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An analysis of Video multicast in VCR Application using MANET

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Abstract. In this paper we analyzed the best video multicast routing protocol for Virtual Class Room (VCR) using Mobile Adhoc NETworks (MANET). A VCR is one that can be established by using mobile devices and whose members can be dynamically added or removed. The implementation of VCR for lesson handling and query discussion using MANET. The application transmits multimedia data like image, audio and video. When we established a group, we configuring a multicasting network and transmitting the data. Video transmission using multicasting is a challenging problem of our application. We analyzed the differences between general multicast trees, wireless multicast trees, tree-based approach and mesh-based approach in multicast routing protocols were highlighted. Also a well-known multicast routing protocol: Multicast adhoc On-Demand Distance Vector (MAODV) is explained in details. As an extension of this protocol, another multicast routing protocol using Multiple Description Coding (MDC), named Multiple Tree Multicast adhoc On-Demand Distance Vector (MT-MAODV), addressed in the application layer, is stated and its algorithm is explained. This later multicast routing protocol has proven to have an effective improvement in the received video quality and select to implement MT-MAODV in our application**.**

Keywords: Mobile adhoc Network, Multicast, Video, Personal Digital Assistant, Virtual Class Room, MDC

1. Introduction

A Mobile adhoc network is an instantly deployable wireless network without any base station or infrastructure support. Mobile adhoc networks are characterized by dynamic topologies, bandwidth-constrain, variable capacity links, energy constrained operation and limited physical security. Many applications can be considered as examples using adhoc networks: VCR, crowd control, automated battlefields, disaster recovery, search and rescue. One of the points that make routing as well as multicasting very hard in adhoc networks is its mobility functionality. No fixed topology exists for these networks as nodes can move in any direction, at any time and thus route discovery are required frequently. Also another point to be considered is that almost all devices using adhoc networks are very limited in battery power and in bandwidth. [7] Multicast is very important in adhoc networks because due to the constraints explained previously, nodes usually achieved a certain task in groups, like in video transmission that is required in acceptable quality [7, 1].

A VCR is one that can be immediately established, and whose members can be dynamically added or removed; the group structure of the members can be reorganized dynamically. Fig 1 illustrates such an idea. The adhoc classroom can support urgent and timely learning activities, thus improving learning effectiveness.

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For example, a teacher may establish a virtual classroom from his residence, students located around can take the opportunity to form an adhoc group to improve the teaching learning process at any time using IEEE802.11g WLAN. VCR based on adhoc network has been constructed as shown in Fig.2. The network has been formed with 30 (Personal Digital Assistant) PDA nodes. Each node in the network is assigned with static IP address. The software components used for development are Microsoft Visual Studio C#.Net 2005, Windows Mobile 5.0 Pocket PC SDK, Microsoft ActiveSync Version 4.2 and Microsoft.Net Compact Framework 2005 and XML technology. The XML technology was used for providing description and representation of data and control packets.

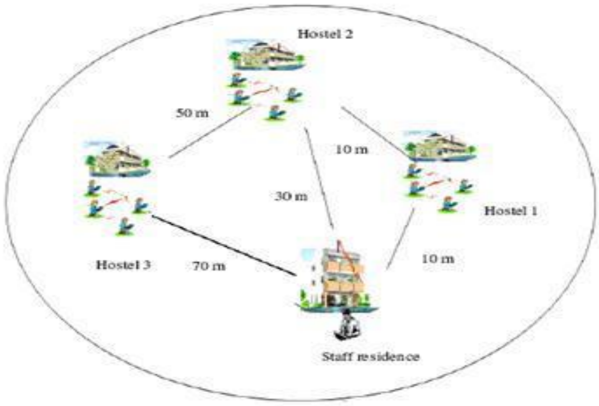

Fig 1. A Scenario of VCR using MANET

The rest of this paper is organized as follows. Section II, Multicast is divided into two sections: Overview and MT-MAODV approach. The first section is stating some general background information about multicast in adhoc networks while the second section is discussing an extension to the well-known routing protocol Multicast AdHoc On-Demand Distance Vector (MAODV). Finally, the paper finishes with concluding remarks and future work.

2. Multicast

In this section, an overview about adhoc wireless multicast routing protocols will be presented. Afterwards, the Multiple Tree Multicast AdHoc On-Demand Distance Vector (MT-MAODV) approach about video multicast using multiple tree multicast routing protocol in mobile adhoc networks will be discussed more deeply. The latter is a multicast protocol addressed in the application layer.

2.1. Overview

Video Multicast - The process of delivering a video to multiple receivers having the same multicast address is called video multicast. Multiple applications use video multicast like group video conferencing, distance learning and video-on-demand [1]. Video applications have different requirements than ordinary data applications and thus have more constraints on the routing protocols. For example, lost, bandwidth, jitter and delay are some requirements associated with video transmission. As most of the routing protocols currently available are designed more efficiently for data applications rather than for video applications, thus they might not be enough for fulfilling the constraints for video transmission [1].

Multicast Tree and Mesh Approaches - Multicast generally needs a tree construction that connects all the members of the multicast group as well as the nodes where data packets are duplicated. A main difference between normal multicast in general and wireless multicast is that this process of tree construction is not of great importance in wireless connection as the wireless nodes have a broadcasting nature [2]. Mainly, two types of multicast routing protocols over adhoc networks can be de-ducted from the past years of research. These two types are mesh-based routing and tree-based routing [5]. Multicast adhoc On-Demand Distance Vector (MAODV) is an example of a multicast routing protocol using the tree-based approach. The main idea behind the tree-based approach is that only one route is created between the multicast tree and any receiver [3]. On-Demand Multicast Routing (ODMR) protocol is also an example of a multicast routing protocol but in contrast with MAODV, using mesh-based approach instead of the tree-based approach [4]. In the mesh-based approach, multiple routes are created between the source and the receiver. Some disadvantages of the mesh-based approach, that we can see in the On-Demand Multicast Routing (ODMR) protocol, is that it has low efficiency in multicast and it requires a high number of forwarding nodes to be able to provide these multiple paths. An advantage of the mesh-based protocol is that, because it contains multiple paths between each source and receiver and if a path is broken than another path can be taken, thus it can be considered as more efficient. This efficiency also has a drawback: more efficiency means more control overhead due to the increase of data sources. The tree-based approach has, as a disadvantage, a higher possibility of dropping compared to the mesh-based approach. This is due because of the availability of a single path between the multicast group and the receiver, thus no backup route. This can be caused if there is high node mobility in the network cloud. As one advantage of the tree-based approach that can be considered, is the fact of having efficient and high forwarding because of its single path property [1].

MAODV - Multicast AdHoc On-Demand Distance Vector (MAODV) is a well-known routing protocol in the field of adhoc networks and is an extension of the unicast protocol, adhoc On-Demand Distance Vector (AODV) [5]. This protocol contains two main parts: multicast tree construction and multicast tree maintenance. It is also categorized as a receiver-initiated protocol. In a multicast group, a group leader exists which is the first member that joined this multicast group. This group leader should always maintain the multicast group's sequence number. The first part, which is multicast tree construction, begins by a tree-way handshake that is begun by the node that wants to join the multicast group. A join flag (RREQ J) is sent in a unicast packet by this node to the multicast group leader or it can also be broadcasted in the network. If this request was broadcasted, then any group member can then reply to the request and send back to the node, a packet containing the join flag (RREPJ). The node, receiving the reply, chooses the shortest route to the multicast tree and sends an activation request in a packet including the join flag (MACT J). After doing these steps, the node is now considered as part of the multicast group. The second part, which is the multicast tree maintenance, is the responsibility of the group leader. The group leader keeps sending, every fraction of time, a group hello message (GRPH). When a group member receives the hello message, it has to update the group information. The goal of this process is to keep track of the tree connectivity [1]. Each node has to keep three tables: unicast route table (UR), multicast routing table (MR) and group leader table (GL). The unicast route table (UR) is responsible for the unicast traffic and thus it saves the destination's next hop. The multicast routing table (MR) has a list indicating the next hop for the tree constitution of each multicast group. It also indicates if the next hop is an upstream because it is near to the group leader or if it is downstream because it is not. The group leader table (GL) saves the group leader address of any multicast group known to this node and also the group leader's next hop [3].

2.2. MT-MAODV Approach

Reason behind MAODV and MDC - Due to the mobility of nodes in mobile adhoc networks that changes rapidly the network topology, video multicast becomes challenging and thus the framework used must be fault-tolerant to be able to have video streaming without interrupts. For this reason, it was found that a possible solution for this challenge is to use diversity by distributing the video to be transmitted over many disjoint trees. This can be achieved by using the Multicast adhoc On-Demand Distance Vector (MAODV) and transform it to be able to construct in only one routine, two disjoint multicast trees [1]. Also as Multiple Description Coding (MDC) provides the functionality of dividing the video into many equally and independent video description which will be needed when transmitting the video, thus this coding scheme was chosen [6].

MT-MAODV Algorithm Explained - Multiple Tree Multicast adhoc On-Demand Distance Vector (MT-MAODV) routing protocol consists mainly of constructing two disjoint trees. To accomplish this, each node can have one of five statuses: multicast group member, ON GROUP; forwarding node of the two trees: ON TREE 0; forwarding node of tree-one: ON TREE 1; forwarding node of tree-two: ON TREE 2; not tree member: NOT ON TREE. As in Multicast adhoc On-Demand Distance Vector (MAODV) routing protocol, a node begins by sending the RREQ J request. If this node's status is ON TREE 0 then it needs to change it to ON GROUP and thus needs not to send the RREQ J because it is already member of both trees. A field in the

RREQ J request, named tree is chosen to represent which tree the node wants to join: one, two or zero if it wants to join both trees. If the node has no information about the group leader in the group leader table (GL) or it is not its first trial to send a RREQ J request, then if it is ON TREE 1, it should broadcast RREQ J with value two in the tree field, if it is ON TREE 2, it should broadcast RREQ J with value one in the tree field, otherwise if it is NOT ON TREE, it should broadcast RREQ J with value zero in the tree field. If the node has information about the group leader in the group leader table (GL) or it is its first trial to send a RREQ J request, then if it is ON TREE 1, it should unicast a RREQ J with value two in the tree field to the group leader, or if it is ON TREE 2, it should unicast RREQ J with value one in the tree field to the group leader, otherwise if it is NOT ON TREE, it should unicast RREQ J with value one in the tree field to the group leader and then wait for ARP TIMEOUT which is 30 ms and then unicast RREQ J with value two in the tree field to the group leader. This part is considered as the first step in the algorithm. Then step two is about the intermediate nodes that are in step one. They should do two things: if the node is the successor of the node sending the join request, then it should save its ID in the first hop field, if it is not, then it should forward only one RREQJ. In the third step, the multicast members should reply to the RREQJ request. Priority is given first to construct two disjoint trees and then if no different route exists, then priority is given to the tree connectivity rather than disjointness. Step four is about forwarding the RREQJ. The fifth step is storing the best RREQJ request received. Finally the last step in the algorithm, step six is about the trees activation. This step is done as in the Multicast adhoc On-Demand Distance Vector (MAODV) routing protocol: if no reply is received, the node can resend its request or become the GL for the multicast group if the maximum number of retries is achieved [1].

MT-MAODV Routing Example - It is an example explaining the Multiple Tree Multicast adhoc On-Demand Distance Vector (MT-MAODV) routing protocol based on the example given in paper [1]. In Fig 2, the multiple trees construction is shown and in Fig 3, each node's status is given. First, we consider that GL is the group leader, that node A, B, C and D join the multicast group in the order given and that they don't save in their GL tables, any information. Beginning with node A, it sends a join request and the GL replies with the two upstream nodes available, y and z. Node A then receives the replies with both tree fields as zero and thus it can select one of them for tree-1, like node y in this example and the other for tree-2,

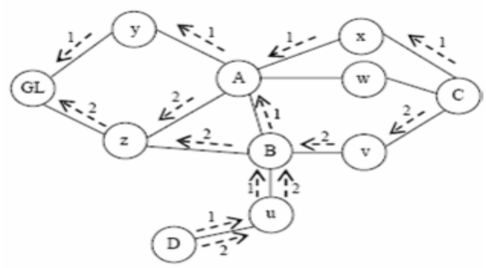

Fig 2. Multiple Trees Construction [1]

Node	Status	Tree-1 Up	Tree-1 Down	Tree-2 Up	Tree-2 Down
GL	ON_GROUP	leader	y	leader	z
A	ON_GROUP	y	x, B	z	-
B	ON_GROUP	A	u	z	u, v
C	ON_GROUP	x	-	v	-
D	ON_GROUP	u	-	u	-
u	ON_TREE_0	B	u	B	u
v	ON_TREE_2	-	-	B	C
w	NOT_ON_TREE	-	-	-	-
x	ON_TREE_1	A	C	-	-
y	ON_TREE_1	GL	A	-	-
z	ON_TREE_2	-	-	GL	A, B

Fig 3. Multicast table for Topology Fig 2 [1]

which is node z here. Then, node B also sends a join request. The same as for node A happens; a reply from node A which has tree=0 and another from node z with tree=2 are received. In this case, node B will choose node z to be the upstream of tree-2 while node A for tree-1. For node C, there's a difference because three replies will be returned: node A will return two replies with tree=0 from node x and w and node B will return one reply with tree=0 from node v. Here, node x or node w will be chosen for tree-1 and node v for tree-2 because connecting to different tree members or group members has higher priority. Finally, node D request a join and as it has only one node connected to it, node u, and as the priority is given to have a connected tree rather than a disjoint tree, node u will be chosen as upstream for both trees.

Example VCR Application - The VCR application allows the user to initiate a query session with the peer or to lesson handling. The lesson file can include multimedia data like image, audio and video. Whenever a student (who is source of the communication session) wants to discuss any topic with another student or with a staff (who is the destination of the communication session), he can initiate a query session by selecting the destination from the member list displayed. One example application of the Multiple Tree Multicast adhoc On-Demand Distance Vector (MT-MAODV) routing protocol can be video multicast. When using this protocol, the video source must be connected to the two trees. For this to happen, before the beginning of transmitting the video, the video source has to join the multicast group in the same way explained in the algorithm. Assuming that the video is coded with the Multiple Description Coding (MDC), then each tree can easily be forwarding one of the video descriptions independently. According to the results stated in the [1] paper, the quality of the received video is acceptable under the condition that there is no packet loss that happens in the two multicast trees in the same time. In this protocol, this is solved because two optimally disjoint trees are used.

Properties: Evaluation, Limitations - After simulation, the following results were discovered. According to the percentage of bad frames, only when using Multiple Description Coding (MDC) with the Multicast adhoc On-Demand Distance Vector (MAODV) protocol, an improvement of 2% can be observed. When using the complete Multiple Tree Multicast adhoc On-Demand Distance Vector (MT-MAODV) approach, another 2% is added to the improvement. These results are because using Multiple Description Coding (MDC), a bad frame is observed when the two video descriptions sent on both trees are not decodable and as in this protocol, the trees are disjoint, thus it is very rare that both trees break at the same time. This concludes that Multiple Description Coding (MDC) results in a more fault-tolerant video. From the point of the number of interruptions that can be seen while watching a video, using the Multiple Tree Multicast adhoc On-Demand Distance Vector (MT-MAODV) approach, has less than 20 times per video session while Multicast adhoc On-Demand Distance Vector (MAODV) protocol has more than 50 times. This proves that the presented protocol offers a great improvement in the field of video multicast on adhoc networks from the point of the video quality received. When we see from the point of the network, the Multiple Tree Multicast adhoc On-Demand Distance Vector (MT-MAODV) approach has a higher average number of hops traversed by any video packet compared to the Multicast adhoc On Demand Distance Vector (MAODV) protocol. This is because that Multicast adhoc On-Demand Distance Vector (MAODV) protocol always chooses the shortest path while the other approach chooses two paths and thus causes this increase which is less than one hop. Also there's an increase in the amount of routing control packets because they are necessary for constructing and maintaining the two multicast trees. When comparing the forwarding efficiency of the multicast trees, the Multiple Tree Multicast adhoc On-Demand Distance Vector (MT-MAODV) approach is a little worse that the Multicast adhoc On-Demand Distance Vector (MAODV) protocol because of the larger number of hops to be traversed. Based on the analysis, we have to implement MT-MAODV protocol in our application video multicast.

3. Conclusion

In this paper, first we introduced our VCR application and requirements. General overview explaining multiple factors affecting multicast in adhoc networks is introduced. A definition of video multicast and some example applications were given. Then, some of the requirements for video transmission and some of the problems faced with video transmission were stated. Afterwards, a comparison was made in which differences between general multicast trees and wireless multicast trees were highlighted. The same was also done between tree-based approach and mesh-based approach in multicast routing protocols. Concluding the overview is a description of the Multicast adhoc On-Demand Distance Vector (MAODV) where this routing protocol is explained in details. Afterwards, an extension of the well-known Multicast adhoc On-Demand Distance Vector (MAODV) routing protocol was introduced, addressed in the application layer. This extension was named Multiple Tree Multicast adhoc On-Demand Distance Vector (MT-MAODV) routing protocol due to the fact that it uses two disjoint trees. The reasons why this Multiple Tree Multicast adhoc On-Demand Distance Vector (MT-MAODV) routing protocol uses the Multicast adhoc On-Demand Distance Vector (MAODV) as well as the Multiple Description Coding (MDC) were discussed. Then an explanation of its algorithm as well as an example clarifying the algorithm was given. Finally, VCR application as an example application of the Multiple Tree Multicast adhoc On Demand Distance Vector (MT-MAODV) routing protocol was stated and an evaluation highlighting several limitations, properties. We select to implement MT-MAODV in our application for video multicast.

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