

Abstract

Wireless Sensor Networks have been an active research item for the last decade. These networks consist of electronic devices which feature sensors to sense physical values, low-power microcontrollers to process them, memory to store data and low-power wireless communication means to transmit the data. Frequently, the networks are of a multi-hop nature to ensure sensing and communication coverage for a certain area.

The application areas of Wireless Sensor Networks are manifold and reach from wild-life and habitat monitoring to industrial process control as well as from smart-home control to medical e-health applications. The application area of Wireless Sensor Networks covered in this thesis is the domain of transport logistics surveillance.

Originally Wireless Sensor Networks have been static and single-purpose. In recent years these networks have been moving towards applications that need support for mobility and multiple purposes. For example in logistical applications, such as transport condition surveillance, supervising equipment will be moved into and out of containers together with the supervised goods. Any of the involved parties in logistics has – possibly differing – interests in the data of the supervising equipment. This leads to heterogeneous applications and services on the supervising equipment in order to meet the differing interests.

These heterogeneous applications and services demand for a framework which distributes and discovers the various services, so that other pieces of equipment can use them. For an efficient and effective service discovery the algorithms for this distribution of services are of utmost importance, so that the framework can be used in application fields with diverse requirements.

Initially, this framework has been started by the author of this thesis with a simplistic algorithm, which proactively pushes services in a store-and-forward fashion among the nodes and removes the services from the local cache after a pre-defined duration. However, this approach is rather inefficient in static scenarios and ineffective in dynamic scenarios. An algorithm, which is efficient in static scenarios and also effective in dynamic scenarios has been proposed for other applications in the literature. This so called Trickle algorithm has been studied, extended, analytically modelled, simulated and employed in measurements in a Wireless Sensor Network testbed at the service layer in this thesis. The obtained results apply to

the application of the Trickle algorithm at lower protocol layers as well. Given application delay requirements, the realisable distances and number of nodes for two network topologies have been derived from the 95 percentiles obtained by simulation.

The analytical model of the Trickle algorithm includes a model for the number of packets that are sent, which directly relates to the power that is spent. Additionally, a model for the time until a service is discovered for various network topologies is derived. It has been shown that the analytical models match the results from simulations for various network topologies (differing in number of nodes and in the distance between them as well as for different scenario layouts). The analytical model results can be obtained about $1/60^{\text{th}}$ of the time of the simulation and approximately $1/200^{\text{th}}$ of the time necessary for measurements.

It has been shown that service discovery frameworks can be efficiently and effectively employed in resource constrained Wireless Sensor Networks. The analytical models of the Trickle algorithm have been developed and gave insight into the behaviour of the algorithm. Previous published work focussed on studying the algorithm by means of simulations and measurements only. Furthermore it has been shown, that a non-adaptive algorithm (Regular Interval Pushing) can be parameterised to match either the delay characteristics or the overhead of the Trickle algorithm, but that it cannot match both metrics at the same time.

The service framework, employing the algorithm with its optimised parameters, is used in logistical feasibility studies in the research project 'The Intelligent Container' for the supervision of various transports with industrial research partners.

Services in Wireless Sensor Networks
Modelling and Optimisation for the Efficient Discovery of
Services

Becker, M.

2014, XXVII, 179 p. 99 illus., 7 illus. in color., Softcover

ISBN: 978-3-658-05401-4