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Effective Video Multicast Over TDMA-Based Dual Homing Wireless Mesh Networks

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Abstract:
I provide an effective video multicast framework where each multicast receiver has its own video quality demand. Here use time division multiple access (TDMA)-based wireless mesh networks (WMNs) and overlay multicasting. During video multicasting, different relay nodes in the same multicast tree may have different transmission rates. This multicast framework provides effective multicast routing, scheduling, and rate allocation algorithms. The multicast routing and scheduling is to obtain a minimum length schedule which satisfies given quality demands of receivers. If the schedule is not feasible even with its minimum length due to the limited number of time slots in the network, rate allocation algorithm adjusts the transmission rates of relay nodes to generate a feasible schedule. To improve survivability of the overlay multicasting, i propose to use dual homing approach, i.e., each peer is connected to the overlay by two separate access links. I introduce several tree construction strategies and conduct simulation experiments to investigate problem of providing survivability to both static and dynamic types of network. Simulation results show that the proposed multicast routing and scheduling algorithms outperform existing schemes.

1. Introduction

A wireless mesh network (WMN) is a communications network made up of radio nodes organized in a mesh topology. Wireless mesh networks often consist of mesh clients, mesh routers and gateways.. Mainly WMNs have focused on unicast rather than multicast communication. A mesh network is reliable and offers redundancy. When one node can no longer operate, the rest of the nodes can still communicate with each other, directly or through one or more intermediate nodes. Time division multiple access (TDMA) is a channel access method for shared medium (usually radio) networks. It allows several users to share the same frequency channel by dividing the signal into different time slots. The users transmit in rapid succession, one after the other, each using his own time slot. This allows multiple stations to share the same transmission medium while using only a part of its channel capacity.

In TDMA-based WMNs, the network bandwidth is divided into time slots. In unicast communication slots are assigned to links ,but in the case of multicast communication slots are assigned to nodes because packets transmitted from a sender are received by all nodes that are within the transmission range; The goal is to obtain a schedule with minimum length which satisfies the required demand rates of receivers.

A video stream is encoded at the highest resolution and divided into layers such that each receiver can decode the video stream at its preferred rate and resolution with a set of layers. The base layer includes the information required for displaying the minimum quality video frames, and additional layers, namely the enhancement layers, provide refinements. As the user receives more enhancement layers, the video quality the user experiences accordingly rises. The video streaming rate is adapted to the allocated transmission rate of a node by sequentially dropping video frames in enhancement layers according to their priorities. An effective rate allocation scheme is, thus, necessary to determine the transmission rate at each relay node in order to satisfy the total required transmission rates for giving demands within a limited number of time slots. Multicast routing and time slot scheduling algorithm are considered to obtain a minimum length schedule which satisfies required video quality demands of receivers. the rate allocation algorithm adjusts the transmission rate of each relay node to obtain a feasible schedule. For video multicasting, I am interested in the construction of a multicast tree which satisfies the heterogeneous demand rates of receiver nodes.

The tree has to minimize the total transmission rates of all relay nodes such that the schedule length of time slots is minimized. Services such as internet radio, high definition video or audio streaming are very useful for network users, but often require a lot of bandwidth, which can be costly [1]. To reduce maintenance and investment cost, the concept of overlay multicasting is applied. An overlay multicasting technology is based on a multicast delivery tree consisting of peers (end hosts). Also known as End System or Peer-to-Peer Multicast. High bandwidth multi-source multicast among widely distributed nodes is a critical capability for a wide range of applications including audio and video conferencing, multi-party games and content distribution. Throughout the last decade, a number of research projects have explored the use of multicast as an efficient and scalable mechanism to support such group communication applications. Multicast decouples the size of the receiver set from the amount of state kept at any single node and potentially avoids redundant communication in the network.

The limited deployment of IP Multicast, a best effort network layer multicast protocol, has led to considerable interest in alternate approaches that are implemented at the application layer, using only end-systems. In an overlay or end-system multicast approach participating peers organize themselves into an overlay topology for data delivery. Each edge in this topology corresponds to a unicast path between two end-systems or peers in the underlying Internet. All multicast-related functionality is implemented at the peers instead of at routers, and the goal of the multicast protocol is to construct and maintain an efficient overlay for data transmission.

In many related works, the authors assume that users of a multicast network can leave the system. That kind of overlay network is called *dynamic* or *evolving* [4]. A dynamic network allows a mobile access router to register its mobile networks dynamically with the home agent, which advertises the mobile network as an attached network. Among examples of such a system are popular protocols like Torrent [5], eDonkey [6] or Skype [7].Another network type is so-called a *static* network, where hosts form static structure and are not allowed to leave the system, and which well-known example Set-top box (STB) technology used in IPTV, A static network supports stub routers only and allows a mobile access router to roam about, behaving like a mobile node. The home agent treats this mobile node as a mobile access router.In my work, i apply the overlay multicasting in a dual homing architecture to improve network survivability, defined as the ability to provide the continuous service in the presence of failures. The dual homing approach assumes that all hosts (*nodes*) have two disjoint links (*homes*) to the network. Those links provide the network protection because of redundancy.

2. Multicast Framework

I am interested in the construction of multicast tree that satisfies the demand rate of each receiver node and also minimizes the total transmission rates of all relay nodes (MTRMT). An efficient heuristic algorithm, Multicast Tree for Heterogeneous Demand (MT4HD) is investigated in Algorithm1. The main idea of MT4HD is to integrate the min-cost path from source s to a selected multicast receiver at each step.

Algorithm 1 first initializes tree structure to have only the source as an element, where the source node's transmission rate $txRate_{req}(s)$ is set to the maximum demand of multicast receivers. Then, the algorithm decides the level of each node by using breadth first search (BFS). Nodes are partitioned into levels according to their hop counts from the source. BFS is a widely known graph search algorithm which visits a node with smaller hop count (higher level) first from the root node.MT4HD integrates multicast receivers in higher level first. Among receivers in the same level, a node with highest demand rate is selected first. It is because the node with higher rate affects the resultant tree cost more.

After selecting a receiver to integrate, edge costs are updated according to the demand. To prevent a node from having more than one parent in the tree, the cost of an edge heading to the node which already has a parent is set to infinity. In other cases, if a node's transmission rate is higher than the selected receiver's demand, cost of the edge originating from the node is set to zero. Otherwise, cost is set to the difference between the node's transmission rate and the receiver's demand rate. With these updated edge costs, the algorithm selects minimum cost path from the source to the receiver using Dijkstra's shortest path algorithm and integrates the path to the multicast tree. Then, it updates transmission rates of nodes on the path. This procedure is repeated until all receivers are covered by the multicast tree.

2.1. Survivability for Overlay Multicasting

Two methods are used in order to provide the network survivability: restoration and protection. The main difference between them is that restoration applies dynamic resource allocation while protection needs pre allocated network resources. This results in different overall cost and restoration time. Well-known protection methods are: automatic protection switching (1+1, 1:1, etc.), p-cycles and backup paths/links. In the previous works, proposed to use disjoint overlay multicast trees streaming the same content Peers affected by the failure of one of the trees can use another tree to receive the required data in the case of a failure. This procedure guarantees very low restoration time. The main idea is to create two overlay multicasting trees guaranteeing that each of access links carries traffic only of one of the trees. Since each node has two access links (dual homing), it receives the streaming data from both trees on two separate links. Thus, if one of access links is broken, the node still is connected to the stream, and moreover, it can upload the stream to subsequent peers located in the tree.

A proper configuration of the overlay multicasting with dual homing protects the network from two kinds of failure:

- Uploading node failure - failure impacts all successors of the failed peer in the tree,
- Overlay link failure - overlay link failure comprises failure of both directed links between nodes.

2.2. Tree Construction Strategies

In my strategies, i use specified type of messages between hosts and root node:

- RQT – message sent from a host willing to connect to the overlay network to the root node,
- LST – possible response to the RQT; list of possible parents for the requesting host (with length of 10). In the process of selecting possible parents root node is responsible of keeping multicast trees disjoint,
- DEN – possible response to the RQT message; refusal of connection when there is no feasible parent; host can try again with RQT signal,
- ATT – message sent from a host willing to connect to the network to a feasible parent with a connection request,
- PER – possible response to *ATT*; the requesting node is connected to the network,
- REF – possible response to *ATT*; the feasible parent is refusing connection, e.g., due to lack of free upload capacity,

- CON – message from a host to the root node informing about successful connection,
- DEL – message sent from the parent of a host requesting disconnection from the network to root node,
- CNF – message sent from a child to its parent every 60 seconds. If during 120 seconds the parent does not receive CNF, it sends the DEL signal.

3. Preparation for Scheduling and Rate Allocation

3.1. Conflict Matrix

In fixed power protocol interference model, two nodes i and j cannot transmit simultaneously if any recipient of node i is within the interference range of node j and vice versa. This relationship can be represented by a conflict graph. Each edge in the conflict graph shows the confliction of two nodes connected (i.e., two nodes cannot transmit simultaneously). Conflict relationship between two nodes is represented with N × N conflict matrix, where element (i, j) is 1, if node i and j conflict with each other, or 0 otherwise.

3.2. Conflict Free Precedence Constraints

Graph

Precedence constraints appear in scheduling problems, where one or more jobs have to be completed before another job is allowed to start its processing . A PCG is a directed graph where the node set contains all jobs. Each job has its processing time. A directed edge represents a precedence constraint that the tail job of the edge should be completed before the head job of the edge starts processing. Critical path of a PCG is the path which has the largest total processing time of all jobs on the path, which is equal to the length of minimum schedule. Now, i am going to use the concept of PCG for conflict free TDMA scheduling and video rate allocation with a given multicast tree. For that purpose, i define a CFPCG and its length.

4. Time Slot Scheduling and Rate Allocation

After constructing CFPCG, i can optimally schedule relay nodes with Algorithm 2.The input is a CFPCG ordered node set V.The output is the schedule for all relay nodes(ie the start and end times of each relay node).Time slots are assigned to nodes in the order of precedence. At each step, the algorithm selects a node v that has highest precedence and selects the latest slot that is assigned to v's parents in the CFPCG. Then, it successively assigns N_v time slots to v where N_v is set to $N_{req,v}$

Algorithm 2 may not produce a schedule length that satisfies the schedule period, if too many slots are required to support requested demands. In this case, time slots assigned to relay nodes should be adjusted for feasible schedule length. The objective of the rate adjustment is to maximize the minimum utility of multicast receivers. Algorithm 3generates an optimal max-min utility time slot allocation with given CFPCG. At each step, Algorithm 3 selects the receiver with the minimum utility and allocates a time slot to all parent nodes in the path to the source to improve the utility. This process is repeated to maximize the minimum utility within the limited time slots. This simple rate allocation algorithm provides an optimal solution to the max-min utility problem for given CFPCG.The input is a multicast tree T,a CFPCG for the T and the output is a Max-Min utility time slot allocation A(a vector that contains the start time slot and end time slot of each relay node's transmission)

5. Experimental Results

I implemented the performance of the proposed effective video multicast Over TDMA-based dual homing wireless mesh networks by using Ns2 in a personal computer running : Linux 8.0(fedora 8.0), with the specifications such as processor Pentium III (speed 1.5GHZ), Memory(ram) of 256MB and Hard disk of 40GB.The software used is NS2,and the language is TCL scripting. The below figure shows the simulation results of the proposed system

6. Conclusion

Considering the characteristic of video multicasting that different relay nodes in the same multicast tree may have different transmission rates by utilizing scalable video coding, i propose effective multicast routing, scheduling, and rate allocation algorithms. The purpose of this multicast routing and scheduling is to obtain a minimum length time slot schedule which satisfies heterogeneous user demands. I introduced six different tree construction strategies (of which four provide survivability constraints), along with the overlay simulator, and compare their results for different types of networks in terms of the overall streaming cost and the number of levels in the multicast trees. Simulation results show that MT4HD performs much better than existing procedures. The schedule length is reduced by more than 25 percent. The proposed time slot scheduling algorithm also outperforms RAS when the number of receiver nodes increases.

7. References

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