8.0 Conclusions

Packet radio networks are especially difficult to model because the actions of one terminal depend strongly on the actions of other terminals in the network. System performance is affected by both the number of terminals and their configuration in the network.

This thesis develops a collision model for a CSMA multi-hop packet radio network which will be used as part of a wireless alarm system within homes. The model incorporates topologies of four, five, and six wireless alarm units. The author has validated the collision model with system testing.

The designer of the wireless alarm system found that unanticipated hardware delays introduce a risk of unit-to-unit link failure. In particular, even under seemingly optimal conditions, the system may exhibit up to a 0.0625 probability of unit-to-unit link failure.

Given this circumstance, we assume that the performance of a configuration of wireless alarm units is acceptable if the probability of unit-to-unit link failure is less than 0.0625. The collision model demonstrates that there is one four-unit configuration which yields a unit-to-unit link failure much higher than this, and must be avoided. This worst-case four-unit configuration is a diamond topology in which two middle units attempt to communicate to a fourth unit, but cannot communicate with one another because of obstructions. This situation is an example of the hidden terminal problem associated with CSMA networks.

The four-unit model has been extended to configurations of five and six units. The results demonstrate that there are four valid configurations of five units and eleven valid configurations of six units. Additionally, a serial configuration and configurations in which all units can hear one another are also valid.

Performance of the wireless alarm system is also affected by channel conditions. In particular, radio propagation within homes can affect the maximum allowable distance between units. A literature survey reveals that existing large scale indoor path loss models cannot be directly applied to the wireless alarm system. There are few large scale path loss models which have been developed for use in homes, and of these, none have been developed from measurements in the frequency band in which the wireless alarm system operates.

The author and several colleagues have conducted an indoor propagation study within three homes. Results clearly indicate that propagation within the home cannot be easily modeled. In fact, it has been shown that there is not an apparent “one model fits all” solution.

Despite this, the study does provide some useful information. For example, the data shows that doors within the home have a negligible effect on path loss. Furthermore, path loss within the home can be modeled using the log-distance path loss model with the addition of a distance-dependent floor loss factor. The data does not demonstrate a clear relationship between wall separation, distance, and path loss.

The path loss exponent and floor loss factors within each home are different. In order to obtain a worst-case model of path loss that can be expected within the home, a combination of the resulting parameters was used in the proposed large scale path loss model. The results indicate that in general, the distance between wireless alarm units should not exceed 10 m.

The results of the collision model and the propagation study can be combined to form an installation plan for the wireless alarm system. Valid configurations of units, along with a recommended maximum allowable unit-to-unit separation have evolved from this project.

The results of this work demonstrate that there are some design flaws in the wireless alarm system which need to be addressed. Future work which merits consideration is an investigation into how system performance can be improved. In particular, it may be worthwhile to consider incorporating a return channel into the system to reduce the likelihood of hidden terminals. A more extensive indoor propagation study is also needed. The results of the study discussed in this paper indicate that additional parameters may need to be considered in order to model the indoor channel more accurately. It would be interesting to investigate the effects of building structure, layout, and construction materials on radio propagation within homes.