ICEST 2004 16 - 19 JUNE 2004, BITOLA, MACEDONIA

Analysis of MPLS Network

Seferin T. Mirtchev[1] and Natalia V. Vesselinova[2]

***Abstract* – Analysis of wireless cellular MPLS network is performed in this paper. The convolution algorithm is used to obtain the dependence of carried traffic from the size of the overlapping area of cells. The increase of the amount of carried traffic reaches saturation point after certain level of overlapping.**

***Keywords* – carried traffic, overlapping area, MPLS.**

I. Introduction

There are many efforts underway to incorporate IP based technologies into wireless cellular systems because of the increasing user demand for Internet, providing IP-based multimedia services over wireless. Such networks are expected to provide efficient packet transfer and support of quality-of-service (QoS). In the core of networks, Multi-Protocol Label Switching (MPLS) is used as a technology of choice to facilitate teletraffic engineering (TE) and QoS support. In this paper, an architecture with label switching is considered and the effect of overlapping cells is studied, since the efficient utilization of resources in wireless networks is of importance as well.

The paper is organized as follows. In next section we define the system model used in the analysis. Numerical results are presented in Section 3. Finally, Section 4 concludes the paper.

II. System model

In [1] a hierarchical architecture for label-switched networks supporting wireless users is described. We use the proposed system architecture to develop our analysis.

The considered network consists of base stations (BS), connected to label switching nodes (LSN), along with the components of the standard MPLS network (LSRs, LERs). LSN provides service to BSs and supports fast handoff and location management mechanisms [1]. A routing area (where the location information of the mobiles is stored) is defined to effectively limit the registration traffic and routing updates when the subscribers cross cell boundaries. Another means to further reduce the updates is to group some LSRs and LSNs.

There is one router in each group, which communicates topology information with other representative group routers and thus forming another level of hierarchical label-switched network architecture.

[1] Seferin T. Mirtchev is with the Faculty of Communications and Communication Technology, Technical University of Sofia, blvd. “Kl. Ohridski” 8, 1000 Sofia, Bulgaria, E-mail: stm@tu-sofia.bg.

[2] Natalia V. Vesselinova is with the Faculty of Communications and Communication Technology, Technical University of Sofia, blvd. “Kl. Ohridski” 8, 1000 Sofia, Bulgaria, E-mail: nvesselinova@tu-sofia.bg.

III. Numerical results

We consider two cells in a cellular label switched network. The two cells overlap each other, Fig. 1. Subscribers in area 1 (the region covered by BS1) have access to all its channels n_1, subscribers in area 2 (the region covered by BS2) have access to all n_2 channels, and subscribers in the overlapping area 12 have access to n_1+n_2 channels. The subscribers in area 12 are expected to experience smaller blocking probability due to the larger number of channels.

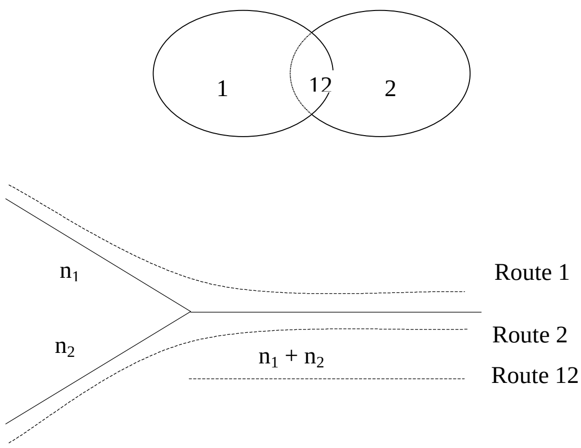


Fig. 1. Two overlapping cells and equivalent routes in a circuit-switched network with direct routing

If we denote the number of existing connections in area i with m_i, then the restrictions are as follows:

$$0 \le m_1 \le n_1 \quad (1)$$

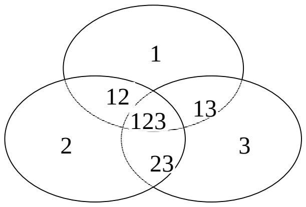
$$0 \le m_2 \le n_2 \quad (2)$$

$$0 \le m_1 + m_2 + m_{12} \le n_1 + n_2 \quad (3)$$

This is equivalent to the circuit-switched network with direct routing [2] shown in Fig. 1. The convolution algorithm proposed by V. Iversen can be applied to networks with direct routing [3].

The convolution becomes multi-dimensional, the dimension being the number of links in the network.

In Fig. 2, a system with three cells, which are mutually overlapping, is illustrated. Subscribers in the overlapping areas (also known as diversity areas) have access to two base stations, but not three. When the subscriber is in the area 23 e.g. and all the channels in area 2 are busy, then we can handover the connection to BS3 if it has enough capacity. Therefore, subscribers in the diversity areas will experience a smaller blocking probability then those in the separate areas. The described model (with restrictions on the number of simultaneous calls similar to Eqs. (1), (2) and (3)) is equivalent to a circuit-switched communication network with direct routing [3]. In the table shown on Fig. 2, the restrictions are denoted as links and the number of separate areas as routes. For the example regarded, the number of routes becomes 6 (there is no overlapping 123 between three cells). The algorithm allows calculation of time congestion, call congestion, and traffic congestion for BPP traffic.



Route

Link	1	2	3	12	13	23	123
1	1	0	0	0	0	0	0
2	0	1	0	0	0	0	0
3	0	0	1	0	0	0	0
12	1	1	0	1	0	0	0
13	1	0	1	0	1	0	0
23	0	1	1	0	0	1	0
123	1	1	1	1	1	1	1

Fig. 2. Three overlapping cells and equivalent circuit-switched network with direct routing

For the purpose of the analysis we considered the case of a system with three cells. Each base station can service a number of 15 subscribers at most, each subscriber occupying only one channel simultaneously. We have assumed that the arrival process is Poisson and that the offered traffic per cell is 15 erl. The subscribers are evenly distributed in the region covered by the three base stations. The PC-tool ATMOS [4], in which the convolution algorithm was implemented was used for the calculations. The results obtained are shown in Fig. 3.

Carried traffic per cell (A_c) increases with the percentage of overlapping area to some extent. The amount of A_c can not be increased after a certain point of overlapping in the systems discussed. This point in our case (for the conditions we set preliminary) is at about 20 – 30 %, when saturation is observed.

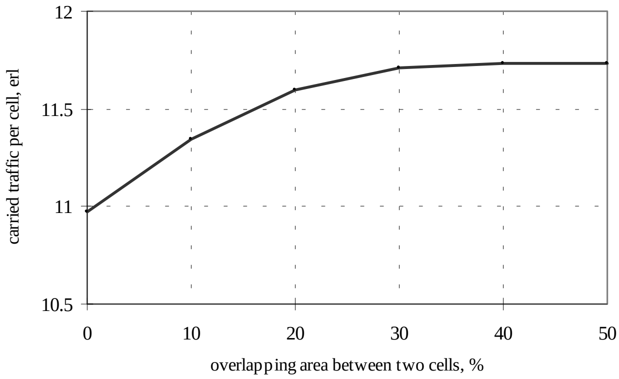


Fig. 3 System with three mutually overlapping cells

In [5] an analytical model of system behaviour, based on the architecture mentioned, is created. It is shown that the overload probability depends on the size of the diversity area in a similar way as the function in Fig. 3.

IV. Conclusions and Future Work

In this paper we applied the convolution algorithm to calculate the carried traffic per cell when cells overlap and the effect of overlapping (to what extent the performance of the system is improved when the size of the diversity area is increased). The algorithm we used is appropriate for small systems. Real systems are usually larger, with base stations maintaining greater number of simultaneous calls. Future work should include simulation study of the behaviour of a larger label-switched network supporting multilink technique.

References

[1] B. Jabbari, R. Papneja, E. Dinan, “Label Switched Packet Transfer for Wireless Cellular Networks”, IEEE WCNC’2000, no. 1, September 2000, pp. 958 – 962.

[2] V. Iversen, “Traffic Engineering of Cellular Wireless Communication Systems”, Modeling and Simulation Environment for Satellite and Terrestrial Communication Networks, Proceedings of the European COST Telecommunications Symposium, September 2000.

[3] V. Iversen, “Traffic Engineering: Chapter 10 – Multi-Dimensional Loss System”, ITU – D, December 2003.

[4] H. Listov-Saabye and V. Iversen, “ATMOS: a PC-based tool for evaluating multi-service telephone systems”, IMSOR, Technical University of Denmark, 1989, pp. 75.

[5] S. Mirtchev, N. Vesselinova, “Architecture and Performance for Wireless Cellular Networks with Label Packet Switching”, TELECOM’2003, Varna, Bulgaria, October 2003.