



Smart Journalism Using Wireless Sensor Network and Optimization of Energy Consumption with Smart Routing

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ABSTRACT

The aim of the present exploratory research is the optimal simulation of a smart journalism model using a wireless sensor network. Regarding the effect of routing information transmission, in the challenge of energy consumption and the idea of smart routing (proposed), the combination of VGDRA protocol and Cuckoo meta-heuristic algorithm has been employed. Therefore, in order to enhance the efficiency of the smart journalism model, the smart mobile sink collects news information from journalists' sensors based on the output of the two function optimizers of position and cost, through moving in a virtual dynamic route. The comparison of the simulation output in MATLAB displays compared to the VGDRA protocol, the proposed method reduces the convergence time of the network, the amount of energy consumed in the construction of the virtual backbone and reconstruction of the route, as well as increasing the lifetime of the wireless sensor network, and finally increasing the opportunity to collect news, by the journalists' sensors. The use of smart technologies in journalism is one of the solutions for competitive developments in the reconstruction of media and news agencies.

Introduction

In the 21st century, the journalism profession has entered an era where the digital world and audience participation serve as two determining factors (Veglis and Kotenidis, 2022): "humans in the role of communicators" and "machines in the role of mediator or facilitator" (Jamil,

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2021). In these communications, journalists can obtain information through the interaction of human and computer, human and robot (cyber) and human agent (Guzman, 2018). In other words, in the discussion of digital processes, algorithms have become a factor of transformation in the production and dissemination of news, and in the human part, citizen journalists and the power of adaptation of the general society (Diakopoulos, 2019; Goksu and Cavus, 2019; Jamil, 2021). Although the emergence of ethical concerns caused by the lack of algorithmic transparency has led to innovation in evaluation criteria and a wider integration of digital data in news (Belda and Gonçalves, 2021; Chen and Chekam, 2021), again, the first concern of journalists and society's demand (McKernan and Hemsley, 2022) is access to first or rare news, especially in times of incidents and crises. This is because the lack of information or the fragile relationship between the stakeholders of the responsible organization and the news agents (Zafra and Maydell, 2018) paves the way for spreading rumors and fake news by cyber activists (Di Domenico et al., 2021).

Hence, it can be concluded that sometimes digital and interactive methods are not useful; Therefore, "maybe the solution is to take advantage of the new revolution of the media industry; that is, a journalist with smart capabilities, in such a way that no geographical or governmental or organizational restrictions become an obstacle to freedom of reporting news or access to information" (Alsamhi, 2021b; Chittoor et al., 2021). In this case, the technology leap in journalism can be considered beyond "the digital world of chatbots and recommender systems, along with the evolution of drones and sensors" (Thurman et al., 2019). The media, with the full use of smart technology, become observers of faster and more accurate access to news, relying on the latest satellites that penetrate more than a thousand megabytes (with the scale of Internet speed); drone cameras that capture clearer and more comprehensive images than can be seen with the naked eye; smart robots that monitor event information when natural disasters and human errors occur on top of skyscrapers or at the bottom of the oceans, or even in artistic, sports, etc. events; wireless sensor network nodes that, by collecting data, search for news information in environments where there is a risk of life for the human agent and a risk of destruction for quadcopters and drones (Almalki and Angelides, 2019; Alsamhi et al., 2021a; Stojanovic, 2022). In general, news coverage by technology is a new model of smart journalism that organizations use this new technology to record and share breaking news, and provide views of natural disasters. Smart journalism or smart media can be defined as "the ability to use smart types of technology, such as portable or automated devices like drones, video cameras, or even sensors to perform media storytelling, reporting, and transmitting multimedia content in more efficient and cost-effective ways" (Almalki et al., 2022).

The effectiveness of smart news media or smart journalism in crisis communication is more evident (Driedger and Westby, 2020). Because of possible damage to the communication infrastructure due to critical events (natural disasters, wars, etc.), it may not be possible to obtain information from citizen journalists or people who witnessed the incident and were present at the scene; therefore, access to exclusive information sources leads news stations in the field of media. In this way, "sensor nodes and drones can, as a journalist, collect all kinds of digital, visual and environmental data in hard-to-pass or dangerous areas for humans, such as battlefields, isolated environments, etc." (Almalki and Angelides, 2019; Almalki et al., 2022). High capacity of live broadcast, fast and flexible collection of short news, incremental scalability, wide angle of coverage, mobility when accessing difficult areas (rural or disaster), and providing media content from disaster and inaccessible areas, using a more secure and more cost-effective device for reporting and recording missions, especially in vulnerable coverage, can be seen as other advantages of setting up drones or wireless sensor networks by news organizations" (Almalki and Angelides, 2019; Almalki et al., 2022). Wireless sensor network or multimedia wireless sensor network is a network consisting of computing and

communication devices used in many critical environments (Wang et al., 2012). Computing and communication devices or sensor nodes feed on battery energy, and after sensing the environment and processing data, they send the information to a central node called the Base Station or Sink for analysis, and the central node sends the information to the user via the internet or the satellite (Tunca et al., 2014; Fadel et al., 2015). These networks are used in critical environments to collect and control information and have applications in laboratory, medical, agricultural, tourism, educational, transportation and partially traffic control, pollutant control, forest fire detection, plant and animal counting, equipment monitoring applications and error prediction, pollution monitoring and pollution source detection, sea search, and more (Ali et al., 2020; Bhanu et al., 2019; Kandris et al., 2020; Shakya et al., 2021).

In these networks, due to the limitation of sensor devices in terms of battery, memory and data processing, if all nodes are close enough to the sink, direct routing and less energy use is possible (Zheyuan, 2015). However, in most networks, the random scattering of sensors in the environment makes multi-step routing unavoidable, and unequal energy consumption between nodes causes the occurrence of focal point (Liang et al., 2014). In order to reduce the focal point and the balance of energy consumption, appropriate methods should be considered to improve the movement of the sink (Di Francesco et al., 2011). Therefore, the most important challenge for wireless sensor systems can be considered low-cost routing to reduce energy consumption and enhance network lifetime. Although the impact of the wireless sensor network in the media is rarely mentioned in the research literature, a point of view regarding the link between this technology and the news research technique is explained. Therefore, in this article, a practical scenario is defined from the point of view of technology (simulation) for smart routing and optimal energy consumption. To achieve the aim of the research, first the wireless sensor network was implemented using the VGDR algorithm, then in the proposed idea, the smart routing method was used with two different but related issues. These two issues are: creating a network of journalists' sensors and designing a virtual backbone for the optimal way of spreading news to sinks. Finally, the comparison of the simulated output in MATLAB shows that, compared to the VGDR protocol, the proposed smart method significantly increases the lifetime of the network and collects and transmits more news reports by reducing the cost of backbone construction, route reconstruction, and energy consumption. In the following, using the exploratory and simulation method, after reviewing the literature and explaining the implementation of the proposed idea, the simulation results of the VGDR algorithm are compared with the proposed method.

Literature Review

According to the interdisciplinary approach in this article, the review of literature is explained in two parts:

Research Related to Smart Journalism

The present research can be considered as one of the first smart journalism scenarios using wireless sensor networks. Few researches about smart journalism have been recorded across the world, and most of these cases are related to the field of aerial journalism, which will be explained below:

Many researchers have explored how drones can be used as a value-add to wireless communications or even any form of drone platform that requires a wireless budget for journalism. They have found that by increasing the throughput, the cost of communication can be optimized, increasing the capacity of live broadcasting, HD aerial imaging, and fast and flexible news gathering (Alsamhi et al., 2021b; Chittoor et al., 2021).

Almalki et al. (2022) combined UAV and an artificial intelligence technique called Radial Basis Function Network (NN-RBFN) to train the neural network in order to obtain an accurate broadcast channel model and enhance aerial journalism. They have been able to provide timely and cost-effective media and journalism services in hard-to-reach areas. The simulation results show that the proposed NN-RBFN achieves an accurate dissemination channel model in a three-dimensional scenario, with an accuracy rate of 99%.

Moguel et al. (2017) presented the SkyMedia system, which aimed to provide a unique media perception for audiences during short-term and large-scale live events using a drone and a wireless sensor network. This architecture can provide two streams of information, namely: aerial images and HD videos by drones, and audio and video content from terrestrial WSN. In addition, SkyMedia can also support real maps that provide a wide view of the drone to obtain event information (Moguel et al., 2017).

Research Related to Routing in Wireless Sensor Network

In recent decades, many virtual infrastructures have been proposed for mobile sinks in wireless sensor networks. These infrastructures are proposed based on information release contracts. According to the movement pattern of the sinks, the data collection or dissemination pattern is divided into two categories, controlled and uncontrolled.

In the controlled model, the movement of the sinks is controlled by an external observer and according to the dynamics of the network; however, in the uncontrolled model, the movement is determined automatically by the way of orientation and displacement of the sink itself (Banerjee et al., 2010; Kinalis et al., 2014). In this research, the movement of uncontrolled sinks has been investigated. In the following, a summary of related works including methods, strengths and weaknesses is presented.

Chen et al. (2013) presented a convergent tree algorithm called "Virtual Combined Circuit Straight Routing" (VCCSR). This algorithm creates a virtual structure of virtual circuit and direct route and specifies a set of nodes as cluster heads. A set of cluster heads form a virtual backbone. To collect data, the sink must maintain its connection with the cluster head boundary. In order for the cluster heads to minimize the cost of re-routing to broadcast the latest sink location information, a set of communication rules must be observed. Although the VCCSR plan reduces the cost of the routes reconstruction in controlling the movement of the sink, the head of the cluster in the center of the sensor field faces the focal point problem in the process of resetting the routes, leading to a sharp decrease in energy (Yarinezhad and Hashemi, 2019).

Erman et al. (2012) have proposed the method of "Hexagonal cell-based Data Dissemination" (HexDD), in which a hexagonal grid structure is created for data addressing. HexDD defines questions and lines based on the six directions of a hexagon to avoid redundant distribution of sink data. Nodes send their information to the nearest boundary line, which after sending, is broadcast to the center of the cell. Then the nodes that are along the border lines store the data and repeat the sending (Erman et al, 2012; Yarinezhad and Hashemi, 2018).

The sink data is pushed to the network and approaches a boundary line node with specified stored data. Data transmission to the mobile sink is done using the reverse path. To deal with sink movement, when the sink moves from one cell to another, the central node must be notified. Moreover, border nodes along the route inform which new cell the sink is currently located .

The result of this work is high energy consumption due to the high speed of the sink. For this purpose, the nodes that are along the border line cell, and especially in the central cell, are vulnerable, because high energy consumption causes the focal point problem to arise.

Oh et al. (2010) have proposed an extension model called "Backbone-based Virtual Infrastructure" (BVI) which uses multi-step and single-step clustering. In this method, to

minimize the total number of clusters and reduce the network overhead, the sink position information is sent to all cluster head nodes. The HEED algorithm is used for clustering nodes, which gives priority to the energy levels of the other nodes in the election of cluster head nodes (Oh et al., 2010; Priyadarshi et al., 2018).

This algorithm for following the route that has information about the position of the sinks, considers the network operator as the specified node of the cluster head and the root of the tree. When the mobile sink connects to the cell field, it records its information using the nearest cluster head. Based on this, the host node of the cluster head is updated. When a mobile sink in a cluster moves, the corresponding cluster head node only maintains the connection of the sink with the cluster and prevents the update location of the sink from being broadcast to the root. However, when a sink joins another cluster, another node registers this factor. Then, it shares its information with the root information and other cluster head nodes in the BVI part. Although multi-step clustering is a good plan to minimize the number of clusters and control network overhead, the existence of a focal point causes rapid energy depletion and shortens the network lifetime.

Tang et al. (2012) presented the MESS method. In this method, a virtual strip is created in the field of sensors. As a result, wireless nodes (sink subset) increase. A set of sub-sink nodes are available along the route, which are used for the rendezvous of mobile sinks and also for collecting and storing data from sensor nodes. A mobile sink places the query along a virtual strip to reach the nodes in the sink subset. Subgroups, after receiving the query from the mobile sinks, submit their data route to the mobile sink and use the geographical forwarding method (Tang et al., 2012; Vikneshkumar et al., 2020).

Mir et al. (2011) presented the QDD method. In this method, after discovering an event, a node calculates a set of rendezvous. Then, by successive partitioning, the physical space of the network is divided into four quadrants of uniform sizes. After network partitioning, the data routes that are closer to the central nodes are placed in one partition. The mobile sink disseminates the query packet in the same way as for packetizing nodes in the nearest primary RP. In static nodes, a set of identical nodes become RP over and over again, as a result of which the initial energy of the nodes is depleted and, thus, the lifetime of the network is generally reduced (Lenka et al., 2018; Mir et al., 2006).

Lin et al. (2010) presented the HCDD method. In this method, a hierarchical cluster architecture is proposed in which the second level of the mobile sink cluster head is elected as the routing agent. Routing agents have the ability to respond and keep information about the location of the route of the last sink, and all cluster heads gather their routes to the nearest routing agent. In this method, when the sinks are moved, the cluster heads inform the nearest routing agent. After that, as soon as the sink realizes the broadcast, information routing agents inform all other agents in the location of the next sink. Nodes tolerate high energy consumption by using HCDD during sink movement (Lin et al., 2010; Saravanan and Sasikumar, 2021).

At the end, Table 1 indicates the summary and comparison of data dissemination protocols based on virtual structure:

Table 1. Comparison of Data Dissemination Protocols Based on Virtual Structure

Model	Location-Aware	Overhead Network Control Cost	Convergence Time	Applicability
VCCSR	Yes	moderate	moderate	wide
HexDD	Yes	moderate	low	wide
BVI	No	moderate	low	wide
MESS	Yes	low	low	limited
QDD	Yes	high	low	wide
HCDD	No	low	low	wide

Source: (Khan et al., 2014)

VGDR Algorithm Network Model

In this scheme, "virtual network based on dynamic route setting" for intermittent data collection improves energy by using mobile sink and distributing nodes in sensor field points. The structure of the virtual network and how new routes are maintained towards the final route to the mobile sink are among the details of the VGDR scheme. The working steps of this algorithm include several parts:

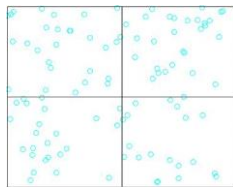
Virtual Structure Construction

In the virtual network structure, according to the number of cells, the sensor field is divided into several cells. The logic of partitioning is to spread the work capacity among the cell-header nodes and increase the network lifetime. To determine the number of cells and the cell-headers, LEACH (Heinzelman et al., 2002), TEEN (Manjeshwar, 2001), and APTEEN (Agrawal, 2015) initiatives have been used, with a 5% of the total number of sensor nodes being considered. According to the number of N nodes, in the VGDR scheme and using equation (1), the sensor field is divided into K cells of the same size. Subsequently, a set of nodes is elected as a cell-header (Khan et al., 2014). In Figure 1, (a), (b), and (c) show the grid celling into cells of the same size for $N = 100, 200$, and 300 , respectively.

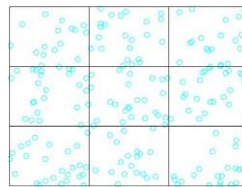
Figure 1

Division of the Field into Cells Based on the Number of Nodes

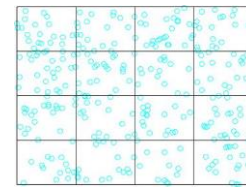
$$K = \begin{cases} 4 & N * 0.05 \leq 6 \\ 9 & 6 < N * 0.05 \leq 12 \\ 16 & 12 < N * 0.05 \leq 20 \end{cases} \quad (1)$$



(a) $K=4$, when $N \leq 100$



(b) $k=9$, when $100 < N \leq 200$



(c) $k=16$, when $200 < N \leq 300$

Source: (Khan et al., 2014)

In electing the cell-header, first in each cell, the nodes closer to the center are elected. In the first step, the nodes identify the dimensions of the sensor field and calculate the midpoint of their cell. To reduce the communication cost, all nodes volunteer, while the nodes whose distance from the center of the cell is less than the threshold are elected (Khan et al., 2014).

After electing the initial cell-header, each cell-header announces its status to all existing nodes and neighboring nodes of its cell. Nodes only respond to the nearest cell-header and share the information of the secondary cell-header with the primary one. In this method, headers of neighboring cells use each other's information through the gateway node. A set of nodes representing the cells make a chain similar to the structure of the virtual backbone.

Setting Dynamic Routes

To deal with the dynamic network topology, the nodes need routes that have the latest information about the position of the mobile sink. Using the flood message sending mechanism to get the last position of the sink is the easiest method; however, it is not compatible with the purpose of saving energy.

In VGDR, only a set of cell-headers that make up the virtual backbone structure maintain new routes to the last location of the mobile sink. To collect information from the sensor field, the mobile sink continuously rotates around the sensor field. As soon as the border nodes see

the sink, they inform the cell-headers about the presence of the sink, and the cell-headers share this information with the rest of the headers in a controlled way. Then, the routes are changed to the sink, and the information from the change of cell-headers is sent to one another to reach the nearest cell-header to the sink, and that cell-header sends the information to the sink (Figure 2). In this algorithm, as a small number of routes are changed, energy consumption is reduced (Khan et al., 2014).

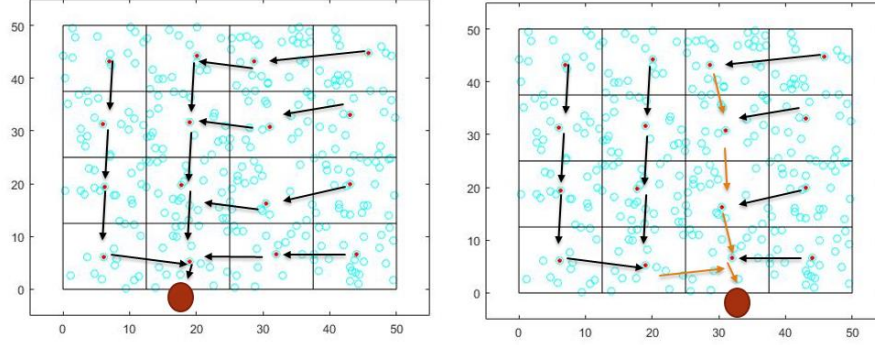


Figure 2. Formation of Virtual Routes to the Sink

Source: (Khan et al., 2014)

Cell-Header Rotation

The cell-header rotates in each cell and is responsible for data collection. Therefore, it consumes a lot of energy, such as the cluster head in clustering algorithms. In order to prolong the lifetime of the network, the cell agent needs to distribute the task among the nodes in the cell. Moreover, to achieve consistent energy loss, the amount of energy of the cell-header is checked; if it is less than a certain limit, the election of a new cell-header is started. In the election process, the node closer to the middle point of the cell and with a higher energy level is elected as the header of the new cell. If no suitable node is found, the search area is slightly increased around the midpoint of each cell. To maintain the virtual structure, the current cell-header shares the information of the new cell-header to all members of the cell and neighboring headers before leaving the task (Khan et al., 2014).

Implementation of the Proposed Model

Hypothesis

Consider a wireless sensor network with N consistent sensor nodes distributed in an environment and continuously monitored. Our assumptions about the principles of the network model and sensor nodes in this research are:

1. Nodes are randomly induced to collect news information.
2. All nodes have a consistent structure and are aware of their location.
3. The nodes adapt their transmission power based on the distance with the destination node.
4. The moving sink has an unlimited source of energy.
5. Nodes have similar capabilities and resources, each node is assigned a unique ID.
6. The sink communicates with media agency through internet or satellite.
7. The sink sends its information online and moment by moment.
8. Before the sensor runs out of energy, the message "I died" is sent to the sink.
9. If a sensor does not send information to the cell-header, it is not assumed to be dead; however, it is assumed to be destructed or destroyed.

Network Modeling

In order to divide the network into cells and elect the cell-header in the proposed method, the VGDDRA algorithm is used. The parameters of energy, centre and search radius have been used to elect cell-headers. In this way, when the average energy of cell-headers is less than the threshold, the election process of the cell-header starts and the search radius in each cell is increased during four steps. Cell-header election is calculated based on equation (2).

$$\text{Cell-Header} = \text{Center} / \text{Energy} \quad (2)$$

Determining the optimal route for the movement of the sink is very effective in energy consumption, which is not possible to set in advance due to the dynamic conditions of the network. In the basic algorithm, the sink only moved around the ground, while in this proposed algorithm, using the cuckoo's meta-heuristic search algorithm, the sink moves smartly in the middle of the ground. During several repetitions and movements in the problem space, this algorithm smartly approaches the best solution; in other words, the best and least expensive position for moving the sink.

Cuckoo Meta-Heuristic Algorithm

The cuckoo search (CS) algorithm is a meta-heuristic algorithm that was inspired by the parasitic and obliging behavior of the nestlings of a certain species of birds called cuckoo (Buaklee and Hongesombut, 2013). Recent studies show that CS is potentially more efficient than PSO and genetic algorithms (Yang and Deb, 2009). Like other evolutionary algorithms, Cuckoo starts with an initial population. This population of cuckoos has some eggs that will lay in the nests of some host birds. A number of these eggs that are more similar to the eggs of the host bird will have a better chance of developing into adult cuckoos. Other eggs are detected by the host bird and destroyed. The amount of grown eggs show the suitability of nests in that area. The more eggs that can survive in an area and are preserved, the greater the profit is allocated to that area. Therefore, the position in which the largest number of eggs are saved will be the parameter that the cuckoo algorithm intends to optimize (Wang et al., 2010).

Finally, after several iterations, the entire population of cuckoos reaches an optimal point with the maximum similarity of the eggs to the eggs of the host birds, as well as the location of the most food sources. This place will have the most overall benefit and the least number of eggs will be lost in it (Sadeghi and Moatar, 2015).

Yang and Deb (2009) considered three ideal rules for CS:

1. Each cuckoo lays one egg (answer) at a time and places its egg in a randomly elected nest.
2. The best nest with the best answer is transferred to the next generation (steps).
3. The number of available host nests is fixed, and the egg (answer) of the alien cuckoo is discovered by the host bird with probability $[0, 1]P_a$. In this case, the host bird can build an entirely new nest by dropping or discarding the eggs.

Simulation of the Proposed Smart Movement Model of the Mobile Sink

In the VGDDRA algorithm, only one constant movement was considered for the sink. However, in the proposed method, a combination of two "fixed and circular" and "smart" movements is included in creating an optimal route for the sink. In constant movement, the sink first moves on a circular route with a radius of 0.20, then it smartly moves to the optimal location in each round by the cuckoo search algorithm. Fixed movement, after various smart movement tests, was determined by the impossibility of wandering around the entire environment (large dimensions) and getting stuck on a single route. Because the sink is continuously receiving and

processing data, if the next position of the sink is the same as the current location, not establishing the constant movement increases the likelihood of stopping the sink in one place. According to Figure 3, the chosen position of the sink is not only a position with minimum multistep but also a position that smartly reduces the estimation of data transmission costs. In the following, the stages of smartization of the movement of the mobile sink will be explained.

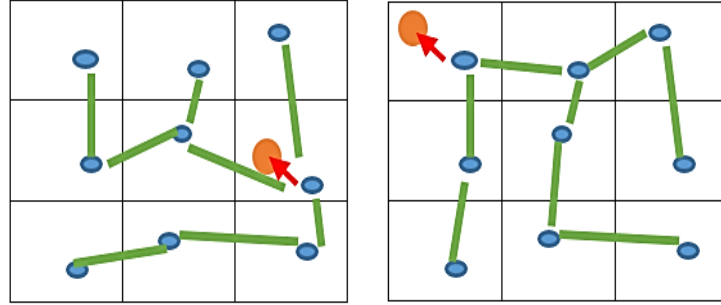


Figure 3. Elected Position of the Smart Well

Defining the Primary Population of Cuckoos

In the implementation of the cuckoo search algorithm, 15 nests or initial population of cuckoos are randomly defined. Only one cuckoo egg is placed in each nest, and each cuckoo egg and nest represents a solution that is determined by two parameters: cost and location. The cost of moving to positions is calculated by estimating the location of the cell-headers. According to the definition of the proposed algorithm, each egg or solution provides a position or a place for the movement of the sink. In the proposed model, first, by determining the size of the population and the number of repetitions of the algorithm, the initial parameters are set according to the cuckoos article (Rajabioun, 2011).

Thus, in equation (3), a set of solutions are defined as an array of x_i 's:

$$X = \{x_1, x_2, \dots, x\} \quad (3)$$

Each position, as the initial search space, includes two values for movement speed and movement angle, which are randomly calculated in the first step of running the algorithm. The upper limit of these two optimization variables is equal to the maximum distance value and 360 degrees. Finally, after executing the steps of repeating the algorithm, the best position based on the minimum amount of cost is determined and the sink is transferred to that place:

$$X_i = \{\text{Velocity}, p_i\} \quad (4)$$

Cost Function

At each turn of implementation, routes called virtual backbone are formed for communication and information transfer between cell-headers, which are effective in calculating the cost function to choose the best location for movement of the sink. The sink can move to any location or position to receive the semi-processed data, while the cost of sending each route is different. The proposed method is to search for a cuckoo (position), using the cuckoo algorithm that creates a route with the lowest cost and the best efficiency.

In the implementation of the cost function, the closest cell (i) to the sink is first determined; then, the ratio of the total remaining energy parameters of the index cell-header to all cell-headers, the number of members of the index cell-header to all cell-headers, and the hypothetical cost of forming the virtual route of the index cell-header to the number of cells are calculated.

The output of the cost function is obtained by the sum of the value and the result of the ratio of the total distance of all cell headers to the new location of the sink, the degree of movement

of the sink towards the index cell header, and the median of all cell headers to the index cell, multiplied by 6 times the number of cells.

(equation 5).

$$\text{Cost Function} = \frac{(\sum_{i=1}^n x_i^{(i+1)})}{k} + \frac{(\sum_{i=1}^n iy_i)}{6k} \quad (5)$$

In this equation, X's is an array of x_i 's, which x_i 's are respectively equal to:

$$X_i = \{\text{Energy, Cost_duty, Number}\} \quad (6)$$

Furthermore, Y is an array of y_i 's which are respectively equal to:

$$Y_i = \{\text{Distance, Moderation, Degree}\} \quad (7)$$

To calculate the value of x and y array parameters, the cell where the sink is located is first considered as an index; then, the values are calculated as follows:

Energy

The more the residual energy of the cell-header is, the longer the network's lifetime increases. This is because when transmitting data from the nodes of its own cell and other cell-headers, the energy of the index cell-header does not run out when the network stops. If the energy of the cell-header is less than the total information collected from the network, the transmission is incomplete and the network is stopped.

Equation (8) calculates the remaining energy ratio of the index cell header.

$$\text{Energy} = \frac{(\sum_{i=1}^k E_{\text{cell}_i})}{E_{\text{index}}} \quad (8)$$

k signifies the number of cells, E_{cell} is the total energy of all cell-headers, and E_{index} is the energy of the current cell-header.

Hypothetical Cost (Cost_duty)

This parameter is the most influential value in determining the location of the sink movement. In this parameter, the communication cost of the cell-header index is calculated hypothetically with other cell-headers in order to receive information, so that finally the sink moves to the cell-header with lower communication costs. If the cell closest to the sink is the cell-header index, then the energy is zero; Otherwise, the cell-header index (the header of the new cell to which the well has moved) informs the header of the previous cell-header (the cell-header that the sink was close to in the previous position) and the communication energy is calculated. In the next step, with the movement of the sink, each cell informs the other cells about the move, so that the cells that need to change direction, towards the cell-header near the sink, are identified, and the new energy route is calculated according to their distance from the cell. Finally, the sum of these energies is considered as a cost. Algorithm (1) shows how to calculate the hypothetical cost:

```

Energy1 ← sum [N.E]
while is not empty (Node)
{
    for: j to Nodes
    {
        H ← Hops to Neighbors
        for i: 1 to length Neighbors

```

```

{
    N1 ← CellHeader
    N2 ← CellHeader (Neighbors)
    Distance ← N(N1) to N(N2)
    Calcute cost of Energy N(N1) and N(N2)
    if
    {
        H(i) is not equal j and Hop(j) is not equal Neighbors{j}(i)
        and is not member (Neighbors{j}(i) and ChangedNodes)
        then
        N ← NN Neighbors{j}(i)
        Hop(Neighbors{j}(i)) ← j
        ChangedNodes ← ChangedNodes Neighbors{j}(i)
    }
}

Nodes ← NN
Nodes ← unique(Nodes)
}
Energy2 ← sum [N.E]
E2 ← Energy1-Energy2

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Algorithm (1) – Hypothetical Cost

Members of the Cell-Header (Number)

The more the number of cell-header index, the lower the energy consumption in the entire network, since the information is sent directly to the sink by the cell-header index. However, if the sink moves to a cell with a smaller number of members, the information must be sent through the virtual route and, in addition to the occurrence of multi-step communication, the participating cell-headers will have a high energy loss in transmitting the data of the cell-header with a large number of members.

The ratio of the number of cell header members to the total number of all cell header members based on equation (9) is equal to:

$$\text{Number} = \frac{N_{\text{cell_index}}}{\sum_{i=1}^k N_{\text{nods}}} \quad (9)$$

In this equation, $N_{\text{cell_index}}$ is equal to the number of the members of cell-header index, and N_{nods} represents the number of non-index node members.

Distance to the Sink

The smaller the distance between the cell-header and the sink, the less energy is consumed during the transmission of information in the entire network. With equation (10), the distance of all cell headers to the new location of the sink is obtained. Then, the ratio of the total distance to the sink and the distance of the cell header (index) where the sink is located is calculated:

$$\text{Sum_all} = \sum_{i=1}^k \sqrt{((\text{NewSink}_x - N_{x_j})^2 + (\text{NewSink}_y - N_{y_j})^2)} \quad (10)$$

$$\text{Sum_index} = \sqrt{((\text{NewSink}_x - N_{x_index})^2 + (\text{NewSink}_y - N_{y_index})^2)} \quad (11)$$

$$\text{Distance} = \frac{\text{Sum_all}}{\text{Sum_index}}$$

In this equation, Sum_all is the distance of all cell-headers to the sink, Sum_index signifies the distance of the cell-header index to the sink, NewSink_x and NewSink_y are the coordinates of the new location of the sink, N_x and N_y represent the location coordinates of all cell-headers, and N_{x_index} and N_{y_index} are the location coordinates of the cell-header index.

Moderation

Being closer to the route of movement of the sink towards the center of the network will increase single-step communications, reduce multi-step communications and, as a result, reduce the energy consumption of data transmission. This does not mean that the median parameter will create a focal point in the network, because with other parameters such as energy, cost, and degree, the best possible position for the smart movement of the sink is taken into account. However, assuming the same cost between two cell-headers, one in the boundary cell of the field and the cell-header index in the center of the field, to maintain the optimality, the sink must move towards the center cell of the field to reduce energy consumption by avoiding multi-step communication. This distance is obtained through the Euclidean distance formula calculated by the Pythagorean theorem in equation (12).

$$\text{Moderation} = \sum_{i=1}^k \sqrt{((N_{x_cellindex} - N_{x_j})^2 + (N_{y_cellindex} - N_{y_j})^2)} \quad (12)$$

N_xand_y_cellindex is the position of cell-header index while N_xand_y_j is the position of other cell-headers.

Degree

This parameter is used to not stop the sink in one area, maintain the dynamics of the network, and balance the energy consumption. In this way, every time the sink moves to the cell-header index, the number of moves for that cell is stored; therefore, if there are similar conditions in choosing to move to the cell-headers, the sink moves to the cell with a lower degree.

Updating Cuckoos

In this step, the cuckoo with the lowest cost (output of the cost function) is considered as the best location for moving the sink. Then, in order to change all the positions to the best cuckoo in each generation of the cuckoo population, their positions are updated in the next generation and the cuckoo algorithm is repeated for the size of the cuckoo population.

Choosing the Best Cuckoo and Discarding the Worst Cuckoo

The new position of each cuckoo is equal to the previous position of the cuckoo, which has moved to the best cuckoo by a percentage. The formulas in this part are obtained from the research conducted by Rajabioun (2011). If the values exceed the limits of the problem, they are reduced to the limits of the problem and the cost of the new position is calculated. If the cost of the new position is lower, the new cuckoo would replace the previous cuckoo, and if the new cuckoo is better than the best cuckoo, it is considered the best cuckoo.

Based on the output of the cost function, the cuckoo algorithm determines the probability of pa or the rate of discarding cuckoos. Initially, this value was set at 0.25, as in the basic article, but after various tests, it was changed to 0.6. A low value of pa causes more solutions to be discarded, thereby reducing the number of algorithm executions and the lifetime of the network.