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Research paper

Survey on analysis of energy optimization in MANET routing

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Abstract

Mobile Adhoc Network (MANET) is becoming a priority in everyday life due to its flexibility and scalability in networking. All mobile applications using networks are ready to share and receive data and so they are capable of supporting infrastructure less networks. This leads to become MANET a prominent networking solution worldwide. So the research eyes are now focused on how to improve the MANET performance. There are so many aspects to be analyzed to improve the performance of the MANET. Load balancing is such a critical issue to be addressed seriously to attain maximum throughput from the MANET. Effective Load balancing can be attained by disseminating data traffic among the mobile nodes so that the equilibrium of the MANET is not violated. This ensures the stability of the entire network which will result in maximum throughput and fault tolerance. This paper analyses and compare the effect of energy optimization used in various existing methods and how better load balancing is achieved.

Keywords: *Energy Efficiency; Load Balancing; Link Stability; MANET; Node Mobility.*

1. Introduction

Mobile adhoc network is an infrastructure-less network of wirelessly connected mobile nodes. The mobile nodes in a MANET is endlessly self-configuring in nature. MANET has various advantages like scalability and flexibility. Any node can join or withdraw from the MANET any time which adds flexibility and scalability in networking. Since the nodes are mobile, huge amount of uncertainty is there in MANET. This also brings overhead in network management process like routing, load balancing [1] [2] etc...

Unless the wired network, MANET has some critical aspects which is to be considered while operating. Energy usage of mobile nodes is such an issue. All operations in a mobile node is powered by battery. So the consumption of power [1], [2] is a precarious factor which defines the life of the mobile nodes [3] [4] [11]. Mobility and data transfer across the nodes in MANET consumes more power [12]. Consumption of energy due to mobility cannot be avoided, but energy optimization can be done in the data transfer phase so that the per node energy consumption can be optimized, which will result in increased life time and stability of the nodes and better load balancing can be attained [5] [10].

This paper makes a survey on energy optimization techniques introduced in the MANET and analyses how better load balancing can be attained by optimizing energy. Various existing protocols proposed in the area of MANET energy is taken to consideration and the working of each protocol is analyzed and comparison is made based on energy consumption and a conclusion is reached in the light of effect of energy optimization in MANET load balancing.

2. Link stability

Link stability is an important aspect to be considered while evaluating MANET performance. Link stability refers to the regularity of links between nodes. Energy Optimization is a key factor which directly affects the link stability of MANETS. Link Stability and Energy Aware Routing (LAER) Protocol was developed with an objective to maximize the link stability by optimizing the energy utilization based on residual energy and predicting link age. This protocol is particularly used in distributed wireless networks which makes an equilibrium between stability of links and per node minimum energy drain rate. Specifically this routing protocol make use of Link stability and energy aware metric for implementing stable routing in the wireless networks [2].

Considering two nodes a and b with a transmission range T_R, LAER defines the link stability between a and b as

- If the distance between node (a and b) is less that TR , a link will be established between them at the time instant tin.
- If the distance between two nodes (a and b) are greater than TR , the link is considered to be broken at time instant tfin.
- The duration d(a,b) defines the link age[3] between nodes a and b, which is the difference between tfin and tin.

LAER produces an estimation of link age called as link residual life time[3], [4] by observing the link establishment, link breakage and link age for the past time instants. Based on the analysis prediction of stable links are made.

The energy utilization in sending a packet p from node a to node b is defined as

$$E(p,a)=E_{tx}(p,a)+E_{rx}(p,b) \qquad (1)$$

Where $E_{tx}(p,a)$ is the power required to transmit the packet p from node a and $E_{rx}(p,b)$ is the power consumed to receive the packet p in node b.

The power consumed during transmission, reception and overhearing events are being observed by each node. Then it will calculate the drain rate(DR) for every time slot T and making an average by sampling at regular intervals [2] [7].

2.1. Packet forwarding

The hello packet will be disseminated through all out going links of the node. Each hello packet encapsulates the node's current location and its rate of energy consumption. Every node has knowledge about its neighbors. When a hello packet is received, the node will update the information about the neighbor or if it is about a new neighbor a new entry will be created in the table. Once the routes are identified the data transfer phase starts. A greedy approach is followed by LAER in packet forwarding. Only neighbor and destination knowledge is required in the greedy approach. This protocol allows a flexibility in selecting energy/link stability. This selecting sole depend on the application. If the application wants to have more link stability, more stable paths will be selected else the application can go for a longer path with high residual energy.

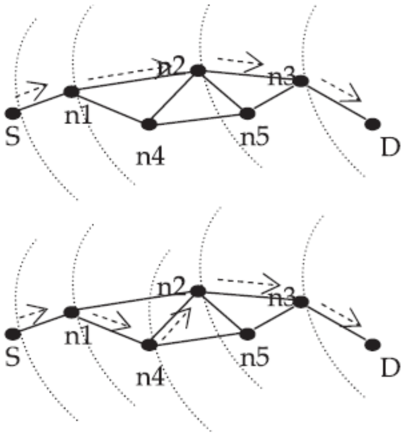

Fig. 1: Path Selection Based on A) Shortest Distance Greedy Approach B) LAER Protocol Selecting Longer Path with High Residual Energy. S=Source, D=Destination, N1,N2,N3,N4,N5=Nodes.

3. Network lifetime

Multipath Routing Protocol for Networks Lifetime Maximization in Ad-Hoc Networks (AOMR-LM) is an energy aware routing protocol based on Adhoc on Demand Multipath Distance Vector Routing(AOMDV) with an improvement of path classification (high, average and low). The path classification is based on the energy levels of the nodes in a path [8] [13] [14]. This methodology categorize paths with homogenous energy nature. This classification helps to soothe the energy consumption. The categorization is based on energy threshold factor and an energy coefficient. This selection helps to balance the energy consumption which in turn result in preserving the residual energy [7] [14].

3.1. Multipath discovery

The path discovery starts on demand by the source node by checking in its routing table. If not found the multipath route discovery process begins. The route request RREQ is broadcasted to all neighbors [7]. A node receiving such a RREQ will check in its routing table for a valid path to the target and if found the RREQ is sent to the next hop targeting the destination, otherwise the node will broadcast RREQ to all its neighbors. Even though the first RREQ is received at the destination, it will wait some more time to collect all RREQ.

The RREQ message in AOMR-LM contains two additional information a) sum of residual energy of source to the current node and b) residual energy of its neighbors [10].

3.2. Multipath selection

Once waiting time is over in the destination node, the route section procedure begins. The destination node will generate the route reply (RREP) and send back to the source. While propagating the RREP, the AOMR-LM takes account of the class node the node. The threshold (α) and energy coefficient (β) classifies the nodes into three classes. The low energy class nodes are separated from middle energy class nodes by the α . β separates the middle class from the high class. The node classification is done by comparing the residual energy of each node and the α and β [1]-[4] [7]. In such a way three classes of routes are presented for the source to start the data transfer. Then the source will select the path from the high class first and moving on to middle and low class when the paths become unavailable in the current class. Once all paths are exhausted the source will go for route discovery process again

4. Energy optimization in link state routing

Energy Efficient Optimized Link State Routing Protocol (EE-OLSR) is an table driven routing protocol based on Multi Point Relays(MPRs) [9]. Due to its quick convergence nature, the algorithm is less prone to network loops. This protocol is scalable in nature but more expensive to implement.

EE-OLSR algorithm works on hierarchical network topology. Optimized link state routing protocol works on the concept known as Multi Point Relays (MPRs). During the flooding process MPRs broadcast the routing request. MPRs are also designated to produce the link state which will be used for routing packets to the destination.

4.1. Energy willingness setting

In OSLR, the process of selecting a node as a MPRs depends on the variable which is known as "willingness". This variable indicates the interest of a node to become MPR. Each node calculates this value and declare it public. The value of willingness is calculated based on two matrices. A) Battery capacity b) predicted life time. Based on this the willingness is classified into default, low or high and it is mapped to a function of battery and life time. This function makes the selection of a node as MPR or note. Table shows the selection values according to the willingness.

After the selection process, the data forwarding phase starts. The next best hop is selected by considering the Minimum Energy drain rate[1]–[3], [5], [6], [15]

5. Path stability and node mobility

Power Efficient Reliable Routing Protocol for Mobile Ad-hoc Networks (PERRA) [5] aims to route packets efficiently by conserving energy based on three basic principles

- Path selection by considering lowest remaining energy of nodes in a path.
- Total energy spent by a path based on packet transmission.
- Stability of a path based on the node mobility.
- This method tries to maximize the power efficiency and minimize the link stability to due to power outage and node movements.

5.1. Energy model

It is clear that the power required to receive, process and handle packet internally is much less that the power required to transmit the packet

$$E_{proc}=E_{tx}/2 \quad (2)$$

Let E_{tx} be the energy required to transmit a packet,

$$E_{tx}= (Packet_{size}*P_{tx})/BW \quad (3)$$

Where

- Packetsize is the size of the packet.
- Ptx is the power of wireless network interface card transmit.
- BW is the bandwidth.

During the packet transmission by a node, the energy required relative to distance is

$$E_{tx}=kd\alpha \quad (4)$$

Where

- k is the proportionality constant.
- d is the distance between two neighbor nodes.
- α is the parameter that depend on the physical environment.

The power consumption is directly proportional to the distance Total energy required at each node is defined as

$$REQ_e=n*(E_{proc}+ E_{tx}) \quad (5)$$

Where n is the total number of nodes.

5.2. Path discovery and route setup

A node will calculates the REQ_e before beginning the path discovery process. This parameter is then recorded into Power Constraint Route Request [7] (PCRRQ) message which is broadcasted to all neighbors. A node receiving such a message will compare its residual energy with the REQe and will join the path if it can contribute enough else the message will be discarded. This process will continue until the message reaches the destination. The destination will reply with PCREP [7] which propagates along the reverse path.

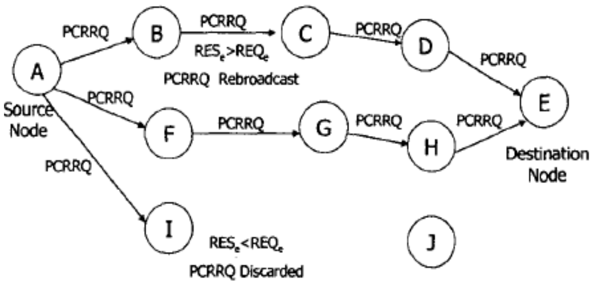

Fig. 2: Propogation of PCRRQ request. PCRRQ=Power Constraint Route Request.

Each intermediate node will compare its residual energy with the path life time (PLT) in the PCREP and if the residual energy is less than PLT then the node will replace the value of PCREP with its value. Then the distance to the neighbor node is calculated will be appended to PCREP and will be forwarded in the reverse path. All nodes will perform the same action if the required energy criterion is met.

5.3. Route selection

PERRA select those route which will satisfy the source nodes energy requirements. This is possible through employing cost function. This creats a mapping between the energy to the number of hopes required to transfer packet. This consist of 1) sum of each node's transmitting energy to send a packet to next hop 2) sum of each node's packet processing energy3) path stability. The source node will calculate the cost function of each reply path and sorts in descending order and the best path is selected for data transfer.

6. Performance evaluation

This paper aims to provide an insight to the effect to energy optimization in balancing the network load in MANETs. Thus four energy optimized protocols are taken into the consideration for the comparison which includes LAER, AOMR-LM, EE-OLSR and PERRA. All of these protocols tries to bring out best routing in terms of energy efficiency.

The following factors are taken into consideration in this section to categorize the performance

- Packet Delivery Ratio.
- Normalized Control overhead with high mobility speeds.
- Average Energy Consumption.
- Variation of node residual energy with maximum node speeds.

6.1. Data packet delivery ratio

Table 1 shows the comparison of DPDR of all of the protocol with different node speed is shown in the Table 1. The study shows that all of the above protocols achieve 99 % packet delivery ratio when the mobility of the nodes are low and the DPDR tends to low as the mobility and network load increases. When the mobility and network load is at its maximum, LAER protocol has performed better than others. This is due to the high link stability achieved by LAER protocols. Among other protocols PERRA has shown poor DPDR as the mobility and traffic load increases. It is because of the reactive nature of PERRA which leads to huge control overhead which in turn leads to bandwidth wastage. At the same time AOMR and EE-OSLR is having an average performance in PDR with high mobility and traffic.

Table 1: DPDR (in Percentage) Comparison vs. Mobility

Node Speed	LAER	AOMR-LM	EE-OLSR	PERRA
1 m/s	99.1%	99%	99%	99%
5 m/s	99%	99%	99%	99%
10 m/s	99%	99%	99%	98%
15 m/s	95.2%	93%	91%	93%
20 m/s	93%	91%	91%	90.5%

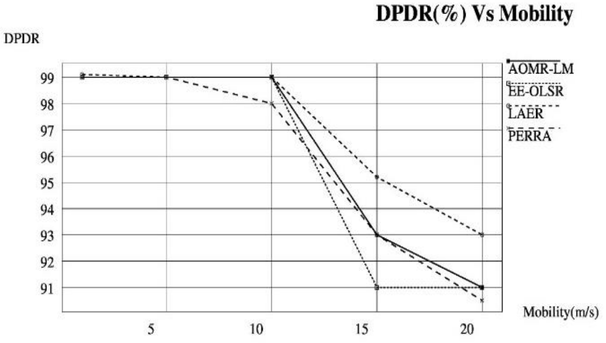

Fig. 3: Comparison of DPDR vs Node Mobility.

6.2. Normalized control overhead with mobility

Control overhead is occurred when a route is established for the first time or the topology changes. Table 2 shows the comparison of the normalized control overhead produced by LAER, AOMR-LM, EE-OLSR and PERRA protocols as the mobility increases. When the nodes are highly mobile in nature, there is high probability to happen path breaks. This also leads to heavy energy drain rate. The study reveals that LAER protocol has less normalized overhead than other three protocols with respect to mobility. LAER has significantly low control overhead because it uses local control packet exchange in case of a topology change. PERRA has shown the highest control overhead in high mobility due to global control packet exchange in case of a topology change. The other two protocols are also showing huge overhead when the mobility increases.

Table 2: Comparison of Normalized Control Overhead vs. Mobility

Node Speed	LAER	AOMR-LM	EE-OLSR	PERRA
1 m/s	6%	6%	6%	6%
5 m/s	9%	10%	13%	18%
10 m/s	18%	22%	22%	35%
15 m/s	20%	35%	38%	61%
20 m/s	24%	42%	47%	94%

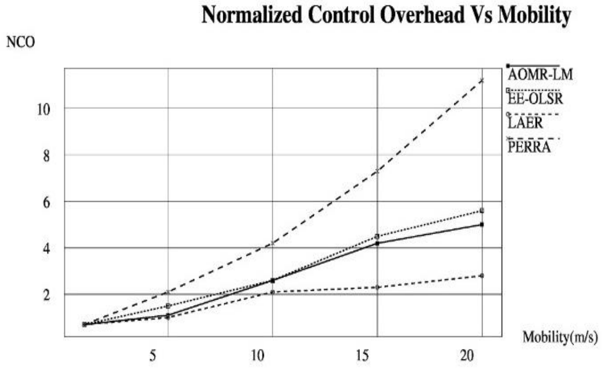

Fig. 4: Comparison of Normalized Control Overhead vs. Node Mobility.

6.3. Average energy consumption

Another parameter taken into consideration for this study is the average energy consumption by the above four protocols when the the total number of mobile nodes increases. Table 3 shows the trend of increased energy consumption as the number of nodes increases. Comparing the four protocols LEAR, AOMR-LM, EE-OLSR protocols has minimum average energy consumption with huge number of nodes. This due to adoption of simplest topology management the route discovery procedure is less energy consuming. PERRA has poor performance again and other two protocols has average performance.

Table 3: Average Energy Consumption vs. Moility

Node Speed	LAER	AOMR-LM	EE-OLSR	PERRA
1 m/s	4%	5%	5%	4%
5 m/s	22%	22%	22%	29%
10 m/s	43%	43%	44%	58%
15 m/s	57%	54%	53%	72%
20 m/s	65%	65%	66%	86%

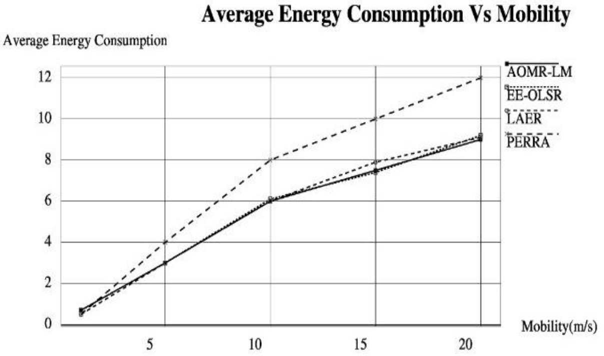

Fig. 5: Comparison of Average Energy Consumption vs. Node Mobility.

6.4. Variation of node residual energy with maximum node speed

The variation of node residual energy with maximum node speed is another parameter to discriminate the load balancing capability of the above four protocols. Since all of these protocols are using energy as routing metric, the all of them trending to have low energy variance with respect to maximum node speeds (Table 4). But here also LAER shows slight better result than other three energy aware protocols due to it has considerations for residual energy drain rate and traffic load on each node. Since all the protocols are performing better, an energy unaware routing protocol is introduced for the better comparison of network load balancing. The standard results of Greedy Perimeter Stateless Routing for Wireless Networks[8] (GPSR) is being compared with the performance of LEAR, AOMR-LM, EE-OLSR and PERRA. It shows that the GPSR has high node energy level variance with maximum node speed.

Table 4: Variation of Node Residual Energy vs. Mobility

Node Speed	LAER	AOMR-LM	EE-OLSR	PERRA	GPSR
1 m/s	20%	27%	27%	25%	37%
5 m/s	17%	20%	22%	20%	35%
10 m/s	14%	17%	17%	18%	29%
15 m/s	12%	15%	14%	14%	22%
20 m/s	9%	11%	11%	11%	15%

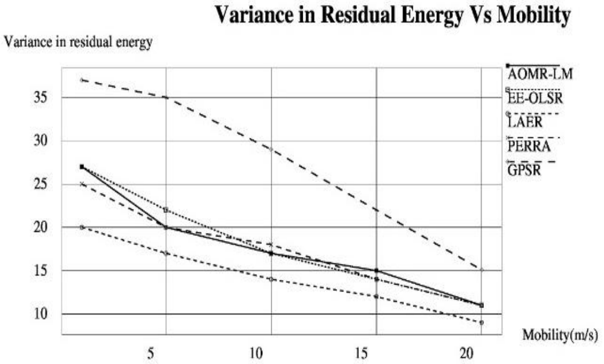

Fig. 6: Comparison of Variance in Residual Energy vs Node Mobility.

The four protocols LEAR, AOMR-LM, EE-OLSR and PERRA are compared on the basis of DPDR, normalized control overhead, average energy consumption and variation of node residual energy. The study evidently shows that LAER protocol which has high link stability by its nature and has given a better and advantageous performance than other three protocols. LAER is also positively characterized by its simple topology change adaptation management by exchanging local control messages. This produces less control overhead. In terms of energy management, LAER preserves the residual energy by monitoring and controlling network load and residual energy drain rate. These three merits bring LAER protocol ahead of AOMR-LM, EE-OLSR and PERRA. Another curious scrutiny that discovered in this study is energy must be considered as a metric during routing process. All of the four energy aware protocols have outperformed GPRS protocol in terms of managing per node energy levels in a very good manner. This shows that energy management is a critical factor to be addressed during routing process to achieve better network life time thus increases the link and path stability which eventually provide performance enhancement in fault tolerance and load balancing.

7. Conclusion

This survey paper aims to provide light on the effect of energy conservation in routing protocols to achieve better load balancing. Four major energy aware protocols LEAR, AOMR-LM, EE-OLSR and PERRA and an energy unaware routing protocol GPSR is taken for the study and comparison. It is evidently shows that the energy aware routing protocols has achieved better load balancing. So study shows that just considering distance as a metric for routing does not provide better load balancing. As MANETs are heavily depending on battery power to survive, energy should be considered as a metric while routing. This paper also classifies the energy aware routing protocols in the basis of network load balancing. In that LAER protocol achieves maximum load balancing in difficult situations like large number of nodes with high mobility and huge data traffic.

References

[1] C. Taddia, A. Giovanardi, G. Mazzini, and M. Zorzi, “Energy Efficient Unicast Routing Protocols Over 802. 11B,” pp. 551–555, 2005.
[2] O. Smail, B. Cousin, R. Mekki, and Z. Mekkakia, “A multipath energy-conserving routing protocol for wireless ad hoc networks lifetime improvement,” Eurasip J. Wirel. Commun. Netw. vol. 2014, no. 1, pp. 1–12, 2014. https://doi.org/10.1186/1687-1499-2014-139.

[3] F. De Rango and F. Guerriero, “Link-Stability and Energy Aware Routing Protocol in Distributed Wireless Networks,” vol. 23, no. 4, pp. 713–726, 2012.

[4] Y. C. Tseng, Y. F. Li, and Y. C. Chang, “On route lifetime in multi-hop mobile ad hoc networks,” IEEE Trans. Mob. Comput., vol. 2, no. 4, pp. 366–376, 2003.

[5] M. Uddin, A. Taha, R. Alsaqour, and T. Saba, “Energy Efficient Multipath Routing Protocol for Mobile ad-hoc Network Using the Fitness Function,” J. Artic., vol. 3536, no. IEEE, pp. 10369–10381, 2017.

[6] J. Liu, J. Chen, and Y. Kuo, “Multipath routing protocol for networks lifetime maximization in ad-hoc networks,” Proc. - 5th Int. Conf. Wirel. Commun. Netw. Mob. Comput. WiCOM 2009, 2009. https://doi.org/10.1109/WICOM.2009.5305828.

[7] Kyung-Sup Kwak, Kyoung-Jin Kim and Sang-Jo Yoo, "Power efficient reliable routing protocol for mobile ad-hoc networks," Circuits and Systems, 2004. MWSCAS '04. The 2004 47th Midwest Symposium on, 2004, pp. II-481-II-484 vol.2. https://doi.org/10.1109/MWSCAS.2004.1354199.

[8] B. Karp and H. Kung, “GPSR: Greedy Perimeter Stateless Routing for wireless networks,” ACM MobiCom, no. MobiCom, pp. 243–254, 2000. https://doi.org/10.1145/345910.345953.

[9] Floriano De Rango; Marco Fotino; Salvatore Marano, "EE-OLSR: Energy Efficient OLSR Routing Protocol for Mobile Ad-Hoc Networks," MILCOM 2008 - 2008 IEEE Military Communications Conference, pp. 1-7, 2008

[10] Juanwei Liu, Jian Chen, Yonghong Kuo, "Multipath Routing Protocol for Networks Lifetime Maximization in Ad-Hoc Networks," WiCom '09. 5th International Conference on Wireless Communications, Networking and Mobile Computing, 2009 https://doi.org/10.1109/WICOM.2009.5305828.

[11] Y. Wu, J. Chen, L. P. Qian, J. Huang and X. S. Shen, Energy-Aware Cooperative Traffic Offloading via Device –to - Device Cooperations: An Analytical Approach, " in IEEE Transactions on Mobile Computing, vol. 16, no. 1, pp. 97-114, Jan. 1 2017. https://doi.org/10.1109/TMC.2016.2539950.

[12] S. A. Sofi, I. Ashraf, F. ud din, A. Ayub and Roohie Naaz Mir, "An analysis of control packets , packet delivery ratio & residual energy in Power Aware Dynamic Source Routing in Mobile Adhoc Networks (MANETS)," Fourth International Conference on Advances in Recent Technologies in Communication and Computing (ARTCom2012), Bangalore, India, 2012, pp.90-94. https://doi.org/10.1049/cp.2012.2502.

[13] D. Wei, H. Cao and Z. Liu, "Trust-based ad hoc on- demand multipath distance vector routing in MANETs," 2016 16th International Symposium on Communications and Information Technologies (ISCIT), Qingdao, 2016, pp. 210-215. https://doi.org/10.1109/ISCIT.2016.7751623.

[14] Z. Chen, L. Guan, X. Wang and X. Fan, "Ad hoc On-demand Multipath Distance Vector Routing with Backup Route Update Mechanism," 2012 IEEE 14th International Conference on High Performance Computing and Communication & 2012 IEEE 9th International Conference on Embedded Software and Systems, Liverpool, 2012, pp. 908-913. https://doi.org/10.1109/HPCC.2012.130.

[15] F. Yang and B. Sun, "Ad hoc on-demand distance vector multipath routing protocol with path selection entropy," 2011 International Conference on Consumer Electronics, Communications and Networks (CECNet), XianNing, 2011, pp. 4715-4718. https://doi.org/10.1109/CECNET.2011.5768227.