A routing protocol based on Context-Awareness for Energy Conserving in MANET

Yun Chen and Kangwhan Lee, *Member, KIMICS*

***Abstract*—**Ad hoc networks are a type of mobile network that function without any fixed infrastructure. One of the weaknesses of ad hoc network is that a route used between a source and a destination is to break during communication. To solve this problem, one approach consists of selecting routes whose nodes have the most stable link cost. This paper proposes a method for improving the low power distributed MAC. This method is based on the context awareness of the each nodes energy in clustering. We propose to select a new scheme to optimize energy conserving between the clustering nodes in MANET. And this architecture scheme would use context-aware considering the energy related information such as energy, RF strength, relative distances between each node in mobile ad hoc networks. The proposed networks scheme could get better improve the awareness for data to achieve and performance on their clustering establishment and messages transmission. Also, by using the context aware computing, according to the condition and the rules defined, the sensor nodes could adjust their behaviors correspondingly to improve the network routing.

***Index Terms*—**Context aware, Architecture, Ad hoc networks, Sensor node, Energy, Rule based

I. INTRODUCTION

In ad hoc network, especially in sensor network the wireless device power is provided by battery, the network node energy is limited. Therefore it becomes very important to use the node energy in high efficiency for prolonging the network lifetime as long as possible.

For the aim of improving the networks lifetime and capability, we should reduce the node energy expending and routing link cost. So that how to establish the network structure and how to choose the routing path are very important in the ad hoc network.

For the above reasons, in this paper an Energy conserving Context aware Clustering algorithm (ECC) is proposed to establish the network clustering structure, and a routing algorithm is introduced to choose the Optimal Energy Routing Protocol (OERP) path.

Manuscript received May 21, 2007.

The authors are with Department of electrical and computer engineering, Korea University of Technol-ogy and Education, Cheonan City Chungnam Provi-nce, Korea (Email: fei822@kut.ac.kr, kwlee@kut.ac.kr)

Because in ad hoc network, the topology, nodes residual energy and energy consuming rate are dynamic changing. The network system should react continuously and rapidly to the changing conditions, and make corresponding action according different conditions. So we use the context aware computing to actualize the cluster head node, the routing path choosing.

In this paper, we show a new Energy conserving Context aware Clustering algorithm(ECC). This algorithm discuss several energy factors: transmit power, node mobility, and node residual energy. Totally thinking of the factors, we choice the nodes which have low transmit power to cover at least N neighbors, more residual energy and low mobility as the cluster head.

There are some previous routing energy algorithms which deal with the energy routing problem in ad hoc network, such as the MER (Minimum Energy Routing) Protocol[1] and OMM (Online Max-Min Routing) - Protocol[2]. Nevertheless, MER only considered the total energy expend on the routing path, the OMM only considered the node residual energy. They only consider one narrow element. This paper proposes a new algorithm OERP, this algorithm includes several elements: the energy expenditure on the path, the minimum energy residual node, and the node expenditure. Synthesize thinking over the above ingredients, we choose an optimal energy routing path to improve the network lifetime.

This paper is organized as follows. In section II, we show the rule based context aware architecture for MANET. In section III, we present the Energy conserveing context aware clustering algorithm (ECC), the optimal energy routing protocol algorithm (EOPR). Section IV provides conclusions.

II. A CONTEXT AWARE ARCHITECTURE

In this paper, a rule based context aware architecture is designed to perform network clustering foundation and networking routing actualizing.

This paper proposes the context aware architecture using the ECA (Event-Condition-Action) rules [5], and designs the main architecture as the following fig.1. The context architecture is composed by three parts: communication unit, the processing unit, and blackboard. In this paper, the architecture only context energy related elements, so a masking part is used. The communication unit gets information from external devices and sends the results to the external counterpart; The processing unit process the context information based on the rules; Blackboard contains the rules memory and context knowledge data part including the if part (condition), the then part (action), context aware super addition temporary variables ,intermediate results and related information.

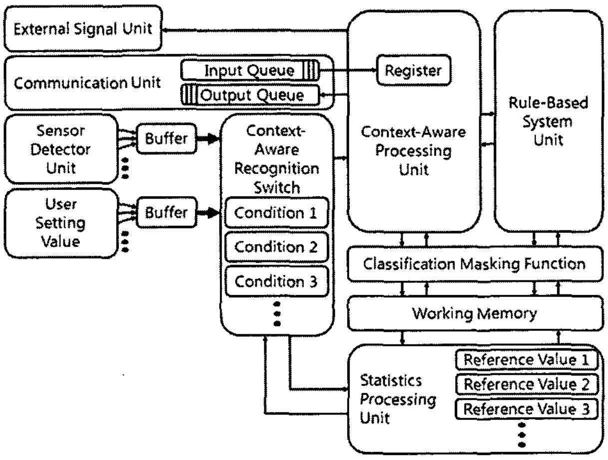

Fig.1 Context aware architecture

Several problems are considered in this paper :

- Establish the cluster.
- Maintenance of the cluster structure.
- Choice the routing path improving the energy consumption
- Information elements included to design the context rules.

These problems will be resolved as the next section

III. CONTEXT ENERGY CONSERVING CONTEXT AWARE

A. The proposed ECC model

This section introduces ECC (energy context aware weighting clustering algorithm).

Table 1 Define Notations in ECC

Notation	Descriptions
i	Node ID
E_i	Residual energy of node i
P_i	Transmit power of node i
D_{ij}	Distance between node i and node j.
V_i	Velocity of node i
N_i	Number of neighbors of node i
S_{ij}	Signal strength from node i to node j
S_{th}	Predefine threshold value of S_{ij}
W_i	ECC Weighting value of node i
W_{th}	Threshold value of W_i
e_{ji}	Energy consumed to transmit unit Information from node j to node i
q_{ji}	Information transmit rate from node j to node i.
R_i	Energy consume ratio of node i
R_p	Energy consume ratio of path p
T_i	Lifetime of node i
U_p	OERP value of path p

1)Clustering models

These algorithms consider the following aspects. Choose the node which has the more residual energy, low mobility, low transmit power to be cluster head. Table.1 defines the notations applied in the algorithm. The velocity can be got based on the signal strength between the node i and its neighbors. And this paper assumes that each node gets the 1-hop and 2-hop nodes as neighbor nodes.

2) Algorithm description

Each node in the network contains a neighbor nodes list, and updates the neighbor nodes list based on the interaction detective message between each node.
The ECC weighting value *Wi* is defined as (1)

$$Wi = Ei^{X1} * Pi^{-X2} * Vi^{-X3} \quad (1)$$

Table 2 weighting value factors

Condition	*X1*	*X2*	*X3*
Average *Vi* is very low	1	1	0
Average V_i is high	1	1	0.5
Average E_i is high	0	1	1

X1, X2, X3 are the weighting value factors, in general network, the three energy elements (Residual energy of node, transmit power, velocity of nodes) is equally important to the energy consumption. In different condition, the *X1, X2, X3* can be defined different values which shown in table.2.

3) ECC algorithm rules

ECC algorithm rules are given as follows:

Step1. Each node i sends neighbor detective message, and listens to other nodes

Step2. Computing E_i, P_i and V_i, get the ECC value W_i.

Setp3. Computing the W_i, if the W_i =W|max.

A. Yes, node i sends parents message to neighbor nodes, declares its parent node beacon, establishes the cluster member list, begins to detect the children nodes information.

B. No, node i listens parents message from the parent nodes. If receives the parent message form the parent noses, sets the cluster ID, become a cluster member and sends child exiting message to parents nodes periodically.

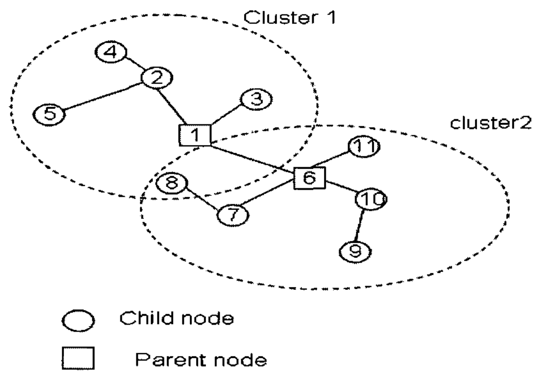

Fig. 2 ECC cluster structure

This paper purposes the context aware architecture to classify the context data into different elements, and an illustration of ECC using classification data is shown as fig.2 and table.3. In this simple illustration, the context classification covers six elements: residual energy, transmit power, velocity, number of neighbors, ECC weighting value, and the condition (shown in table .3). In this illustration, we predefine *X1=X2=X3=1*. According equation (1), get the ECC value, decide the node condition {cluster head: cluster member} based on the ECC weighting value *Wi*. The network cluster structure is shown as fig.2, in cluster 1, node 1 as the parent node, and node 2,3,4,5 children nodes, node 6 as neighbor node.

Table 3 Context classification form

Id	*Ei*	*Pi*	*Vi*	*Wi*	Condition
1	5	10	10	0.05	parent node
2	4	20	20	0.01	Child node
3	6	10	20	0.02	Child node
4	4	20	10	0.02	Child node
5	3	20	20	0.075	Child node
6	6	10	15	0.4	Neighbor node

4) ECC clustering maintenance.

4.1) Maintenance of Parents nodes

If residual energy of parents nodes $W_i < W_{th}$, W_{th} can be defined as β {average W_i}, ($0<\beta<1$). Parent nodes send parent nodes changing message to its children, the cluster head changes, and join to the nearest cluster.

If cluster parent node can't receive exiting message from its children nodes, parent node updates children nodes list, delete the children nodes information.

4.2) Maintenance of Children nodes

If the children nodes receive parent nodes change message, then children nodes leave this cluster, join to the nearest cluster.

If children nodes detect the signal strength less than predefine threshold value, the children nodes will not send exiting message to parent nodes, then leave this cluster, and join a new nearest cluster. Fig.3 shows the flow chart of ECC clustering forming and maintenance

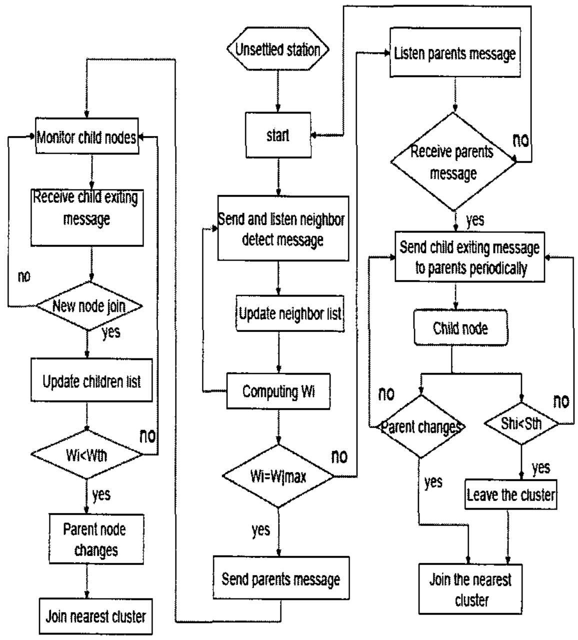

Fig. 3 ECC algorithm flow chart

B. The proposed OERP algorithm (Optimal Energy Routing Protocol) for the ECC cluster network.

In the cluster-based ad hoc network, the problem of data transmission becomes the transmission from the children sensor node to the cluster parent node, and the transmission between the parent nodes.

1) Routing path discovery

To improve the energy conserving of MANET, we adopted multipath routing from source node to destination node, the detail was described in [3]. Energy elements are added to RREQ. In this paper we focus on how to choose the routing path based on energy conserving. Most current energy conserving ad hoc routing protocol only considered one side problem, such as MER [1] and OMM [2]. MER only considered energy consumption on the link path, as OMM only considered the nodes residual energy. This paper proposed a new routing algorithm OERP based on the balance energy value combining the node residual energy and link path energy consumption. In OERP algorithm, the set of all the paths from source node to destination node is defined as P. The selected path is assumed as path p ($p \in P$). The set of nodes on the selected path p is assumed as *Np*. Lifetime of node *i* is:

$$T_i = \frac{E_i}{q_{ji} \sum_{j \in N_i} e_{ji}} \tag{2}$$

Energy consume ratio of node *i* is

$$R_i = \frac{e_{ji}}{E_i} \tag{3}$$

Energy consume ratio of path p is

$$R_p = \frac{\Sigma e_{ji}}{\Sigma E_i} \qquad (4)$$

Otherwise, $\max R_i$ is the maximum value of R_i on the path p. $\min T_i$ is the minimum value of T_i on the path p. Y1,Y2, Y3 are the weighting value factors of the OERP. The OERP value of path p is

$$U_p = \min T_p^{Y1} + \max R_i^{-Y2} + R_p^{-Y3} \qquad (5)$$

2) The performance of OERP algorithm

$\min E_i$ is the minimum value of $E_i (i \in N_p)$ on path p and assumed as Ep, $\min Ep$ is assumed minimum value of $Ep(p \in P)$, $\max Ep$ is assumed the maximum value of $Ep(p \in P)$.

In the illustration shown in fig.4, node 1 is the source node, node 6 is the destination. From source node 1 to destination node 6, there is three paths shown as path1:{1,3,4,6}; path2:{1,2,4,6}; path3:{1,2,5,6}. For the path1 the $\min E_i$=3; for path2 $\min E_i$=2; and for path2, $\min E_i$=4; so for the path set $\min E_p$= min{3,2,4}=2, and $\max E_p$=max{3,2,4}=4.

Step1. When the node receive the RREQ (Route require), if myID=Dest.

A. No, add myID to RREQ, computing R_i, T_i, add R_i, T_i, E_i to RREQ.

B. Yes, node waiting for $\triangle$t, then computing the OERP value U_p of multipath P, choice the paths set P' under the restriction (6):

$$E_p > \min E_p + a(\max E_p - \min E_p), (0 \leqq a \leqq 1). \qquad (6)$$

Under the restriction (6), the path which has the small residuary energy can be avoided to be chosen as routing path. Under this restriction (7), the path $p \in P'$ is selected as the route path.

$$U_p = \max \{U\} \qquad (7)$$

Step2. Send the reply message to the source node.

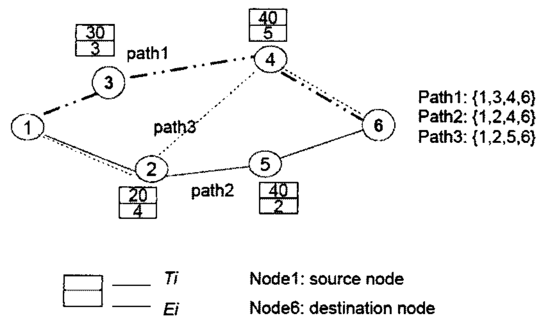

Fig. 4 A simple multipath Routing

Table 4 OERP element value

Path	min*Ti*	1/max*Ri*	1/Rp	E_p	U_p
Path1	30	5	5	3	40
Path2	20	10	5	2	35
Path3	20	5	7	4	32

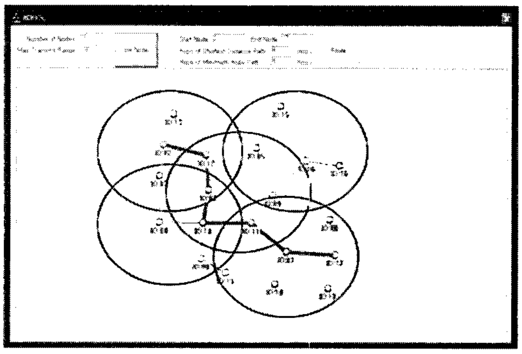

Fig. 4 Simulation results of OERP for ECC algorithm

The proposed OERP of ECC was used for *ns*-2 simulator of performance simulation in modern many treatises. Comparison estimation compared ODMRP of uniformity standard. Computer simulation composes net of 50x50 size for arrangement of node, and nodes were arranged to do random in map. Transmission speed of each node gave equal value. The size decided by 10, and motion of 50 nodes free arrangement select.

IV. CONCLUSINS

This paper proposed energy conserving context aware clustering algorithm (ECC) and an Optimal Energy Routing Protocol (OERP) for the ad hoc network. The proposed ECC, OERP algorithms synthetically considered the energy elements to improve the energy conserving in ad hoc network.

The proposed ECC and OERP could need to know the network topology and residual energy of every node. It would be difficult to perform in large size networks. Otherwise every node should broadcast its residual energy to other nodes. These parameters of energy consumption would also be considered and analyzed as the future works.

ACKKNOWLEDGEMENT

This research was financially supported by the Ministry of Commerce, Industry and Energy (MOCIE) and Korea Industrial Technology Foundation (KOTEF) through the Human Resource Training Project for Regional Innovation

REFERENCES

[1] Doshi S, Brown TX, "Minimum Energy Routing Schemes for a Wireless Ad Hoc Network," Proceedings of the Conference on Computer Communications (IEEE Infocom 2002) 2002.
[2] Li Q, Aslam J, Rus D, "Online Power-aware Routing in Wireless Ad-hoc Networks," Proceedings of Int'l Conf. on Mobile Computing and Networking (MobiCom'2001) 2001.
[3] An HY, Lu XC, Peng W, "A cluster-based multipath routing algorithm in mobile ad hoc networks," Journal of Software, 2007, 18(4):987–995. http://www.jos.org.cn/1000-9825/18/987.htm.
[4] Xu Punping, Wang Panqing,"Research on an improved weighting clustering algorithm," Ordnance Engineering College, Shijiazhuang 050003, China.
[5] Laura Maria Daniele, "Towards Rule-based Approach for Context-Aware Applications".
[6] Tomohiro NAGATA, Hisashi OGUMA, and Kenichi YAMAZAKI, "A Sensor Networking Middleware for Clustering Similar Things".
[7] Keon Myung Lee, Bong Ki Sohn , Jong Tae Kim, Seung Wook Lee, Ji Hyong Lee, Jae Wook Jeon, and Jundong Cho, "An SoC-Based Context-Aware System Architecture."
[8] WANG Haitao, ZHANG Shaoren, SONG Lihua, "Architectures and clustering algorithms for mobile ad hoc network".
[9] Mohamed Younis, Moustafa Youssef, Khaled Arisha,"Energy-aware management for cluster-based sensor networks,"2003.
[10] M. Chatterjee, S.K. Sas and D. Turgut, "An on-demand weighted clustering algorithm (WCA) for ad hoc networks", IEEE Conference on Global Telecommunications, Vol. 3, Nov.-Dec. 2000. pp. 1697-1701.

Yun Chen
received her B.S. degree in electronics information science and technology from Shandong University, China, in 2006. Now she is a M.S course at the School of information Technology of Korea University of Technology and Education. Her master major is computer engineering, and now is studying the energy conserving in MANET and context aware system for wireless UoC system design. Her email address is fei822@kut.ac.kr.

Kangwhan Lee
received his B.S. and M.S. degrees in electronics engineering from Hangyang Univer-sity and Chung-Ang University, Korea, in 1987 and 1989, respecti-vely. He earned his Ph.D. in electronics engineering from Chung-Ang University, Korea, in 2002. And he has finished course work from Korea Advance Institute Technology(KAIST) in 1996. Also, he has work as a invited professor on CICA(Center of Institute Communication Association), France in 1997. Since 1989, he has been a member of senior technical staff at video communications section of Electronics and Telecommunications Research Institute(ETRI), In 2005, he joined the faculty of Korea University of Technology and Education, where he is currently an Associate Professor of electrical and computer engineering. His research interests are in the area of VLSI system design, FPGA/ASIC & Wireless Communication for SoC including UoC(Ubiquitous on Chip) for ubiquitous sensor network.