Overview of Congestion Control Mechanisms for Wireless Sensor Networks

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Abstract

Wireless sensor network (WSN) is a self-organized distributed network with dynamic nature. WSN usually consists of sensors – the autonomous devices with limited energy resources, computational capacity, memory space and thin communicational channels. Communications between sensors are known by regular interruption of each other and drop data because of the unstable and huffish wireless media and their own internal limits. Moreover such kinds of networks are often used for observation of critical parameters in industry such as temperature, sound, vibration, pressure, etc. That is why their proper, stable work with real-time performance is of outmost importance.

One of the new directions in the web development is to adopt the Representational State Transfer (REST) architecture for constrained devices (sensors with limited ROM and RAM) and networks (e.g. 6LoWPAN). The Constrained RESTful Environments (CoRE) working group is developing this problem and that is for Constrained Application Protocol (CoAP) is being developed by it.

CoAP is a lightweight application protocol which was developed for solving the problem of the performance constrained devices in the networks with high bit-error rate and low throughput. One of its main goals is to reduce packet overhead and thus limit expensive fragmentation of the IPv6 packets. It has a lot in common with HTTP protocol, but improves the ability to work with M2M applications [1]. It works over the UDP (User Datagram Protocol), which is the unreliable protocol that doesn’t offer congestion control (CC) mechanism and intimates that the upper layer has one.

The CC mechanism is important for WSN as it helps to manage their fragile nature (detect and avoid collisions and data corruption) and increases efficiency of work. The CC mechanisms follow two steps to prevent or overcome congestion: congestion detection (CD) and congestion avoidance (CA) [2].

An accurate and efficient CD technique is very important as early congestion prediction influences energy consuming mechanisms, making WSN nodes lifecycle longer. There are a great amount of such mechanisms and a brilliant overview of some of them one can find in [3].

Furthermore some mechanisms should be used to regulate sensors power consumption which can occur because of the idle listening of the radio channel. Radio Duty Cycling (RDC) is one of such mechanisms and as it is shown in [2], the RDC influences a lot on all CC mechanisms with which it is used. In terms of RDC it is extremely important to develop an effective mechanism of nodes synchronization.

One more important requirement should be observed and taken into account – fairness of congestion regulation. In terms of WSN it is important to distinguish the sink node and divide network traffic on the upstream traffic (from the sensor node to the sink) and downstream traffic (from the sensor node to the source node) and as is suggested by [4], the congestion is likely to occur in the upstream direction. According to [4] each node has its local differentiation of traffic: source (is the traffic of the current node) and transit (is the traffic that is coming from the downstream nodes). In [4] an idea of weighted fairness is proclaimed, it covers the aspects of the weighted fairness by reducing, the transition traffic of the node. But in large multi-hop networks

it is more crucial to gain periodical information from all nodes even the remote ones than to have stable data delivery from the one particular area (often nearest to the sink). That is why the idea of limitation of the transit traffic has to be accurately observed and weighted.

So, the task is to develop efficient CC algorithm for performing in a constrained environment using simple calculations and limited data about the path characteristics and take into account all concerns listed above.

CoAP defines the simple technique for retransmission of the lost or corrupted data, but it is not enough for preventing the buffer overflow [5]. Current mechanism provides an idea of retransmission of the packets whose timer was expired and the retransmission counter gained a value greater than the maximum number of retransmissions. But redundant retransmissions in WSN can impair link utilization and cause energy starvation of the device. The idea of a constant value of the timer maximum threshold and the counter maximum threshold is of outmost importance as it raises the problem of data freshness. The main question is how to achieve the point of equilibrium between fairness, channel listening, energy efficiency and real-time characteristics of the transmitted data.

It is important to divide the reasons of congestion on two main types: buffer overflow and channel collision. It will be very helpful during the further analysis of preferable techniques. The results of [6] research experiments showed that problems of the channel dominate over buffer drops and "increase quickly with offered load". Due to the ideas that "eventual disruptions in delivery of real-time data in wireless environment are inevitable" [7] and every particular technique of congestion detection and avoidance has its own pros and cons. A proposition to combine the general thoughts of several techniques appeared.

This study is still in quite early phase and primary focused on theoretical research of the field. Different methods and techniques have being studied; propositions and results of various research works have being analyzed. As one of the project deliverables the model of the modified CC scheme will be designed and verified. The goal is to make it efficient enough to become a reliable technique.

Index Terms: wireless sensor networks, congestion control, radio duty cycling.

REFERENCES

[1] Z. Shelby, Sensinode, K. Hartke, C. Bormann, Constrained Application Protocol (CoAP) Internet-Draft draft-ietf-core-coap-07, Expires: January 9, 2012, Universitaet Bremen TZI B.Frank SkyFoundry, July 8, 2011.
[2] Vasilis Michopolous, Lin Guan, George Oikonomous, Iain Phillips, "A comparative study of congestion control algorithm in IPv6 wireless sensor networks".
[3] Rekha Chakravarthi, C. Gomathy, Suraj K. Sebastian, Pushparaj. K, Vinu Binto Mon, "A survey on congestion control in wireless sensor networks", Internationa Journal of Computer Science and Communication, Vol 1, No 1, January-June 2010, pp 161-164.
[4] Saeed Rasouli Heikalabad, Ali Ghaffari, Mir Abolgasem Hadian and Hossien Rasouli "DPCC: Dynamic Predictive Congestion Control in wireless sensor networks", IJCSI International Journal of Computer Science Issues, Vol.8, Issue 1, January 2011, pp 472-477.
[5] L. Eggert Congestion Control for the Application Protocol (CoAP) Internet Draft draft-eggert-core-congestion-control-01 Expires July 31, 2011, Nokia, January 27, 2011.
[6] Bret Hull, Kyle Jamieson and Hari Balakrishnan, "Mitigating Congestion in Wireless Sensor Networks", in SenSys'04, 3-5 Nov. 2004.
[7] Andrei Gurtov, Reiner Ludwig "Lifetime packet discard for efficient real-time transport over cellular links", 26 November 2003.