Reliable Compression Route Protocol for Mobile Crowd Sensing (RCR-MSC)

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Abstract ² According to previous research in Mobile Crowd Sensing (MCS), we have two main challenges to attracting subscribers, the first is energy consumption and the second is the cost of data transmission. In this paper, we suggested framework to control on the this problem and reduce it as soon as possible, the proposed work consisted of aggregator users and target users, where the tasks performed by the aggregator user is to sense the data from the environment (using Wi-Fi, %OXHWRRWK DQG ,5 FRPSUHVV GDWD« HW FRPSUHVV WKH GDWD VHOHFW secure level, and create a transfer path protocol called "Multi-three way handshake protocol" , where this protocol responsible for transferring the data to the target user without uploading it to the data center server. When the data reached the target users, he will uploade it to the data center server by using Wi-Fi or 3G communication (via piggyback) with free cost. This paper presented a novel Reliable Compression Route protocol for Mobile Crowd Sensing (RCR-MSC), which reduces power consumption and cost of data transmission with multiple level of processes. As well as the present an equation which exposed the energy consumption by this Protocol. After many calculation and experiments procedures ,the result proved improvement performance of work compared to other articles.

Index Terms² Wireless sensor network, Mobile crowd sensing, three-way handshaking

I. INTRODUCTION

Mobile Crowd Sensing (MSC) is an effective model that enhances portable sensors from community members to monitor changes in the environment, such as temperature or air pollution [13]. According to Previous research (Zhang et al. 2014a), there are two major parts in Mobile Crowd Sensing [the organizer and the participants], where the organizer is the individual or organization [23] that selected the sensing task, employ participants and collects the data. While the participants involved in the sensing task and routing the sensing data to the data center (organizer). There are two major concerns that may affect the willingness of the participants to join a Mobile Crowd Sensing (MSC) task, the cost of data transmission and the energy consumption. Therefore, reducing data cost and energy consumption incurred can attract more people to participate in crowd sensing tasks. There are many papers presented many solutions for attracting participants in mobile crowd-sensing. Some researchers presented a solution by suggested three-levels life cycle to the mobile crowd sensing (i.e task sensing, task assignment, task execution). In addition, use protocol (three-way handshaking) to send the data with a tolerant delay of time to reduce energy consumption and mobile data costs [1]. However, we are working to reduce energy consumption and mobile data costs. This paper proposes a protocol by mixing between the data compression and routing techniques , this protocol reduces the cost of data transmission and reduces the energy consumption.

II. RELATED WORKS

A. MCS Applications

There are studies classify MCS applications based on three categories being measured or mapped, which included (environmental, infrastructure, and social) [22]. For example, applications for mapping of various large-scale environmental. In [23] proposed four [3] or three [1]-stage life cycle to characterize the MCS process. All this application enabled by the participatory management to crowd sensing frameworks [4] and studied the data uploading strategies [14].

B. Energy Saving MCS

For minimizing the total energy consumption in a MCS task, started by reducing the number of subscribers, for thus smart algorithm should be used. In order to determine the minimum number of participants to cover a selected area, many different task models were proposed [4], [24]. Each participant within MCS performs the following tasks (sensing; computing; and data uploading). Therefore, energy consumption should be reduced during these stages, sensing and computing, are responsible for receiving and processing data from sensors. To reduce the energy consumption of sensing by using low power sensors [7]. And used low power processors to reduce the energy consumption of computing, in MCS systems [8]. The proposed work focuses on the three stages sensing, routing, and uploading, most of the above-mentioned approaches with data compression can be combined with new protocol (multi-three way handshaking), to make crowd sensing more energy saving. With data compression, the used of low power communication methods (Bluetooth, Wi-Fi, or parallel data uploading with voice calls) [15] will significantly reduce power consumption in the process of uploading data to the data

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center. The proposed protocol (multi three-way handshaking) organizes data transfer between users until they reach the specific user who has the best chance for energy-saving approaches and uploading data with the free cost.

C. Compressing Data

Uploading part of the data while assuming the rest [14], or compressing data before uploading [16]. Although these methods consume additional energy, this paper has proven to be effective in conserving energy consumption compared to conventional methods as a result of reducing the size of data transmission from one user to another, by using Run coding length (RLE) method of data compression.

D. Data Cost Conservation

To decrease data cost in uploading, previous researchers have focused on reducing data size via aggregate sensed data before uploading by additional computation on the local mobile devices [6]. Therefore, the energy-saving Z R U N F D Q U H G X F H G D W D F R V W V L J Q L I L F D Q W O \ especially when the data size is big, but cannot eliminate it completely. In this paper, the data uploading by doing by target users who will be using free Wi-Fi and Bluetooth, the cost will be zero.

III. Problem Statements

Recently, energy consumption and data cost uploading for Mobile Crowd Sensing have shown an increasing interest in reducing by researchers. Many researchers have designed many crowd sensing applications by using low energy consumption and low-cost uploading. Many existing studies have designed MCS applications such as reality mining [6]and environmental monitoring [24] that sense data and upload it to data center after some delay (a max tolerable amount of delay dmax) in order to decrease data cost incurred and energy consumption. The V H Q V H G G D W D J H Q H U D W H G D W W uploaded to data center during [t0, td], where td= t0 + dmax. In a recent study [1] divided environment to slave area and master area. Users in slave area are sensing and orienting data to users in the master area. While users in the master area are uploading the data to the server with zero cost and low energy which they are at home or at work (free WI-FI zone). From previous studies, a new framework has been proposed which is divided the environment two groups: aggregator users and target users, where aggregator users are sense the data and compress it as well as orient it to other aggregator users or a target user. Finally, the target user is responsible for uploading the data to the data center with zero cost and low energy consumption. The next section will illustrate the proposed framework in detail.

IV. Reliable Compression Routing Protocol for Mobile Crowd Sensing (RCR-MSC)

To explain the RCR-MSC framework, this section illustrates the main parts as follows:

A. Mobile Sensing user Description

The detail description of RCR-MSC will be explained for the mobile sensing area and all the connections between participants and the environment. In the crowdsensing process, the following definitions have been assumed as follows:

Definition 1:

All smart devices will be named nodes and the RCR-MSC supports various types of devices. They can be a tablet computer, mobile phone, a smart camera with Wi-Fi, Bluetooth or infrared. These devices can send various messages for example texts, images, voices.

Definition 2:

RCR-MSC starts with classifying the nodes to two groups of users: aggregator users and target users. The users should organize as a star topology.

Aggregator User (U_{AGG}): each participant becomes a U_{AGG} when it is at home or at work when Wi-Fi is available and the battery can easily be charged. This user is responsible for uploading the compressed data to the server with zero cost by the Wi-Fi only.

Target User (U_{TAR}): this user is responsible for sensing, collecting, compressing, and orienting the compressed data to a U_{AGG}.

Definition 3:

An application is responsible for switching each user from U_{AGG} to U_{TAR} user depending on the Wi-Fi connection in order to upload the sensed data to the server. The aggregator users should be data sensors while the Target users should be data uploaders.

Definition 4:

$ O O X V H U V ¶ Q R G H V V K R X O G E H L G H order to switch the user from Aggregator to Target and vice-versa.

B. The Life Cycle of RCR-MSC

There are different stages to complete the life cycle of MSC. In [3], [10], it was designed three stages: creating, assignment, and execution, while another study designed four stages (creating, assigning, executing, and data integration) tasks. By using these two studies, we designed a new life cycle of MSC as follows:

1-Task creation: mobile sensing applications create a 0 6 & W D V N R Q H D F K X V H U ¶ V Q R G H E \ W MEDUSA framework developed such that application.

2- Task assignment: it is the second stage after task F U H D W L Q J , Q W K L V V W D J H S D U W L F L and assigning with separate sensing tasks on each node [3]. In this framework, the participant can be an aggregator user (U_{AGG}) or a target user (U_{TAR}) based on their area.

3- Task execution: when the assigned sensing task is received, the participant is trying to complete it during a predefined period in parallel with other tasks [3]. There are two types of task execution:

C. Task Preparing (Sensing, Compressing, Orienting, and Sending)

The task of Aggregator User U_{AGG} is completing in four subtasks:

Sensing: this sub-task is accomplishing in the U_{AGG} node via sensing the environment by various sensors such as infrared and camera. 7KLV GHYLFH¶V VHQVRU LV connected with the outside environment to sense various changes to the environment such as noise and pollution. The Bluetooth communication can be used in the process of sensing.

Compressing: in this sub-task, the sensed data is compressed to reduce the size of sensed data and, therefore decreasing the energy consumption during sending the data.

Orienting: when the sensed data is compressed, the application on U_{AGG} node should build a full route from the U_{AGG} to the U_{TAR} for uploading the sensed data to the data center through the U_{TAR} by the Wi-Fi connection only. The route can build through three protocols that will be clarified later in the next section.

Sending: when the route is completed, the sensed data should be sent in order to delivered to the U_{TAR} and consequently uploading it under this user.

D. Task Computing (Collecting, Uploading, Integration)

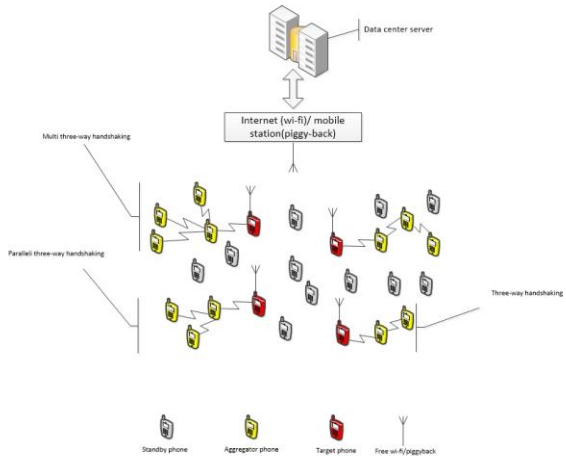

Fig. 1. Sensing area

When the U_{TAR} node received the sensed data, this user should upload it to the data center through two approaches. The first uses the Wi-Fi communication, and the second uses by piggy-back with 3G mobile communication. These approaches are zero-cost data uploading to the data center. Fig. (1) shows the routing data with PCR-MCS from sensing data to the uploading.

To transfer data between participants in mobile crowd sensing, we proposed multi-three way handshaking route as an important part in our proposed protocols. Called Multi three-way handshaking route, which construct by two sections:

V. Multi Three-way Handshaking

A. The Communication between the Participants

Our proposed protocol resolves the hidden terminal problem. To describe this problem, we supposed have four users (A, B, C and D), if the user A wants to send data to the user D but there is another user B and C want to send data to the user D, where (A, B and C) cannot hear each other, where they are going to sense the carrier if they start sending. This leads to a collision. MACA protocol [20] solved this problem. In this paper, we present a protocol called multi three-way handshaking. This protocol used as a solution to the hidden terminal problem in the different way to build the route.

As we have already assumed four users (A, B, C, and D), if the user A wants to send data to the user D but there is another user (B) and (C) want to send data to the user D, where (A, B and C) cannot see or hear each other. MACA protocol supposed that A will send a request called sending request (SR) to C, if C is free, it will send a replay called open path (OP) to A, then start to transfer the data and block the others [2]. The multi three-way handshaking supposed that node D can accept the sending data (connection) from tree or more (with more delay) nodes by building a route can synchronize between (A, B AND C) called Capsulation. Figure (2) shows the capsulation of the data multi three-way handshaking, where D user accepts the SR from both (A, B and C), and starts receiving the data from (A,B and C) as messages where the data already partitioned as messages at the source (A, B or C), where D receives the message one from A in a time and receiving the other messages from (B and C) as sequence in a different delay time. After (D) finished receiving the messages, it will capsulate the data by adding an address, priority, security and transfer time, then it provides a header and a trailer for each message. In this format, it is easy to U_{TAR} to de-capsulate the data. A, B and C are U_{AGG} and D could be U_{AGG} to pass the data to another user or could be U_{TAR} to uploading the data to the data center.

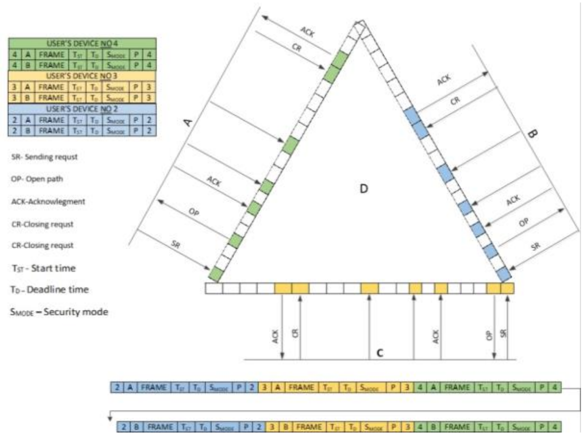

Fig. 2. Multi three-way handshaking

To send data to U_{TAR} users all U_{AGG} users send a request to send to each other, and in this case, build the transmission route. Figure 3 shows the transfer route between the nodes.

There are several routes will construct to transfer data, as follows

1- Three-way handshaking[1], this is a one - to - one relationship with high security.

2- Parallel-three way handshaking, In this protocol two users send data at the same time, but it is considered a normal secure relationship.
3- multi-three way handshaking, In this protocol three users send data at the same time.

The sending data (message) from any user such as A to B contains other information with each message as shown in Fig. 2, the format as follows:

P- Priority factor, Precedence (priority) of each message on the other, there are two values: H- high, and L- low.

T0, Td: T0 it is the start time for send message, Td the deadline for the arrival time, these parameters are very important in real time situations.

The number of the message and sequence this parameter very important to avoid missing information and may use for ordering the sequence of data.

Header and Trailer- this parameter pointing to the start and end of each message.

B. Building the Route

After partitioning the data between A, B and C , the message produced will send to D. The D user would capsulate all the messages and sending them to the next user to reach the destination user U_{TAR} through the transition route as shown in Fig. 3. Fig. 4 (a, b, and c) shows the algorithms to build this route.

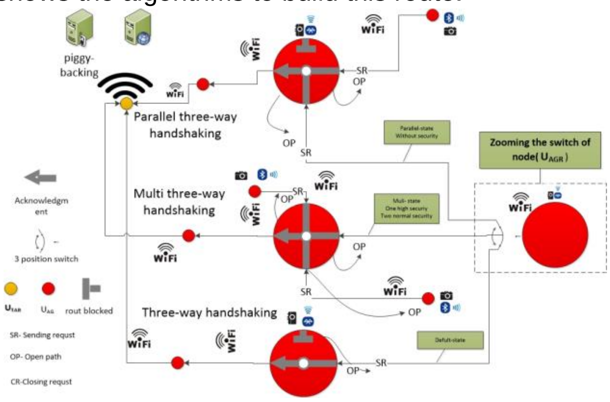

Fig. 3. The transition routes

//ALGORITHM 1: MAIN ALGORITHM
1. BEGIN
2. LOCATION BY GPS
3. IF THE NODE IS AGGREGATOR
{ CALL UAGG
4. ELSE CALL UAGG }
5. END

ALGORITHM 2: AGGREGATOR NODE (UAGG)
1. BEGIN
3. GET THE SENSED TIME
4. GET THE ORIENTATION TIME
5. SWITCH ON THE BLUETOOTH
6. 20 SECONDS FOR SENSING DATA
7. {
8. COLLECTING DATA
9. }
10. SWITCH OFF THE BLUETOOTH
11. SWITCH ON THE WIFI
12. BUILD THE ROUTE
13. IF ONE User SEND SR (sending request) remote THEN // Three Way Handshaking
14. IF OP remote= TRUE THEN //the local send clear to send (open path) to remote
15. {
16. IF OP local=TRUE { // THE LOCAL READY TO ACCEPT THE DATA
A. Segment the Local data into messages
B. Insert the properties for each message
C. Encapsulate the Local data with Remote data
D. Sending the data }
17. ELSE {
A. Segment the Local data into messages
B. Insert the properties for each message
C. Sending data as messages }
18. }
19. ELSE IF TWO Users SEND SR remote // Parallel-Three Way Handshaking
20. IF OP remote= TRUE THEN // the local send clear to send (open path) to remote
21. {
22. IF OP local=TRUE { // THE LOCAL READY TO ACCEPT THE DATA
A. Segment the Local data into messages
B. Insert the properties for each message
C. Encapsulate the Local data with Remote data
D. Sending the data }
23. ELSE {
A. Segment the local data into messages
B. Insert the properties for each message
C. Sending data as messages }
24. }
25. ELSE IF THREE Users or MORE SEND SR remote // Multi-Three Way Handshaking
26. IF OP remote= TRUE THEN // the local send clear to send (open path) to remote
27. {
28. IF OP local=TRUE { // THE LOCAL READY TO ACCEPT THE DATA
A. Segment the Local data into messages
B. Insert the properties for each message
C. Encapsulate the Local data with Remote data
D. Sending the data }
29. ELSE {
A. Segment the Local data into messages
B. Insert the properties for each message
C. Sending data as messages }
30. }
31. ELSE
32. {
33. Waiting
34. GO TO: Protocols
35. }
36. SWITCH OFF WiFi
37. }
38. END

Algorithm3: UTAR node algorithm

1. BEGIN
2. {
3. DETECT THE CONNECTION
4. ZZ: If SR remote =TRUE THEN
5. {
6. CTS local=TRUE
7. RECEIVE THE DATA
8. DECAPSULATE THE DATA
9. ELSE {
10. Waiting
11. GO TO ZZ }
12. UPLOADING Using WI-FI or by Voice Call (Parallel Uploading)
13. }
14. End

VI. Rules for Data Cost Uploading and Energy Consumption

As we mentioned earlier to obtain an optimal level of performance for MCS, there are two types of problems that should be dealing with it, data cost uploading and energy consumption. Previous research has found that a relationship between (time to transfer) and (energy consumption)"[1]. In this article, we will improve the consumption of power with a slight increase in time of data processing by using data compression. so we divided our work as follow:

A. The Time Consumption by Sending

In order to formulate a precise time for sending the data, the rules are applied as follows:

R1: there is a time for sensing an information from the surrounding environment, where the organizer MCS should regularly repeat this process. This time is called sensing time (T_{sen}) and it may sense an event (E_{sen})

R2: As we mentioned earlier in the task preparing of WKH 0&6¶V, all the nodes (UAGG) should build a routing path before sending the data. Before sensing the data (before T_{SEN}), the node should check the opportunity to build the routing path. The reason for this procedure is to find the active path Apath (from U_{AG} to U_{TAR}). As a result, the nodes that are involved in the path will only be in active mode, while the other nodes will be in sleep or inactive mode.

$$T_{pre} = T_{SEN} - T0 \quad (1)$$

For explaining that, if TSEN is starting every hour. For H[DPSOH WKH ILUVW VHQVLQJ LV VWDUWHG DW R¶FORFN and T0 =20 seconds, then T_{pre} R¶FORFN IROORZLQJ 76(1 ZLOO EH DW R¶FORFN DQG VR RQ

R3: when the T_{pre} is started, all U_{AGG} send SR to all surrounding nodes to create the routing path to the U_{TAR} and waiting for the reply. if the reply is OP (Open Path), it means the route is open, otherwise the reply is PB (Path Blocked) and therefore the user's device will be blocked. The following three protocols that will be used for sending the sensed data between nodes, as follows:

1- Three-way handshaking- According to three-way handshaking protocol, one user's device will obtain OP, This is a pear - to - pear relationship, it is considered a high secure relationship.

2- Parallel-three way handshaking- According to parallel-three way handshaking, In this protocol two users send data at the same time, and the period time to FDSVXODWH WKH XVHU¶V GDWD VKRXOG the next St, it is considered a normal secure relationship.

3- Multi three-way handshaking- According to muli-three way handshaking, most user's device will obtain OP, it is considered a low secure relationship.

In order to calculate the time that is spending for each XVHU¶V GHYLFH in the route and active path (A_{path}), we need to calculate some parameters to obtain the final equation, called time for capsulation (T_{cap}):

1- The round-trip delay time RTD: is the length of time it takes for a signal to be sent plus the length of time it takes for an acknowledgment of that signal to be UHFHLYHG VR LW QHHGV WR 57' IRU

2- The time spent for sending the data to each XVHU¶V GHYLFH $T_{TRAN.}$

Time spent (T_{sp}) for three-way handshaking protocol;

$$T^J_{sp}|_{U_{AGG}\in path_x \cap E^J_S} = T_{TRAN.} + 2\text{RTD} \quad (2)$$

J- frequently time to sense;

E_S^J - event detection time

Time capsulation (T_{cap}) for parallel-three way handshaking protocol;

$$T^J_{cap}|_{U_{AGG}\in path_x \cap E^J_S} = \sum_n^2 T^n_{TRAN.} + 2RTD \quad (3)$$

N = the node number which transfers data through U_{AG} in the route x

Time capsulation (T_{cap}) for multi three-way handshaking protocol;

$$T^J_{cap}|_{U_{AG}G\in path_x \cap E^J_S} = \sum_N^M T^n_{TRAN.} + 2RTD \quad (4)$$

1 WKH XVHU¶V GHYLFH QXPEHU Z through U_{AG} in the route x;

0 WKH QXPEHU RI WKH XVHU¶V GHY

To calculate the total spend time for an event by U_{AGG}, we should know the time for compression T_{comp}.

B. Time for Compression (Tcomp)

Is the time spent to compress the sensed data which is immediately after the process of sensing within the same user's device before the process of sending data, for local data only. Now we could write an equation to show the total spend time for all protocols by U_{AGG}, its as follows:

$$T^{TOTAL}_{SP} - U^J_{AGG}|_{path_x \cap E^J_S} = T_0 + T^J_{cap}|_{U_{AGG}\in path_x \cap E^J_S} + T_{comp} \quad (5)$$

The spent time by U_{TAR} to upload the information to the data center, for all protocol, its as follows:

$$T^{TOTAL}_{SP} - U^J_{TAR}|_{path_x \cap E^J_S} = UPLOADING\ TIME + T^{TOTAL}_{SP} - U^J_{AGG}|_{path_x \cap E^J_S} + T_{comp} \quad (6)$$

In this equation, the uploading time showed it in a specific case because of it relies on the type of the Q H W Z R U N L Q J D Q G X V H U ¶ V G H Y L F

R4: the Bluetooth and other sensing tools will switch off after the U_{AGG} sensed the data to decrease the energy consumption by the device. Switching on the Wi-Fi will be based on the spending time for each user's device.

C. Energy Calculatio

In other articles the energy consumed is calculated as follows [2]:

$$En_{user}^{total} \quad \min \sum En(t_o, t_d) \tag{7}$$

This paper derived the total energy consumption (ET) equation from the relationship between the time spend equations (4) and (5). Therefore the (ET) by U_{AGG} and U_{TAR}., as in the following equation;

$$E^T_{U_{AGG} \cap U_{TAR} \in path_x \cap E_S^j} = \sum_j^M E\left(T_{SP}^{TOTAL} - U_{AGG}^J\right) + E\left(T_{SP}^{TOTAL} - U_{TAR}^J\right) \tag{8}$$

R5: The user would upload the data when he is making any phone call in a parallel way with the phone call via 3g piggyback facility.

VII. ENERGY EVALUATIONS

In this section, we illustrated the energy evaluations for mobile phone. Several studies calculated the important functions of various mobile phones as shown in Table I which used the 3G call and Bluetooth scanning in the experiment test. While Table II shows the consumed power of the Wi-Fi and 3G download and/or upload functions that are used in the experiment test. In addition, the required time with the delay by two communications has shown in Table III. This delay produced because of the Round Trip Time (RTT), where 2*RTT is used by the Three, Parallel-Three, and Multi-Three protocols.

TABLE I: THE ENERGY CONSUMPTION FOR THE DIFFERENT PHONE ACTIONS

Action	Power(W)	Time (s)	Energy (J)
Idle	0.15	60	0.9J
3G Call	1.265	60	75.9J
SMS	0.0583	60	3.5J
Bluetooth Scanning	0.225	20	4.5J

TABLE II: THE POWER CONSUMPTION FOR THE DOWNLOAD AND UPLOAD PROCESS BY MOBILE PHONE.

Action	Power(W)	Speed (KB/s)
Wi-Fi download	1.1	143.1
Wi-Fi upload	1.1	115.3
Wi-Fi download/Upload	1.5	430
3G download +3G call	1.4	48
3G upload +3G call	1.4	43

TABLE III: THE TIME REQUIRED FOR THE DIFFERENT COMMUNICATION TYPES

Link type	Bandwidth (typical)	One-way distance (typical)	round-trip delay time DRT
Dial-up	56Kbps	10km	87 µs
Wireless LAN	54 Mbps	50m	0.33 µs

VIII. EXPERIMENTAL RESULTS

In this section, we presented the experimental results, which based on our suggested rules and the information in energy evaluations section.

A. Data Compression Results

In this section, we showed the difference between the data before and after the compression process, for this; we applied samples of images of different sizes and compressed them by using Matlab as shown in Fig. 5.

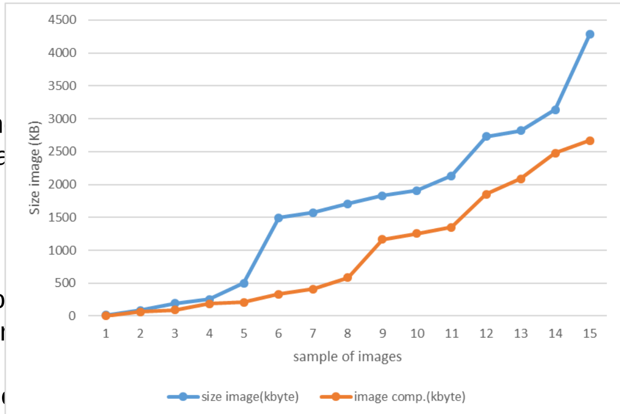

Fig. 5. Data before and after compression process

B. The Energy Consumption by Downloading

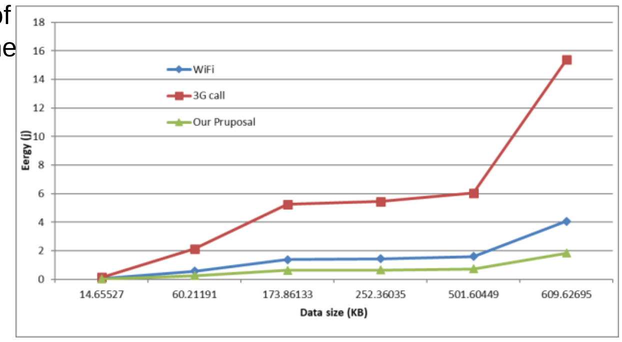

Fig. 6 The energy consumption by downloading

Fig. 6 shows the compared result of the consumed energy by download using WI-FI, 3G and our proposal, where our proposal outperforms the other proposals in the energy consumption.

C. The Energy Consumption by Uploading

Fig. 7. shows the status of data upload and comparison with other proposals (WI-FI and 3g), It shows the advantage of our proposal on the rest of the proposals.

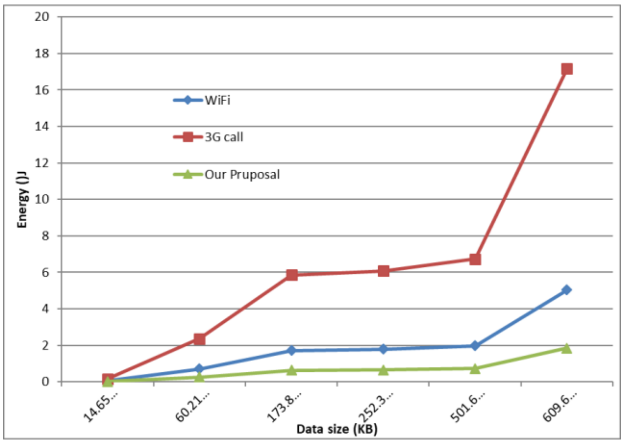

Fig. 7. The energy consumption by uploading

D. The Energy Consumption by UAGG and UTAR

Fig. (8) shows the consumed energy by U_{AGG} and U_{TAR}, according to the energy evaluations, and we reformulate equations (7) and (8) by experimental evaluation with consistent to the information in Table II. Here we summarized the practical representation according to the following equation:

As previous researchers calculated the consumed energy using the normal method for any user:

$$E^{T}_{user}\quad E_{scan}\quad E_{download}\quad E_{(3Gcall\ upload)} \tag{9}$$

With our suggested, we need to split the users into U_{AGG} and U_{TAR}. The consumed energy by the user U_{AGG}

$$E^{T}_{U_{AGG}\in rout_x \cap E^{J}_{S}} = E_{scan} + E_{COP} + E_{download} + E_{(download+upload)*N} \tag{10}$$

It N is the number of U_{AGG} in route x;

Ecop is the energy consumption for a compression data process, other researchers calculate the energy consumption which caused by compression process very few about 0,0053 mJ[25], so we neglected.

When we applied, the equation above us obtained the following results according to the table (1,2):

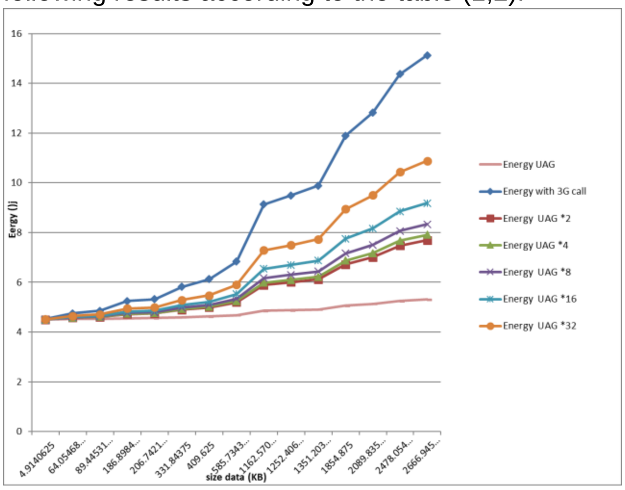

Fig. 8. The energy consumption with an increasing data size to the Aggregators users U_{AGG} by different situations, where the Energy with the 3G call: this the normal method applied by previous researchers.

Energy U_{AGG} * N: it is the route to transfer data to a number of user's devices.

To calculate the energy consumption by U_{TAR} we have two cases as the following;

1- If U_{TAR} used WI-FI to upload the data:

$$E^{T}_{U_{TAR}\in rout_x \cap E^{J}_{S}} = E_{(download+upload)*N} \tag{11}$$

2. If UTAR used 3G to upload the data:

$$E^{T}_{U_{TAR}\in rout_x \cap E^{J}_{S}} = E_{(3g+upload)} \tag{12}$$

When we applied the above equation, the following results obtained according to the table 1 and 2 as shown in Fig. (8).

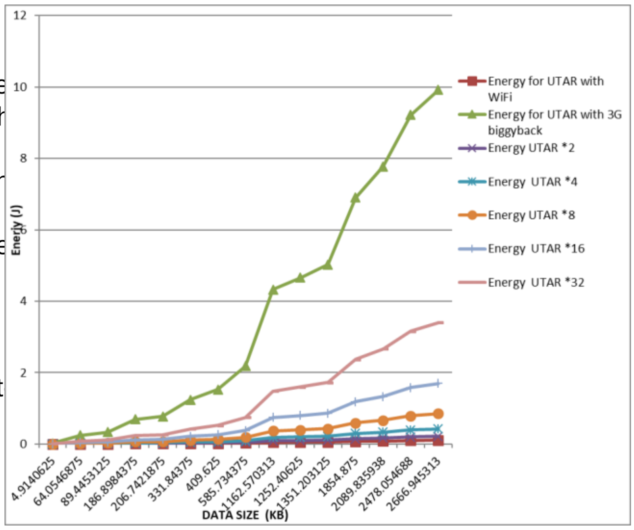

Fig. 8. The energy consumption with an increasing data size to the target users U_{TAR} by different situations, where the Energy for U_{TAR} with 3G piggyback call that the updated information by U_{TAR} via 3G piggyback call with free cost.

Energy U_{TAR} * N: refer to the number of U_{TAR} could share to upload the data.

Energy for U_{TAR} with Wi-Fi: the uploading the data by Wi-Fi by U_{TAR}

IX. CONCLUSION

The main goal of the current study was to decrease the energy consumption and the cost of data uploading in MSC. We proposed three protocols which are three-way handshaking, parallel three-way handshaking, and multi three-way handshaking protocols to achieve the routing path from user to user. These protocols split the users into two groups: aggregator users and target users. The target users are responsible for the uploading process of the data after receiving it from the aggregator users. While the aggregator users are responsible for the sensing process of the data from the surrounding environment as well as gathering the data from other aggregator users to transfer it to any target user. Furthermore, the parallel and multi three-way handshaking protocols handle the hidden terminal problem and make the nodes to receive all the requests from other devices to transfer the data by the end to the target user. Additionally, the protocols let the users who joined with MCS need not concern to the charging of the battery and the inconvenience incurred because these protocols decrease energy consumption and cost of data uploading. This paper has reduced the total energy consumption in a MCS task with zero cost data uploading by clustering the environment into two areas as well as compressing the sensed data. As a result, we have obtained a real-time framework with low energy consumption and zero cost data uploading.

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