there, many things can be controlled especially to improve the longest network lifetime. Same as balancing of traffic load in the transmission line also need to have thorough research to overcome the packet loss and premature deaths in earlier than other nodes. Many solutions can be performed so that in the future need to be studied in depth to make communication in Wireless Sensor Network work perfectly.

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