Simplified model of wireless network throughput changes resulting from client mobility

[Poster abstract]

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ABSTRACT

The simulation models of wireless networks use the mobility models to represent the changes of location of the network nodes. The client location is used to calculate the signal propagation conditions, which is further used to estimate the effective bitrate and packet loss ratio in the simulation. We propose a simplified model, simulating directly the changes of bitrate and packet loss ratio in time, without the full representation of nodes' location. This technique allows to significantly reduce the simulation computation time. The model is based on the measured passage times for zones with specific bitrate in WiFi network. It has been validated by a comparison to a NS-3 simulation with full signal propagation calculations.

Categories and Subject Descriptors

C.2.1 [**Computer-Communication Networks**]: Network Architecture and Design—*Wireless communication* ; I.6.8 [**Simulation and Modeling**]: Types of Simulation—*Discrete event*

General Terms

Performace

Keywords

WiFi, Mobility modeling, Mobile network simulation

1. INTRODUCTION

The performance of the transmission in mobile wireless network is determined by two dominant factors: the bitrate of the communication and the packet loss ratio. Both these factors are determined by the location of the network nodes. The network based on most popular wireless standards, e.g. IEEE 802.11, LTE and IEEE 802.16, are using fixed base stations or access points and mobile clients. The discrete event simulation is a very popular tool used for performance evaluation of such networks. In the simulation models the locations of access points and base stations are given, but the clients may move during the transmission. The locations of clients are calculated by the mobility model or are predefined basing e.g. on measured GPS traces. Large number of mobility models have been proposed, from very simple, such as Random Waypoint [1] or Gauss-Markov [5]; to models capturing human behavior properties: Lévy flight characteristic of human walk[7], social relationships [2], daily and weekly patterns in human mobility [4].

The discrete event simulation environments for wireless networks, such as NS-3 or OMNeT++, use the mobility model to calculate the nodes' location during any instant of the simulation time. Next the the radio signal propagation model, such as e.g. Okumura-Hata[6], together with the MAC layer simulation, is used to calculate the effective data throughput and packet loss rate. These calculations are CPU intensive and limit the speed of the execution of the simulation. We propose to simplify this by creating a model that directly generates the bitrate and the packet loss ratio. In our model we concentrate on IEEE 802.11 standard, but the model can be adapted also to other standards. In WiFi networks the Access Point selects a data rate for transmission to a particular client basing on the reports provided by the client about the ratio of successfully delivered packets. The coding rate which provide maximum effective number of successfully delivered bits per second is used. As the result, for a given location of the client a single coding rate is used to transmit the majority of the packets. The effective amount of bits delivered per client per second is a function of this coding rate, the number of clients connected to the same access point and the effectiveness of the MAC layer - it can vary between 0.4 and 0.8 of the coding rate speed [3].

2. PROPOSED MODEL OF WIRELESS NETWORK THROUGHPUT

We assume that within the area on which a single coding rate is used the throughput offered to a mobile client is constant and depends only on the packet size and number of other clients connected to the same AP. This is a simplification, but bases on assumptions made already by most of the discrete event simulation models, such as e.g. neglecting the influence of interferences. To determine the data rate offered to a client we need to define the moments at which

Simutools 2014, March 17-19, Lisbon, Portugal

DOI 10.4108/icst.simutools.2014.254794

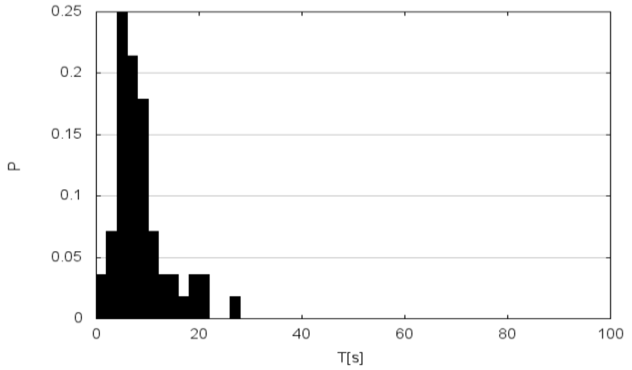

Figure 1: Distribution of single coding rate area passage time in a case of client moving along a straight road in AP range.

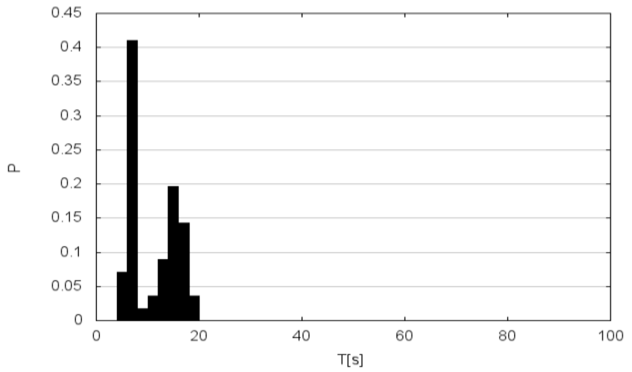

Figure 2: Distribution of single coding rate area passage time in a case of client moving through crossing in AP range.

it enters and leaves the area with particular coding rate. We used the distances provided in [8].

In the simulation model we propose the transmission time of a packet is determined by the client bitrate (which is selected according to the area in which currently the client is). Between two consecutive packet transmissions a guard time is added, which represent the MAC layer activity. It is calculated basing on the packet size and the number of clients connected to the same AP, according to values provided in [3]. When multiple clients are using the same AP the traffic is served using round robin scheme, which represent a fair allocation of radio resources.

To select moments at which clients move into or out of an area with a specific coding rate we gathered GPS traces of multiple travels among a single path by the same person. The GPS traces are used to collect the distribution of passage time between points in space which represent the change in transmission conditions - the moments of entering and leaving the area. The points in time have been selected according to signal propagation model, to calculate the maximum and minimum distance at which specific coding scheme is optimal. We defined some location of the WiFi access points and calculated the distributions of time in which the client enters the range of the access point and crosses the borders of areas with different signal levels.

Figure 3: Map of simulated AP with marked path and point at which coding rate changes.

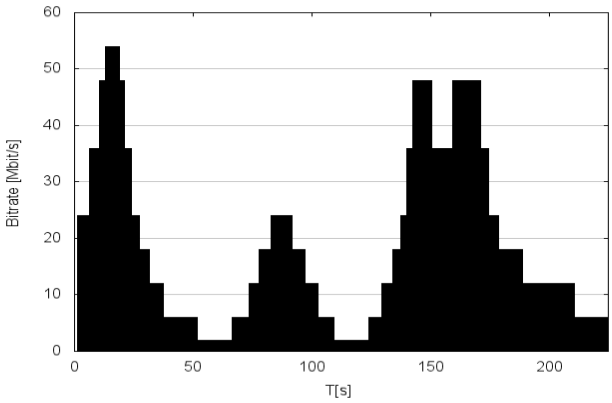

Figure 4: A sample simulation results with model of changes in coding rate in time.

3. SAMPLE RESULTS

The measured distributions of the passage time per area were matched with common statistical distributions, and showed to fit into normal distribution in most of the cases. In some cases, the location of the AP heavily influences the distribution of time of the change, e.g. when an AP is located near to the traffic lights, the change must be modeled using bimodal or multimodal distribution. Such distributions for a straight road within AP access is present and when a crossing is on the way are shown on the figures 1 and 2. The model can be parametrized to correctly represent such elements like crossing and traffic light on the way.

The GPS trace represent a typical path taken by single mobile client. It provides a good representation of the rate of changes during a typical way to work, or a travel on a predefined path. The sample track that we used in the simulation, with marked points at which the coding rate changes is shown in figure 3. It represents a single path for a single client, to model multiple clients we need to use multiple instances of the same node (but this will represent multiple clients using the same path) or gather GPS traces from multiple clients.

The result of the model showing the coding rate simulated in time for a sample path is presented on figure 4. This is an input to the packet delay model, which takes into account also the packet size and the number of clients connected to the same AP and calculates the packet delay.

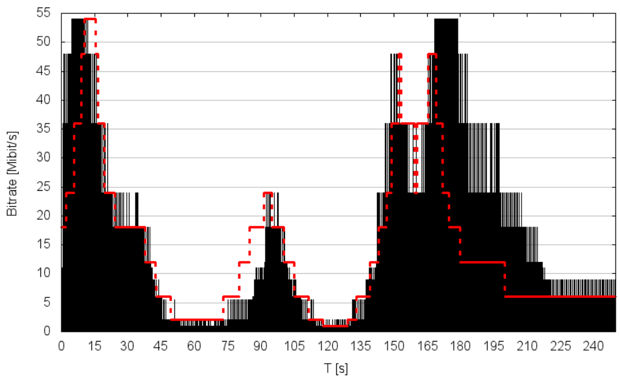

Figure 5: Comparison of bitrate generated by the proposed simplified model (red) and bitrate used in ns-3 simulation (black).

The computational complexity of the calculation of the bitrate is more than one order of complexity lower than the calculation of the full client mobility model. In our proposition the simulation environment executes only one event per few seconds to change the link throughput. The classical mobility model requires much more often recalculation of the client position and the processing of signal propagation calculations per each packet. In our tests in OMNeT++ environment [9] the simulation speed was more than one order of magnitude faster for our simplified model than the traditional method based on radio signal propagation model.

3.1 Validation of the model

To validate the proposed simplified representation of bitrate changes we have compared the results with a simulation model of the same area developed in NS-3 environment. The simulation consists of 3 WiFi Access Points and a single client, moving according to the GPS trace imported into the simulation. The Free Space signal propagation model was used.

We have collected the WiFi bitrate of packet transmitted in the simulation and compared it to the bitrate generated by proposed simplified model. The 3.1 shows how both bitrates changed in time. The results of both models match quite well and in the simplified models provide similar values of bitrate in time, however the simulation shows that in some cases the modulation and coding scheme in WiFi constantly jumps between two values, what is not captured by our model.

4. CONCLUSIONS

The proposed mechanism allows a simplified representation of changes in transmission speed in simulations models of wireless networks. It allows to speed up the simulation execution, at the cost of simplified and less accurate representation of the packet delay.

Acknowledgments

This work has been supported by grant of Polish National Center for Research and Development LIDER/10/194/L-3/11

5. REFERENCES

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