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Review

Wireless Sensor Network transport protocol: A critical review

A.J.Dinusha Rathnayaka *, Vidyasagar M. Potdar

Digital Ecosystems and Business Intelligence Institute, Curtin University of Technology, Perth, Western Australia, Australia

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ABSTRACT

The transport protocols for Wireless Sensor Network (WSN) play vital role in achieving the high performance together with longevity of the network. The researchers are continuously contributing in developing new transport layer protocols based on different principles and architectures enabling different combinations of technical features. The uniqueness of each new protocol more or less lies in these functional features, which can be commonly classified based on their proficiencies in fulfilling congestion control, reliability support, and prioritization. The performance of these protocols has been evaluated using dissimilar set of experimental/simulation parameters, thus there is no well defined benchmark for experimental/simulation settings. The researchers working in this area have to compare the performance of the new protocol with the existing protocols to prove that new protocol is better. However, one of the major challenges faced by the researchers is investigating the performance of all the existing protocols, which have been tested in different simulation environments. This leads the significance of having a well-defined benchmark for the experimental/simulation settings. If the future researchers simulate their protocols according to a standard set of simulation/experimental settings, the performance of those protocols can be directly compared with each other just using the published simulation results. This article offers a twofold contribution to support researchers working in the area of WSN transport protocol design. First, we extensively review the technical features of existing transport protocols and suggest a generic framework for a WSN transport protocol, which offers a strong groundwork for the new researchers to identify the open research issues. Second we analyse the experimental settings, focused application areas and the addressed performance criteria of existing protocols; thus suggest a benchmark of experimental/simulation settings for evaluating prospective transport protocols.

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* Corresponding author. Tel.: +61430612341.
E-mail addresses: abekoon.rathnayaka@postgrad.curtin.edu.au (A.J.Dinush. Rathnayaka), v.potdar@curtin.edu.au (V.M. Potdar).

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1. Introduction

Wireless Sensor Network (WSN) (Culler et al., 2004) is comprised of tiny embedded devices termed as "motes" that has inbuilt features for sensing, processing, and communicating information over wireless channels. Transport protocol has gained fundamental importance in WSN as it establishes end-to-end connections over the network, while offering services such as congestion control, flow control, fair allocation of bandwidth, reliability, packet-loss recovery, energy efficiency, and heterogeneous application support. However proven transport protocols like User Datagram Protocol (UDP) (http://tools.ietf.org/html/rfc768, 2008) and Transmission Control Protocol (TCP) (www.ibiblio.org/pub/docs/rfc/rfc793.txt, 2008) are inappropriate for WSN due to many constraints in terms of throughput and energy efficiency. One of the major limitations in TCP is that it involves with end-to-end reliability model and enables expensive retransmission mechanism along every hop of the path between the source and the sink, if the packet is lost. TCP exhibits low throughput since it assumes that packet drop occurs due to congestion only and reduces the transmission rate. In contrast, UDP does not offer reliability, flow control, and congestion control, which are critical in WSN applications. The recent research community has attempted to overcome the limitations of standard protocols by developing novel transport protocols targeting WSNs. However different transport protocols use different technical parameters and mechanisms in achieving steady data communication in WSNs. Based on those parameters and mechanisms, these existing contributions can be classified into three categories: (i) protocols that support reliability only, (ii) protocols that support congestion control only, and (iii) protocols that support both (Table 1). Section 2 of this article extensively analyses the technical features and mechanisms used by different protocols and present a generic framework for WSN transport protocol based on those diverse features and mechanisms. In literature, we can find several research articles that compare the technical features and mechanisms of different transport protocols (Justin and Atiquzzaman, 2007). However, those works have not attempted to investigate all the protocols that we have analysed in this article, or to present a generic framework for WSN transport protocol.

Generally the researchers verify the concepts and confirm the performance advancements offered by their models through simulations and/or experiments. However different researchers have used different experimental/simulation environments having different settings such as packet size, number of exploited sensors and their distribution in the field, buffer size, coverage area, simulation duration and initial traffic load. As a result, the new researcher cannot directly compare the performance simulation results of the new protocol with the published performance simulation results of existing ones. In addition, it is impractical to run all the existing protocols in the same simulation environment, which is used to simulate the new protocol, due to the difficulty in finding simulation source codes for all existing works and time constraints. In literature, we can find that certain researchers have compared their new protocol with TCP and its variants and sometimes compared with few other recent protocols, but not with all existing protocols (Alam and Hong, 2009; Wang et al., 2006a, b). Considering all these issues, we can say that one of the fundamental challenges faced by the researchers

Table 1
Existing transport protocols classification.

Both congestion control and reliability support	
ART (Tezcan and Wang, 2007)	Asymmetric and reliable transport
CRRT (Alam and Hong, 2009)	Congestion aware and rate controlled reliable transport
CTCP (Giancoli et al., 2008)	Collaborative transport control protocol
DST (Gungor and Akan, 2006)	Delay sensitive transport
ESRT (Sankarasubramaniam et al., 2003)	Event-to-sink reliable transport
Flush (Kim et al., 2007)	Flush
PORT (Zhou and Lyu, 2005)	Price-oriented reliable transport
RCRT (Paek and Govindan, 2007)	Rate-controlled reliable transport
$(RT)^2$	Real-time and reliable transport
STCP (Zhang et al., 2005)	Sensor transmission control protocol
TRCCIT (Shaikh et al., 2010)	Tunable reliability with congestion control for information transport
Reliability support only	
DTC (Dunkels et al., 2004)	Distributed TCP caching
DTSN (Marchi et al., 2007)	Distributed transport for sensor networks
ERTP (Le et al., 2009)	Energy-efficient and reliable transport protocol
GARUDA (Park et al., 2004)	GARUDA
PSFQ (Wan et al., 2003)	Pump slowly fetch quickly
RBC (Gouda, 2005)	Reliable bursty convergecast
RMST (Stann and Heideman, 2003)	Reliable multi-segment transport
Congestion control only	
ARC (Woo et al., 2001)	Adaptive rate control
CCF (Ee and Bajcsy, 2004)	Congestion control and fairness
CODA (Wan et al., 2003)	Congestion detection and avoidance
Fusion (Hull et al., 2004)	Fusion
PCCP (Wang et al., 2006)	Priority-based congestion control protocol
PHTCCP (Monowar et al., 2008)	Prioritized heterogeneous traffic-oriented congestion control protocol
Siphon (Wan et al., 2005)	Siphon
Trickle (Levis and Patel (2004))	Trickle