CHAPTER I

INTRODUCTION

Wireless mobile communication has become prevalent in the globalization era. In this thesis we propose a theoretical model pertaining to wireless mobile communication and investigate a few interesting problems.

1.1 Statement and Significance of the Problem

The field of networking is central to computer science, and, in fact, to many different arenas. Wireless networking is becoming more and more prevalent in many countries because of its benefits, i.e., low-cost, ease of installation, scalability, and convenience to mobile users [2, 8]. A wide range of research on wireless networks has been carried out. In what follows we give some examples. In [3] the authors presented a new distributed routing protocol for mobile, multihop, wireless networks. Lin and Gerla described a self-organizing, multihop, mobile radio network which relies on a code-division access scheme for multimedia support [4]. Royer and Chai-Keong provided an overview of eight different protocols by presenting their characteristics and functionality, and provided a comparison and discussion of their respective merits and drawbacks [5]. In multimedia applications a framework for multimedia networking in a wireless and mobile environment was presented and discussed in [6]. In a wireless mobile ad hoc network, host mobility can cause a problem and often broadcasting is used to solve it. A method of broadcasting by flooding is often used but it is very costly. A group of researchers from Taiwan proposed several schemes to reduce redundant rebroadcasts and differentiate timing of rebroadcasts to alleviate this problem [7]. Short et al. presented a simulation environment that can be used to examine, validate, and predict the performance of mobile wireless network systems [9]. An overview of ad hoc routing protocols that make forwarding decisions based on the geographical position of a

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packet's destination was discussed in [10]. In a traditional wireless network setting, access points are mounted on some fixed locations. Users can communicate and stay mobile if they are in the network coverage. However, this kind of traditional settings poses a limit in a situation in which both users and access points need to be mobile. For instance, in a tsunami-affected area where communication is completely collapsed, mobile wireless networks could become extremely valuable. More specifically, we consider a model of a *wireless mobile network* in which, in addition to moving users, access points themselves may be moving. To date, we are not aware of any other research that explores the complexity of a mobile wireless network model similar to ours except in [1], where Greenlaw and Kantabutra proposed a wireless mobility model and a set of decision problems in a two-dimensional grid. Longani and Kantabutra [16, 18] later solved some of the decision problems in [1] and discussed the complexities of a set of decision problems related to the model. It is apparent that wireless communication with several moving access points and users could become really complex, especially in a three-dimensional grid.

In this work we want to apply the complexity theory [13, 14] to determine just how complex the communication can be in two-dimensional grids. Three interesting problems related to the mobility model are selected; they are as follows: the User Communication Problem or UCP, the Source Reachability Problem or SRP, and the Access Point Location Problem or APLP. We show that UCP and SRP are in fact in the complexity class *P*, and our algorithms to solve the two stated problems in two dimensions are time-optimal. In addition, we have also proved the intractability of a version of APLP in the two dimensional case by a reduction from (u,v)-Hamiltonian Path on a Grid (UVHAMG).

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1.2 Objectives

In this section we briefly summarize the objective of our work:

- To design time-optimal algorithms for User Communication and Source Reachability Problems in the two-dimensional grid for studying wireless communication.

- To show that the Access Point Location Problem is intractable. Therefore, it cannot be solved by any polynomial-time algorithm, unless *P* = *NP*.
- To find mathematical properties of the algorithms for the decision problems in the two-dimensional grid for studying wireless communication by employing the methods of our proofs.

1.3 Outcomes of this Study from Theoretical Perspectives

The outcomes of our research as listed in what follows:

- Time-optimal algorithms for solving the User Communication and Source Reachability Problems in the two-dimensional grid for studying wireless communication.
- NP-Completeness proof of showing the intractability of the Access Point Location Problem.
- New knowledge about wireless network theories that can potentially be adopted to real applications and be used to improve the efficiency of wireless networks.

1.4 Scope of Study

The scope of our study follows:

- To find algorithms for solving the two decision problems, namely User Communication and Source Reachability Problems, in the two-dimensional grid for studying wireless communication.
- To characterize the running times for the algorithms we design.
- To prove that the algorithms for the two problems are time-optimal.
- To prove that the Access Point Location Problem is intractable and cannot be solved by any polynomial-time algorithm, unless *P* = *NP*.

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1.5 Research Design and Methods

We briefly described our methodology next:

- To examine the mobile wireless network in a two-dimensional grid for studying wireless communication, wireless networking, graph theory, growth of functions, and the methods of proofs.
- To gain inside into these problems and prepare for designing algorithms for solving the stated decision problems, and prove the correctness of these algorithms.
- To design the algorithms and analyze time-complexities for the User Communication and Source Reachability Problems in the two-dimensional grid for studying wireless communication.
- To prove that the algorithms for these two problems are time-optimal.
- To prove that the Access Point Location Problem is intractable and cannot be solved by any polynomial-time algorithm (unless $P = NP$) by giving a reduction from (u, v)-Hamiltonian Path on a Grid.

1.6 Working Places and Equipment

The setting for our work is described in what follows:

1.6.1 Working place

- Computer Science Department, Faculty of Science, Chiang Mai University.
- Chiang Mai University Library.

1.6.2 Equipment

- Personal computer.
- Window XP professional software.

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