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Maximizing the Profit of Telecom Telcos by a Novel Traffic Scheduling Policy

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Introduction

Due to the fast technological advancements, telecom telcos face a number of challenges:

- The set of services offered to users rapidly becomes out of date and must be innovated continuously and updated frequently (almost on a monthly basis) [1];
- Prices of IP equipment and optical connections rapidly decline, while the bandwidth increases;
- The presence of competition forces telcos to use the "cost-plus" pricing method, limiting the profit to a percentage (margin) of income, that is long term limited by the economy average;
- Telecom telco (telco) monopoly is not supported by government authorities any more, meaning that temporary monopoly can be based only on their know-how or technology;
- Traditionally, telecom business was a highly profitable industry, due to the high value of electronic communications for users, but it is expected that it will become an average or even low profit industry, as new and new competitors enter the market;
- Social and economic benefits from high quality and affordable communication services are proven practice in the societies of today, so that it cannot be expected that governments will allow monopolies in the future.

Despite the current global economic crisis, telcos reported continued growth in the field of investment and in the field of income. This growth was still significantly reduced compared to previous years, so that telcos and equipment manufacturers seek new ways to maintain and improve the business. Table 1 presents the current state in the investment area.

Table 1. Investments in the world telecommunications market in the period 2005 -2009

(in billions $)	**2005**	**2006**	**2007**	**2008**	**2009**
Fixed telephony	421,8	405,8	386,4	366,4	349,5
Mobile services	546,4	612,4	687,5	742,2	790,5
Data and Internet	196,1	215,6	236,2	256,1	276,9
In total	**1164**	**1234**	**1310**	**1365**	**1417**
Annual growth (%)	5,7	6,0	6,2	4,2	3,8

Source: *IDATE*

So, for telcos, the major question is how to keep the profit rate at a reasonably high level in order to attract investors and thus the ability to follow technological advancements.

Actual practice of continuous introduction of new services, supported by continuous encouragement of customers to use them, still yields a high profit margin. New services and new technologies offer new possibilities, but require a change in the conduct and business management. The usual reasons for introducing new services lays in the fact that enormous capacities are being built, especially in the optical infrastructure, with the consequence that a surplus of unused capacities exists which, in order to be attractive to users, is billed at ever decreasing prices. Technical aspects of new services are obscured by the fact that:

- The users are not fully aware of and do not have full need for the new features and contents;
- New services are too complicated for understanding and use for majority of users,
- The new service cannibalizes the old milking cows, rendering the profit unfeasible, e.g. mobile telephony suppressed the revenues from the fixed one, as observed from Table 1.

So, the problem should not be posed as to how to sell something new, but how to satisfy the user requirements according to their maximum willingness to pay in a certain moment, all in the presence of competition. While the users are now expecting the prices to decrease on a quarterly basis, they are still posed to pay much higher prices in the moments of need.

In this paper, we propose a new concept aimed to maximize the profit earned by the telco, using the aforementioned brief periods of need to send or receive a specified content at the required quality of service (QoS). Besides the competition among them, it should be introduced between the users as well. Telcos compete through QoS and price. Users should compete through reservation of telco resources in the required time slots and at required QoS. This is reality in the situations when telco, at one site and in precisely defined time period, does not have enough resources to meet all of the user requirements. Telecommunication resources are services and QoS in particular time period and between particular sites (communication end points). A possible solution in these situations is a technical concept that will allow preemption (termination) of the cheapest connection.

The paper is organized as follows: section 2 gives the idealized solution to the problem posed above. In section 3 we presented the current state of routing schemes in telcos, and the way in which our idealized solution can be adapted in order to be compatible with them, with intention to lose as little as possible as compared to the idealized solution. Section 4 describes the network simulator structure, while the fifth section presents the results of the simulation. The sixth section discusses the business opportunities opened by the introduction of the new system. Directions for future work are explained in the conclusion.

Idealized solution

The system functions as follows. There are two types of contracts, one for connection to the system and the other for the service itself. While the first one is long term (intended to last for years), the other one is for a very short period (can last just for a couple of minutes, even seconds). The first is for a fixed and not small price, whereas the second is priced according to the algorithm explained below.

The basic idea of the new system is to enable the user to choose the parameters of the service contract for a specific transmission. The parameters of this contract (PoC) are [Preemptivity, Price, QoS], where Preemptivity is the consent to the telco to preempt the connection, Price is the price offered and the penalties requested for nonconformance with the contract (preemption included), and QoS includes logical and physical parameters of service, logical being time interval to start, time duration of the connection and probability of connection loss, while the physical are throughput, delay, jitter buffer and packet loss.

The user connects to the telco user interface, and chooses among one of the standardized PoC. Telco either accepts the chosen PoC or not, according to the availability of the resources and the price at the moment. In the case of contract rejection, the user may either choose PoC that is better for the telco, or search for another telco. Since the service contracts are standardized to be short-term, and are made on one-time basis, the user is probably more inclined to offer better price, than to incur the costs and delays associated with the change of telcos (new connection contract).

Telco is interested in accepting as many contracts as possible at maximum price and minimum penalty, for the given QoS. In order to do so, it has to define the policy of acceptance of the chosen PoC. When its capacities are underused, it will be inclined to accept every contract offered. As the occupancy of the capacities increase, the acceptance conditions become more and more stringent.

As mentioned above, there are two types of contracts: preemptive and non-preemptive. The full bandwidth of the telco is divided into two parts, one for each type of contract. The capacity of the two parts is initially set so as to give the zero bandwidth to the non-preemptive part. Any new demand for a contract states whether the connection will be regarded as preemptive or not.

In the preemptive part, as long as there are unused bandwidth slots, the new contract is awarded at the price offered (though a minimum is required). If there are no empty slots, the new contract is accepted if a previously accepted contract in that (preemptive) category offered a price that, together with the penalty paid by the telco for preempting it, is lower than the newly chosen price, and the capacity is allotted to the new user.

The policy in the non-preemptive part is different. Since preemption in this part is not possible, each new contract is granted if the price offered is higher than the average of the previous ones by a certain amount, and, at the same time, higher than the minimum price contracted in the preemptive part. The new slot is awarded at the expense of the preemptive part, meaning that the bandwidth of the non-preemptive part is increased, and that of the preemptive decreased.

The average prices of non-preemptive part is formed by adding a fixed number of virtual users with prices equal to $(1+k_1)$, where k_1 is the initial discount. The new user pays the price equal to max{average price $*(1+k_2)$, min(price + penalties in preemptive part)} where k_2 is the designated price increase.

Novel telecommunication network management scheme

As stated in section 1, we need to take into account the current state of routing schemes in telecom telcos, and adapt our idealized solution in order to be compatible with them, with intention to lose as little as possible compared to the idealized solution. Today we have two different traffic policies, that we call E-policy (E-P) and L-policy (L-P). E policy is based on fixed bandwidth sharing (multiplex) among different classes of services (CoS). In this MUX, for each CoS a fixed part of the bandwidth is allocated and it is not possible that one CoS occupies the bandwidth allocated to a different class. In L-P, services from different classes share the same bandwidth according to the rules defined by the traffic policy of the telco. It is possible that one CoS takes a part of the bandwidth from another class if it has higher priority. Even then, preemption of low priority connections is allowed if profitable for the telcos. EF (expedited forwarding) class, used for VoIP and real time video traffic, has the highest priority. AF (assured forwarding) class, with virtual private (VPN) traffic follows, while BE (best effort) class, which conveys internet data traffic (WWW, ftp, e-mail, etc.) is assigned the lowest priority. Maximization of the telco profit is realized by an on-line auction process explained in the sequel.

The novel telecommunication network management scheme has top level specification presented in Fig. 1, which is the class diagram of the proposed system in the object oriented unified modeling language (UML) [2].

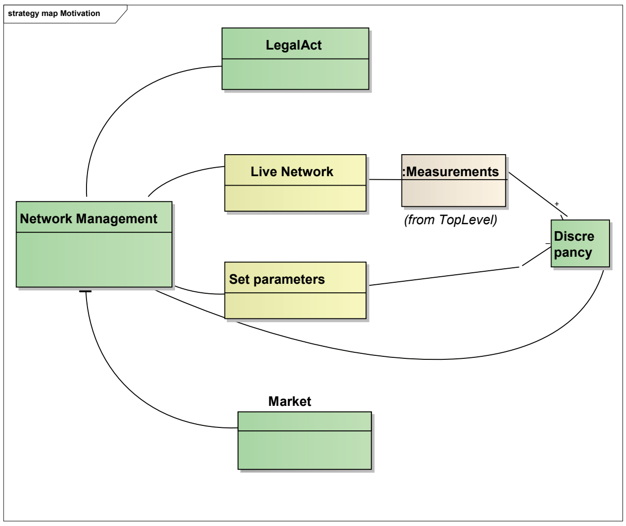

Fig. 1. Top level specification of the proposed system

Network management entity accounts for the legal act and controls the network. System is adaptive, i.e. dynamic and loop backed. Two errors are considered: in QoS, which is the technical aspect and in profit, which is the business view of the system.

Profit is the top objective of the proposed scheme. Its maximization is achieved by higher occupancy of resources during periods of low traffic, increase in prices in non-preemptive part during periods of high traffic, and additional liquidity in the preemptive part as a result of speculative resources purchases. Mechanisms that support this decision are: on-line auction for network resources and user accounts with money deposits for auction advancements, while telcos can break down the arrangement with penalty payment, say the double amount of the advancement. Telco can also take into account long term user policy for golden users and strategy for attracting new users.

Network management has technical and business part (the focus of this paper). Thus, traffic measurements are converted into money units (MU), and telco internal rules maximize the profit. Objectives are transformed into logical control sentences (non-negotiable facts) such as:

- Telcos guarantee QoS for the accepted connections;
- If QoS is not satisfied, telco will pay compensation;
- The object of the auction is, say, 20 MB of network bandwidth, with premium QoS, at the specified link;
- The opening bid is 10.000 MU;
- Winning user's bid is debited from his deposit account;
- Telco is free to cancel the arrangement at any time, even during the transmission time;
- If the telco cancels the arrangement it is due to pay a penalty to user, double of the price.

Telco can have other options, such as:

- If some other user offers enough money, telco is free to accept this arrangement and preempt active connections;
- If user rated as golden user wants to use resources subject to an existing contract, telco is free to terminate existing contract, even during live transmissions of other users, subject to a minimal price offered.

Structure of the Simulator

The structure of the simulator is specified in Fig. 2.

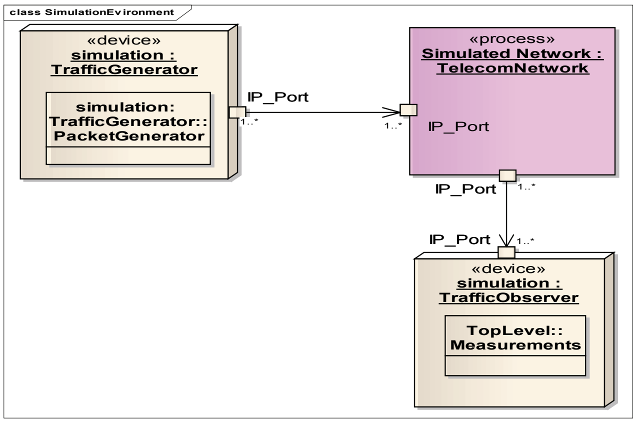

Fig. 2. The simulation structure

Traffic generator block generates random packets that are defined as ordered quad (arrival time, length, CoS, price). Software structure of the simulator is reduced to a simple packet and money counter for each CoS. The sum of earnings for all three CoS gives the total amount earned in E and L routers.

In our system we classify the traffic according to the persistence into:

- Ephemeral packets (BE);
- Semi permanent connections (EF and AF).

Ephemeral packets convey BE traffic, where each packet is datagram that is treated independent from other packets with the same address label.

For semi permanent connections (EF and AF packets) the first packet reserves the bandwidth for the succeeding packets and we treat this packet flow as a connection. It can be preempted by connection with greater priority (a more expensive one).

In Fig. 3 detailed software structure of the simulator is shown. The decision block is an active class (process) that contains the main loop. It calls the components of the other system via their subroutines (methods). When the packet is generated by the traffic generator, E and L router buffers are checked for free room. If the buffers are full, the new packet enters on-line auction process, where it competes for bandwidth with the lowest priced active connection. If its price is greater than the price + penalty of the existing connection, the latter is preempted.

Packets generated from the traffic simulator emulate traffic load with different class of service attributes. The semi permanent packets (EF and AF CoS) produce stable and constant load. They are in competition for the network resources, based on network pricing policy. Simulation results are presented in Fig. 4. Here, when the new permanent connection packet arrives and there is no available bandwidth, the new user presents its offer for paying for the connection. Then, the router finds the cheapest connection that is already scheduled and compares its price + penalty with the offered one. If the offered price is larger, the old user is asked to increase the price for its connection and preempted if it does not. The existing user has the advantage in that, in the case of penalty equaling the price, his price increase has to be doubled by the new competitor. Eventually, if preempted, the existing user gets the penalty paid to his account. Thus, there is an element of speculative behavior, which in the end increases the profit.

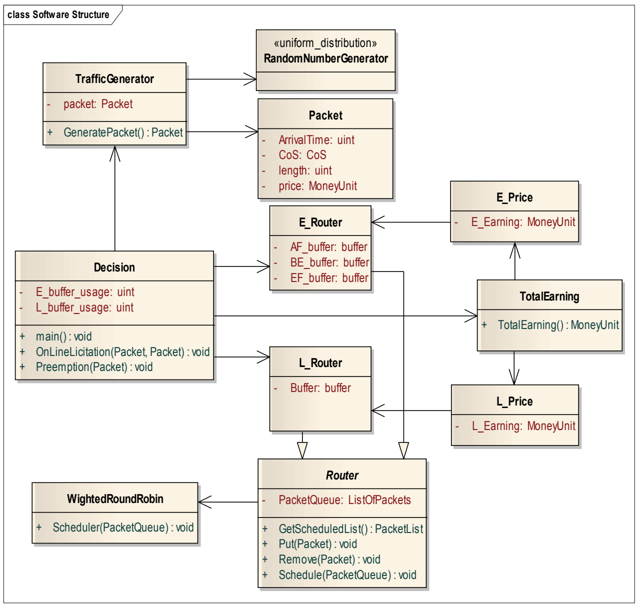

Fig. 3. Structure of simulators software

Simulation Results

We assumed that we have two routers, one with E policy, which we will call E router (E-R) with bandwidth E_B and the other with L policy, which we will call L router (L-R), with bandwidth L_B. They share the same output bandwidth (B). In our tests we fixed B at 100 Mbps according to the following equation:

$$B = (1-\Theta)\cdot E\_B + \Theta\cdot L\_B. \quad (1)$$

Within the E router we fixed bandwidth allocation between different CoS as follows:

- EF traffic bandwidth = 2.5% of E_B;
- AF traffic bandwidth = 10% of E_B;
- BE traffic bandwidth = the rest of E_B (87.5%).

A single test measures profit for a fixed value of Θ (single point on the diagram in Fig. 3) and to draw the whole diagram we vary Θ from 0 to 1, in steps of 0.01, or in other words from 100% E routing to 100% L routing. To obtain a statistically valid set, we averaged the results of 500 tests, with the same parameters and a different seed for random number generator.

This simulation was repeated several times on sets of 500 tests, with very similar results. Fig. 4 shows a composition of two simulation results, each giving the average of 500 different measurements, with curves plotted in two colors. We can observe that:

- 100% E-P routing has profit about 4.7 Mega units;
- 100% L-P routing has profit about 3.83 Mega units.

Between these extremes, where Θ varies from 0.01 to 0.99, the profit has a repetitive parabolic shape, with maximum above both pure E-P and L-P routing profits. The curve is of cyclic nature, with the cycle period of about 0.1 (10%). The absolute maximum is achieved for 92% from total bandwidth allocated to L-P type routing and it is approximately 6 mega money units in both tests, which is about 28% better than pure E-P and 42% than pure L-P routing. Slight variations in data artifacts from two tests are due to the stochastic nature of conducted tests, as well as the consistency of measurements which can therefore be regarded as very precise.

Business opportunity

Nowadays, telcos strive to maintain the income and user base and, if possible, increase them. The system proposed in this paper is completely compliant with this trend, requiring the change of rules of conduct, from focusing on technical parameters towards observing and satisfying the needs of the user. Dynamic and transparent auction of services and capacities offers the availability of critical resources to most interested parties and, at the same time, augments telco profit.

The profit maximization is achieved by:

- Higher resource occupancy during low traffic periods;
- Increase in prices in non-preemptive part during periods of High traffic;
- Additional liquidity in the preemptive part as a result of speculative resources purchases.

During the periods of low traffic, users are expected to use preemptive service. By the terms of this service, users will bid for an agreement and receive lower prices. This price discount would result in the higher occupancy rate. The experiment from section III shows that higher income is gained with lower prices and higher occupancy. Furthermore, lower and flexible prices in the period of low occupancy, allow service provider to charge higher than average market price during the high occupancy period. Additional income would be provided by speculators, who would bring liquidity to the auction system. The characteristic of the auction process that pays back double the amount of preempted agreement should initiate risk takers to "invest" into such an agreement and wait for the agreement to be preempted. That way, the investment would be doubled in amount and speculator would profit from preemption. The auction process assumes the following to be true:

- Possibility to conclude on-line agreements (legal and technical requirements);
- Trained staff;
- Adaptable and modular user interface.

So, our system assumes that the agreement is a function of

$$PoC = f[routing\ policy, price, QoS] \quad (2)$$

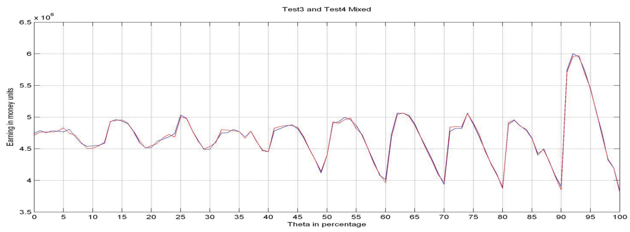

Fig. 4. Simulation results, two sets of 500 runs show the dependancy of profit of Θ (percentage of total bandwidth allocated to L policy) as well as the consistency of simulation results

The advantage of the new system relies on the fact that the investment cycle is redirected from physical equipment towards logical software applications (billing, connection, auction, preemption). The new investment paradigm proposed in this paper insists on one-time spending instead of frequent purchase of new and new physical infrastructure and technologies, and brings the following benefits:

- Full utilization of communication infrastructure and other network resources;
- Continuous and timely satisfaction of user needs;
- Decrease of investments into communication infrastructure, new technologies and services (restricted to cases of real need);
- Increase in the profit rate of telcos.

Conclusions

In this paper we have introduced a new concept of network management scheme aimed at maximizing the telco profit. Besides the competition among telcos, it is introduced between users as well. Telcos compete through quality of service and price. Users compete in reservation of resources, i.e. services and QoS in the specified time period and between particular sites. This concept should be supported by two different traffic policies, which we call E-policy and L-policy. E-policy is based on static (fixed), while L-policy on dynamic (statistical), MUX techniques.

Major components of the system are: legal acts defined by legal authorities, telco rules for network management and control, the network under control and the traffic observer. Legal act is a public document which ensures transparency to end users.

The results of simulation, obtained through extensive testing, prove the correctness of proposed method for optimizing telco profit and show that, neither pure E nor pure L policy, can give the maximum profit. This stems from the fact that both prioritize, albeit differently, the type of traffic, whereas in order to maximize the profit telco should schedule the routers to prioritize traffic by the price offered–to–bandwidth and QoS required ratio Our mixing procedure, keeping the current router schemes, and thus not requiring any new investments in equipment, makes the step in this direction, and immediately shows a possible 40% increase in telco profit due to this simple combination.

In the future, we plan to widen the research in two directions. The first one is business direction, where we shall implement and test different control techniques, such as PID, fuzzy [3, 4], hybrid PID and fuzzy [5], genetic programming [6], etc. In the second research area, we plan to develop various scheduling algorithms (round robin, deficit weighted round robin, etc.) and to compare scheduling algorithms based on effective QoS they achieve. We also believe that it is possible to develop novel scheduling algorithms for specific traffic policies. In long term, we also plan to extend E-P and L-P into full MPLS implementation of the simulated network and the QoS will have to be supported [7].

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This paper introduces a novel traffic scheduling policy whose objectives is to maximize the profit of telecom telcos. Telecommunication network management is reconsidered from the business point of view, introducing competition between users for resources of the telecom telcos, in addition to existing competition between telcos themselves. Business control of network is supported by loop back control that should be realized as on-line technology supplied with intelligent control algorithms. The results od simulation, obtained through extensive testing, prove the correctness of proposed method for optimizing telco profit and show that, neither pure E nor pure L policy, can give the maximum profit. To specify and implement the proposed system we use unified modeling language (UML). Ill. 4, bibl. 7, tabl. 1 (in English; abstracts in English and Lithuanian).

Ž. Bojovic, E. Šecerov, D. Dobromirov, V. Šenk. Naujo duomenų srautų valdymo algoritmo taikymas // Elektronika ir elektrotechnika. – Kaunas: Technologija, 2011. – Nr. 7(113). – P. 67–72.

Aprašomas naujas duomenų srautų valdymo algoritmas, taikomas telekomunikacijų įmonėje, siekiant didinti įmonės pelną ir skatinti konkurenciją tarp įmonės išteklių naudotojų bei pačios bendrovės. Tinklo kontrolė vyksta taikant pažangius tinklo kontrolės algoritmus. Sistemai įgyvendinti buvo naudojama UML programavimo kalba. Il. 4, bibl. 7, lent. 1 (anglų kalba; santraukos anglų ir lietuvių k.).