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Increasing Coverage in Wireless Mesh Networks: Mobile mesh networks

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Abstract: ***These Mobile ad hoc networks (MANETs) are an epitome for instances where a fixed infrastructure is not available or infeasible. Today's MANETs however, possibly suffer from network partitioning. This kind of constraints makes MANETs illegible for applications such as crisis or catastrophe management and extreme battlefield communications, in which team ought to endeavor in groups scattered in the application territory. In similar applications, intercommunication within the group is vital to the team effort. To address this flaw, we have come up with this paper, a totally new class of ad-hoc network called Mobile Mesh Network. In Contrary to the existing typical mobile-mesh networks, the nodes of an mobile mesh networks can pursue the mesh clients in the application territory, and organize themselves into a network topology which is suitable to assure good connectivity for intra and intergroup both communications. We lay before a distributed or evenly spread client tracking solution to deal with the charismatic nature of client mobility, and present modus operandi for dynamic topology adoption in compliance with the pattern of mobility of the clients. Our imitated results indicate that mobile mesh network is robust against network partitioning and cover the more no of clients compare to the standard wireless network that is here we track the disappeared clients.***

Keywords: Mobile ad-hoc network (MANET), Mobile meshes networks, Distributed client tracking solution, Dynamic topology.

1. Introduction

When WIRELESS technology has been one of the most revolutionizing and empowering technologies in recent years. In precise, mobile ad hoc networks (MANETs) are amongst the most caught on and researched network communication methodologies. In such situations, there is no requisite of a communication infrastructure. The mobile nodes also play the stint of the routers, serving to propagate data packets to their destination or terminus via multi-hop relay. This kind of network is legible for situations where a fixed infrastructure is not present or infeasible. They are amongst the best and price effective solutions, because same ad hoc network can be relocated, reimbursed and transferred in distinct places at different times for various applications.

One great challenge in crafting robust MANETs is to curtail network partitions. As autonomous mobile users move in a MANET, the network topology might change at high pace and unpredictably over time and excerpts of the network might get intermittently partitioned. This condition is undesired, particularly for mission-critical applications such as crisis or catastrophe management and war field communications. We have come up with a new solution for this highly posing problem in this paper by throwing a new class of robust mobile ad hoc network called Mobile Mesh Networks.

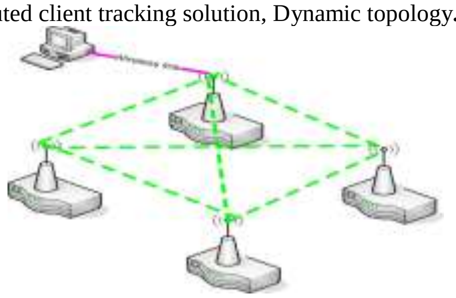

Fig 1. Mobile mesh network

Within a standard wireless-mesh network, the stationary nodes give the routing and relay abilities in the network. They form somewhat mesh-like wireless network that agrees mobile mesh clients to communicate with others through multi-hop communications in the network. Such a network will be scalable, flexible, and low in maintenance cost. In an event if a mesh node fails, it can be easily replaced by a new node and the mesh network will identify out the new mesh node and will automatically reconfigure itself. The proposed mobile-mesh network will have the following additional advantage. The mobility of the mesh clients is confined to the constrained area serviced by a standard wireless mesh network due to the stationary mesh nodes. In contrast, mobile mesh network is a wireless mesh network with autonomous mobile mesh nodes. In annexation to the standard routing and relay functionalities, these mobile mesh nodes move along with their mesh clients, and have the intelligence to auto-adapt the network topology to provide optimal service.

We assume that each mobile mesh node is equipped with a localization device such as GPS. In addition, a mobile mesh node can detect mesh clients within its sensing range, but does not know their exact locations. For instance, this can be achieved by detecting beacon messages transmitted from the clients. Alternatively, RFID has been proposed for location-based applications [1]. Similarly, mesh clients can be tagged with an inexpensive RFID and mobile mesh nodes are equipped with an RFID reader to detect the presence of mobile nodes within their sensing range.

Our challenges in designing the proposed mobile mesh network are twofold. First, the mesh clients do not have knowledge of their locations making it difficult for the mobile mesh nodes to synthesize a global map of the user locations. Second, the topology adaptation needs to be based on a highly efficient distributed computing technique to keep up with the dynamic movement of the mobile users. These challenges are addressed in this paper.

2. Related work

We classify the works related to mobile mesh network into three categories: 1) stationary wireless mesh networks: mobile mesh network is a new type of mesh networks, but supports dynamic topology adaptation, 2) sensor covering: the techniques for sensor covering is related to the design of covering mobile clients in mobile mesh network, and 3) location tracking: tracking mobile clients in mobile mesh network is an application of location tracking. Stationary wireless mesh networks. In the last few years, stationary wireless mesh networks have been developed to enable last-mile wireless broadband access [2]. Past work on stationary mesh networks focuses on routing traffic in a mesh topology to best utilize the network capacity [3], [4]. Some literatures further study how to utilize non overlapping channels [5], [6], [7] and explicitly control the network topology [8], [9] to improve the network capacity of a stationary mesh. Our work builds on the concept of such a stationary mesh-based infrastructure, and extends it to enable communication among partitioned mobile clients. We study dynamic deployment of an mobile mesh network in this work, and leave utilizing non overlapping channels to improve network capacity as our future study. Sensor covering. Our work on router deployment is also related to recent work on sensor covering in a stationary sensor network [10], [11], [12]. These schemes ensure that each point in a target field is in the interior of at least k different sensors. Several work [13], [14], [15] further takes energy efficiency into account, and assigns each sensor a sleep-active schedule to guarantee sensor cover and, at the same time, prolong the lifetime of a sensor network. More recently, some work exploits sensor mobility to improve the performance of sensor covering. A self-deployment protocol is proposed in [16] to enable randomly scattered sensors to automatically move to the target planned positions. Instead of deploying stationary sensor nodes to cover the entire monitoring field, an alternative is proposed in [17], [18] to use mobile mules to move around different monitoring areas and gather data along the traversed paths. All the above studies focus on deploying sensor nodes to monitor a given target area. Our work differs from the sensor coverage schemes in that it builds a dynamic mesh infrastructure for mobile clients that have unpredictable moving patterns and move around a non predefined application terrain.

3. Proposed system

3.1 Architecture

System architecture is the calculated configuration that characterizes the structure and conduct of a framework. A structural engineering depiction is a formal portrayal of a framework, composed in a manner that backings thinking about the structural properties of the framework. It characterizes the framework segments or building pieces and gives an arrangement from which items can be obtained, and frameworks added to, that will cooperate to actualize the general framework.

The System architecture is shown below. The system architecture mainly have mesh client and mesh node. Whenever any application requests the packet the client will forward the packet to the mesh node (mesh router). Then the mesh node which contains routing agent forwards the packet to the next hop via the route calculated by routing agent. Since both mesh client and mesh node are mobile in nature, we need to track the clients. Here client continuously emits the beacon messages that indicate the presence of client within the range of router, the mesh node tracks the clients and decides whether to move or not. Then to reduce the end to end delay incurred by many unnecessary intergroup routers to construct the bridging networks, we use the local topology adaptation and global topology adaptation algorithms for the topology adaptation of network and after this routing is takes place.

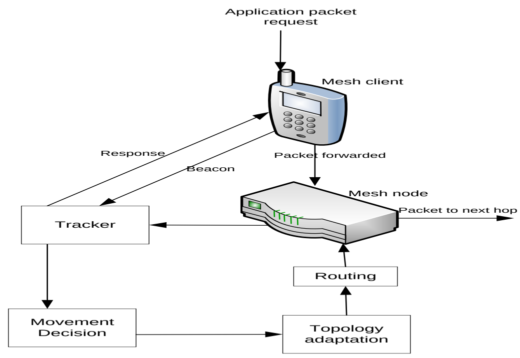

Fig 2. Architecture

3.2 Figures and Tables

Such a dynamically changing mesh topology, mobile mesh nodes can be classified into the following types according to their current roles in this network:

• Intragroup routers. A mesh node is an intragroup router if it detects at least one client within its radio range and is in charge of monitoring the movement of clients in its range. Intragroup routers that monitor the same group of clients can communicate with each other via multi-hop routing.

• Intergroup routers. A mesh node is an intergroup router, i.e., square nodes if it plays the role of a relay node helping to interconnect different groups For each group, we designate at least one intergroup router that can communicate with any intragroup routers of that group via multihop forwarding as the bridge router, for example, router b1 for group G1.

• Free routers. A mesh node is a free router if it is neither an intragroup router nor an intergroup router.

Algorithm 1. Distributed Client Tracking for Router r.

for each *Beacon message interval* **do**
  switch *mode of router* r **do**
    case *Intra-group*
      if *detect missing clients* **then**
        Request the client list from neighboring intra-group routers;
        if *all its clients are covered by neighbors* **then**
          Switch to the *Intergroup* mode;
        else
          Assign free routers to navigate its coverage boundary;
        end if
      end if
    case *Intergroup bridge*
      Piggyback its location in the forwarded packets;
      Retrieve the locations of other bridge routers and the identity of the intergroup routers along the bridge networks from the forwarded packets;
      Initiate topology adaptation if necessary (see Algorithm 3);
    case *Free*
      if *receive the tracking request from intra-group routers* **then**
        Navigate the assigned segment to detect the missing clients;
        if *locate the missing clients* **then**
          Switch to the *intra-group* mode;
          Request some of the free routers to follow this new intra-group router;
        end if
      end if
  end switch
end for
return

3.3 Topology adaptation

The protocol discussed so far ensures that the mesh nodes maintain the connectivity for all clients. The resulting networks, however, might incur long end-to-end delay with potentially many unnecessary intergroup routers because the bridging networks are constructed independently.

Local Adaptation:

A star topology generally provides shorter relay paths, and, as a result, requires fewer intergroup routers. To construct a star topology, we let the bridge routers exchange their location information opportunistically, and perform local adaptation as shown in Algorithm 2 when some bridge routers detect that they are close to each other.

Algorithm 2. Topology Adaptation (initiated by router r).

input: (Collected in Algorithm 1) $\mathcal{R}_b$: set of bridge routers known by r opportunistically; L_b: location of router $b \in \mathcal{R}_b$; $\mathcal{R}_i$: set of intergroup routers connecting all known bridge routers $b \in \mathcal{R}_b$

if *number of free routers in r's group* $< \delta$ **then**
  Call Algorithm 3 to perform global adaptation;
else
  Compute the single star topology $\mathcal{S}$ for $\mathcal{R}_b$;
  Build a bridge network $\mathcal{B}$ connecting to any bridge router $b' \notin \mathcal{R}_b$;
  $N_i' \leftarrow$ number of intergroup routers needed for $\mathcal{S}$ and $\mathcal{B}$;
  if $N_i' \leq \alpha|\mathcal{R}_i|$ **then**
    Trigger the assigned intergroup routers to adapt their topology to $\mathcal{S} \cup \mathcal{B}$ after a three-way handshaking;
    Reclaim the rest of intergroup routers to the free-router poor;
  end if
end if
return

Global Adaptation:

Local topology adaptation provides local optimization. It is desirable to also perform global topology adaptation to achieve global optimality. The motivation is to achieve better overall end-to-end delay and free up intergroup routers for subsequent local adaptation. A simple option for global optimization is to apply Algorithm 2 to construct a star network for all the bridge routers in the mobile mesh network. Such a star network, however, would be inefficient and require more intergroup routers than necessary, particularly when there are a significant number of groups in the network.

Algorithm 3. Hierarchical Star Topology Construction.

Input: M: size of a bounding box

Broadcast a message to all the bridge routers to collect information and coordinate global adaptation;
$\mathcal{R}_b \leftarrow$ set of bridge routers;
$L_b \leftarrow$ location of router$b \in \mathcal{R}_b$;
$\mathcal{R}_i \leftarrow$ set of nonbridge intergroup routers;
Classify all $r \in \mathcal{R}_b$ into cluster $\mathcal{C}_i, i = 1, 2, \ldots, k$;
$M \leftarrow \frac{|\mathcal{C}_i|}{k}$;
$\mathcal{T} \leftarrow$ R-Tree($\mathcal{R}_b, \mathcal{L}_b, M$);
for all *vertex* v *in* $\mathcal{T}$ **do**
  while v *is a leave node and any* $r_i, r_j \in v$ *belong to the same group* **do**
    Remove r_j from v;
  end while
  if *not all elements* $r \in v$ *are interconnected* **then**
    Deploy a subset of intergroup routers in $\mathcal{R}_i$ as a star topology to connect all $r \in v$ and remove those routers from $\mathcal{R}_i$;
  end if
end for
Reclaim the remaining routers in $\mathcal{R}_i$ as free routers;
return

4. Simulation results

Scenario 1:

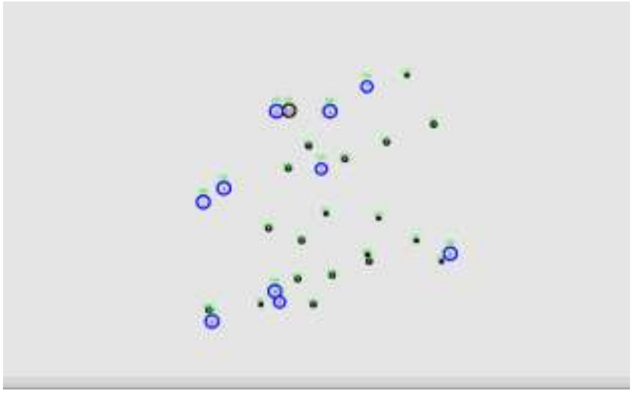

Fig 1: Mesh clients mesh routers

Initially we create nodes and initialize some nodes as mesh clients and mesh routers. Then we set the beacon interval of seven seconds.

Scenario 2:

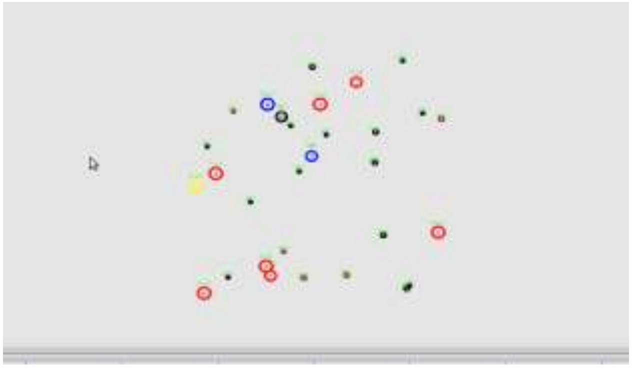

Fig 2 : Mesh nodes change their roles after beacon interval

In the second scenario after seven seconds of beacon interval the mesh nodes or mesh routers change their roles to intragroup, intergroup, or free router.

Scenario 3:

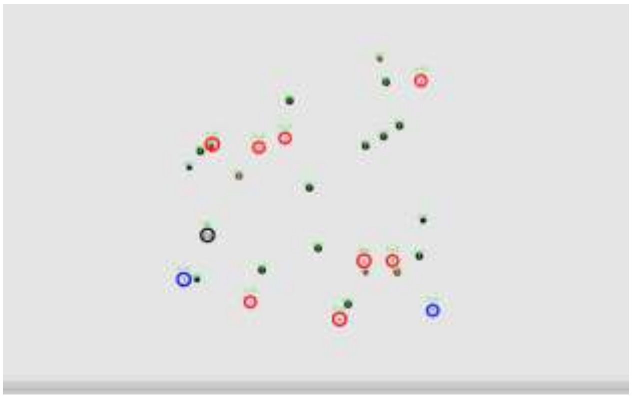

Fig 3:Redundant routers tracks the disappearing clients

In the final scenario we assign the redundant mesh routers to track the disappeared clients in the network. Here the redundant or free routers track the missing client.

Scenario 4:

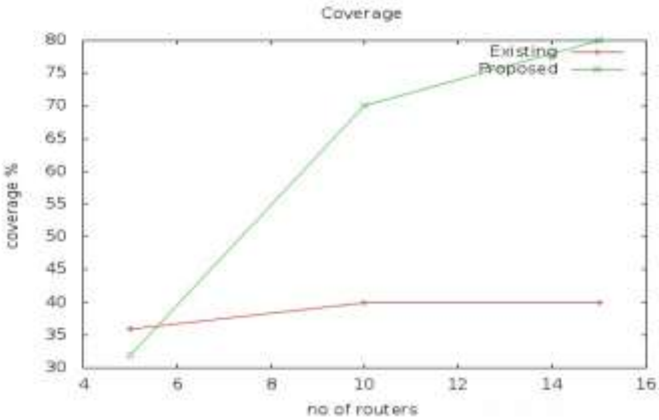

Fig 4 : Coverage of clients

By seeing the above graph we conclude that in the mobile mesh network same number of routers cover more of clients than in the standard mesh network.

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