# An Energy Effective Protocol for Clustering Ad Hoc Network

**Kangwhan Lee and Yun Chen,** *Member, KIMICS*

***Abstract***— In ad hoc network, the scarce energy management of the mobile devices has become a critical issue in order to extend the network lifetime. Therefore, the energy consumption is important in the routing design, otherwise cluster schemes are efficient in energy conserving. For the above reasons, 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 in this paper. 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 consider a novel routing protocol using the cluster schemes to find the optimal energy routing path based on a special topology structure of Resilient Ontology Multicasting Routing Protocol (RODMRP). The RODMRP is one of the hierarchical ad hoc network structure which combines the advantage of the tree based and the mesh based network. This scheme divides the nodes in different level found on the node energy condition, and the clustering is established based on the levels. This protocol considered the residual energy of the nodes and the total consuming energy ratio on the routing path to get the energy efficiently routing.

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

An ad hoc network is a mobile self-organized network with dynamic topology. And every node can serve as a router. 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.

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 node. To saving the energy, before the clustering performing, we use transmit adaptive scheme.

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 loss, 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 related work. In section III, we present the

Manuscript received March 17, 2008; revised May 20, 2008. The authors are with Department of electrical and computer engineering, Korea University of Technol-ogy and Education, Cheonan City Chungnam Provi-nce, Korea (Email: kwlee@kut.ac.kr, fei822@kut.ac.kr)

Energy conserving context aware clustering algorithm (ECC). In section IV, we present the optimal energy routing protocol algorithm (EOPR). Section V provides conclusions.

## II. RELATED WORK

In this paper, a rule based context aware architecture is designed to perform network clustering foundation and networking routing actualizing. The architecture is shown as Fig.1.

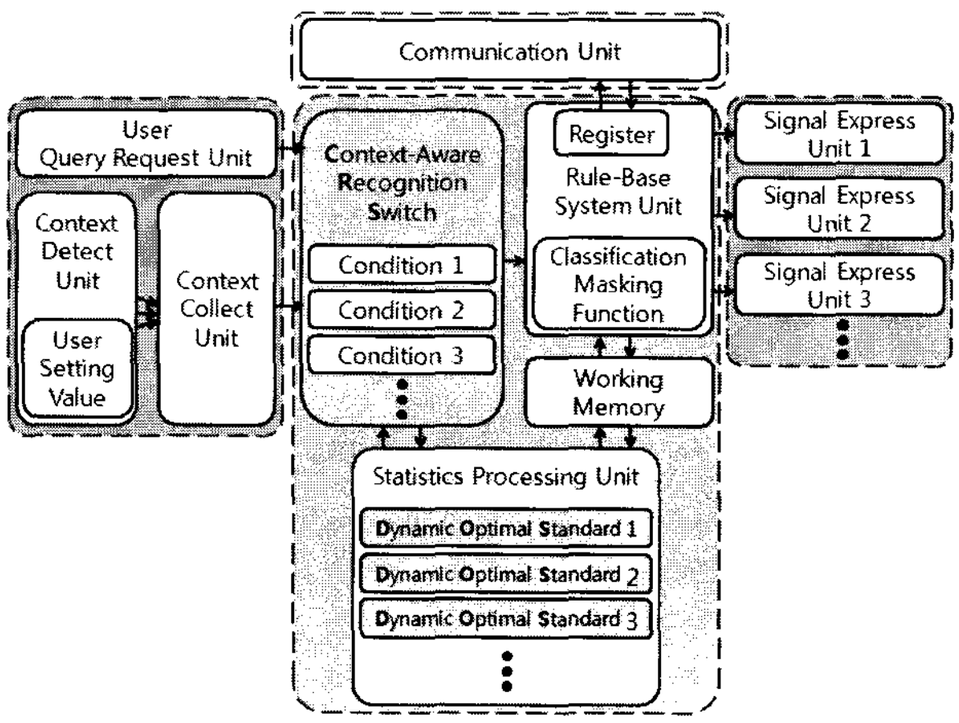


Fig. 1. context aware architecture

The algorithm we proposed in this paper is performed in a particular network structure RODMRP Structure[12]. RODMRP is the Resilient Ontology-based Dynamic Multicast Routing Topology for ad hoc network. This topology combined the tree-based structure and mesh-based structure.

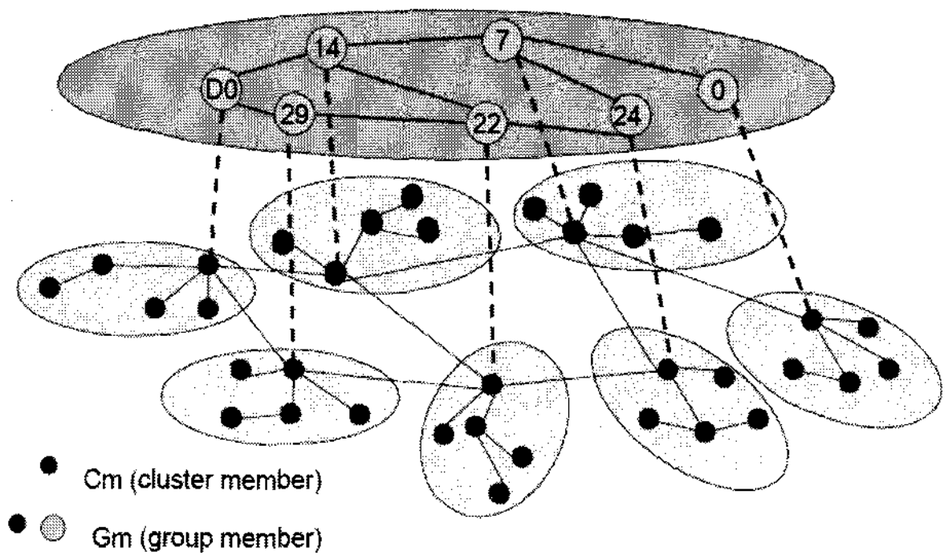


Fig. 2. RODMARP Topology Scheme

As shown this topology, there are two family nodes in this structure network. The nodes in the same family are layer tree-based structure, in the same Depth, the connection mode between each node is peer-peer. Otherwise, RODMP is cluster-based structure, the nodes in the same nodes as a cluster member node, the parents nodes are defined as Group member, the normal nodes are defined as cluster members. Besides, among the two families, the group nodes connect based mesh structure.

## III. ECC ALGORITHM

### 3.1 *The proposed ECC clustering model*

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

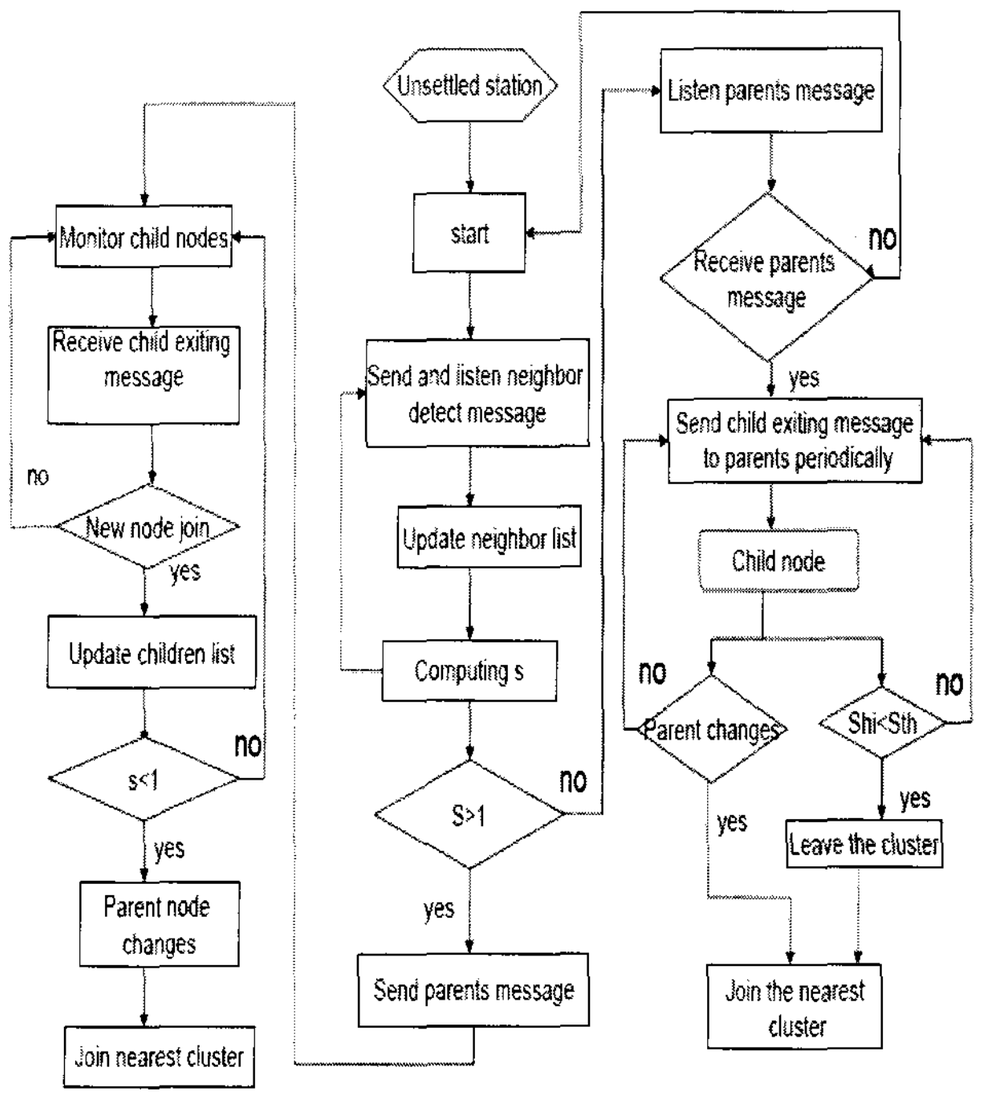


Fig. 3. ECC algorithm flow chart

### 3.2 *Energy level definition*

In this paper we define Ei as the residual energy of node i. In this scheme, the residual energy is divided for different levels using the predefine threshold X as the following.

$$S = \begin{cases} 0\ , 0< E<X1 \\ 1, X1<E<X2 \\ 2, X2<E<X3 \end{cases}$$

If S=2, then the node I is the cluster head. If S=1, the node is defined as the cluster member, but can be used for the backup cluster head. If S=0, the node is defined as the ordinary cluster member.

### 3.3 *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 $E_i$ get the ECC value *S*.

**Setp3**. Computing the *S,* if the $S>1$.

**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. The cluster procedure is shown as Fig.3.

At first the head node broadcasts message to cluster member using the same transmit power Pmax around the range of radius Rmax. Based on formula 1 child node send back an child exiting message to the parents node on transmit power Prj. When the head node receive this message, the parents node will adjust the transmit power Ptj corresponding to Prj based on formula (1).

$$P_r = \frac{P_t G_t G_r \lambda^2}{(4\pi)^2 d^{\alpha} L} \quad (1)$$

Because $\frac{G_t G_r \lambda^2}{(4\pi)^2 L}$ is a constant, so we can define $A = \frac{G_t G_r \lambda^2}{(4\pi)^2 L}$, so the formula 1 become to formula (2).

$$P_t = \frac{P_r d^{\alpha}}{A} (2 \le \alpha \le 4) \quad (2)$$

The flow chat of the clustering establishment and the transmit power adaptive scheme is shown as following figure 4.

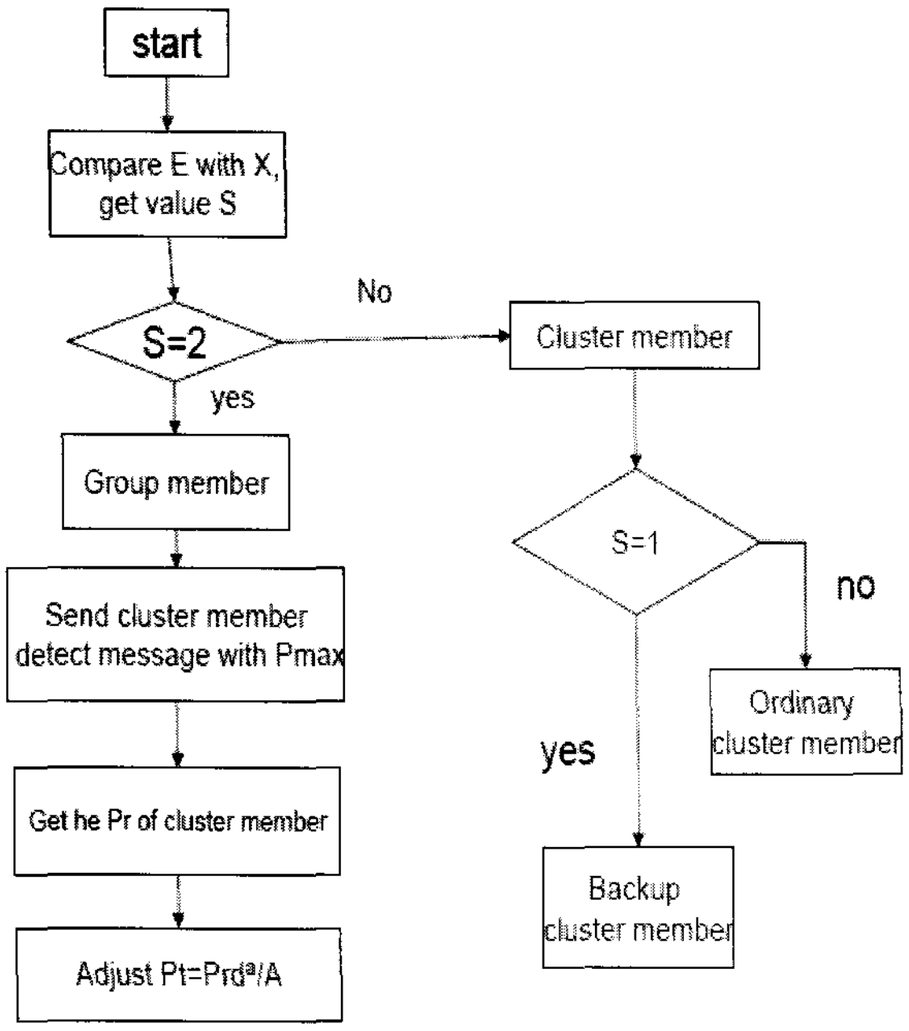


Fig. 4.The transmit adaptive scheme flow chart

## IV. The proposed OERP (Optimal Energy Routing Protocol) algorithm

The algorithm we proposed in this paper is performed in a particular network structure RODMRP Structure which is shown as Fig. 5.

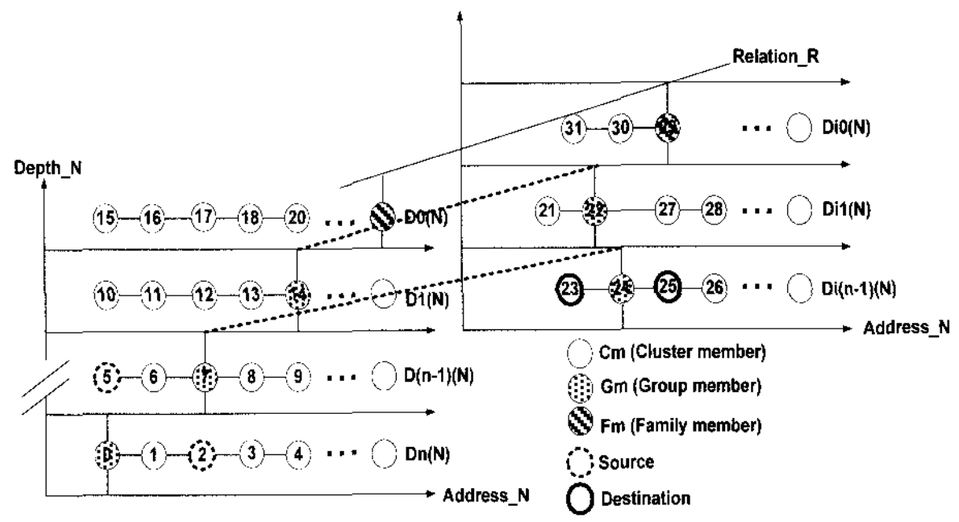


Fig. 5. RODMRP path structure

As shown from fig. 5, the there are several paths from the source node 5 to destination node 22.

Path1:{5,7,24,25}
Path2:{5,7,14,22,24,25}
Path3:{5,7,14,D0(N), 29,22,24}

The propose OERP algorithm chooses an optimal energy routing path from the source node to destination node.

### 4.1 *Path loss on the routing*

Because nodes consume a considerable amount of energy to transmit/receive messages, so how to reduce the energy consumed for radio communications is an important issue. This section give an approach to reduce the energy needed to send a message from source node to destination node.

Assume that the path loss exponent is α, the one hop path loss is considered as $d^{\alpha}$ to send a message from i to j is at least. The distance from the source node i to destination node j is D .the path from source to destination is at least as $\frac{D}{d} d^{\alpha} = D d^{\alpha-1}$

If we consider the path loss between the node

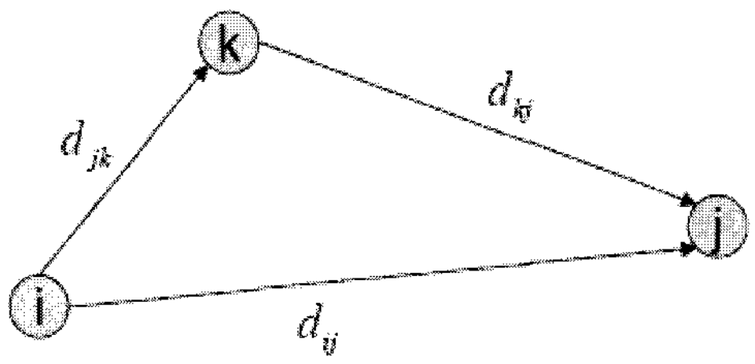


Fig. 6. Path loss Routing

If $d_{ij}^{\alpha} > d_{jk}^{\alpha} + d_{kj}^{\alpha}$, the transmit power consumed on the path(i , j) is more than that consumed on the path(i,k,j).

And another case, if $d_{ij}^{\alpha} < d_{ik}^{\alpha} + d_{kj}^{\alpha}$, the result is inverse. The parameter α is a constant value which relates with the network environment. And in the free space propagation model α=2. This paper is assumed in the model.

The parameter α is a constant value which related with the network environment[11].
It is defined as table 1.

Table 1. Path loss exponent value

| Environment | Path loss exponent $\alpha$ |
|---|---|
| Free space | 2 |
| Urban area | 2.7 to 3.5 |
| Shadowed urban | 3 to 5 |
| In building LOS | 1.6 to 1.8 |
| Obstructed in building | 4 to 6 |
| Obstructed in factories | 2 to 3 |

As shown in Fig. 7, If the node k inside of the circle, $d_{ij}^{\alpha} > d_{ik}^{\rho} + d_{kj}^{\alpha}$, path loss on the path (i,k,j) is less than that on path(i, j). If the node outside of the circle, $d_{ij}^{\alpha} < d_{ik}^{\alpha} + d_{kj}^{\alpha}$ path loss on the path (i,k,j) is bigger than that on path(i,j).If node k is on the borderline. The path losses are same.

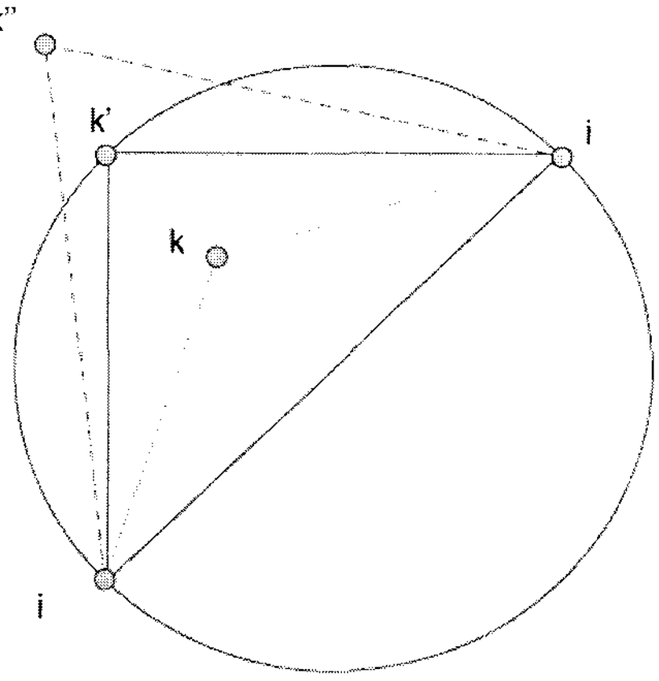


Fig.7. Path loss Routing model

According to the previous mentioned theory, the routing path can be decompose as Fig. 8. In Fig.8, the node 1 is the source node, node 2 is the destination node, the path loss of the different paths has the following relation.

Path loss(1,2)=path loss(1,3'2)>path loss(1,3,2)=path loss(1,4',3,5'2)>path loss(1,4,3,5,2).

Therefore, only consider the energy consumed on the routing path, the path (1,4,3,5,2) is the optimal routing path. Otherwise, in the ad hoc network, not only considered the energy consumed, also try to keep the energy consumed averagely in the network to avoid the bottle-neck nodes. Therefore, the residual energy of the nodes is also considered in the OERP.

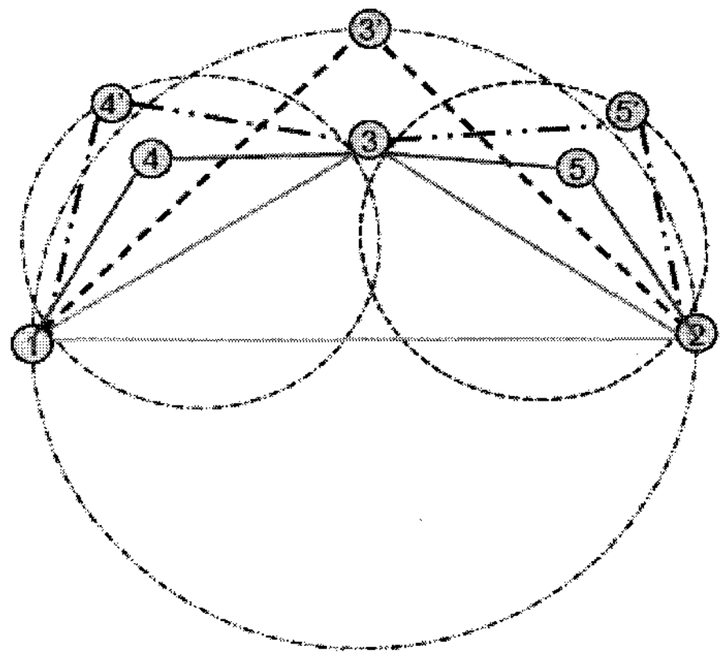

Fig. 8. Routing path diffusion in OERP

### 4.2 *Implement of OERP algorithm*

For the total path, we considered the link cost as a weighting value C, one of the parameters is the minimum residual energy on the path which defined as Emin, another parameter is the ratio value of the sum of path loss and the sum of residual energy.
The link cost is shown as formula (3).

$$C = [Min(\frac{E_i}{\sum_{j \ni N} d_i^{\alpha}})]^{-Y_1} + [\frac{\sum d^{\alpha}}{\sum E_i}]^{Y_2} \quad (3)$$

The path which has the minimum value will be chosen as the routing path. In this function, a,b,Y1, Y2 are the weighting value, and (a+b=1).

When Y1,Y2 take different value, the algorithm to choice the routing path is different which as shown in table 2.

Table 2. Weighting value factors

| F(Y1.Y2) | Algorithm |
|---|---|
| Y1=0,Y2=0 | Shortest hop |
| Y1=0, Y2=1 | Minimum path loss |
| Y1=1,Y2=0 | Max-min algorithm [2] |
| Y1=1,Y2=1 | OERP |

If the average residual energy is very high, the minimum path loss algorithm can be used, if the average residual energy is very low, the OERP algorithm can be used.

## 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.

The OERP use a parameter path loss, we find the relation of the distance and energy consumption when nodes transmit information. We use a geographical location to analysis the energy consumption. Besides, a balance value between the bottleneck node and the energy consumed on the path is considered.

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.

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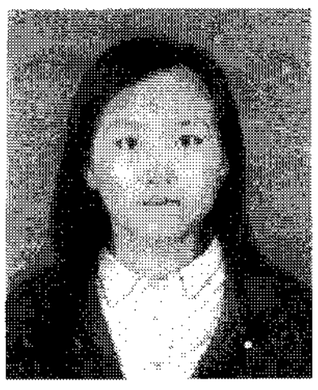
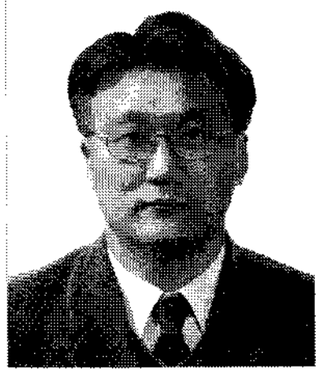


**Yun Chen**
received her B.S. degree in electronics information science and technology from Shandong University, China, in 2006. Now she is a M.S course at the School of information Technology of Korea University of Technology and Education. Her master major is computer engineering, and now is studying 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.