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Implementation of N-Level Clustered Architecture For Multicasting Using PMAC In Wireless Networks

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Abstract

The significance of latency and throughput with respect to clusters in wireless cellular networks has increased substantially. Also, an energy efficient environment in wireless cellular networks is required. This paper proposes an n-level multicasting clustered architecture using Pattern-Medium Access Control (PMAC) protocol.
PMAC plays a significant role in communication of clusters under heavier traffic and light loads.
The proposed algorithm performs efficient offline direct Consumer to Consumer (C2C) transactions where the dependency on online intermediary for selling / buying / marketing products are avoided by deriving the features of PMAC protocol. The influence of existing protocols such as Sensor-Medium Access Control (SMAC) results in degradation of network throughput under heavy traffic.
This paper proposes a wireless application which uses network clusters that communicate using PMAC protocol for multicast communication pattern with the help of implicit forwarding.

Keywords: Business to Consumer (B2C), Business to Business (B2B), Consumer to Consumer (C2C), n-Level Multicasting, PMAC, Implicit forwarding, Power-consumer state, Power saver state, Recursive forwarding algorithm and clusters.

Introduction

Introduction to N-level Clustered architecture:

Wireless cellular networks are new types of generic-purpose ad hoc networks. In order to communicate with one another, each node uses multiple hop routing and peer-peer packet transmission mechanism [1]. The approach in designing n-level cluster architecture for multicasting requires power efficient Medium Access Control (MAC) protocol [2]. This is one of the ways where the network throughput will be improved.

The purpose of implementing n-level cluster networks using multicast communication pattern is to develop an application for direct offline Consumer to Consumer (C2C) transactions using clustering. The proposed application is a system that is to be used by all the consumers who want to sell / buy / market their products. In existing applications there is a huge dependency on online intermediaries and the Internet, which is based on Business to Consumer (B2C) / Business to Business (B2B) transactions. Once the consumer defines the nodes, registrations of the nodes are completed. Progressively the source node will search for pre-defined nodes that are in range and alert them so as to enable them to know about their product. As the message is initiated by a node, it will be recursively propagated to all the pre-defined nodes of that particular node using implicit forwarding. This message recursively iterates up to ‘n’ hops where all connected nodes receive the message. The limitation of the existing systems in C2C wireless cellular applications is that it will propagate the message only to one immediate hop. The use of heterogeneous networks requires a modified Pattern-Medium Access Control (PMAC) protocol for communication of the product message [3]. PMAC helps two neighbors within the network to communicate with each other making the channel collision free, thus it increases the network throughput [4].

Some of the key challenges are the use of wireless cellular networks for finding and passing messages between nodes, implementation of message passing algorithm for optimized message passing through the network and the designing of a scalable architecture to support this system efficiently. The Carrier Sense Multiple Access (CSMA) or Carrier Sense Multiple Access/Collision Avoidance (CSMA/CA) provides a contention based MAC Protocol that does not requires any coordination among those nodes that are accessing a particular channel [5].

Introduction to N-level Clustered architecture using MAC Protocol in wireless cellular networks:

A MAC protocol is used for communication using shared access medium. In communication protocol stack, MAC acts as the kernel that assures the Quality of Service (QoS) in any wireless networks [6]. This is considered because it increases the sleeping duration, reduces overhearing and idle listening and abolish packet collision as well as hidden terminal problem [7]. The successful execution of any operation within the network is ensured by the MAC protocol as it avoids the collision interference among the nodes [8]. In certain MAC protocol, each node will have specific information about their neighboring nodes and this status information is propagated throughout the entire network [9]. Another MAC protocol, Zebra-Medium Access Control (ZMAC), is also known as hybrid MAC protocol since it adopts the characteristics of Time Division Multiple Access (TDMA) and CSMA [10]. It has low power listening time for energy efficiency [2][11][12]. The scheduling-based protocol known as Mobility Adaptive Medium Access Control (MMAC) guarantees collision avoidance. The transmission rights are provided to the nodes on the basis of their mobility pattern and traffic information [13]. Lightweight-Medium Access Control (LMAC) has power saving mode with low power wakeup for data transmission [14][15]. In the case of Sensor-Medium Access Control Protocol (SMAC) the nodes adaptively switch the mode in accordance with the network traffic [16]. SMAC consumes less energy when the traffic is low [17] and it uses duty cycles that sleeps and wakes up in a fixed time slot resulting in degradation of network throughput.[2][11]. This is not sufficient for cluster oriented and multicast communication pattern based wireless applications [2] [3]. Since SMAC has poor traffic contention handling, a novel duty-cycle MAC protocol called Routing enhanced MAC protocol (RMAC) makes use of cross-layer routing to avoid this issue and thus saves energy [18]. This paper proposes a wireless application which uses network clusters that communicates through modified PMAC protocol for multicast communication pattern. This means there will be direct offline C2C transactions where the dependency on online intermediary for selling / buying / marketing products is avoided.

Existing Systems:
In existing applications there is a huge dependency on online intermediaries and the Internet which is based on B2C / B2B transactions. This discourages the possibility of consumers who want to sell / buy / market their product offline. In order to assist them we propose a wireless application for cellular networks to complete their transactions offline.

Procedure and N-Level Multicasting Algorithm

A. Introduction
In today's world, there is an immense need of message communication in e-commerce applications. A tree based n-level multicasting ensures that maximum nodes receive the message under a short period of time. As there are a large number of nodes involved in the cluster the power management is very essential. The PMAC provides a power management scheme by adaptively determining the duty cycles of wireless cellular nodes. An android application developed will implement this n-level multicast cluster and power management scheme of PMAC. The procedure comprises of different phases in android application mentioned below. It includes the registration phase and the messaging phase.

B. Registration Phase
The registration phase involves the registration of wireless cellular nodes. A source node which triggers the message has to complete the registration of its nodes before sending the message.

A source node (f0) with android mobile installs this application using the apk file. The source node (f0) can choose 1 to 5 people (f1, f2…f5) from his/ her contacts and a notification in the form of a custom message is sent to the respective selected nodes informing them that they are registered under the source node as shown in the Fig. 1.

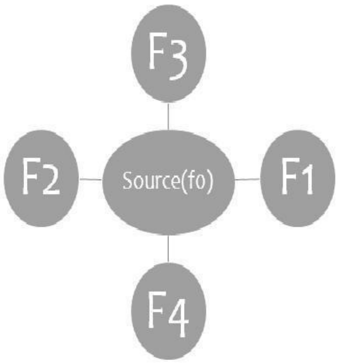

Figure 1: Registration of Nodes By A Source Node Is Shown

Following are the attached snapshots of the Registration Phase:

Fig 1.1 Index Page generally the icon of the application which can be viewed once the user installs to access the application. Once the user clicks on this icon, he\she will be redirected to Menu shown in Fig 1.2. Here, the Registration Phase is carried out in the Contact icon and the Messaging Phase is handled in the Messages Icon showed in Fig 1.2. Since, it is the Registration Phase, once if the user clicks on the Contact Menu, he\she will be directed to the page to add the contact of the another person in his\her contact list as shown in Fig1.3. Once, the user clicks on the “add contact” icon given right below after typing the contact number, a default message,“U have been added to SMS chain group” will be sent to the added user/users as shown in Fig 1.4. Figure 1.5 shows the list of the people the source user has added to the contact list of the SMS Chain Group.

Figure 1.1: Index Page

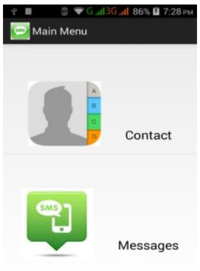

Figure 1.2: Menu screen of the application

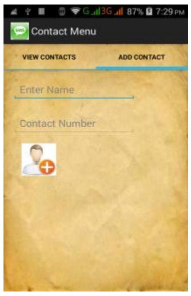

Figure 1.3: Contacts screen to add new contacts in the application.

Figure 1.4: Confirmation Messages to inform that you have been added to the group.

Figure 1.5: Contacts screen to view the added contacts.

C. Messaging Phase

The messaging phase commences only after the registration phase is completed. The source node triggers the message and the message is propagated to its registered nodes. The registered nodes act as new source node and these registered nodes being the new source node have to register new nodes as shown in the Fig. 2.In this way n-level cluster is built to assist communication of messages to maximum number of nodes.

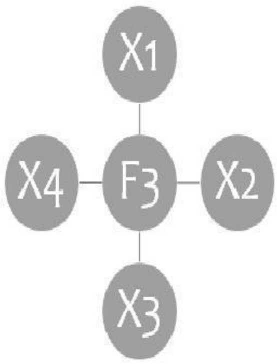

Figure 2: Registration of nodes by a new source node is shown

Once the message is triggered by node f0 in Fig 1, the message is received by its registered nodes f1, f2, f3 and f4. This message is implicitly forwarded by f1, f2, f3 and f4 to their respective registered nodes. This message is recursively forwarded to all the registered nodes in the cluster. The prime contribution of the application is that the source node that triggers message can decide the number of cluster levels the message can travel.

Following are the attached screenshots of the Messaging Phase:

Once the confirmation message has been send to the newly added user, the source user will be redirected to the Main Menu shown in Fig 2.1, wherein he\she can select the "Messages" Icon to type the required message which he\she is intended to send to the newly added person in his\her SMS group. Figure 2.3 displays the message which has been sent by the source user to the newly added user. After every message been sent you can view the history of all the earlier sent messages as shown in the Fig 2.4

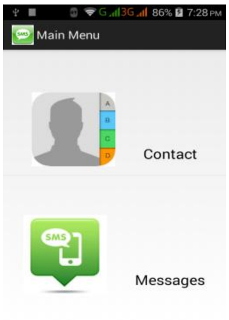

Figure 2.1: Main Menu

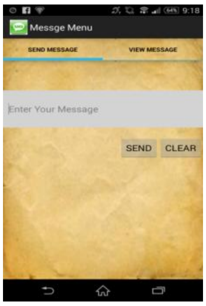

Figure 2.2: Page to enter the necessary message to the newly added user.

Figure 2.3: Page to view the message sends from the source user to the newly added user.

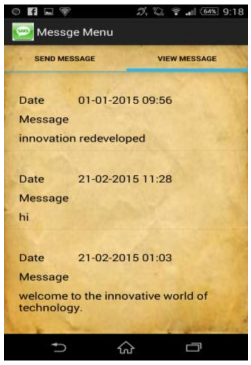

Figure 2.4: Page to view the history of the previous messages.

D. Algorithm

To calculate the total number of nodes receiving the message will include the below two cases:

Case1: when "n" remains constant and assumed to be same throughout the cluster.

$$\sum_{i=1}^{\infty} n^{i} \quad (1)$$

Where: 'n' = number of nodes chosen by the source node.
'i'=number of levels in the cluster or the depth of the cluster.

Case2: when "n" is varying at each level and assumed to be same throughout the cluster level.

$$\mathrm{n_t = (n_t * n)_{n=1\ldots\infty}} \quad (2)$$

Here: $\mathrm{n_t}$ is 1 initially and is the number of nodes in the $\mathrm{i^{th}}$ cluster level.

$$\mathrm{n_{t-1} = (n_{t-1} * n)_{n=1\ldots(\infty-1)}} \quad (3)$$

Here: $\mathrm{n_{t-1}}$ is 1 initially and is the number of nodes in the $(\mathrm{i} - 1^{\mathrm{th}})$ cluster level.

$$\mathrm{n_{t-(i-1)} = (n_{t-(i-1)} * n)_{n=1\ldots(\infty-(i-1))}} \quad (4)$$

Here: $\mathrm{n_{t-(i-1)}}$ is 1 initially and is the number of nodes in the first cluster level. Finally, the total number of nodes receiving the message will be:

$$\sum_{i=t}^{t-(i-1)} n_{i} \quad (5)$$

Experimental Analysis

The above algorithm is implemented using an android application. Table I shows the Experimental result of the algorithm. The application has to be installed in the wireless cellular node (mobile). The person who installs the application has to initiate registration by selecting up to 5 mobile numbers. Registration is only successful if all the selected wireless cellular nodes have already installed the application. As this registration of wireless cellular nodes prolongs, a cluster of wireless cellular nodes with n-levels are formed. A custom message regarding any new / used product of e-commerce application triggered by source node is propagated to all the nodes that formed the cluster. The total time taken for the message to reach all the nodes is highly cohesive on transmission delay and processing delay.In safety critical applications, time is a significant parameter; where in a maximum number of people has to be addressed within very short period of time. In existing applications, any Global System for Mobile Communication (GSM) message is explicitly forwarded by all the people. This explicit forwarding forms its own ad-hoc network. Contrastingly, our application provides implicit forwarding where the message is automatically propagated to all the nodes in the cluster.Table I provide two different cases of algorithm as mentioned below.

Table 1: Experimental Results of The Algorithm

Case	Description	Results(Total nodes 'N' and time taken 't' to reach all the nodes N) GSM transmission delay = 1.75 (in sec) GSM processing delay = 0.25 approx (in sec)
1	When "n" remains constant and assumed to be same throughout the cluster. (n = 5, i = 5)	N = 3125, t = 10 (in sec)
2	When "n" is varying at each level and assumed to be same throughout the cluster level. (n_i = 5, 4, 5, 4, 5, i = 5)	N = 2000, t = 10 (in sec)
1	When "n" remains constant and assumed to be same throughout the cluster. (n = 5, i = 4)	N = 625, t = 8 (in sec)
2	When "n" is varying at each level and assumed to be same throughout the cluster level. (n_i = 5, 4, 5, 3, 3, i = 5)	N = 900, t = 10 (in sec)
1	When "n" remains constant and assumed to be same throughout the cluster. (n = 5, i = 3)	N = 125, t = 6 (in sec)
2	When "n" is varying at each level and assumed to be same throughout the cluster level. (n_i = 5, 4, 3, 4, 3, i = 5)	N = 720, t = 10 (in sec)

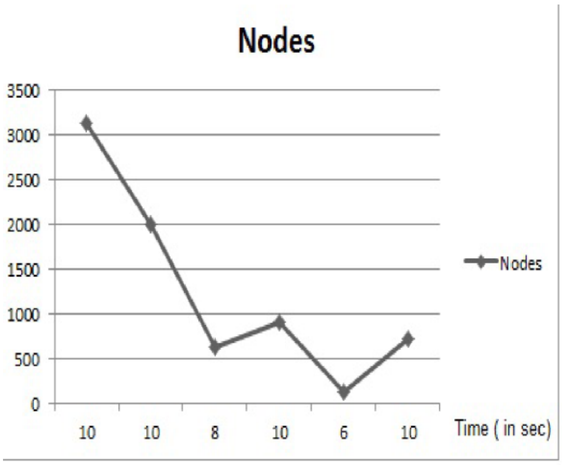

Figure 3: A Graph Representing Total Nodes and Total Time Taken By Different Clusters Is Shown

The algorithm is tested by implementing the android application. A number of different clusters of wireless cellular nodes are created with different values of ‘n’ and ‘i’ with reference to equations (1) and (5). As an example from Table I, applying the values of ‘n’ and ‘i’ in equation (1) $\sum_{i=1}^{\infty} 5^5$, we get the total nodes as 3125 and total time taken is 10 seconds. The total time taken is calculated by taking into account of the total GSM transmission delay and processing delay. Similarly, unique values are applied to different case in order to test the feasibility of the algorithm. As mentioned before, the two significant parameters time and maximum connectivity are achieved by propagating the message to maximum nodes under specific limited period of time. In the implemented android application, a wireless cellular node can register up to 5 cellular nodes. If the algorithm is implemented applying the values of ‘n’ and ‘i’ in equation (1) $\sum_{i=1}^{13} 5^{13}$, we get the total nodes as 1,220,703,125 and total time taken as 26 seconds. The above statistics suggest that the 17.5% of world population which is the entire Indian population of 1,264,360,000 formed as a cluster can receive the message in 26 seconds approximately. This elaborates the significance of n-level multicasting within a cluster. The experimental results in Table I are represented in Fig. 3 as a line chart representing the total nodes and total time taken by different clusters. From case ‘1’ when ‘n’ = 5, ‘i’ = 5, the total nodes are 3125 and total time taken is 10 seconds. From case ‘2’ when n_i = 5, 4, 5, 4, 5, i = 5, the total nodes are 2000 and total time taken is 10 seconds. From case ‘1’ when ‘n’ = 5, ‘i’ = 4, the total nodes are 625 and total time taken is 8 seconds. From case ‘2’ when n_i = 5, 4, 5, 3, 3 and i = 5, the total nodes are 900 and total time taken is 10 seconds. From case ‘1’ when ‘n’ = 5 and ‘i’ = 3, the total nodes are 125 and total time taken is 6 seconds. From case ‘2’ when n_i = 5, 4, 3, 4, 3, i = 5, the total nodes are 720 and total time taken is 10 seconds.

Table 2: Experimental Comparison of GSM Messaging Approaches

Proposed N – level cluster based multicast GSM messaging system (Total time 't' in sec)	Ad-hoc single level GSM messaging system. (Total time 't' in sec)	Nodes
t = 10 (implicit forward)	t = 6250 (explicit forward)	3125
t = 8 (implicit forward)	t = 1250 (explicit forward)	625
t = 6 (implicit forward)	t = 250 (explicit forward)	125

The comparison of two different approaches is represented in Table II. The existing ad-hoc single level / single hop GSM messaging system relies on explicit forwarding. In explicit forwarding, the person using the wireless cellular node is free to either forward the message or neglect the forwarding. In comparison to proposed system, it also takes more time to reach all the nodes in the cluster. As an example from Table II, it takes 250 seconds to forward the messages to 125 wireless cellular nodes in ad-hoc GSM messaging system wherein it takes only 6 seconds in the proposed n-level cluster based multicast GSM messaging system. Thus the above experimental results enlighten the need of the proposed n-level cluster based multicast GSM messaging system.

Power Management

The proposed n-level cluster based multicast GSM messaging system comprises huge amount of wireless cellular nodes. This results in huge amount of power consumption. The average CPU power consumed by the implemented android application is 0.56 mAh (milliampere-hour). This does not require any wifi (wireless fidelity) power as this is an offline GSM android application.

From the above proven experimental results, it is clearly evident that in equation (1) $\sum_{i=1}^{13} 5^{13}$, we get the total nodes as 1,220,703,125 which require an efficient power management technique. In existing ad-hoc networks the power management is done implicitly with dynamic clustering of the network [19], whereas in cellular networks the PMAC protocol enriches the proposed system by achieving an efficient power management scheme [2] [20]. The PMAC protocol determines the sleep–wake up schedules for a node based on network traffic and its neighbors. This protocol is expected to conserve a lot of energy under light loads [3][11]. We implement power management scheme in the proposed android application by extracting the features of PMAC protocol. The duty cycle of the android application is adaptively determined by two different states. When the wireless cellular node has to transmit a message, it acts as the source node in the cluster that has already been constructed in the registration phase of android application. This source node triggers the message and attains the “power-consumer” state where the application is turned on and the message is forwarded. As soon as the message is forwarded to the registered nodes of the source node, the source node attains the “power- saver” state. The registered nodes of the source node are in “power-saver” state until there are any incoming messages from the source node and attain the “power-consumer” state as soon as the message is received. Immediately, the message is implicitly forwarded to all the nodes in the cluster without any user intervention and it turns back to “power-saver” state waiting for the messages from source node. Thus PMAC plays a significant role in implementing this power management scheme where the average CPU power consumption of the wireless cellular node is decreased significantly throughout the cluster [3]. The person using this android application can explicitly decide the number of cluster levels the message should travel. This makes the android application more flexible and feasible. In some cases, where the messages has to be limited only up to certain number of nodes this feature of the proposed application helps in avoiding of unnecessary message propagation to all the wireless cellular nodes in the cluster. This also results in efficient power management. Thus the implemented application along with the extracted features of PMAC provides a significant contribution to the power management in the proposed n-level cluster based multicast GSM messaging system.

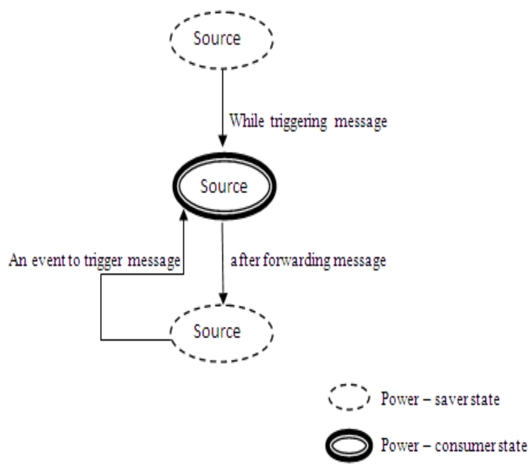

Figure 4: A flow model representing the two different states of the source node in the cluster is shown.

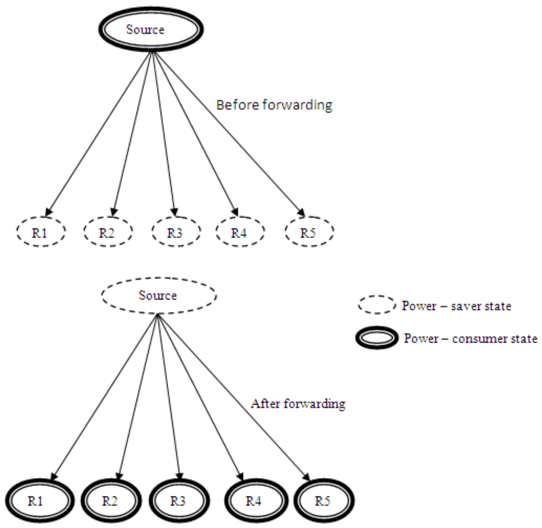

Figure 5: A flow model representing the two different states of the registered nodes of the source node in the cluster is shown.

Conclusion and Future Work

This paper is based on the concept of n-Level clustered architecture for multicasting using PMAC in wireless networks. We have built an android application for messaging through which any consumer will be able to advertise/sell their products, request for a social cause and other such activities without the use of Internet or any online intermediary. Our application allows the user to perform transaction, request help for a social cause or such activities by creating a messaging service application where the messages are recursively forwarded automatically without any explicit forwarding by the users. This application allows the message to be passed to a chain of people creating a new clustered network. The power consumed is minimal as the application utilizes the features of PMAC protocol for efficient power management. In the proposed application, the implementation is done using GSM. It is also planned to integrate “cloud computing” to the existing application where the transactions are performed in the cloud with a centralized database. The scope of the application would help people in a very significant manner if the transactions performed are analyzed and people behavior studied to take high level decisions.

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