Adaptive Context-Aware Data Management Scheme for Mobile Environments

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Abstract— **Data sharing and delivering in mobile environments is one of the most important interest issues in such environments. Therefore, data management is one of the biggest problems in these dynamic environments. In this dynamic environment, a user's context such as user's profile, user's social situation, and user's interests may affect the overall performance of this system. So, we need to find a new data management scheme that takes into account all available users' context. In this paper, we propose a new adaptive Context-Aware Data Management Scheme to adapt data management by broadcasting a data and information to a set of mobile users who have a context that similar to source node. By using this scheme, we can control the spreading of data through these dynamic environments by evaluating mobile nodes using a context, the evaluation process relies on multi-criteria decision making approaches FAHP and SAW. Our simulation results show the effectiveness of the proposed algorithm.**

Keywords— **Context, Data Management, Data Sharing, and Mobile Communications**

I. Introduction

Context-aware computing is a rapidly growing field in ubiquitous computing, which concerning with the adaptation of mobile application to the changes of surrounding environment and situations. Context-aware is a prosperous field of research involving communication engineering, computer science, information technology, and more precisely mobile communication. Also, the context-aware computing has important uses in human computer interaction, wearable computing, augmented reality, data management, feature extraction, artificial intelligence, and decision making.

Context-aware system uses the context attributes such as location, time, and user's activity to obtain the best services to mobile users. The key objective of these systems is to significantly simplify computing devices usage by realizing the changes in entities status and surrounding environments. Recently, there are many systems use context-aware by way of example, not exhaustive enumeration (Health care, Services discovering applications, Advertising, E-commerce, E-learning/M-learning, Tourism and Travelling, Office and other Business applications, Entertainment, Emergency applications, Smart environments, Gaming, and Social community applications). Context-aware systems use the context to clarify the current situation and adapt mobile system to be suitable for user and device requirements. Context attribute represents any single information about mobile users, device or the surrounding environments.

Mobile environments represent what is in place and surrounding, including users, devices and other resources. These environments provide a challenging and realistic environment for the current systems development because of mobility, limitation of energy and computations, and other resources of environment's entities. So, we cannot apply any of the standard approaches to develop a mobile system suited to these types of environments. In order to build mobile system compatible with these changeable environments, the developers must take into account the importance of environmental context. This environmental context allows these systems to be appropriate to the nature of the mobile environments which are located. Also, using the contextual information leads to increase the utility, the efficiency, and reliability of the mobile applications.

Data sharing and delivering a message is one of the basic challenges in these dynamic environments, because it drains the network's resources such as energy, bandwidth and memory. Also, sharing data in emergency times can rescue victims in disaster situations such as earthquakes and fires. By sending data to all nodes in the network or most of them and does not take into account if a user will utilize this data or not. Recently, utilizing user's context in mobile devices is receiving considerable attention to meet these challenges. In context-aware systems, mobile applications use the contextual information such as user's location, day time, nearby people and devices, and user's activity in useful way to solve data management issues in these dynamic environments.

In this paper, we will propose an Adaptive Context-Aware Data Management Scheme called ACADMS. This scheme is based on evaluating each node in the network according to its user's dependent context. Gad-ElRab in [3] defines user's dependent context as the contextual information that characterizes the mobile users such as user's activity (Information about what an entity does), user's social situation, user's profile, etc. The evaluation process will accomplish using two multi-criteria decision making approaches (AHP and SAW) in fuzzy environment. The proposed data management scheme uses the cluster-based routing protocol in [2] to route messages and data through the network. The main objectives of ACADMS are to maximize the number of reached mobile nodes, and deliver data to users who will utilize these data. In addition to minimize broadcast delay time, it will minimize the bandwidth utilization and energy consumption.

The rest of the paper is organized as follows. Section 2 includes a detailed survey of the related work. Section 3 introduces Multi-Criteria Decision Making Approaches that is used to evaluate the mobile node. Section 4 describes and formulates the proposed data management scheme. Section 5 introduces the simulation and analysis of the experimental results. Finally, Section 6 concludes the paper.

II. Related Work

There are many data broadcasting management protocols that have been proposed in mobile networks. In this section, we will give a brief overview of some of these protocols in this section.

A. Broadcasting in Mobile Environments

Mobile network consists of a set of wireless mobile nodes that are free to move in any directions at any speed. This does not require any pre-existing fixed infrastructures, and therefore it can be built on the fly. Since nodes in a mobile network operate on batteries and have limited transmission ranges and memory, minimizing unnecessary communications is essential to improve the network life and throughput.

Broadcasting is a fundamental communication operation in which one node sends data to all other nodes in the network. Broadcasting can be used for many purposes like discovering neighbors, collecting global information, addressing, and helping in multicasting. For many mobile network protocols, the broadcasting forms the basic mechanism. Sometimes the broadcast can be used for the permanent updating in network's topology, maintenance of networking, or to send data or control. The main objective of broadcasting algorithms is to reduce the number of broadcasts while keeping the bandwidth and computational overhead as low as possible.

To ensure that the broadcast protocol compatible with the mobile environment's requirements. The broadcast protocol must achieve the following objectives:

- Maximizing the number of reached nodes.
- Minimizing delay time.
- Minimizing the energy consumption.
- Minimizing the memory utilization.
- Minimizing the bandwidth utilization.

There have been several proposals for data management by broadcasting in mobile networks. The difference between them lies in the method of data dissemination and how to control the data transmission to reduce the network overhead. Some of these protocols are detailed out below.

Simple Flooding: In simple flooding method [8], a source node broadcasts a data message to all its neighbors, each of these neighbors will check if they have seen this data message before, if yes the data message will be dropped, if not the data message will be rebroadcasted at once to all their neighbors. The process continues until all reachable network nodes have received the packet. Although, this method is very reliable for a mobile network with low density nodes and high mobility, but it is very harmful and unproductive as it causes severe network congestion and quickly exhausts the battery power. Simple Flooding ensures that broadcast packet is received by all network nodes; it generates many redundant transmissions which can trigger high transmission collision and contention in the network, a phenomenon referred to as the broadcast storm.

Simple Flooding is one of the most fundamental operations in mobile networks. Most of the major routing protocols, like DSR, AODV, LAR, ZRP, etc, rely on flooding for disseminating route discovery, route maintenance, or topology update packets. Flooding is a very frequently invoked function in mobile networks. Therefore, an efficient implementation of the flooding scheme is crucial in reducing the overhead of routing protocols and improving the throughput of networks. As a result of the simplicity of this data broadcast type, there are many problems with traditional broadcast. So, we introduce these problems as follows:

- It takes only the message urgency into consideration.
- It does not take into account the type of the broadcast message and contextual information of message's sender.
- There is no guarantee that the broadcasting process will reach the targeted nodes in suitable time.
- Mobile nodes that distant from the data source will receive the data late, because this method disseminates data to the remaining nodes by using the sequential method.
- This method drains network resources such as memory, energy and bandwidth.

Probability Based Methods: The Probabilistic scheme in [10] is similar to Flooding, except that nodes rebroadcast the message according to a probability value, this value is determined in advance. In dense networks multiple nodes share similar transmission coverage. Thus, randomly having some nodes not rebroadcast saves node and network resources without harming delivery effectiveness. In sparse networks, there is much less shared coverage. Thus, nodes won't receive all the broadcast packets with the Probabilistic scheme unless the probability parameter is high. When the probability is 100%, this scheme is identical to flooding.

Neighbor Knowledge Methods: As introduced in [6], this protocol requires that each node have knowledge of its first hop neighbors, which is obtained by sending "Hello" packets. Each node stores its neighbors list in the header of each broadcast packet. Any node receiving a broadcast packet compares its neighbor list to the sender's neighbor list from broadcast packet header. If the receiving node would not reach any additional nodes, it refrains from rebroadcasting; otherwise the node rebroadcasts the packet.

Most of previous broadcasting algorithms do not care about wasting of network resources such as memory, energy and bandwidth. So, we introduce a broadcasting protocol based on user's contextual information, and detail the proposed protocol in the following sections.

III. Multi-Criteria Decision Making Approaches

A. *Fuzzy Sets and Fuzzy Number*

Zadeh (1965) introduced the Fuzzy Set Theory (FST) to deal with the uncertainty and ambiguous of data. A major contribution of FST is the capability of representing uncertain data. FST also allows mathematical operators and programming to be performed to the fuzzy domain. A Fuzzy Set (FS) is a class of objects with a continuum of grades of membership. Such a set is characterized by a membership function, which assigns to each object a grade of membership ranging "between" zero and one [9], [5].

Fuzzy Set: A fuzzy set $\tilde{A}$. In a universe of discourse X is characterized by a membership function $\tilde{\mu}_A(x)$which associates with each element x in X a real number in the interval [0, 1]. The function value $\tilde{\mu}_A(x)$ is termed the grade of membership of x in $\tilde{A}$. L.A. Zadeh [1].

Triangular Fuzzy Number: A triangular fuzzy number $\tilde{A}$ can be defined by a triplet (L, M, U) shown in Fig-1. The membership function $\tilde{\mu}_A(x)$ is defined in [4] as

$$\tilde{\mu}_A(x) = \begin{cases} 0 & x < L \\ \dfrac{x-L}{M-L} & L \le x \le M \\ \dfrac{x-U}{M-U} & M \le x \le U \\ 1 & x > U \end{cases} \qquad (1)$$

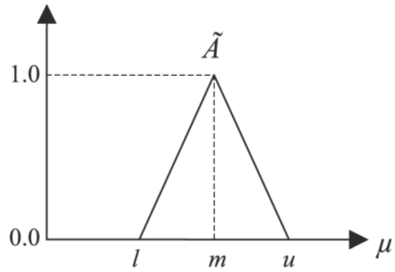

Fig. 1: Triangular Fuzzy Number (L, M, U)

A Symbol "∼" will be placed above A if the A shows a FST. A Triangular Fuzzy Number (TFN) A, $\tilde{A}$ TFN represented with three points as follows: (L, M, U). L stand for the lower bound of the fuzzy number, and U stand for the upper bound. This representation is interpreted as membership functions and holds the following conditions.

- L to M is increasing function
- M to U is decreasing function
- $L \leq M \leq U$.

Fuzzy sets were originally proposed to deal with problems of subjective uncertainty. Subjective uncertainty results from using linguistic variables to represent the problem or the event, linguistic variable is a variable that is expressed by verbal words or sentences in a natural or artificial language. Linguistic variables are also employed as a way to measure the achievement of the performance value for each criterion. Since the linguistic variables can be defined by the corresponding membership function and the fuzzy interval. Linguistic variables were proposed in [11], For example, linguistic variables with triangular fuzzy numbers may take on effect values such as very high (very good), high (good), fair, low (bad), and very low (very bad). So, we can naturally manipulate the fuzzy numbers to deal with the FMADM problems. The membership function of linguistic variables represented in triangular fuzzy number showed in Fig-2.

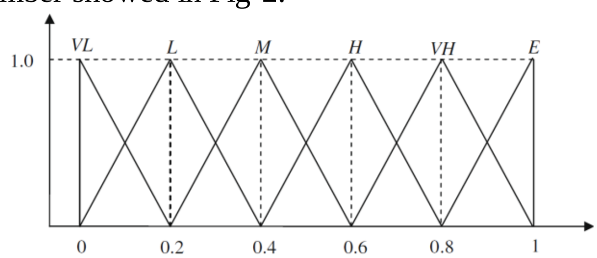

Fig. 2: Triangular fuzzy numbers of linguistic variables

B. Analytic Hierarchy Process (AHP)

Bernoulli (1738) proposed the concept of utility function to reflect human persuit, such as maximum satisfaction, and von Neumann and Morgenstern (1947) presented the theory of game and economic behavior model, which expanded the studies on human economic behavior for multiple criteria decision making (MCDM) problems [11], an increasing amount of literature has been engaged in this field. The MCDM can be summarized in five main steps as follows:

1) Define the nature of the problem.
2) Construct a hierarchy system for its evaluation Fig-3.
3) Select the appropriate evaluation model.
4) Obtain the relative weights and performance score of each attribute with respect to each alternative.
5) Determine the best alternative according to the synthetic utility values, which are the aggregation value of relative weights, and performance scores corresponding to alternatives.
6) Outrank the alternatives referring to their synthetic fuzzy utility values from Step 5.

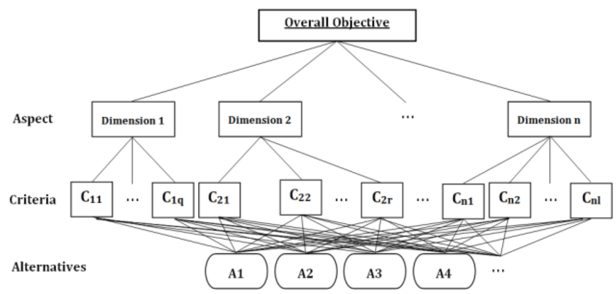

Fig. 3: Hierarchical system for MADM

The analytic hierarchy process (*AHP*) was proposed to derive the relative weights according to the appropriate hierarchical system. There are four methods, including the eigenvalue method, the geometric mean method, the linear programming method and the lambda-max method to derive the weights using the *AHP*. Only the eigenvalue method is employed to deal with crisp numbers and the other methods are adapted to handle the *AHP* under fuzzy numbers [11].

In *AHP* method, the pairwise comparisons for each level with respect to the goal of mobile evaluation are conducted using a nine-point scale. Each pairwise comparison represents an estimate of the priorities of the compared context attribute. The nine-point scale developed by Saaty (1980). Table I expresses preferences between options as equally, moderately, strongly, very strongly, or extremely preferred. These preferences are translated into pairwise weights of 1, 3, 5, 7, and 9, respectively, with 2, 4, 6, and 8 as intermediate values.

TABLE I
Ratio Scale in AHP (Saaty (1980))

Linguistic	Intensity Importance	Description
Equally important	1	Two factors contribute equally to the objective
Moderately more important	3	Experience and judgment slightly favor one over the other
Strongly more important	5	Experience and judgment strongly favor one over the other
Very strongly more important	7	Experience and judgment very strongly favor one over the other. Its importance is demonstrated in practice
Extremely more important	9	The evidence favoring one over the other is of the highest possible validity
Intermediate values	2, 4, 6, 8	When compromise is needed

C. Fuzzy AHP

The global weights for each candidate is determined and the candidates fuzzy priorities are calculated based on sub-factors using Linguistic variables, which are defined for the triangular fuzzy numbers, see Table II:

TABLE II
Linguistic Values and Fuzzy Numbers

Linguistic values	Fuzzy numbers
Very low (VL)	(0, 0, 0.2)
Low (L)	(0, 0.2, 0.4)
Medium (M)	(0.2, 0.4, 0.6)
High (H)	(0.4, 0.6, 0.8)
Very high (VH)	(0.6, 0.8, 1)
Excellent (E)	(0.8, 1, 1)

The geometric mean method was first employed by Buckley (1985) to extend the *AHP* to consider the situation of using linguistic variables (Zadeh 1965). The degrees of the pairwise comparison of linguistic variables can be expressed using the fuzzy numbers see the following table. Table III.

TABLE III
The Pairwise Comparison of Linguistic Variables Using Fuzzy

Intensity of fuzzy scale	Fuzzy numbers	Number user defined
$\tilde{1}$	(L,M,U)	(_, 1 ,_)
$\tilde{3}$	(L,M,U)	(_, 3 ,_)
$\tilde{5}$	(L,M,U)	(_, 5 ,_)
$\tilde{7}$	(L,M,U)	(_, 7 ,_)
$\tilde{9}$	(L,M,U)	(_, 9 ,_)
$\tilde{2}, \tilde{4}, \tilde{6}, \tilde{8}$	(L,M,U)	(_, _ ,_)

From the information of the pairwise comparison, we can form the fuzzy positive reciprocal matrix as the following:

$$\tilde{A} = \begin{bmatrix} a_{11} & a_{12} & \cdots & a_{1n} \\ a_{21} & a_{22} & \cdots & a_{2n} \\ \vdots & \vdots & \vdots & \vdots \\ a_{n1} & a_{n2} & \cdots & a_{nn} \end{bmatrix} \quad (2)$$

Where $\tilde{a}_{ij} \odot \tilde{a}_{ji} \approx 1$ and $\tilde{a}_{ij} \cong \frac{w_i}{w_j}$

Then, the geometric mean method for finding the final fuzzy weights of each criterion can be formulated as the following:

$$\tilde{w}_i = \tilde{r}_i(\tilde{r}_1 \oplus \tilde{r}_2 \oplus \ldots \oplus \tilde{r}_n)^{-1} \quad (3)$$

Where

$$\tilde{r}_i = (\tilde{a}_{i1} \odot \tilde{a}_{i2} \odot \ldots \odot \tilde{a}_{in})^{1/n} \quad (4)$$

The fuzzy weights of each criterion can also be defuzzified by center of area (CoA) in order to obtain a crisp solution.

D. Simple Additive Weighting Method

Churchman and Ackoff (1954) first utilized the SAW method to cope with a portfolio selection problem. The SAW method is probably the best known and widely used method for multiple attribute decision making MADM. Because of its simplicity, SAW is the most popular method in MADM problems and the best alternative can be derived by the following equation:

$$A^* = \{U_i(x) | max_i U_i(x), i = 1, \dots, n; \} \qquad (5)$$

Or the gaps of alternatives can be improved to build a new best alternative A* for achieving aspired/desired levels in each criterion.

$$U_i(x) = \sum_{j=1}^{n} w_j r_{ij}(x) \qquad (6)$$

Where $u_i(x)$ denotes the utility of the i^{th} alternative and $i = 1,2, \dots, n$; w_j denotes the weights of the j^{th} criterion; $r_{ij}(x)$ is the normalized preferred ratings of the i^{th} alternative with respect to the j^{th} criterion for all commensurable units; and all criteria are assumed to be independent. In addition, the normalized preferred ratings ($r_{ij}(x)$) of the i^{th} alternative with respect to the j^{th} criterion can be defined by:

- For benefit criteria (larger is better)

$$r_{kj}(x) = \frac{x_{ij} - x_j^-}{x_j^* - x_j^-} \qquad (7)$$

Where $x_j^* = max_i\ x_{ij}$ and $x_j^- = min_i\ x_{ij}$ or setting x^* is the aspired/desired level and x^- is the worst level.

- For cost criteria (smaller is better)

$$r_{kj}(x) = \frac{x_j^- - x_{ij}}{x_j^- - x_j^*} \qquad (8)$$

Therefore, the synthesized performance is:

$$P_i = \sum_{j=1}^{m} w_j r_{ij} \qquad (9)$$

Where P_i is a synthesizing performance value of the i^{th} alternative; w_j denotes the weights of the j^{th} criterion; r_{ij} is the normalized preferred ratings of the i^{th} alternative with respect to the j^{th} criterion for becoming the commensurable units; and the criteria are assumed to be independent of each other. If the units of the performance matrix are the commensurable units, we do not need to transfer the data matrix into the normalized preferred rating scales. Next, a simple example is given to demonstrate the procedures of SAW in determining the preferred order of alternatives.

IV. PROPOSED DATA MANAGEMENT SCHEME

This section proposes an adaptive User's Context-Aware Data Management Scheme called ACADMS. ACADMS is based on a mobile user dependent context as we classified in [3]. In this section, we will introduce how this data message will be delivered using our proposed protocol. Also, ACADMS using our proposed routing protocol [2] to route data and messages through the network.

ACADMS consists of five phases as follows.

1. Extracting user's context.
2. Obtaining criteria weight and determining node similarity threshold.
3. Sending information to clusterhead nodes.
4. Evaluating mobile nodes.
5. Sending shared data to similar nodes.

In the remaining of this section we will introduce each phase in details.

A. Extracting User's Context

ACADMS is a broadcasting scheme designed for mobile environments to preserve mobile networks resources such as energy, memory and bandwidth. The basic idea of this scheme is to use the mobile user's context to adapt the broadcasting process. The adaptation means that sending data to maximum number of mobile nodes which will utilize the shared data and saving the wasting in network resources by stopping sending data to nodes will not utilize these shared data because these data are not suitable for these nodes (users). So, we introduce our user context-aware data management scheme to deliver data to all similar users in the network. Our proposed scheme based on extracting the contextual information that characterizes a data sender and a broadcasting data. By using this information, we can evaluate each mobile node in the network. The context-aware middleware is committed with supporting our scheme by user's context [3].

B. Obtaining Criteria Weight and Determining Similarity Threshold

Evaluating a mobile node based on user's context is a multi-criteria decision making problem. In this research we use the fuzzy analytical hierarchy process FAHP to obtain the weight of each context attribute. Let node *U* needs to broadcast a data message (News, Text message, Video, Audio or any type of information) to most of the similar nodes in the network. When mobile node *U* needs to share a data to the network. Initially, node *U* will determine its context and its shared data's context using the context-aware middleware [3], and then it will compute the criteria weight using FAHP and determine a Similarity Threshold value. The *Similarity Threshold* value, *ST* expresses the minimum similarity value between the source node *U* and any other node in the network. If the *User Dependant Context Rank*, UDCR, value of a mobile node is greater than or equal to the threshold value; then this node will receive the broadcast data otherwise the node will not receive the shared data, because the *ST* value between this mobile node and the source node *U* is very small. In other words, this node will not utilize the broadcast data.

C. Sending Information to Cluster heads Nodes

After computing the weight of all criteria and determining the similarity threshold value, the source node *U* will use the cluster based routing protocol in [2] to send "Hello" message to all cluster heads in the network. This message contains the context attribute names that will be used in the evaluation process, criteria weight and the similarity threshold value, *ST*.

D. Evaluating Mobile Nodes

Each cluster head which receives the source node's information message, will forward it to its member nodes. At this time the member nodes start the evaluation process based on the received information from node *U* based on its user's context. In this research, we use the Simple Additive Weighting Method (SAW) to obtain the User's Dependant Context Rank UDCR for each mobile node which is based on the acquired context attributes and the received criteria weights. Now each node has its User's Dependant Context Rank value (UDCR). This value expresses the similarity value between its user and the user of source node *U*. Then all member nodes will check if its UDCR value is greater than or equal to the threshold value or not, if yes then it will send an approval message to its cluster head. This message informs the cluster head that there is a node will utilize the broadcast message. Then each cluster head which receives the member approval message will send a cluster head approval message to the source node *U* and stores the member node *ID* in member approval list. The cluster head's approval message informs the source node *U* that the approval message sender needs the broadcast message.

E. Sending shared Data

When the source node *U* receives a cluster head approval message, it starts to send the shared message to each cluster head that needs the message. Each cluster head which receives the broadcast message, will forward the message to all member nodes in the member approval list. Fig-4 shows the proposed ACADMS protocol.

If any node *V* belongs to the network and needs this message at any time. This node can request the shared message from its cluster head, if the cluster head does not receive the shared message; then the cluster head will obtain this message from other neighbor cluster heads and sends the shared message to the node *V*.

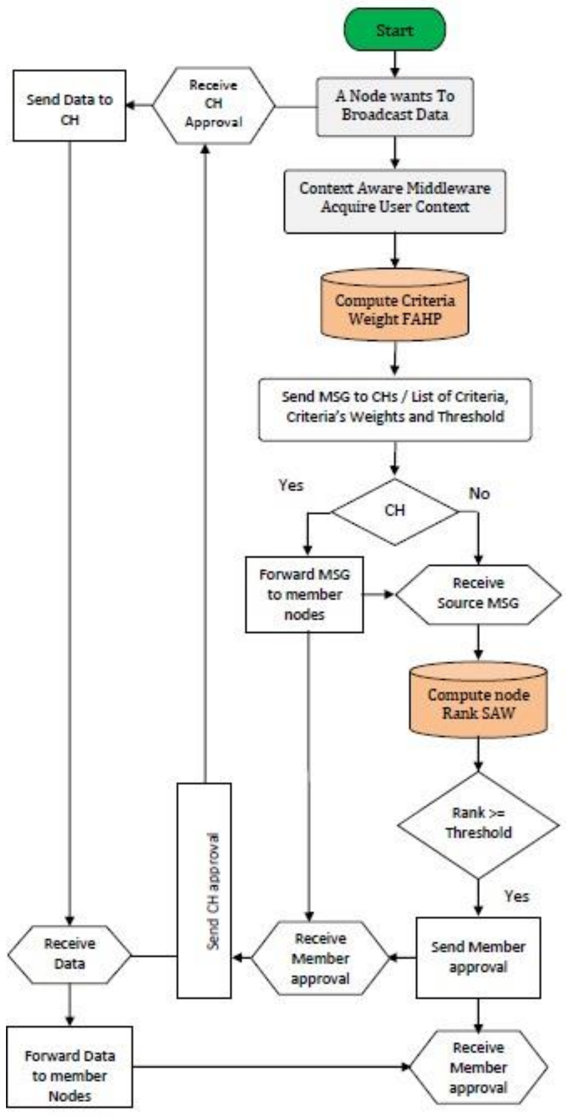

Fig. 4: Flow Diagram of Proposed Scheme

V. SIMULATION AND RESULTS

In this section, we will discuss the simulation results of the comparison between the proposed data management scheme ACADMS and the Simple Flooding protocol. We introduce the simulation results of a scenario of sharing a message. The message sender characterized by, level of stress, type of emotion, activity and interested in football. The context-aware middleware will collect this information from mobile sensors and share the context through social applications. In this paper, we use the OMNET++ simulator [7] to simulate our proposed protocol.Table IV shows our simulation parameters.

TABLE IV
Simulation Parameters

Parameter	Value
Network Area	1000m x 1000m
Number of Nodes	50 - 300
Initial Energy	5 J
Mobility Type	RandomWPMobility
Radio Transmission Range	250m
Bandwidth	3 - 30 Kbps

The simulation will study the performance of the proposed ACADMS and the traditional Simple Flooding protocol. We used many different ways to study the proposed protocol. The performance of ACADMS protocol evaluated according to the following metrics:

- Number of reached nodes.
- Message average delay time.
- Energy consumption.
- Memory utilization.

A. Simulation Results and Analysis

In this section, we will discuss the simulation results and evaluate the performance of ACADMS according to energy consumption, message average delay time and number of reached nodes.

Fig-5 compares the Average end to end delay for ACADMS and simple flooding protocol. As the number of nodes increases the Average end to end delay decreases. We can see that the Average end to end delay of proposed protocol is clearly better than the simple flooding protocol and our protocol can scale up to larger network. Because more connections and congestions appear in higher density network, this reason decreases the distance between network's nodes, which reduces the Average end to end delay.

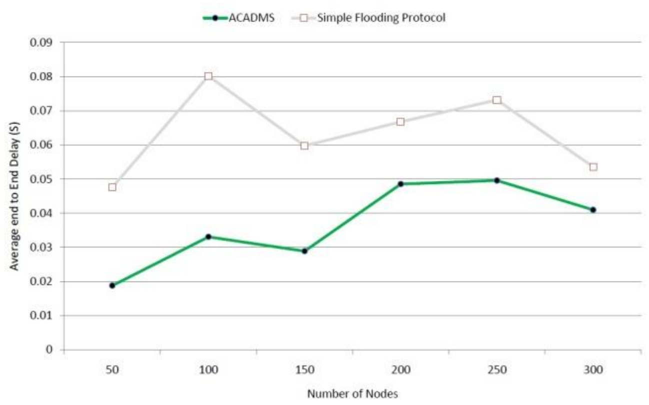

Fig. 5: Average End to End Delay (S) vs. Number of Nodes

The comparison of the Energy Consumption and Number of nodes is shown in Fig-6. We can see that as the number of nodes increases, the energy consumption increases, because more connections and congestions appear in higher density network. It can also be concluded from this figure, that the proposed ACADMS approach consumes much less energy than the Simple Flooding protocol.

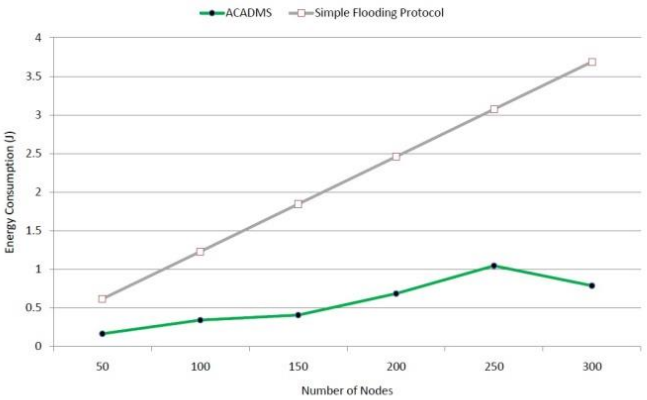

Fig. 6: Energy Consumption vs. Number of Nodes

Fig-7 compares the Number of reached Nodes for ACADMS and Simple Flooding protocol. The comparison based on sending 5 messages with different sizes. We can see that the Simple Flooding protocol sends the broadcast message to all network nodes, whether they utilize the message or not, which increases the waste of network resources. On the other hand, the ACADMS sends the message only to those who benefited from it, depending on the degree of similarity between the message sender and the rest of the mobile nodes in the network. This significantly reduces the drain in network resources such as energy, memory and bandwidth.

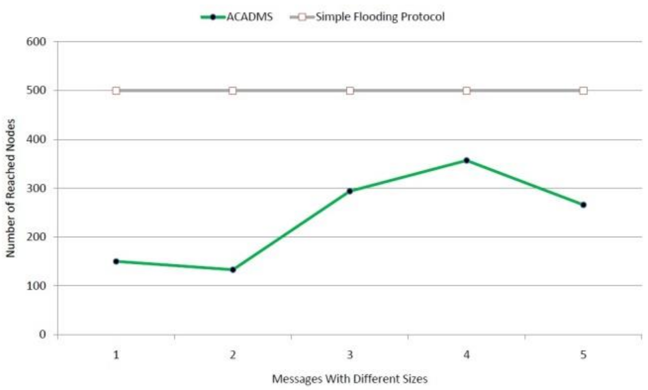

Fig. 7: Number of Reached Nodes vs. Different Messages

The comparison of the Energy Consumption is shown in Fig-8. We can see that as the message size increases, the energy consumption increases, because of the increased in message's sending time. Also, we can conclude from this figure that proposed ACADMS consumes less energy than the simple flooding protocol.

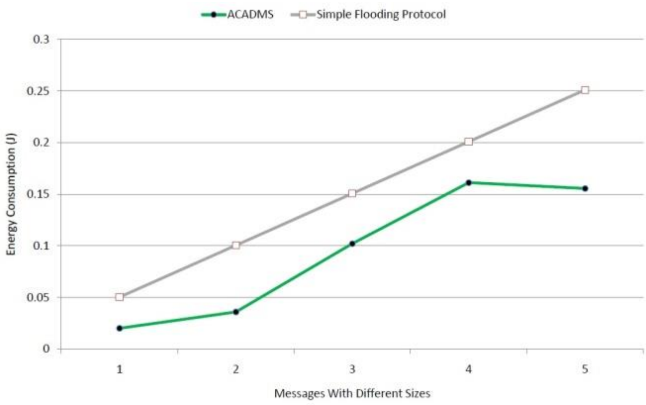

Fig. 8: Energy Consumption vs. Different Messages

VI. CONCLUSIONS

In this paper, we have introduced a new data management scheme for mobile environments which is called adaptive Context-Aware Data Management Scheme, ACADMS. ACADMS can broadcast data to nodes that will utilize this data. ACADMS is based on using the user's contextual information to find most of similar mobile nodes in the network. In this research, we introduced the similarity of nodes as User's Dependant Context Rank (UDCR) value. Node's UDCR value is obtained using a multi-criteria decision making approach (SAW). Our simulation results, shown that ACADMS is power efficient protocol and it can reduce broadcast redundancy and the average end-to-end delay much better than the simple flooding protocol. Also, the simulations have shown that ACADMS protocol can reduce energy consumption and memory usage of nodes and network's bandwidth usage.

Our future work involves using ACADMS protocol to develop a new adaptive service provider based on user's context.

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