CHAPTER VI

Conclusions

In this chapter, we present conclusions about the two-dimensional and three-dimensional mobility model for studying wireless communication that we applied from Greenlaw and Kantabutra model, and present some open problems. Also, we suggest the use of this work in the future.

6.1 Research Contributions

For this work, we show the fact that *m* sources cover $3m+2$ grid points in an infinite grid area and cover $3m-2$ grid points in a square grid size of $p \geq 4$ at the maximum in Chapter III. We also show that the lower bound number of sources to cover a square grid of size $p \geq 4$ is equal to $\left\lceil \frac{p^2+2}{3} \right\rceil$. In Chapter IV, we propose GRID POINTS COVERAGE (GPC), propose SQUARE GRID POINTS COVERAGE (SGPC) problems, and present APPROX-SQUARE-GRID-POINTS-COVERAGE (ASGC), an algorithm to give an approximate solution to SGPC. ASGC run in $O(p^2)$, where *p* is the size of the square grid, and it will be useful if SGPC is intractable. The algorithm also guarantees the approximate ratio equal to $1+\frac{p-2}{p^2+2}$ and $1+\frac{2p-10}{p^2+2}$ when $5 < p \leq 8$ and $p > 8$, respectively. The status of GPC and SGPC are unknown and we left them open for the future work. In Chapter V, we introduce a wireless mobility model on a three-dimensional grid and its communication protocol. This model is extended from the original two-dimensional model in [14] to make it more realistic. We then give the definition of MULTI-SOURCES SIMULTANEOUS COMMUNICATION PROBLEM (MSSCP). This problem model the real situation in which *k* pairs of sources communicate without sharing a source. We show that efficiently computing a solution to MSSCP is very unlikely unless $P = NP$.

We also extend the *NP*-completeness proof to MULTI-USERS SIMULTANEOUS COMMUNICATION PROBLEM (MUSCP) and show that this problem is intractable.

6.2 Open Problems

There are more problems, proposed by Greenlaw and Kantabutra [14], related to the mobility model are given and left open. We begin with several key decision problems.

ACCESS POINT LOCATION PROBLEM WITH EQUAL DIAMETERS

INSTANCE : A mobility model $M = (S, D, U, L, R, V, C, O)$, two designated users u_a and u_b from U, an access point diameter d, and a natural number k.

QUESTION : Can users u_a and u_b communicate throughout the duration of the model if k or fewer access points of diameter d are placed appropriately in the grid?

ACCESS POINT LOCATION PROBLEM WITH VARYING DIAMETERS

INSTANCE : A mobility model $M = (S, D, U, L, R, V, C, O)$, two designated users u_a and u_b from U, a set of corresponding access point diameters $\{d_1, d_2, ..., d_k\}$, and a natural number k.

QUESTION : Can users u_a and u_b communicate throughout the duration of the model if k or fewer access points of diameter d are placed appropriately in the grid?

ACCESS POINT PLACEMENT PROBLEM

INSTANCE: Two mobility models $M = (S, D, U = \{u_1, u_2\}, L, R, V, C, O)$ and $M' = (S, D, U = \{u_1, u_2\}, L, R', V', C', O')$.

QUESTION : Can u_1 and u_2 communicate for more steps in model M than they can in model M'?

OBSTACLE REMOVAL PROBLEM

INSTANCE : A mobility model $M = (S, D, U, L, R, V, C, O)$, two designated users u_a and u_b from U, and a natural number k.

QUESTION : Can u_a and u_b communicate throughout the duration of the model if k or fewer obstacles are removed?

These problems can be solved in both two and three-dimensional grids and some suggestions for developing and using this work in the future are given next.

6.3 Future Works

For future research, we can find a polynomial time algorithm to solve GPC and SGPC, or proof that GPC and SGPC are intractable. We may prove the complexity status of MSSCP in a two-dimensional grid. We may also find an approximation algorithm for MSSCP in a three-dimensional grid or solve some particular cases of MSSCP in polynomial time. We may find time complexities for the open problems previously stated in both two and three-dimensional grid. We can define problems and find time complexities of the problems that are related to the mobility model but have not been presented in this work. If some of these problems are *NP*-complete, we can use traditional approaches of randomized and approximation algorithms to obtain efficient partial solutions to them. If some of the problems are in *P*, we can try to find the most efficient algorithms for these problems. We may find time complexities for the open problems both in serial and parallel settings. We may vary the radius of sources, work on some other types of the grid, or extend the area into any shape. We may define the movement steps from a starting position to make the coverage area and guarantee the time and the battery consumption. We may include more objects to our model for more realistic. (Adding some obstacles to block the wireless signal.) We may add movement and velocity to each source to have mobility as in the real world. We may improve the proposed algorithm. (better time bound, tighter with a better analysis). We may adopt these problems in real life situations, such as in the case of natural disasters and military usage.