Chapter 3
Mobile Ad Hoc Networks:
Protocol Design and Implementation

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ABSTRACT

Mobile communication networks have become an integral part of our society, significantly enhancing communication capabilities. Mobile ad hoc networks (MANETs) extend this capability to any time/anywhere communication, providing connectivity without the need of an underlying infrastructure. The new coming realm of mobile ad hoc networks is first investigated, focusing on research problems related to the design and development of routing protocols, both from a formal and technical point of view. Then link stability in a high mobility environment is examined, and a route discovery mechanism is analyzed, together with a practical implementation of a routing protocol in ad hoc multi-rate environments which privileges link stability instead of traditional speed and minimum distance approaches.

INTRODUCTION

Mobile ad hoc networks consist of interconnected mobile hosts with routing capabilities. Considerable work has been done in the development of routing protocols for ad hoc networks, starting from Internet protocols developed in the seventies. In recent years, the interest in ad hoc networks has grown due to the availability of wireless communication devices.

New research directions in theoretical computer science and in particular in protocol design make use of game-theory concepts and tools. From this "perspective", protocols are viewed as games with players represented by network nodes which "play" (participate in) the game; each node (agent) has its own utility function, such as network flow (to be maximized) or energy consumption (to be minimized.) This approach thus is a natural point-of-view of a distributed computing architecture,

the most interesting paradigm in actual computer science.

This is especially true since the advent of wireless networks based on IEEE 802.11 Protocol (IEEE, 1999, 2003) (and in particular with the definition of the new draft "n") where it is possible to deal with a variable-speed link going from 1 to about 300 Mbps (Fan, 2004). Besides, considering that mobile networks (see Mobile landscape, 2009) have the peculiarity of movement (which makes the link speed highly variable and therefore very unstable), stability of routes becomes a difficult undertaking.

Furthermore, as for its intrinsic nature, the same protocol IEEE 802.11 introduces a considerable network overhead to control the transmission at the expense of throughput. So we think that choosing a stable routing – mainly considering stable links – is preferable to taking into account only the link speed and/or length.

BACKGROUND

Distributed Computing Environments

In a distributed computing environment, such as a network, different pieces of software interact by following one or more well-defined protocols. As an example, the request to access a Web page (which is routinely issued by a simple mouse click) is served by a number of such interactions that involve, besides the browser and the remote Web server hosting the page, also a number of intermediate "agents" (called *routers*) that make the request/response message delivery possible.

There is a plethora of protocols, which are primarily classified according to the ISO/OSI layered model of networking (see Figure 1).

At the one end of the stack we have the physical layer protocols, whose goal is to make possible the delivery of raw sequences of bits between directly connected computers. At the

Figure 1. ISO/OSI networking layered model
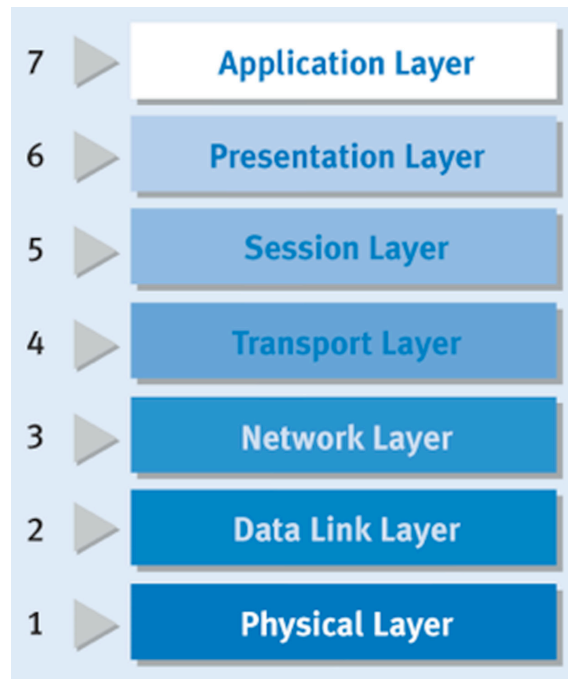
other end there are the application protocols supporting well-known high-level services, such as the already mentioned Web service (through the http protocol.) The most fundamental protocols are probably those that fall under the general term of *TCP/IP*: these are the protocols upon which the Internet is based, since they implement the key functions of routing and congestion/flow control.

One common assumption in the distributed computing and networking literature is that the agents participating in a protocol execution follow the guidelines specified by the protocol itself (say, a router that is expected to route a data packet closer to its destination point will always do so, unless it is temporarily out of service.) There are clearly a number of settings in which this assumption makes sense. An obvious case, for instance, is that of a private network owned by a single Corporation.

In the field of mobile networks (the one which we are most interested in here) there are application settings in which the above assumption applies

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