FUZZY BASED SCHEDULING AND LOAD BALANCING FOR ZONE ROUTING PROTOCOL (ZRP) IN MOBILE AD HOC NETWORKS

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Abstract
This paper proposes Fuzzy based power scheduling and load balancing technique for ZRP in Mobile Ad Hoc Network (MANET). In this technique, the duty-cycles of the border nodes are adaptively adjusted based on the queue state, predicted residual energy and distance to border nodes. During each round, the nodes are in active state and then enter into the sleep mode based on estimate duty-cycle length. Then the zone leaders (ZL) are adaptively changed whenever its load exceeds.

Keywords: border node, duty cycle, fuzzy, load balancing, power schedule, queue state, residual energy.

Abbreviations: MANET, mobile ad hoc network; ZRP, zone routing protocol; ZL, zone leader.

INTRODUCTION
MANET is a group of active, automated and radio fortified nodes deprived of any substructure. MANET need every single intermediary node to perform as forwarders, getting and advancing data to every another node. This sort of network is commonly positioned in numerous situations in which immediate connectivity turns out to be the on-going need, either in alternative circumstances such as a calamitous emptying condition or in an unplanned gathering for performances [1]. Due to frequent node mobility, network disconnections and link failures are common in this network [2]. Hence, routing becomes a critical job in MANET [3].

ZRP [14] handles issues by combining the best properties of both proactive and reactive routing protocols [4]. But still, many issues exist in ZRP which are to be solved. Data forwarding is performed by each node with maximum power thus ignoring its position in the zone. If the distance between the source and destination node is minimum, it leads to power wastage. On the other hand, if the distance is high, the destination may lie outside the zone radius. While increasing its broadcast attempts to determine the border node, the bandwidth consumption of source node will increase [5].

Location Based Topology Control approach was proposed by Niranjan Kumar Ray et al [6]. It combines topology control and power management techniques to reduce the transmission power of each node. Nodes are put into sleep mode based on the traffic load such that the network is not disconnected.

Zone based Collision Guided (ZCG) protocol has been developed by Shadi S. Basurra et al [7]. ZCG uses parallel and broadcasting techniques for route determination. The determined routes have high connectivity and lesser energy consumption. It splits the network into various zones in which reliable leaders are elected.

A new routing algorithm was proposed by Indrajit Bhattacharya et al [8], which uses ZRP and Minimum Estimated Expected Delay (MEED) protocols. In this algorithm, the data is transmitted to the destination, within a specific deadline

The routing protocol proposed by Bency Wilson et al [9], combines both proactive and reactive routing methods. Like ZRP, it applies proactive routing inside the zones and reactive

routing outside the zones. The speed and locations of each node are monitored continuously. This approach results in increased bandwidth utilization, reduced power consumption and less routing overhead.

Nassir Harrag et al [10] have proposed an algorithm Particle swarm optimization (PSO) and ZRP, to adaptively adjust the zone radius of each node. It enhances the performance of ZRP by reducing the delay, increasing the delivery ratio and reducing the control overhead.

A Genetic Zone Routing Protocol (GZRP) was proposed by Sateesh Kumar et al [11]. It applies Genetic algorithm for IERP and BRP components of ZRP. It determines multiple paths to the destination to perform load balancing. GZRP outperforms the existing ZRP to provide scalability and robustness.

An improved ZRP has been proposed by Xueqin Yanga et al [12]. It divides the networks into various clusters and proactively selects the cluster head in each cluster. .

An enhanced IERP has been proposed by Yuria Oigawa et al [13]. The node id of each zone is stored in a Bloom filter, which is exchanged between the border nodes. The bloom filter assists in forwarding the routing packet to the specified link, thereby reducing the control overhead.

MATERIALS AND METHODS
This paper proposes Fuzzy based power scheduling and load balancing technique for ZRP in MANET. In this technique, the duty-cycles of the border nodes are adaptively adjusted based on the queue state, predicted residual energy and distance to border nodes. During each round, the nodes are in active state and then enter into the sleep mode based on estimate duty-cycle length.
Then the zone leaders (ZL) are adaptively changed whenever its load exceeds.

In ZRP, a routing zone (RZ) with radius r is constructed for each node, individually. (ie) Each zone consists of nodes within r hop distance at the maximum. Hence zones may overlap each other. ZRP contains a proactive and reactive routing modules: IntrA-zone Routing Protocol (IARP) and IntEr-zone Routing Protocol (IERP). IARP manages a routing table for all nodes which belongs to its RZ. IERP applies route discovery

technique to set up routes for the nodes which are outside the zone.
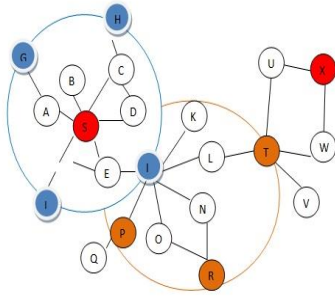

Figure 1 ZRP architecture

For example. let is consider the network depicted in Figure 1. In this network, R is fixed as two hops. S and X indicate the sender and receiver nodes and their routing zones are marked in blue and brown circles, respectively. S examines the routing table, whether X belong its zone. In this figure, since X is exterior to the RZ of S, the route request is broadcast to the border nodes G,H, I and J (marked blue color in figure). When node I receives the request, it again broadcast to its border nodes P, R and T (marked brown color in figure). Since the destination X belongs to routing zone of T, it includes path from itself to X. Then X sent route reply which contains reverse route to S.

Fuzzy logic is used to determine the optimum duty cycle period by considering the predicted residual energy and distance to the ZL parameters, as input. Depending on the output of fuzzy logic, duty cycle is adaptively adjusted. The distance from the node N_i to ZL is denoted as D_{iZL}. When estimating the residual energy on nodes in a path, the traffic load of the nodes has to be considered. The total energy consumed by a node N_i at time is then given by

$$TEC_i(t) = QL(t).EC \quad (1)$$

Where EC is the energy consumption required to transmit a single packet, which is given by

$$EC = (E_{tx} + E_{rx}) \quad (2)$$

Where,

E_{tx} is the energy utilized for transmitting a packet

E_{rx} is the energy utilized for receiving a packet

QL is the queue load at time t which depends on the queue size of the node and estimated using the following Eq.

$$QL_i(t) = [\frac{Q}{Q_{max}}] \quad (3)$$

where Q is the number of packets in the queue

and Q_{max} is the maximum size of the queue

Then the predicted residual energy of N_i after transmitting n packets can be computed by

$$RE_p = CRE_i(t) - n.TEC_i(t) \quad (4)$$

Where $CRE_i(t)$ is the current residual energy of N_i at time t.

Let RE_{max} be the maximum remaining energy of a node.

Then the sleep duty cycle of the receiver is computed as

$$Time_{sleep} = Int_{sl} + w.(RE_{max} - RE_p) \quad (5)$$

Where Int_{sl} is number of sleep intervals and w is a weighting constant.

The value of w is adaptively adjusted using Fuzzy logic, as explained in the next section.
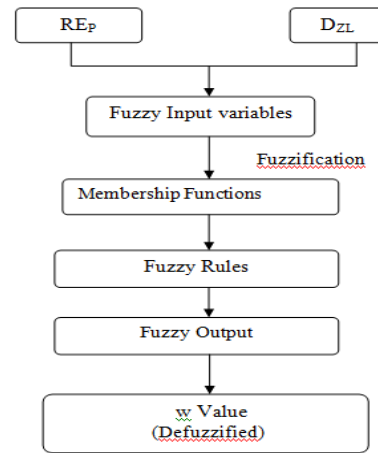
The FLD model is illustrated in Figure 2.

Figure 2 FLD Model

The FLD model involves the following phases: Fuzzification, rule evaluation, Fuzzy rules aggregation and Defuzzification.

Fuzzification: In this phase, the input variables are represented as fuzzy sets with three values high, medium and low. Figures 3, 4 and 5 show the fuzzy sets and membership functions of the input and output variables. Triangular fuzzy set is used in our model.
For RE_p, Low = 0 to 4 joules, Medium = 2 to 6 joules, High=4 to 8 joules
For D_{ZL}, Low = 0 to 4 hops, Medium = 2 to 6 hops, High =4 t0 8 hops
For w, Low = 0 to 2, Medium = 1 to 3, High = 2 to 4.

Fuzzy rules aggregation: Table 1 shows fuzzy decision rules, based on the membership functions. The outcome of each rule is combined to derive a fuzzy decision.
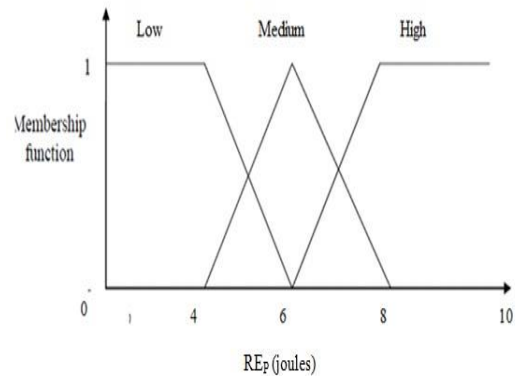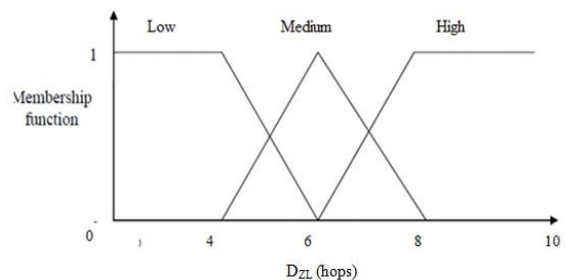

Figure 3 Membership Function of RE_p
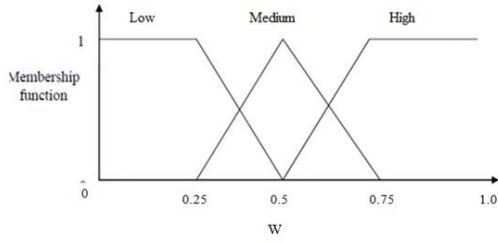

Figure 4 Membership Function of D_{ZL}(hops)

Figure 5 Membership Function of w

Table 1 Fuzzy decision rules

Rule no.	RE_P	D_{ZL}	w value
1	Low	Low	Medium
2	Low	Medium	High
3	Low	High	High
4	Medium	Low	Medium
5	Medium	Medium	Medium
6	Medium	High	Medium
7	High	Low	Medium
8	High	Medium	Low
9	High	High	Low

When the RE_p of a node is low, then it could not forward the packets to ZL, hence it has to be in sleep state for longer time. However, if the node is nearer to ZL, it has to be active, a little bit earlier. Hence in rule no 2, 3, w is assigned as High and in rule 1, it is assigned Medium. If the RE_p is medium, then the w is assigned a Medium value, irrespective of the distance to ZL. Hence rule no, 4, 5 and 6 , Medium value is assigned to w. Finally, if the RE_p is high, then the node can be in active node for more time. Hence in rule 8 and 9, the w is set as Low value. However, if the distance to ZL is less, then w value is set to

Defuzzification
For obtaining the crisp value from the fuzzy output set, the **Centroid of Area** defuzzification technique is applied, which is given by the following equation

$$FC=[\sum_{allrules} f_i * \alpha(f_i)/\sum_{allrules} \alpha(f_i)] \qquad (6)$$

Where FC is the fuzzy cost function, f_i and $\alpha(f_i)$ are the fuzzy rules and their membership functions, respectively. Here, FC returns the crisp value of the output.

The following algorithm shows the steps involved in the fuzzy based adaptive duty cycle scheduling.

Algorithm-1
_____
1. For each source $S_i = 1,2, \dots N$
2. For each intermediate node $N_j, j = 1,2 \dots. K$
3. N_j estimates RE_P and D_{iZL}
4. RE_P and D_{iZL} are passed as input variables to Fuzzy Logic Decision(FLD) model
5. Fuzzification is performed over the input and output variables
6. Fuzzy rules are applied as per Table 1 and fuzzy output is returned.
7. Defuzzification is performed and the value w is returned.
8. Estimate the duty cycle of N_j based on the output w, using Eq.(5)
9. N_j is put in sleep mode for the period of $Time_{sleep}$
10. End For
11. End For
_____

Load Balancing
Let $L_j^1, j = 1,2 \dots K$ are the zone leaders along the zone radius of source S_1.
Let P_1 be the route from S_1 to D
Let PC_j be the path counter which stores the number of paths that pass through ZL_j^1
Let PC_{max} be the maximum number of paths that can be handled by ZL_j^1 without overload
Let $OLrate_j$ be the rate of overloaded incoming traffic at ZL_j^1
Let C_{max} is the maximum capacity of ZL_j^1

Algorithm- Load Balancing at Zone Leaders
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1. For each S transmitting data to D
2. For each ZL_j^1
3. $PC_j = 1$
4. If another source S' tries to transmit data through ZL_j^1 , then
5. $PC_j = PC_j + 1$
6. End if
7. If $PC_j > PC_{max}$ then
8. ZL_j^1 is overloaded
9. Transmission though ZL_j^1 is stopped
10. Determine $OLrate_j$ as $OLrate_j = QL_i - C_{max}$
11. ZL_j^1 transmits OLrate value as a feedback to S_2.
12. S_2 transmits the overloaded part of the traffic through another ZL.
13. End if
14. End For
15. End For
_____

RESULTS AND DISCUSSION
FSLBZRP is implemented in NS2 and contrasted against PSO-IZRP [11] protocol. The experimental settings are given in Table 2.

Table 2 Experimental settings

Number of nodes	25 to 100
Topology size	800m X 800m
MAC protocol	IEEE 802.11
Traffic type	Constant Bit Rate (CBR)
Number of connections	5
Type of propagation	Two Ray Ground
Antenna model	Omni Antenna
Assigned energy	20 Joules
Transmit power	0.8 watts
Receive power	0.5 watts
Data sending rate	250Kb/s
Speed of nodes	5m/s to 25m/s

Case -1 Varying the nodes

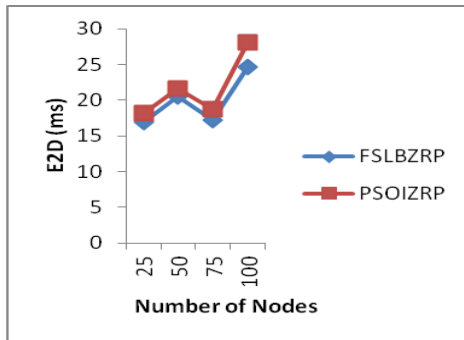In first test case, the network size is increased from 25 to 100 nodes.

Figure 6 E2D for case-1

Figure 6 shows the results of E2D for case-1. As per the figure, the delay of FSLBZRP, varies from 16.8 ms to 24.6 ms and delay of PSOIZRP varies from 18.2 ms to 28.1 ms. Hence FSLBZRP achieves 8% lesser delay than PSOIZRP.
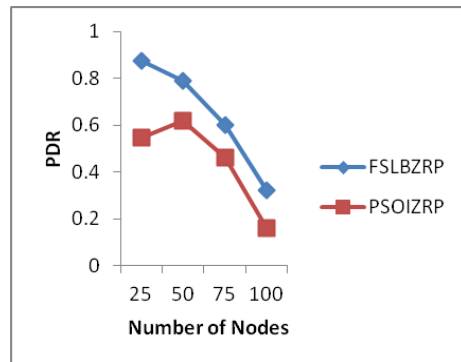

Figure 7 PDR for case-1

Figure 7 shows the results of PDR for case-1. As per the figure, the PDR of FSLBZRP, decreases from 0.87 ms to 0.32 and PDR of PSOIZRP decreases from 0.54 ms to 0.16. Hence FSLBZRP achieves 33% higher PDR, than PSOIZRP.
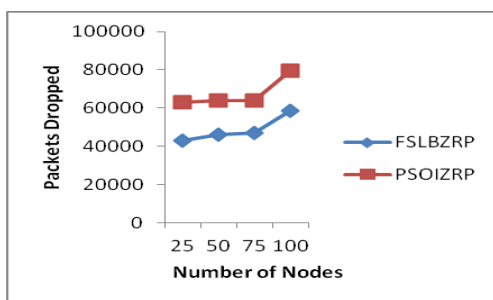

Figure 8 Number of packet drops for case-1

Figure 8 shows the number of packet drops for case-1. As per the figure, the number of dropped packets for FSLBZRP increases from 43090 to 58372 and the same for PSOIZRP increases from 62975 to 79615. Hence FSLBZRP achieves 28% lesser packet drop than PSOIZRP.
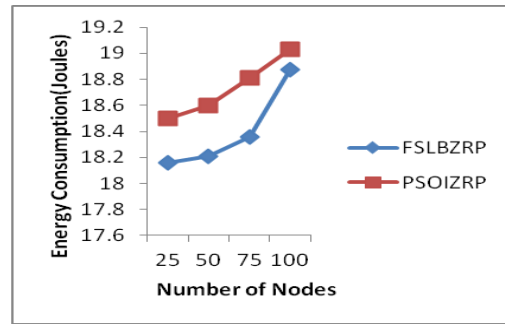

Figure 9 Energy Consumption for case-1

Figure 9 shows results of average energy consumption for case-1. As per the figure, consumed energy of FSLBZRP varies from 18.1 joules to 18.8 joules and consumed energy of PSOIZRP increases from 18.5 joules to 19 joules. Hence FSLBZRP achieves 2% lesser energy consumption than PSOIZRP.

Case-2 Varying the node speed

In second test case, speed of the mobile node is varied from 5 to 25 m/s.
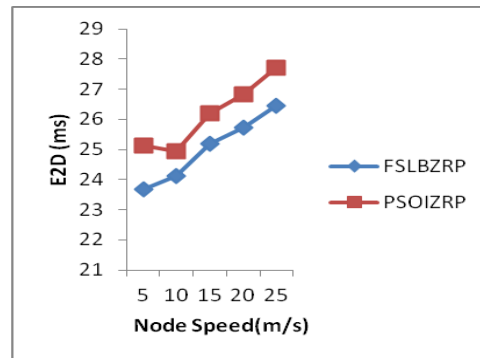

Figure 10 E2D for case-2

Figure 10 shows the results of E2D for case-2. As per the figure, the delay of FSLBZRP, varies from 23.6 ms to 26.4 ms and delay of PSOIZRP varies from 25.1 ms to 27.7 ms. Hence FSLBZRP achieves 4% lesser delay than PSOIZRP.
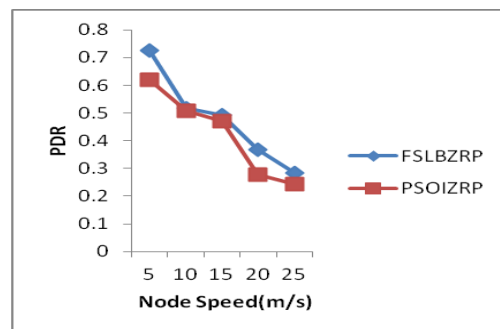

Figure 11 PDR for case-2

Figure 11 shows the results of PDR for case-2. As per the figure, the PDR of FSLBZRP, decreases from 0.72 ms to 0.28 and PDR of PSOIZRP decreases from 0.62 ms to 0.24. Hence FSLBZRP achieves 11% higher PDR, than PSOIZRP.
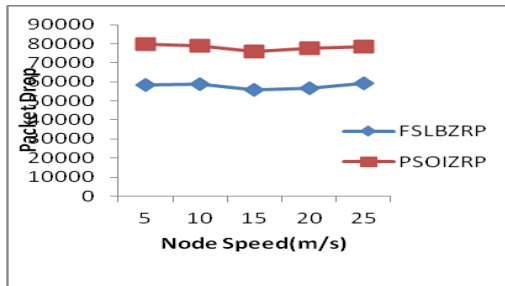
Figure 12 Number of packets dropped for case-2

Figure 12 shows the packets dropped for case-2. As per the figure, the number of packet drops for FSLBZRP increases from 58372 to 59115 and the same for PSOIZRP increases from 79615 to 78503. Hence FSLBZRP achieves 26% lesser packet drop than PSOIZRP.
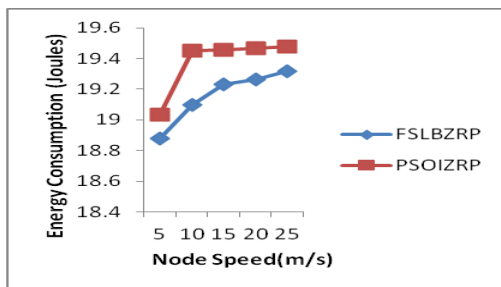

Figure 13 Energy Consumption for case-2

Figure 13 shows results of average energy consumption for case-2. As per figure, consumed energy of FSLBZRP varies from 18.8 joules to 19.3 joules and consumed energy of PSOIZRP varies from 19.0 joules to 19.4 joules. Hence FSLBZRP achieves 2% lesser energy consumption than PSOIZRP.

CONCLUSION
In this work, Fuzzy based power scheduling and load balancing technique for ZRP (FSLBZRP) has been proposed. In this protocol, the sleep time period of zone member nodes is adaptively adjusted. Then the zone leaders (ZL) are adaptively changed whenever its load exceeds. The proposed FSLBZRP technique is implemented in NS2 and its performance is compared with PSO-IZRP protocol. Simulation results have shown that FSLBZRP attains increased PDR with reduced energy consumption.

FUTURE SCOPE
Future work focus on integrating some location based routing protocols over zone routing protocols.

Conflict Of Interest:
The authors don't have any conflict of Interest.

REFERENCES
1. Basetty Mallikarjuna and p Venkata Krishna,(2012), "VCZRP: Enhancing Performance of Mobile Ad Hoc Networks Using Virtual Coordinates",Indian Journal of Computer Science and Engineering (IJCSE),Vol. 3 No. 2.
2. Nicklas Beijar,(2014), "Zone Routing Protocol (ZRP)", Networking Laboratory, Helsinki University of Technology,2008.
3. Dhanya Sudarsan,(2014), "Modified Distance Aware Zone Routing Protocol for Less Delay Transmission in MANET",IJREAT International Journal of Research in Engineering & Advanced Technology, Volume 2, Issue 5, Oct-Nov.
4. Jesin Mary Chacko and K.B.Senthilkumar,(2016), "SINR Based Hybrid Multipath Routing Protocol for MANET",IEEE.
5. Arun Subramaniam, "Power Management In Zone Routing Protocol (ZRP)",University Of Central England, Birmingham,2003.
6. Niranjan Kumar Ray and Ashok Kumar Turuk, "A Hybrid Energy Efficient Protocol for Mobile Ad Hoc Networks", Journal of Computer Networks and Communications,2016.
7. Shadi S. Basurra, Marina De Vos, Julian Padget, Yusheng Ji, Tim Lewis, Simon Armour, "Energy Efficient Zone based Routing Protocol for MANETs",, Ad Hoc Networks, Elsevier 2014.
8. Indrajit Bhattacharya,Debasmita Bhattacharyya and Subhadip Barman, "ZMEED: A Zone based Enhanced Hybrid Routing Protocol for Delay Tolerant Network", International Journal of Computer Applications,2013.
9. Bency Wilson, Geethu Bastian, Vinitha Ann Regi and Arun Soman, "EZR: Enhanced Zone Based Routing In Manet",International Journal of Modern Engineering Research (IJMER),Vol. 3, Issue. 3, May.-June. 2013 pp-1832-1836,2013.
10. Nassir Harrag,Allaoua Refoufi and Abdelghani Harrag, "PSO-IZRP: New enhanced zone routing protocol based on PSO independent zone radius estimation",Int J Numer Model. 2019,doi.org/10.1002/jnm.2461.
11. P. Sateesh Kumar and S. Ramachandram, "Load Balancing in Genetic Zone Routing Protocol for MANETs",World Academy of Science, Engineering and Technology ,International Journal of Computer and Information Engineering ,Vol:3, No:11, 2009
12. Xueqin Yang, Qiangwei Chen, Chaobo Chen and Jianhua Zhao, "Improved ZRP Routing Protocol Based on Clustering",Elsevier,Procedia Computer Science 131 (2018),pp:992-1000,2018.
13. Yuria Oigawa and Fumiaki sato, "Improvement in IntErzone Routing Protocol of ZRP Based on Bloom Filter",Journal of Information Processing,Vol-26,pp:124-131,2018.
14. N.Kavitha,Dr.V.Srinivasa rao and Dr. B.Chandramohan, "Advanced and Distributed Relative Segment and Opportunistic Routing for Congestion Control and Traffic Management in MANET", Jour of Adv Research in Dynamic Control & Systms,vol.10,09 special Issue,2018.
15. Santulli, G.Epidemiology of cardiovascular disease in the 21st century: Updated updated numbers and updated facts(2013) Journal of Cardiovascular Disease Research, 1 (1), .
16. Susi Ari Kristina, Ni Putu Ayu Linda Permitasari. "Association of Secondhand Smoke (SHS) Exposure with Health-Related Quality of Life (HRQOL): A Systematic Review." Systematic Reviews in Pharmacy 10.1 (2019), 61-66. Print. doi:10.5530/srp.2019.1.10