A Cross Layer Opportunistic Routing Protocol for Wireless Sensor Network: Analysis, Modelling and Quality of Service Support

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Abstract

A wireless sensor network (WSN) provides a platform for embedded sensing and ubiquitous computing. For ad hoc WSNs, multi-hop routing has been adopted in order to save communication power consumption. By acknowledging the lossy characteristics of radio channels on low-power WSNs, the Opportunistic Routing (OR) protocol provides an efficient method for exploiting the spatial and temporal characteristics of these wireless networks by considering multiple forwarding relays for each transmission. The main contribution of this thesis is to provide analysis and modelling for variants of the OR protocol for WSNs.

Firstly, based on the basic concepts that underpin OR, we propose a new variant of OR that can be used in WSNs. It is known that communication in WSN is the most power consuming operation; hence, we propose a variant of OR that specifically reduces the total number of transmissions required during the coordination step used in OR. We investigate the effectiveness of this approach and compare it with OR that adopts existing and common candidate coordination schemes. In addition, we also propose a retransmission scheme based on provisional reliability constraints for local loss recovery that can be used in this new variant of OR.

Secondly, we propose a comprehensive new analytical framework that is based on Markov Chain and Queueing theories that takes into account the key component strategies of OR (prioritization, selection and coordination) as well as the communication components of WSN. The proposed framework can be used to model the end-to-end *reliability* and *delay* performances of WSNs using OR.

Thirdly, taking into account the potential deficiencies of OR due to its static coordination scheme, we introduce a variant of OR that is aware of the *online* quality of its selected forwarding relays that we have named as the Adaptive Coordination Opportunistic Routing (ACOR) protocol. We propose a new local metric to be known as the Opportunistic Quality Score for ACOR to improve the performance of WSNs and, in particular, to support Quality of Service delivery of messages in these networks. In addition, we provide an analytical framework for ACOR that incorporates the adaptive coordination scheme that has been developed.

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Abbreviations

ACOR	Adaptive Coordination Opportunistic Routing
ACK	ACKnowledgement
CCA	Clear Channel Assessment
CRC	Cyclic Redundancy Check
CRS	Candidate Relay Set
CSMA/CA	Carrier Sense Multiple Access/Collision Avoidance
CTS	Clear To Send
ETX	Expected Transmission Count
GPS	Global Positioning System
MC	Markov Chain
NTC	Non-Time Critical
OQS	Opportunistic Quality Score
OR	Opportunistic Routing
PRR	Packet Reception Rate
QoS	Quality of Service
RTS	Request To Send
TC	Time Critical
TDMA	Time Division Multiple Access