The mixed telemetry/image USN in the overload conditions

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Abstract — **The Internet of Things (IoT) is a new concept for telecommunication development. The IoT and things determinations are considering in accordance the ITU-T recommendations. The Ubiquitous Sensor Network (USN) is one of the general IoT components. The traffic models for such network are the important field of research presently. The mixed telemetry/image USN behavior in the overload conditions is the investigation goal of this paper. This investigated USN is multi-application network with AODV (Ad Hoc On Demand Distance Vector) signaling protocol. The paper results show that the USN efficiency can reduce in the overload conditions likely the same effect for the PSTN and NGN networks.**

Keywords— **IoT, USN traffic, image applications, Hurst parameter**

I. Introduction

The Internet of Things (IoT) is the new ITU-T concept for the network development. The IoT will be based on the Ubiquitous Sensor Network (USN) [1, 2]. So the USN traffic models should be studied well. The USN traffic models considered for telemetry applications in [3], for medical applications in [4]. The image applications are very special for USN in according with the necessary big data capacity for trans-mission and rates. Usually, the USN for the image applications includes the telemetry sensor nodes too. The USN traffic models for mixed telemetry/image application were studied in [5].

There are many investigations which proposed difference image compressions methods for efficient image transmission in the USN [6, 7, 8]. All of these methods used for special USN, named visual sensor networks or camera sensor networks [9, 10]. The traffic investigation for camera sensor networks revealed that the traffic for similar networks could be modelling by semi-Markov chain [10].

We studying in this paper the multi applications USN and a widely used JPEG will be considered as the compression method. The video amount of data per frame were defined well and have been fit to lognormal, gamma, and Pareto probability distributions or combinations of them [11]. The image amount of data were deter-mined in [5] for monochrome and color images. The probability density functions for both distributions described by Gamma distribution that was confirmed by Kolmogorov–Smirnov criteria.

The mixed telemetry/image USN behaviour in the overload conditions is the investigation goal of this paper. The Hurst coefficient as a function of the nodes number for differences ratio between telemetry and image nodes are obtained by simulation in the ns-2 system. The image nodes share decreases adduce to the decrease the Hurst parameter value at the first step. The Hurst parameter value reduces this then the image nodes share will be too much. It proves that the USN efficiency can reduce in the overload conditions likely the same effect for the PSTN [12] and NGN networks [13].

The results can be enhanced to M2M networks [14].

This article is divided into several parts. The first part presents the results of modelling the USN during increasing the number of nodes - sources of image data. The second part is devoted to the scenario with increasing the number of telemetry nodes, while the sensor field and the number of nodes - sources of image data don't changing. The last part presents conclusions and the future work.

II. Simulation Model and Tools

The results of previous works proved the self-similar nature of the traffic in the sensor network. But they did not answer to question how the Hurst coefficient depending from different traffic composition.

The sensor field of 30 by 30 meters was selected as base model for investigated USN likely previous experience. The data collection node located in the centre of the field. In according with high interference at the 2.4 GHz broadcast frequency and low power of transmission the guaranteed range of data transmission selected around 15-20 meters. Thereby, the proposed model adequately describes the network with mini-mum number of multi-hop transmission with a single node for data collection. If necessary, the sensor field expansion for data collection by more sink nodes can be placed in parallel.

Two types nodes randomly located in the network. The first type of sensors is nodes that gathering telemetry data, whose task is to transfer small amounts of data with a given period. The transmission frequency is determined for each node type accidentally ranges of 15-60 seconds in steps of 15 seconds. The second type of sensor node is transmitting images. Each of these nodes transmits at a random time interval batch of packets that simulate the transfer of photos size of 640x480 pixels. The amount of data transmitted is randomly selected based on the evaluation of the results get in previous works [5].

The Network simulator 2 system was used for modelling. TCL scripts are generated by scripts in the Python programming language.

III. Overloading by image data

In order to analyse the changes of the Hurst coefficient while changing of number of nodes several tests were performed. Maintaining the total number of nodes equal to 55, authors gradually increasing the number of nodes - sources of image data. The number of nodes varied from 5 to 53 in steps of 2.

The simulation results for selected scenarios with random variables cannot be used to evaluate, so every type of scenario was performed 100 times and the average Hurst coefficient used calculated.

The simulation results are shown in Figure 1, the results for black and white images show as 'x' and for colour - as 'o'.

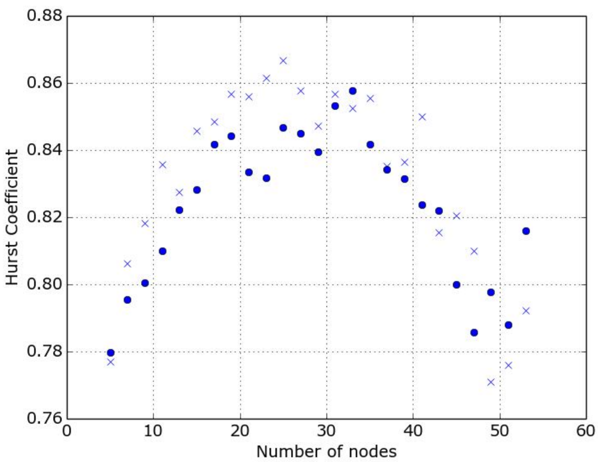

Figure 1. The Hurst coefficient as a function from the number of photo transmitters

As we can see, parabola can be used as a function. Using the mathematical capabilities of the library NumPy the curve parameters were get for the black-and-white and color images. The results are presented in Figure 2 and 3 respectively.

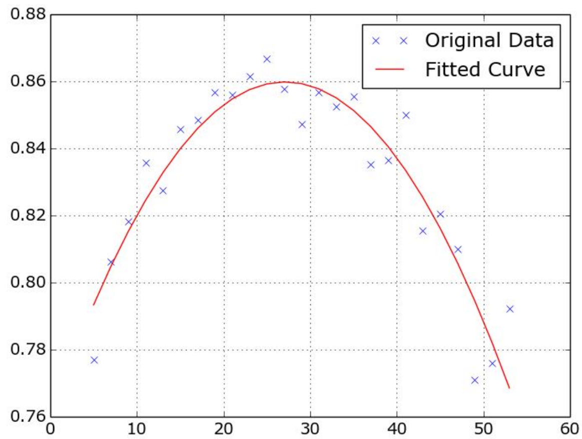

Figure 2. The Hurst coefficient approximation for black and white photo transmitters

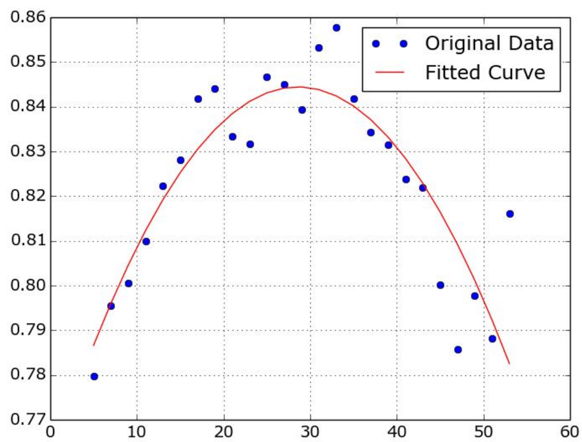

Figure 3. The Hurst coefficient approximation for colour photo transmitters

The overload condition is a state when the network can't handle fully photo transfer. It is easily seen that the Hurst coefficient reaches its maximum in about 30 nodes - transmitters. It's clear that the result of changes in the structure of traffic, and there-fore the Hurst coefficient changes caused by network overloading.

We can use the Hurst parameter derivative further. If it is greater than zero means Hurst coefficient is growing and has not reached its maximum. In the case of a nega-tive value of the derivative, we can talk about the problems in the sensor network.

So, the overload control can be made by the Hurst parameter functions derivatives value change. For example we can handle batch of traffic and save calculated Hurst parameters during the time line. Based on Spencer's formulas we can choose the basis of the calculated parameter is it random or matches the distribution. After the derivative changes sign the overload conditions can be defined.

IV. OVERLOADING BY TELEMETRY DATA

Second case, examined by authors is an increase the number of nodes collecting telemetry data, while maintaining the size of the sensor field and the number of nodes that transmit the image data don't changing. For this simulation were performed scenarios with increasing total amount of nodes from 20 to 150 for scenarios with 5, 10, 15 and 20 nodes - image sources. Each scenario was execute 100 times.

The simulation results for a 5 nodes transmit images are shown in the Figure 4. The results for black and white images are shown as 'x' and for color as 'o'.

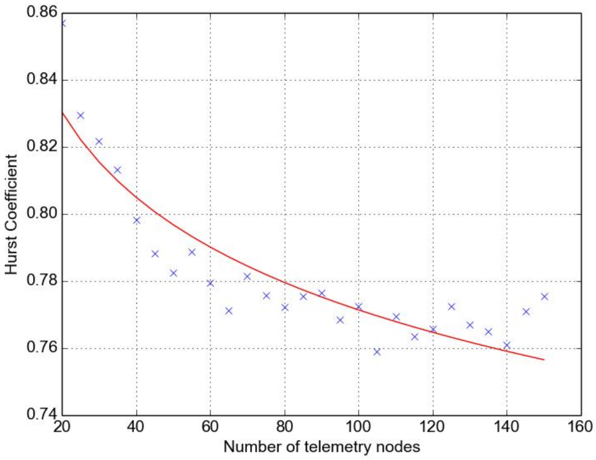

Figure 4. The Hurst coefficient as a function from number of telemetry transmitters

While increasing the number of nodes - sources of telemetry data, load created by nodes - sources of photo ceases to affect the overall structure of the load and the coefficient of Hurst stabilized. The log(1/x) function can be used. Comparative characteristics for black-and-white images are shown in the Figure 5 and in the Figure 6 for color images. As the number of photo sources and in consequence of the amount of the transmitted load, Hurst coefficient has lower values on all the investigated intervals.

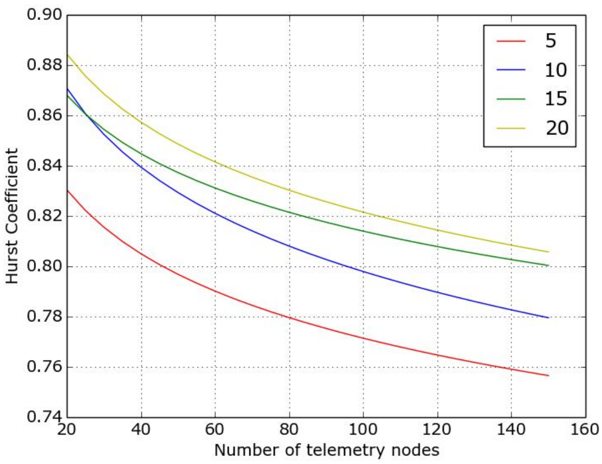

Figure 5. The Hurst coefficient approximation for different number of black and white photo transmitters

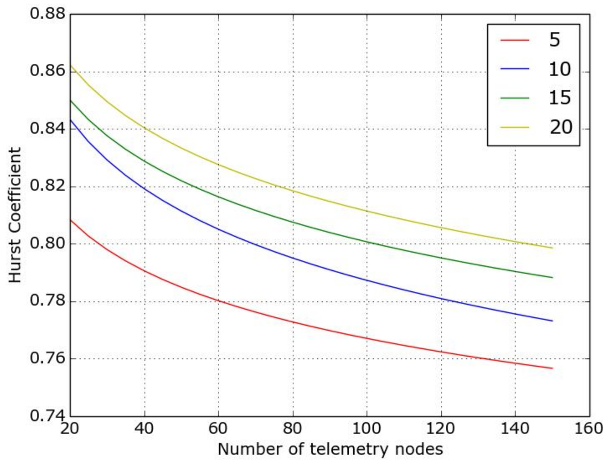

Figure 6. The Hurst coefficient approximation for different number of color photo transmitters

Analyzing the results we can see that the presence of photo traffic lead to bigger value of Hurst coefficient. The increasing the number of telemetry nodes contribution of photo nodes becomes not significant and value of Hurst coefficient decreasing.

V. CONCLUSIONS

It proves that the USN efficiency can reduce in the overload conditions likely the same effect for the PSTN and NGN networks.

The Hurst coefficient reaches its maximum in about 30 nodes - transmitters. It's clear that the result of changes in the structure of traffic, and therefore the Hurst coefficient changes caused by network overloading. The Hurst coefficient functions derivatives can be used for the USN overload detection.

The photo traffic in mixed USN network has a bigger value of Hurst coefficient. The increasing of the number of telemetry nodes contribution of photo nodes becomes not significant.

The routing in the USN is developed further. The new routing protocol RPL (Routing Protocol for Low energy and lossy networks) [15] became the standard protocol for USN networks. This protocol is designed for IPv6 low power and lossy networks. The directed acyclic graphs are the base for RPL.

Each connection in the RPL network is described by set of metrics such as bit rate, power consumption, encryption support, etc., based on which acyclic graphs are created. In one network possible to create multiple graphs and the node will transmit data depending on the purpose of the data. The graphs for telemetry and image data transmission can be organized by most energy efficient way in the RPL networks.

The future works will include traffic models in the mixed USN network with RPL protocol investigation.

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