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Interference-Aware Robust Topology Design in Multi-Channel Wireless Mesh Networks

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ABSTRACT-The performance of wireless networks can be significantly improved by multi-channel communications compared with single-channel communications since the use of multiple channels can reduce interference influence. In this paper, we study interference-aware topology control in IEEE 802.11-based multichannel wireless mesh networks with dynamic traffic. Channel assignment is one of the most basic and important issues in such networks. Different channel assignments can lead to different network topologies.

Over the last decade, the paradigm of Wireless Mesh Networks (WMNs) has matured to a reasonably commonly understood one, and there has been extensive research on various areas related to WMNs such as design, deployment, protocols, performance, etc. The quantity of research being conducted in the area of wireless mesh design has dramatically increased in the past few years, due to increasing interest in this paradigm as its potential for the "last few miles", and the possibility of significant wireless services in metropolitan area networks.

This recent work has focused increasingly on joint design problems, together with studies in designing specific aspects of the WMN such as routing, power control etc. in isolation.

INTRODUCTION :

A Wireless Mesh Network (WMN) is formed by a set of gateways, mesh routers, and mesh clients. Gateways and mesh routers form the backbone of the network, where mobility is reduced.

Mesh clients can be cell phones, laptops or other wireless devices. Routers communicate with the external network (e.g. the Internet) by forwarding each other's trac (including clients trac) towards the gateway nodes, which are directly connected to the wired infrastructure.

In a WMN, each router forwards packets on behalf of other nodes (that may not be within direct wireless transmission range of their destinations).

Moreover, the gateway functionalities enable the integration of WMNs with various existing wireless networks such as Wi-Fi, cellular networks, WiMax, among others.

Paper is based on the novel definition of co-channel interference which can capture the impact of interference by fully considering both interferenceand connectivity, we define the *Interference-Aware Robust Topology* I-ART) problem which seeks network topology design and a channel assignment such that the induced network topology has the minimum network interference among all 2-connected topologies.

In this work,

2-connectivity is required for survivability and load-balancing purposes. We assume the transmission power of each NIC is fixed. So the topology control problem studied here is quite different from all previous topology control problems in which the network topology is controlled by carefully adjusting the transmission power at each node.

The authors developed a set of centralized algorithms for channel assignment, bandwidth allocation, and routing. The Hyacinth architecture consists of a multi-channel (WMN) core, which is connected to a wired network through a set of wired connectivity gateways. Each WMN node has multiple wireless NICs, each operating at a distinct radio channel. A WMN node is equipped with an access point-like traffic aggregation device that interacts with individual mobile stations. The multi-channel WMN relays data traffic to/from mobile stations. The links between nodes denote direct communication over the channel indicated by the number on the link. In this example, each node is equipped with 2 wireless NICs. Therefore the number of channels any node uses Simult-aneously cannot be more than 2; the network has a whole uses 5 distinct channels.

Load-Aware Channel Assignment

- A central design question in *Hyacinth* architecture is how to bind each network interface to a radio channel.
- Unlike in cellular networks, neighbouring nodes in *Hyacinth* communicate over wireless links, and therefore need to share common channels with each other.
- On the other hand, as more NICs in an interference neighborhood share a particular channel, the capacity of each NIC and its associated virtual links reduces.

Therefore, in our algorithm neighboring nodes distribute their NICs across as many channels as possible while maintaining the required connectivity among themselves.

- As some links in the network may carry more load than others, link load information is also considered while distributing the virtual links across different channels.
- At the end, our load-aware channel assignment results in a proportional bandwidth allocation, where more heavily loaded links get more capacity.

EXPERIMENTAL WORK:

The body of research is to find an optimal channel for a single packet transmission, essentially avoiding inter-ference and enabling multiple parallel transmissions in a neighborhood.

The architecture does not perform channel switching on a packet-by-packet basis; our channel assignment lasts for a longer duration, such as hours or days, and hence does not require re-synchronization of communicating network cards on a different channel for every packet.

This property makes it feasible to implement our architecture using commodity 802.11 hardware. Additionally, our system takes a more global approach by adjusting channel assignments and routes based on the overall network traffic patterns.

The goal of channel assignment in a multi-channel wireless mesh network is to bind each network interface to a radio channel in such a way that the available bandwidth on each virtual link is proportional to its expected load.

A simple approach to the channel assignment problem is to assign the same set of channels to the interfaces of each node, e.g., channel 1 to the first NIC, channel 2 to the second NIC

This *identical channel assignment* indeed provides throughput gains by utilizing multiple channels.

Scope:

- Data flow is high,
- Bandwidth will be high,
- Packet delay is less ,
- collision will be less
- and finally sequence no. generated will not be produce Single-channel wireless mesh network

PACKET LOSSES IN WIRELESS NETWORK

There are various causes for packet losses in wireless multihop networks .

We classify the various reasons into three groups

1.Channel induced factors

This includes the random bit error from signal attenuation, multipath fading,shadowing and noise

2.Interference induced factors

Includes in and out of the mesh network that operates on the same channel as the desired transmission

3.Node induced factors

for example on the linux system each processor has soft_net data structure Which holds a list with the incoming packets received by the network interface card(NIC)

ALGORITHMS:

Algorithm 1 Interference Aware Robust Topology control

Find 2-connected subgraph of G, G (V, E) such that G has the *minimum number of edges*;

for each link e in G **do**

Find the *PIE*(*e*) and calculate the *PIN(e)* of e;

end for

Initialize A(u) to ∅ for all u ∈ V ;

for (all the links in G) **do**

Select links one by one *in a descending order of PINs*;

For the selected link e ∈ G , assign channels for all edges in *PIE*(*e*) based on the following rules:

for all end nodes of edges in *PIE*(*e*) **do**

Select the nodes in *PIE*(*e*) one by one *in a descending order of node degree*;

if there are l(≥ 1) empty NICs on the selected node u **then**

Use the l least used channels to fill all the empty NICs on node u;

for all *unassigned edges* e= (u, v) where v has empty NICs **do**

Assign the currently least used one among the l channels to edge e ;

Assign corresponding channel on node v;

end for

for all *unassigned edges* (u, v)where v has NO empty NIC **do**

Channel Swap(G, u, v, (u, v));

end for

end if

if (No empty NIC on node u) **then**

for all *unassigned edges* e= (u, v) where v has empty NICs **do**

Assign the currently least used channels on u on e ;

Assign corresponding channel on node v;

end for

for all *unassigned edges* (u, v) where v has NO empty NIC **do**

Channel Swap(G, u, v, (u, v));

end for

end if

end for

end for

Algorithm 2 Channel Swap(G, u, v, (u, v))

if A(u) ∩ A(v) = ∅ then

doing nothing

else

let k be the least used channel in *PIE*(*e*) among channels in A(u) ∪ A(v). Without loss of generality, assume that k ∈ A(u).

Let k = k be an channel in A(v) that is most used in *PIE*(*e*).

Replace k in A(v) by k.

for all the edges (v, w) already assigned **do**

if the change of A(v) makes A(v) ∩ A(w) = ∅ **then**

replace k in A(w) by k.

This replacement may be performed recursively.

end if

end for

end if

Simulation Environment

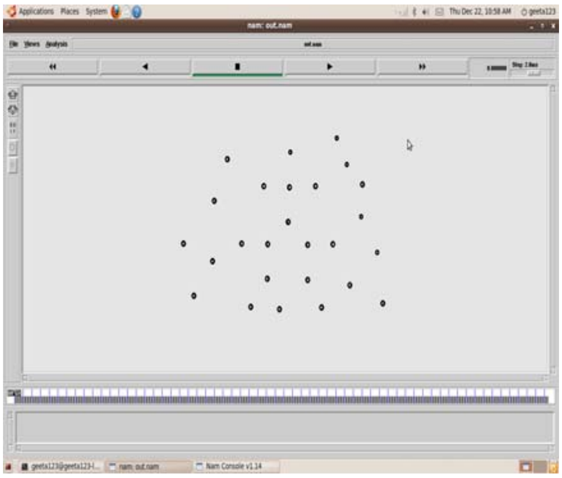
NS2 is the simulator used for our work. Network simulation software enable us to predict behavior of a large-scale and complex network system such as Internet at low cost under dierent congurations of interest and over a longer period of time. Many network simulators, such as NS2, Openet, Omnet, Qualnet, etc., are widely available.

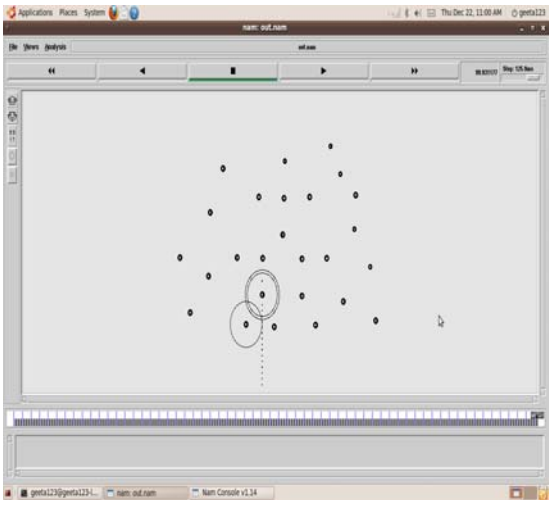
We used NS2 for this thesis. NS2 is a discrete event simulator written in C++, with an OTcl interpreter shell as the user interface that allows the input modelles (Tcl scripts) to be executed. Most network elements in NS2 simulator are developed as classes, in object-oriented fashion.

Users create new simulator object through the OTcl interpreter, and then these objects are mirrored by corresponding objects in the class hierarchy in C++. NS2 provides substantial support for simulation of TCP, routing algorithms, queueing algorithms, and multicast protocols over wired and wireless (local and satellite) networks, etc. It is freely distributed, and all source code is available.

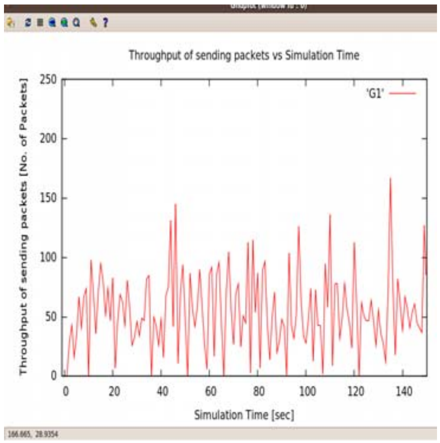
Simulation length in seconds: 148.6940401
Number of nodes: 25
Number of sending nodes: 25 , Number of receiving nodes: 13
Number of generated packets: 9006, Number of sent packets: 8832
Number of forwarded packets: 5011,Number of dropped packets: 1470
Number of lost packets: 5161,Minimal packet size: 32
Maximal packet size: 1078,Average packet size: 316.5768
Number of sent bytes: 3789838,Number of forwarded bytes: 2526772
Number of dropped bytes: 319966,Average delay: 0.4050813792

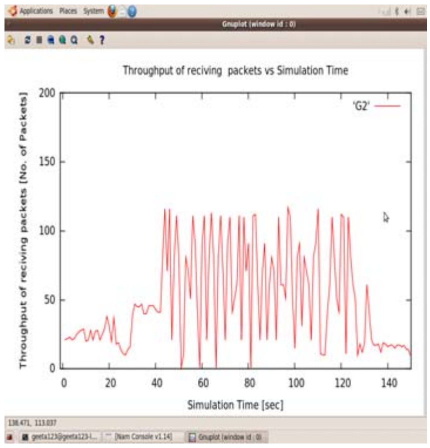
OUTPUTS:

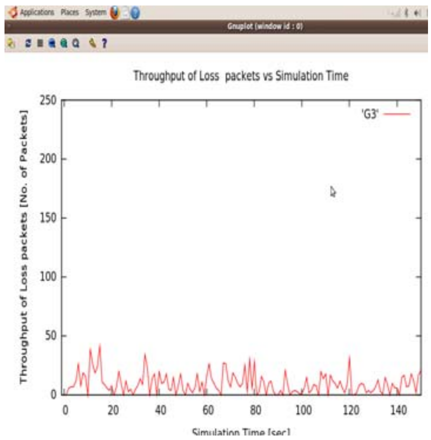


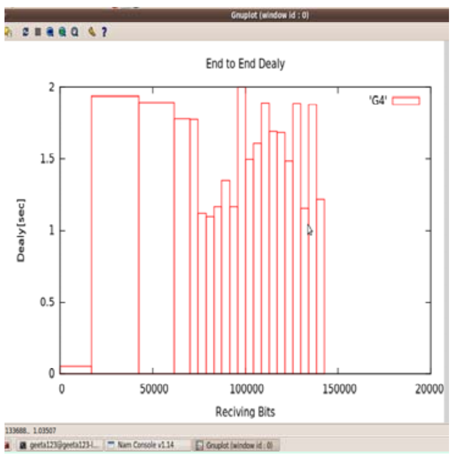


GRAPH:









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