Investigation into Long-Range Wireless Sensor Networks

Thesis submitted by

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STATEMENT OF THE CONTRIBUTION OF OTHERS

The work contained in this thesis was developed by the author with contribution in the form of technical advice from the staff of the Department of Electrical and Computer Engineering (ECE) at James Cook University. In particular, contribution was provided by the thesis supervisor, Associate Professor Cornelis Jan Kikkert. A/Prof Kikkert provided guidance and technical advice covering all areas of this thesis, particularly RF circuit design, antenna design and radio propagation modelling. All papers that resulted from this thesis were jointly published and were written by the author with guidance and input from A/Prof Kikkert.

Parts and equipment required for this thesis were funded by an annual post-graduate allowance provided by James Cook University, as well as a once off Graduate Research Scheme Allocation provided by the School of Engineering. For the duration of this thesis the author received a stipend in the form of an Australian Postgraduate Award.

Physical devices were constructed by the ECE technical staff and the author using equipment provided by James Cook University.

The wireless sensor nodes developed for this thesis were programmed using TinyOS, an open-source operating system for wireless sensor networks. Much of the TinyOS code was re-used in the development of the test applications. The contribution of other TinyOS programmers is noted in the program code contained in Appendix L.

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ABSTRACT

Advances in technology have allowed for the development of wireless sensor networks consisting of small autonomous sensor nodes that communicate with one another via wireless technology. Most designs of wireless sensor networks concentrate on miniaturisation where sensor nodes can only communicate over a short distance and must be closely positioned to monitor an area. In contrast, this thesis presents a long-range wireless sensor network where nodes are separated by large distances, giving the advantage of being able to monitor a large geographic area.

The long-range communications capability allows the sensor network to monitor environmental conditions over a large area. This technology has practical agricultural applications such as monitoring the level of water in cattle feeding troughs or monitoring soil moisture to ensure that irrigation is conducted efficiently. The sensor network can also be deployed on the Great Barrier Reef to constantly monitor the water quality.

The design of the long-range wireless sensor network emerged from a long-range radio propagation model developed particularly for this application. This model was used to develop the specification for the radio transceiver hardware which was later developed and integrated with a commonly-used node called the Mote. A CSMA/CA (carrier-sense, multiple access with collision avoidance) MAC (Medium Access Control) protocol and a routing protocol were then selected for use on a four-node prototype network which was deployed across Townsville for field-testing.

The results of field-testing showed that a long-range ad-hoc network was formed and the maximum operational wireless link was 13.2 km long. This project shows that it is possible to use a wireless sensor network over a long-distance. Future work in this field should include further optimisation of the MAC and routing protocols.

TABLE OF CONTENTS

TABLES

FIGURES