ELECTRONICS AND ELECTRICAL ENGINEERING
ISSN 1392 – 1215 *2006. No. 8(72)*
ELEKTRONIKA IR ELEKTROTECHNIKA

TELECOMMUNICATIONS ENGINEERING
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TELEKOMUNIKACIJŲ INŽINERIJA

Performance Evaluation of WLAN depending on Number of Workstations and Protocols

A. Ipatovs
Riga Tehnical University,
Dzirciema 76-14, LV-1055 Riga, Latvia, tel.: +371 29 689 893; e-mail: aleksandrs.ipatovs@ijsd.riga.lv
E. Petersons
Riga Tehnical University,
Ikšķiles 7-71, LV-1057 Riga, Latvia, tel.: +371 29 480 679; e-mail: ernestspetersons@yahoo.com

Introduction

Wireless local networks come into our life very quickly. WLAN with standard 802.11.g. becomes the most popular today. It is not a secret that real throughput in this network differs a lot from the nominal parameters, that are described in the manual of the equipment. Besides, it also depends on number of active workstations in zone of main access point. There are many reasons of this problem, including problems in CSMA/CA algorithm. That's why before you build new network, you should know variables of performance in it. It will be good if you'll find dependence of network performance from number of connected to the access point workstations.

In this work we'll make an attempt to find dependence of wireless network performance from number of connected to the access point workstations. We'll make a lot of experiments using "Chariot v5.4" to find real throughput in wireless network depending on number of active workstations in zone of main access point.

In this work will be develop and install wireless network with protocol 802.11.g. Basic descriptions of wireless networks and similarly principles and methods of their development and installation are presented in work.

We'll try to find mathematical model for wireless networks with 802.11.g. standard.

Experiment Description

We made experiments on real network to give answers on these questions. Our network situate in the education establishment. The metrical system in these experiments was program "Chariot" from the "Netiq" company. It consists from the "end points of the productivity" for all famous operating systems (Windows ME/NT/2000/XP, Linux or Solaris/x86 Sun) and from central console for measure management. Any of our end points can be connected into the communication pairs in everyway during our work. Every pair has communication protocol (TCP, UDP, RTP, including variants for IPv6, and also SPX, IPX and APPC) without restrictions and user protocol. The "Chariot" program can simulate a lot of communication processes.

For analysis of wireless network performance we have almost standard "Throughput" scenario that generates standard network traffic. Experiments were made either with bounded volume of information or in the limited time interval. In our test we used the second method. We have not only clear figures (average value of effective throughput, time of reaction and transferred data value), but we can see change of absolute values in time (graphic results). Sharp rejections can be seen easily, so it is possible to repeat experiments more times. One can see influence of different factors on the real throughput very quickly. For example, if there are two protocols in one cell, such as 802.11.b. and 802.11.g, clients who has "g" standard can see that their throughput goes downward. The "Chariot" program make this situation easer, because communicated pairs can start sending data with random set delay during one session.

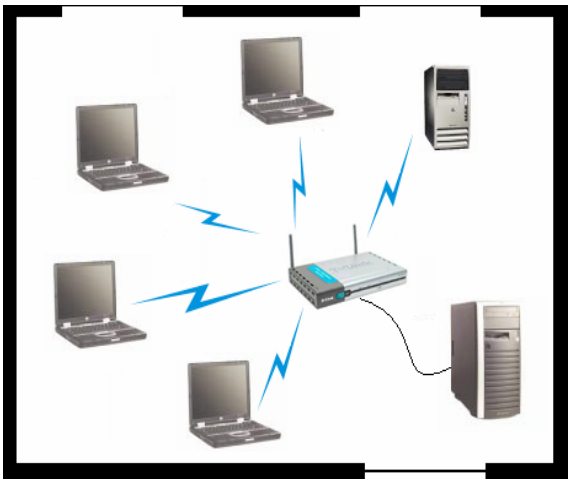

Fig. 1. Visual structure of network

What kind of network do we have? There are following equipment in experiment:

- D-Link access point;
- Server, which is connected to the access point with twisted pair;
- Computer with wireless network device ;
- 4 notebooks with wireless network device;
- Network emulator;
- Network traffic generator.

There is “Chariot” program installed on the server. Client version of “Chariot” program is set on other computers in our network. Then is following actions with “Chariot” program:

- Different traffic simulation (HTTP, FTP, POP3, SMTP, IMAP, etc.);
- Establise traffic channel with one or more workstations;
- Evaluate channel throughput with every workstation and all workstations together;
- Make graphic analisys.

Maximal throughput of network with one workstation was found first. It was equal to 18.15 Mbps. After that has been increased number of workstations by one. We have got different average throughput values with different number of workstations.

Some results from a lot of experiments one can see at Fig. 2. But there is only simple result for one, two and three workstations. To have sufficient accuracy we made more measurements and found average values. These results are presented in Table 1.

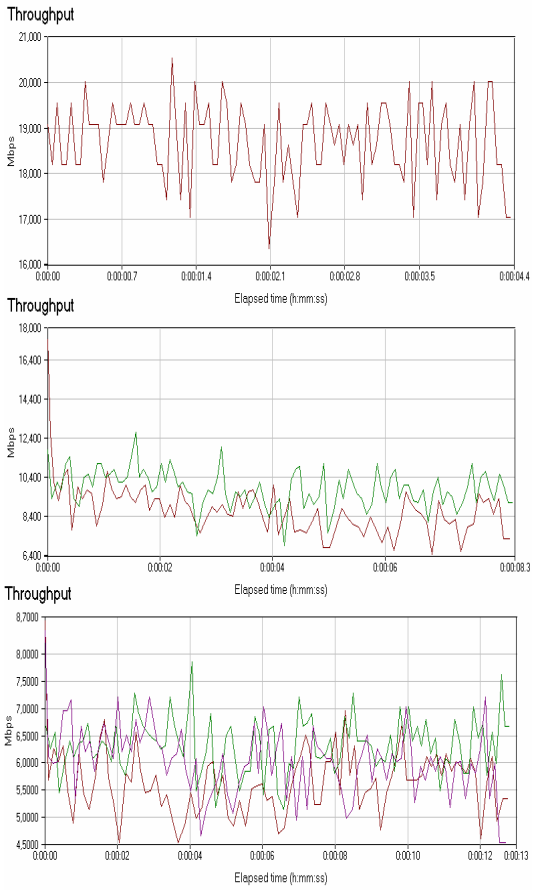

Fig. 2. Graphical analysis of throughput in the “Chariot” program (one, two and three workstations)

From these results it may be concluded that decrease of throughput in dependence from number of workstations is not linear, and actual throughput decrease exponentially (see graphic in Fig. 3.).

Table 1. Result of practical experiments and results from our model

Number of workstations	Practical values	Model values
1	18.15	18.15
2	8.02	7.26
3	5.4	5.67
4	4.4	4.47
5	3.6	3.62
6	3.1	3.02

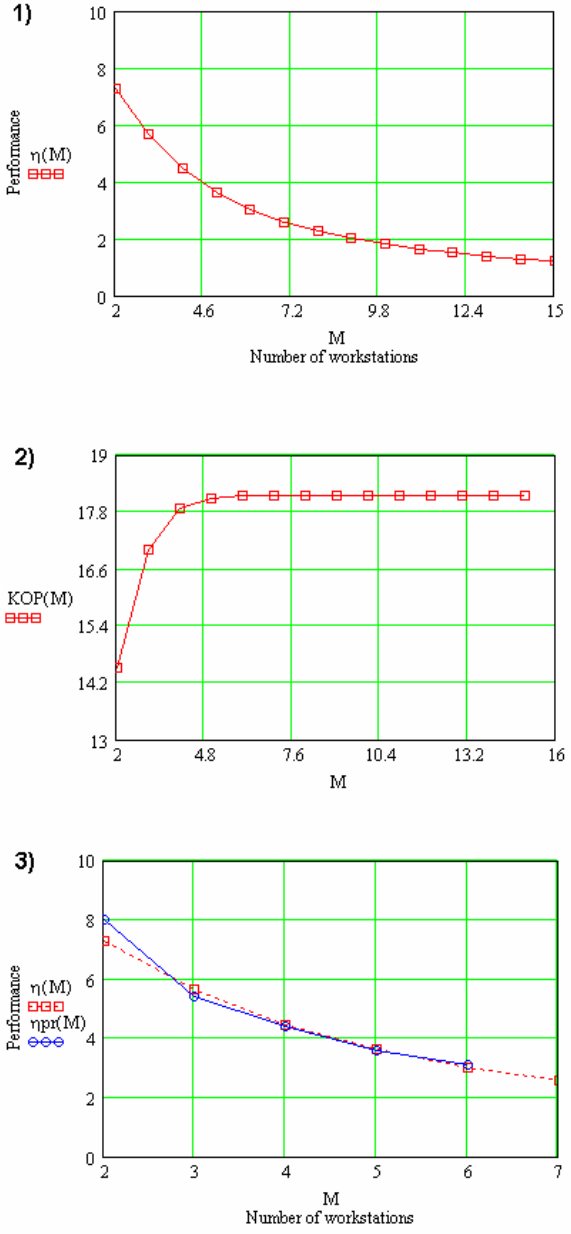

Fig. 3. Graphical analysis. First graphic is theoretical throughput decrease in dependence from number of workstations. Second graphic is total theoretical throughput. Third graphic shows comparison of theoretical and practice throughput result

Theoretical Model

When developer is planning to build new wireless network, should be able to make prognosis depending on it structure and technical values. Mathematical model of the system gives substantial help in this situation. The problem of construction of adequate mathematical model consists in absence of objective rules of transition from the engineering and technical values of projecting system and mathematical symbols of this model, such as probability of transitions, intensity of service of model queries, etc. In this work we try to build mathematical model, using practical results of testing wireless network with protocol 802.11.g. This model behaves to the closed queuing systems class.

The count of workstations in network are designated through M. Intensity of queries from our station to the access point are designated through λ. Under the stream of queries can considered the stream of transactions (1500 byte stream packages). Every query is served by the base station at first, and then is served by server. The throughput of the server in experiment was great, so it is possible delete server from model. That's why service of queries goes on the access point only. Service intensity of queries we will designate through μ. Intervals between the queries and duration of service are casual and have the own unknown laws of distributing. However, according to [z], in case of the rational distributing of these times (either mode of service of queries with distributing of time or distributing of processors resources (this is in our network) are included into this class). In that case average values of proper variables will be equal to $1/\lambda$ and $1/\mu$.

According with that model network performance will be expressed as:

$$\eta = (1 - p_0)\mu, \qquad (1)$$

where p_0 is probability that the system has not requests for service. Then throughput for one workstation of the network will be

$$\eta = (1 - p_0)\mu/M, \qquad (2)$$

where M is count of workstations in the network ($M \geq 2$). In this model

$$p_0 = \left[\sum_{k=0}^{M} \frac{M!}{(M-k)!} \left(\frac{\lambda}{\mu} \right)^k \right]^{-1}, \qquad (3)$$

where $M \geq 2$. Let's put values into variables of model. First of all will see intensity of service, which is equal to maximum value of throughput. This value was exposed by "Chariot" program at maximal load of access point from one workstation.

Now will expose dependence of point performance in the dependence from count of workstations

$$\eta_1 = f(M), \qquad (4)$$

Now will imagine case of heavy load of access point, when $\lambda \to \mu$, but $(\lambda/\mu) \to 1$. Graphic of this dependence, from (2) and (3) is shown in Fig. 3. as number 1. But values are shown in table 1.

How one can see from graphic number 3 in Fig. 3, there is difference between theoretical and experimental results. They are about 6-10 percents.

Conclusions

1. In this work was made an attempt to find dependence of wireless network performance from number of connected to the access point workstations. There were made a lot of experiments using "Chariot v5.4" program to find real throughput in wireless network depending on number of active workstations in zone of main access point.
2. In this work was developed and installed wireless network with protocol 802.11.g. Basic descriptions of wireless networks and similarly principles and methods of their development and installation are presented in work.
3. This job result, exactly mathematical model of wireless network performance depending on the amount of the connected work stations to the access point, can be used for the calculation of the productivity in modern wireless networks.
4. Experimental throughput of wireless network with 802.11.g. standard by "Chariot" program it three times less then nominal (54 Mbps).
5. It is possible to draw following conclusion, that for prediction of conduct of wireless local network you may use mathematical closed model of service system with exponentially distributed intervals between queries and time of their service according with equations (2) and (3).

References

1. **Kleinrok L.** Computing Systems with queries. Moscow: MIR. –1979. – 600 p.
2. **Gast M.** Creating and Administering Wireless Networks. – 2002.
3. **Harte L.** Introduction to 802.11 Wireless LAN (WLAN). – 2004.
4. Website of the "**Chariot**" program – http://www.netiq.com/.

Submitted for publication 2006 03 27

A. Ipatovs, E. Petersons. Performance Evaluation of WLAN depending on Number of Workstations and Protocols // Electronics and Electrical Engineering. – Kaunas: Technologija, 2006. – No. 8(72). – P. 15–18.

The main idea that is described in this work is that detection of throughput in network with protocol 802.11.g. depends on number of connected workstations to the central access point. Some experimental performance measurements of the network were made and the simple mathematical model for developing that dependence was offered. Ill. 3, bibl. 4 (in English; summaries in English, Russian and Lithuanian).

А. И. Ипатов, Э. Петерсон. Оценка производительности в зависимости от количества рабочих станций и протоколов в беспроводных сетях // Электроника и электротехника. – Каунас: Технология, 2006. – № 8(72). – С. 15–18.

Главная идея – определение пропускной способности сети с протоколом 802.11.g. в зависимости от числа рабочих станций подключенных к центральной точке доступа. Было сделано несколько экспериментов по измерению характеристик сети и предложена простая математическая модель для улучшения производительности. Ил. 3, библ. 4 (на английском языке; рефераты на английском, русском и литовском яз.).

A. Ipatovs, E. Petersons. Bevielių tinklų našumo priklausomybės nuo darbo stočių ir protokolų skaičiaus nustatymas // Elektronika ir elektrotechnika. – Kaunas: Technologija, 2006. – No. 8(72). – P. 15–18.

Pagrindinė idėja – tinklo su protokolų 802.11.g. rinkiniu pralaidumo nustatymas priklauso nuo darbo stočių, sujungtų su centriniu tinklo mazgu, skaičiaus. Buvo atlikti eksperimentiniai tinklo parametrų matavimai ir pasiūlytas paprastas matematinis modelis, kurio pagrindu galima toliau tirti šią priklausomybę. Il. 3, bibl. 4 (anglų kalba; santraukos anglų, rusų ir lietuvių k.).

DOI: 10.5755/j02.eie.10781