Chapter 3
Overview and Challenges of Multi-Interface and Multi-Channel Multi-Hop Wireless Networks

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ABSTRACT
The throughput improvement problem in wireless networks is considered. The main causes of that issue is the shared wireless medium and node spatial problems which either prevent some nodes from transmitting or jam their transmissions. We consider the use of both nodes equipped with multiple network cards and multiple channels as means to improve the throughput in wireless networks. That approach implies to handle some challenges namely channel distribution between the node interfaces and routing in such channel-diverse networks. This chapter analyzes some solutions proposed to deal with these challenges so that the throughput is improved. Some possible orientations are also discussed based on the advantages and drawbacks observed in existing works.

INTRODUCTION
As far as network transmissions are concerned, people used to communicate through wired networks. Satisfying requirements such as sporadic cheap on-demand connections anywhere were hardly achieved with these networks. So, the wireless networks came as means to solve that issue with a wired equivalent performance. Users can build wireless local area networks without a great amount of deployment charges, just for a meeting or a congress.

However, considering the throughput performance, wireless networks are not as efficient as the wired ones. They generate some issues related to their wireless nature. First of all, the data are transmitted on a wireless medium called a channel. So, the transmissions are sensitive to any natural disturbance such as human movements or other
device processing. These uncontrolled interfer-
ences limit the throughput. In addition, the chan-
nel is shared by all nodes in the network. If two
nodes use it at the same time, it ends with packet
collision. The latter also favors the throughput
decrease. This issue gets worse when the node
number increases. Another reason for the limited
throughput in wireless networks is the problem
of hidden terminals (Tobagi, 1975). Assume that
there are two nodes A and C which are outside
the carrier sensing range of each other but have
a common neighbor, say B. B can hear signals
from A and C but A and C cannot hear each other.
Packets from A and C collide at B’s if they are
transmitted simultaneously. Node C is a hidden
terminal for node A and vice versa. The transmis-
sions of both the two nodes are thus delayed. The
throughput decrease is a consequence of that situ-
ation. The same issue occurs in another use case
wherein there are exposed stations (Iyer, 2006).
Let us consider again nodes A, B, C and another
node D. Assume that they build a chain topology
so that A and C are B neighbors but are not in the
carrier sensing range of each other. B and D are
C’s neighbors but cannot directly communicate
with each other. If node A is transmitting data to
node B, the exposed station C is prevented from
using the channel until this transmission is com-
plete because it hears signals from B. However,
if nodes B and C are enough far away from each
other, they can use the channel simultaneously
with few packet losses. Multi-hop communications
also reduce the throughput in wireless networks.
The data forwarding is slow down because the
packets are relayed by intermediate nodes over
multiple hops; and these nodes have to wait until
the packet reception is complete before starting
to forward them towards the destination.

So, the throughput improvement in multi-hop
wireless networks is a great challenge. Using
multiple network cards per node and dedicating
a channel to each of them is a method to handle
that challenge. But that approach mandates to
manage some aspects like channel distribution
between node network cards and data forwarding
in such channel-diverse networks.

**BACKGROUND**

Lets us firstly define some key terms which are
used later.

A collision domain is a set of nodes that are in
the interference range of each other. These neigh-
bor nodes cannot use the channel simultaneously.
So they compete for accessing it.

The channel assignment is the process of dis-
tributing channels between node network cards.
It is run in a network in which multiple channels
are available. Later, the term *interface* refers to
a network card.

The deafness problem occurs when a node
neighbor cannot join it on their expected com-
munication channel.

Routing is the process of forwarding data
packets from a source node to a destination one.
The entity that handles this process is called
a routing protocol. To convey the data, these
routing protocols have to select a sequence of
intermediate nodes (a path) based on different
criteria. These paths are called routes and the
criteria are the metrics. A metric example is the
shortest-path which means that the used criterion
is the minimum hop number.

Existing solutions about improving the
throughput of multi-hop wireless networks can
be classified into three categories. The first one
consists of those which assume that all nodes are
equipped with one interface and share a unique
channel. The main followed approach is to bound
the interferences in order to reduce the collisions
on the channel. A way to achieve this goal is to
implement a power control mechanism (ElBatt,
2000, Muqattash, 2005). This latter allows nodes
to adjust their transmission power so as to only
reach a specific set of nodes in their vicinity and
not interfere with the others. This set of nodes
is called the node connectivity range. In another