Analysis the Results of Frequency Planning in Mesh Networking Standard IEEE 802.11

Sergey Garkusha

Abstract – **The paper analyzes the influence of stations territorial separation and technological characteristics of multiradio multichannel mesh networking upon the quality of of the allocation of channels problem solution.**

Keywords – **Wireless Mesh Network, Mathematical Model, the distribution channels, transmission range, multiradio, multichannel.**

I. INTRODUCTION

One of the main ways of increase productivity wireless mesh networks (WMN) is use a multiradio multichannel (MR-MC) mode of operation with a corresponding distribution channels between radio network interface cards (NICs) stations. Today, there are wide enough range of approaches [1], allowing a distribution channels in multichannel mesh networking standard, IEEE 802.11.Thus it is necessary to note that adequacy and effectiveness of the distribution channels problem solution, using different method is often determined by a mathematical model, upon which it is based. It is also important to understand that the effectiveness of technological solutions of the problem of distribution channels in a multichannel mesh networks is largely determined by requirements to described mathematical model formulated in [1] the completeness of accounting. The most complete account of these requirements is seen in the models of the distribution channels, presented in [2-5]. However, the three-index character of the mathematical models presented in [2-4] defines the high dimensionality of the problem on the distribution channels in the mesh network the solution of which is necessary to be provided in the real time. Compared with the model proposed in [2-4], in two-index mathematical model proposed in [5] reduced the total number of control variables determining the order of channels distribution, which reduced the computational complexity of the channels distribution problem.

II. ANALYSIS THE RESULTS OF FREQUENCY PLANNING

In order to assess the quality of the solutions of the channels distribution problem, using a two-index mathematical model introduced in [5] has been analyzed and its dependence on the following initial data:

- characteristics of mesh network;
- of wireless technologies using;
- geographically dispersed mesh network stations.

In the analysis as these initial data were the following:

- number of using non-overlapping channels;
- the total number of stations in the mesh network;
- the degree of overlapping of transmission range;
- heterogeneity topology mesh network;
- number of NICs at mesh network stations;
- size of transmission range.

In the result of analysis solutions the problem distribution channels between NICs mesh network by using different amounts of non-overlapping channels we found that increasing of the using of non-overlapping channels reduces the number of stations belonging to different collisions domains. The number of mesh stations belonging to one or another collisions domain determines its throughput. The capacity of the collisions domains, in its turn, will affect the bandwidth of communication lines passing through it.

Herewith throughput the direction of communication will be determined by throughput of the most low-speed collisions domain, through which passes this line of communication. The throughput of the collisions domain working for k-th channel ($\Pi_{c.d.}$) was determined by using the following expression:

$$\Pi_{c.d.} = \Pi / \left(\sum_{n=1}^{N} x_{n,k} \right) \quad (k = \overline{1,K}; z = \overline{1,Z}; n \in G_z),$$

where Π – maximum transmission rate used technology wireless communication (Mbits/s); N – their total quantity of the stations in mesh network; K – the total number of non-overlapping channels used in wireless mesh network (in technology IEEE 802.11b/g is available $3 \div 4$ non-overlapping channels, and in technology IEEE 802.11a – 12 non-overlapping channels); $\{G_z, z = \overline{1,Z}\}$ – multitude of areas of transmission range (TR), where Z – the total number of transmission range in wireless mesh network, $|G_z|$ – capacity of z-th submultitude, i.e. the number of mesh stations belonging to the z-th transmission range.

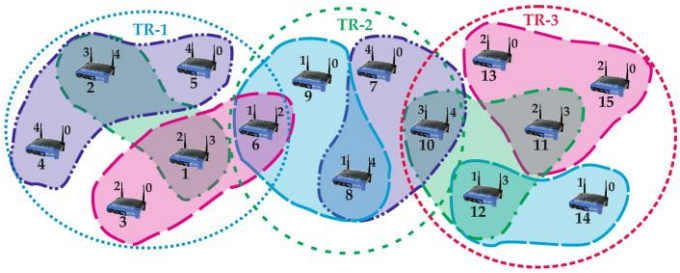
We also found out the use of each additional channel can increase the bandwidth of wireless mesh network by 20-25%.

To analyze the quality of the problem solution of the channels distribution, their dependence on the number of stations used in WMN was examined. The example used in the analysis peculiarity is that the network stations are divided into transmission range with an equal of mesh stations number. This eliminated the dependence of the obtained solutions on the number of mesh stations in transmission range. The analysis revealed that the analyzed mesh network was divided into connecting collisions domains, the maximum size for all the cases was the same. From the obtained results we can conclude that the solution formed of the channel distribution does not depend on the size of mesh network, on condition of transmission range with an equal number of stations formation.

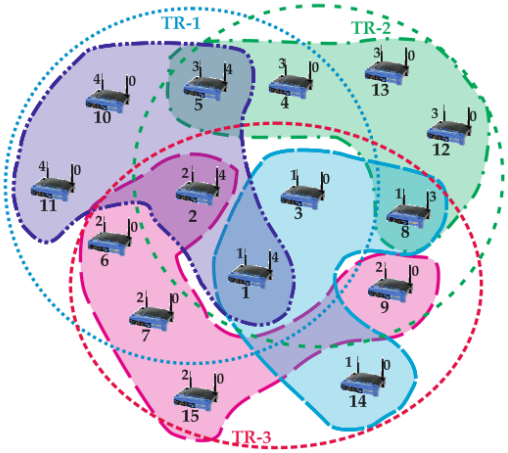
Also analyzed the dependence of the channels distribution problem solution quality on the degree of transmission range of mesh network (Fig. 1). In this case, the degree of overlapping of transmission range by the number of mesh

Sergey Garkusha - Poltava University of Economics and Trade, 3, Kovalya Str., Poltava, 36014, UKRAINE, E-mail: sv.garkusha@mail.ru

stations located at their intersection is determined, i.e. stations belonging to several transmission range. The analysis showed that increasing the degree of overlapping transmission range leads to an increase in the size of created collisions domain working in one channel and thus reduces the productivity of mesh network. The degree of overlapping transmission range reducing can be achieved by managing the power of mesh network stations. However, the management of the power is beyond the scope of the studies.



a) low degree of overlapping transmission range



b) high degree of overlapping transmission range

Fig.1 An example of solving the problem of channel distribution in mesh networks with varying degrees of overlapping transmission range

There was also analyzed the influence of heterogeneity of topology WMN on the quality of the problem solutions of the channel distribution between the NIC stations. Under the heterogeneity mesh network topology, we mean the difference in the size of transmission range the mesh network consists of. Thus, if the mesh network consists of transmission range with different number of station, then the topology of a mesh network is heterogeneous, and vice versa, if the transmission ranges are of the same size then the topology will be homogeneous. The analysis showed that in a heterogeneous mesh network maximum collisions domain size will be determined by the biggest sized transmission range. As a result, there is no possibility of minimizing the size of the generated domains collisions in transmission range of a smaller size. Therefore, in mesh networks with heterogeneous topology the channels distribution problem solution, does not guarantee getting maximum throughput across the whole mesh network.

There was also analyzed the channels distribution problem solution, using a different number of present NICs at the stations mesh network. During the analysis there was found out the fact that the result of the channels distribution problem solution does not depend in any way on of NICs the employed, at the using the number of non-overlapping channels which does not exceed the total number of stations. In the case where the number of non-overlapping channels exceeds the total number of mesh stations network, that the increasing of NICs number using leads to increasing collisions domains forming their number. As a result the sizes of the created collisions domains are minimal and consist of two mesh stations. In such networks the NICs usage increasing doesn't beat to throughput increasing within created collisions domains, however it allows to get the WMN structure of bigger quality for multipath routing problem solution.

III. Conclusion

There was provided an analysis of the solutions obtained by performing a mathematical model proposed in [5]. The analysis showed that the quality of the obtained solutions in large extent depends on such parameters of mesh network: number of using non-overlapping channels, the degree of overlapping of transmission range, heterogeneity topology mesh network, number of NICs at mesh network stations, size of transmission range. The transmission range size decreasing allow to increase the obtained solutions quality and lessen the number of the used channels. We also found out the use of each additional channel can increase the bandwidth of wireless mesh network by 20-25%.

References

[1] Лемешко А.В., Гаркуша С.В. Классификация методов распределения частотных каналов в многоинтерфейсных многоканальных mesh-сетях стандарта IEEE 802.11, *Проблеми телекомунікацій*, № 2 (4), С. 139–149, 2011, http://pt.journal.kh.ua/2011/2/1/112_lemeshko_classification.pdf.

[2] Gogolieva M. "Mathematical model of distribution of frequency channels in multichannel mesh-networks" *Modern Problems of Radio Engineering, Telecommunications and Computer Science. Proceedings of the Xth International Conference TCSET'2010*, Lviv-Slavsko: Publishing House of Lviv Polytechnic, 2010, pp. 31.

[3] Gogolieva, M., Garkusha S., Abed, A.H. "A mathematical model of channel distribution in multichannel mesh networks 802.11" *11th International Conference The Experience of Designing and Application, CAD Systems in Microelectronics CADSM'2011*, Polyana-Svalyava: Publishing House of Lviv Polytechnic, 2011, pp.71–73.

[4] Лемешко А.В., Гоголева М.А. Модель структурной самоорганизации многоканальной mesh–сети стандарта IEEE 802.11, *Проблеми телекомунікацій*, № 1 (1), С. 83–95, 2010, http://pt.journal.kh.ua/2010/1/1/101_lemeshko_mesh.pdf.

[5] Гаркуша С.В., Гоголева М.А. Двухиндексная модель структурной оптимизации многоканальных mesh-сетей стандарта IEEE 802.11, Материалы 9-ой международной научно-технической конференции, Владим. гос. Университет, 2011, pp. 45-48.