Networks

ON A PROBLEM OF QOS CHARACTERISTICS INTERPRETATION IN TRANSIT NETWORKS

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Abstract: The paper is on common approach to the problem of a subscriber choice for the making connection through the telecommunication network. One opportunity is to make repeated calls; the second one is to choose other provider. The problem of the traffic (and therefore, the income) lost induced by a low quality of service is given in detail. Quality of service dependence of the number of repetitive calls is proposed and verified by real network traffic measurements.

Keywords: quality of service, repeated calls, answer seizure ratio, traffic engineering

ACM Classification Keywords: G.3. Stochastic processes K.6.4 System Management, Quality assurance

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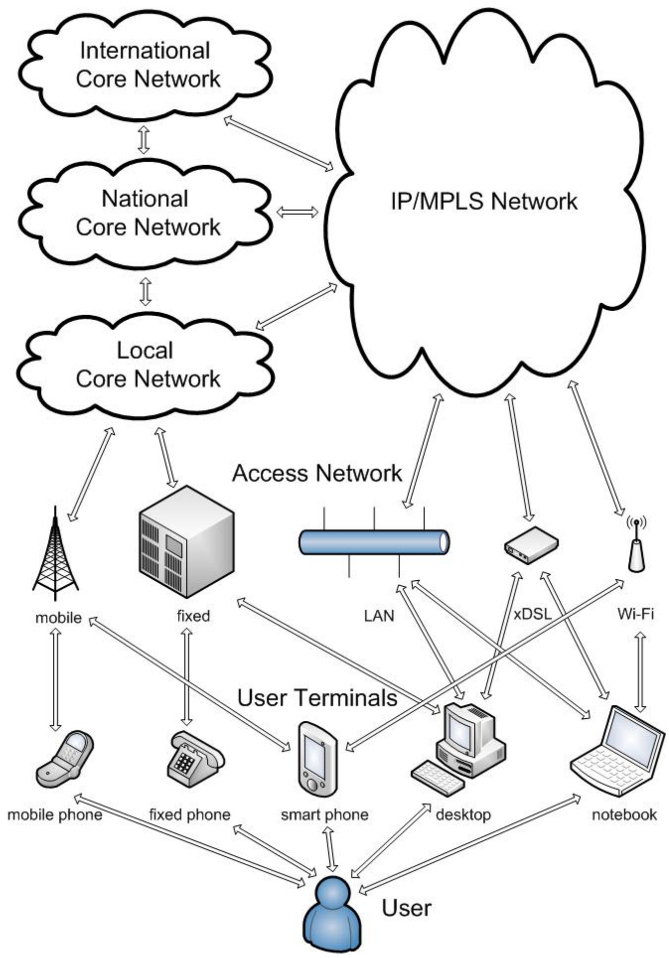
Introduction

The main subject of this study is an influence of repeated calls on the value of a cost functional. The functional gives an income from the traffic service. Therefore, the repeated calls influence on the choice of call route in the given quality of service (QoS) and economical efficiency parameters. Now the efforts of scientists mainly put on the packet switching traffic models. There is an opinion that the circuit switching theory is awfully studied and all useful dependencies are investigated. But it is not true. Subscriber persistence and human factors may strongly distort the quality of service indicators, and for the taking of this distortion into account we should consider the service model in the network. Other opinion is that circuit-switching networks are past and packet-switching networks are future. What can we say against it? At the OSI model higher levels we can get the circuit (virtual circuit) switching network similar to a public switching telephone network. Systems in circuits switching mode Subscriber behavior affects on the calls distribution in an informational flow. But also it affects on the traffic flows in the network themselves. In the first case Poisson flow will be distorted by the fact that the independence of events gets lost. If A-user gets any information about the network status or B-user status then he can make a decision to make once more effort to reach B-user. In this case, bids for making a connection between A and B are dependent in a short time interval because they are generated by one demand for an information transfer from A to B. By this reason, they make alterations in both the call flaw distribution and the integral performance indexes indicators. If all repeated attempts of A-user are unsuccessful then he has an opportunity to use an alternative terminal, an access network, and even an other transit network. So, in a current state of the telecommunication network subscriber has a wide range of choices. Besides reliability of connection establishment (B-user availability) parameters such as the quality of speech transfer, the reliability of access (service availability), the service cost, etc. can be influenced of the choice. Possibility of the choice leads to redistribution of the call flaws on the network, and it must be taken into account in the network maintenance and business planning.

Therefore, it will be very useful to obtain more specific information about the services on virtual circuit-switching network providing. In this paper, we give a short observation of possibilities and then refine the idea of QoS parameters measurement with taking repeated calls into the consideration.

Call service in the common virtual circuit-switching network during the providing of telecommunication service

In accordance with the ITU-T terminology, the network is divided into layers. Every layer shows the purposes of the equipment in its boards. This approach is also acceptable for a virtual circuit-switching network. The most popular example of such network is a simple telecommunication circuit-switching network which is divided into an international part subnetwork and a national part subnetwork, the national part subnetwork includes a local part subnetwork and a transit part subnetwork [1]. This three-level hierarchy is related to the core network. By analogy with packet transfer networks we can give forth level – an access network. The rest levels contain user terminals and users themselves.



Pic. 1. Network layers interaction

The first layer is User (see picture 1), it should be marked out as an independent layer because just user makes the important decision on which terminal will be used. If QoS of one of the available networks stops to satisfy the user then he can use other terminal and get other access and other transit network. And the cheapest network will be chosen, if in the same quality, tariffs of the access networks are better.

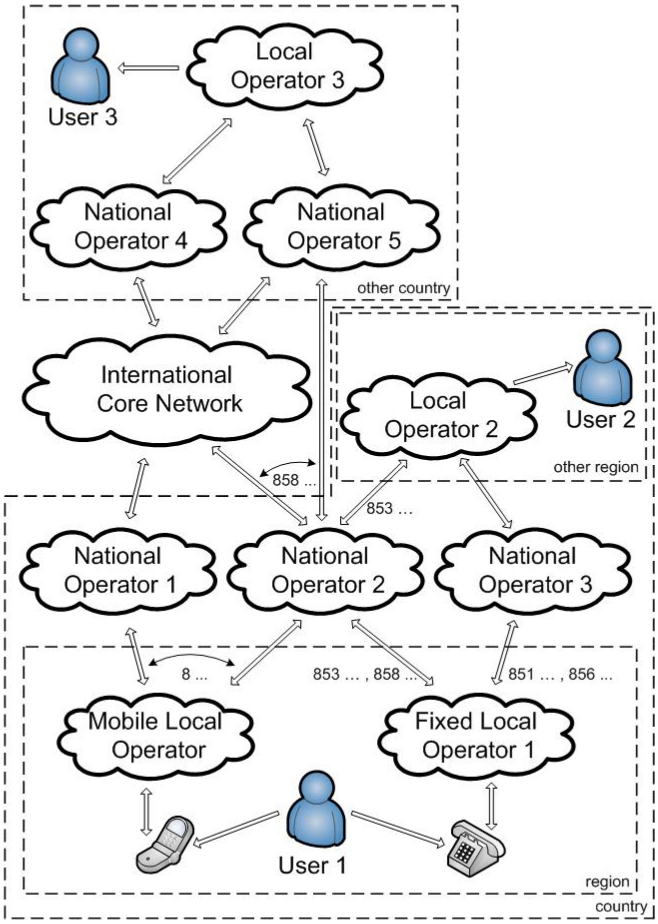
The next level is User Terminals. Earlier, when a mass user had single terminal, we could start the picture from User Terminals. But now, user has in a workplace typically at least three terminals, which we should take in account both in a tariff and a quality policy forming. They are a fixed terminal, a mobile terminal, and a personal computer, connected to a telecom network. Hybrid terminal types are possible but they don't change the matter.

Since the network examination is making on an example of a classical telecommunication network, it causes the further layer detachment. The next layer is Access Network. There are more variants of interaction here than between User and User Terminal. Typical combinations of Access Network sharing are xDSL (common telephony and computer telephony), GPRS/EDGE/3G (mobile telephony and computer telephony). And a converse interaction is possible. There is an opportunity to choose different Access Networks from one User Terminal.

Access Network leads us to Local Network. Depending on B-number prefix User can choose one of National Operators. The choice of National Operator can also be made by default by the local operator itself. Let us give some examples to illustrate the choice in a telecommunication network.

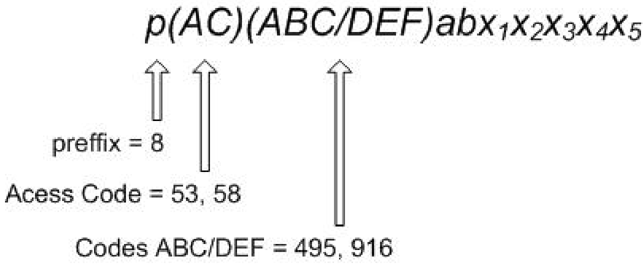
A subscriber from the fixed Local Network of Russian Federation has some opportunities. If he dials access code (prefix) of OJSC “MTT” carrier (853 for national or 858 for international communication) then he can get the long-distance communication service from this operator. If he dials other prefix then he gets service from other transit network. At the same time, the possibility to use computer platforms and to go through IP/MPLS network exists too. Moreover, the subscriber has opportunities of choice on the terminal equipment level and on the access network level. The existence of such varied choice is very important for the subscriber persistence estimation. The persistence measured on the transit (National or International) network part is lower when there is an opportunity to use alternative ways.

Large number of choice opportunities in a telecommunication network is shown on the picture 2. For illustrating the User 1 possibilities in his making choice we need to consider the B-number structure in Russian Federation. If a user made a decision to call via a TDM network then he can dial the number from mobile phone or from fixed phone. In case of long-distance communication from mobile phone, the choice of transit carrier will be made by mobile carrier at its discretion. In case of national or international communication from fixed phone, User 1 can make a choice himself.



Pic. 2. User choice opportunities

So, the number consists of the prefix of access to long-distance telecommunication – 8, access code to the long-distance communication operator (2 or 4 digits). Then, in case of an international communication, the sequence is as follows: the international communication country code [2], the area/operator code and the subscriber number. In case of national communication in Russian Federation, ABC/DEF (area/operator) code and then 7-digits subscriber number go straight away after the long-distance telecommunication prefix “8” and the access code. Total B-number structure is shown on the picture 3.



Pic. 3. B-number structure

If it is making a national connection then the long-distance operator delivers the call to the requested region of Russian Federation and terminates it to the Local Operator network, where User 2 telephone station is situated. If it is necessary to direct the call to an international network then the transit operator (e.g. National Operator 2) can choose the operator in the traffic terminated country or choose International Network for routing. It is important that if we do not deliver the call by one operator (it named “first choice operator”) then the next operator can be chosen etc. We need to take this fact into account while measuring on the transit network. As a result, one dialing by User 1 the User 3 number can deliver several calls into the network of transit National Operator 5 from international operators (see picture 2). So, we can obtain repeated calls (caused by equipment) between National Operator 5 and Local Operator 3. The reason of these calls can be e.g. congestion in the Local Operator 3 network, and National Operator 2 tries to use all alternative routes of the international network to deliver the call.

An opportunity of the International Network choice is non-unique reason of the equipment to cased repeated calls. Let us take up the transit operator network itself. Some switches of this network are connected every one to each other and some are not. As a result, a call is going sometimes via two or three consecutive trunk groups of the transit network. On every switch, an opportunity of the automatic choice of the route undoubtedly exists. ?The number of alternatives is not more than three. But even so, we can observe several dozens of CDRs (Call Detail Records) for unsuccessful repeated calls under the measurement in the transit network. At the same time, the real initial call can be successful. PDD (Post Dial Delay) period [3] of this call is on several seconds longer than of the normal one (this time is wasted for unsuccessful repetitions), and measured ASR (Answer Seizure Ratio) for the sample of such calls is dozen times lower than the real one.

All the mentioned above should be taken into account when we choose a measurement point to obtain the quantity dependence of the user-generated repeated calls number.

Clean Answer Seizure Ratio and quality of service parameters

For the traffic management tasks it is necessary to take into account QoS parameters. One of the most important QoS parameters is ASR [4]. This parameter is defined as “On a route or a destination code basis, and during a specified time interval, the ratio of the number of seizures that result in an answer signal, to the total number of seizures” [8].

There are some repeated attempts among these call attempts. Let repeated call be the unsuccessful call that was done after the previous one from the same A-number to the same B-number during short time interval comparatively to the previous unsuccessful call. Unsuccessful call means that the result of this attempt does not enlarge NER (Network Effectiveness Ratio) parameter. In other words, if QoS in the given direction became perfect then the observed sample would not contain the repeated attempts.

It is clear that since many QoS parameters are ratios of something to the number of all calls, all these parameters are distorted with repeated calls. In this case it is useful to consider “clean” QoS parameters, e.g. “clean” ASR. Let us name it CASR – Clean Answer Seizure Ratio.

Let k be the mean number of repeated calls attempts per one initial call attempt (initial call attempt is “The first attempt of a call demand that reaches a given point of the network” [8]) in the given direction. This number depends on ASR in general. Therefore if the common number of arrived calls is n then the number of initial calls n_{in} is $n_{in} = \frac{n}{k+1}$.

So, $ASR = \frac{n_{ans}}{n} \cdot 100$, where n_{ans} is the number of answered calls. And previously defined by us “clean” ASR, $CASR = \frac{n_{ans}}{n_{in}} \cdot 100$ amounts to

$$CASR = ASR \cdot (k+1). \quad (1)$$

$CASR$ parameter allows to calculate directly the income which is not got amount in full because of insufficient QoS. Its amount according to E.420 ITU-T after the introduction of "clean" target ASR – CTASR (Clean Target Answer Seizure Ratio) can be presented as $\frac{CTASR - CASR}{CTASR} \cdot 100$. The company receives less this percentage of its income from the traffic on given direction if QoS is low on it.

Repeated calls and quality of service parameters

Let p be loss for the given direction which causes the repeated calls. Then mean repeated calls to initial ones ratio [5, 6] is

$$k = \frac{Hp}{1 - Hp}, \tag{2}$$

where H is the subscriber persistence.

We can not measure p in the network directly. For interpretation we were guided by the definition of successful call from the network point of view according to ITU-T E.425 recommendation [7]. But this recommendation itself has a complicated fate. At first, there was no NER parameter in it in 1992. Then in November, 1998, this parameter is sharply defined through the definite set of CV (Cause Values) in SS7. And in one of the last versions in March, 2002, they prefer already not to list definite CV constituent NER, but to say common words about the dividing of all CV on user's and network's one, or to put it more precisely about the impossibility of such exact dividing.

In this paper, we assumed the set of CV for NER definition by the 1998's version of E.425 and the value of measured losses is equal to

$$q = 1 - \frac{NER}{100}. \tag{3}$$

Not all calls that included in these losses bring about the subscriber starts to repeat calls. Thus measured losses can be divided into two components: losses p that cause repeated calls and constant (relative to quality) losses p_c that don't cause repeated calls. Losses that cause repeated calls are applied to part of calls that already suffered from losses that don't cause repetitions. Therefore,

$$q = 1 - (1 - p_c)(1 - p) \tag{4}$$

and by expressing p through q and substituting in (2) we get

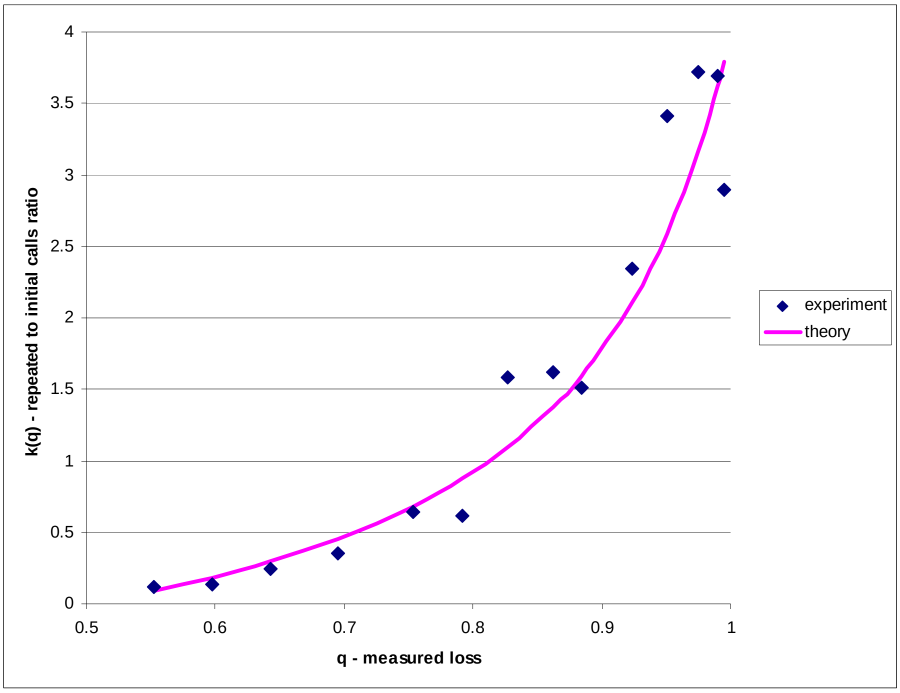
$$k(q) = \frac{(q - p_c)H}{1 - p_c - (q - p_c)H}. \tag{5}$$

In formula (5), the repeated calls to initial ones ratio dependence of measured loss for given p_c and H is expressed.

Losses and repeated calls effect on network redimensioning in the overall telecommunication system with channel switching are detailed considered in [9].

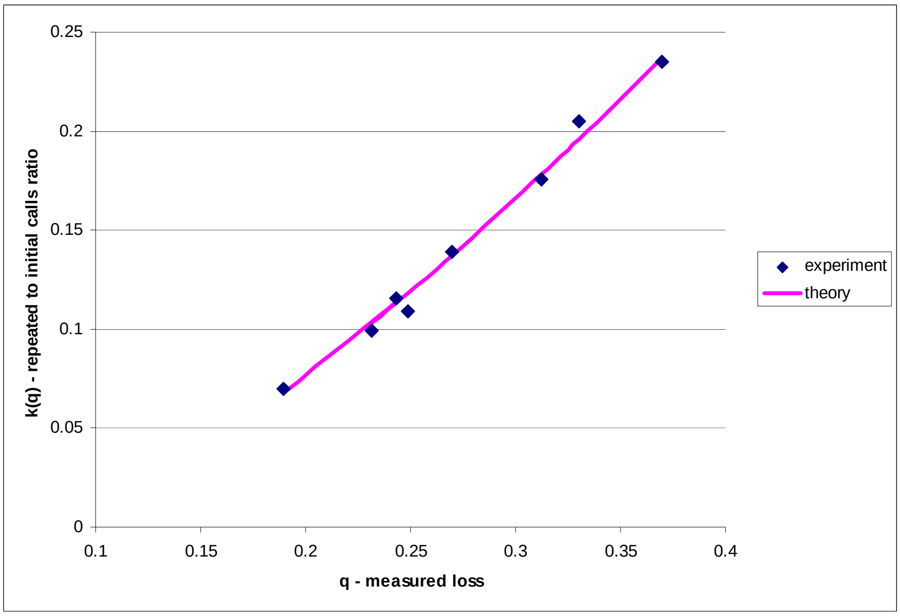
Persistence and constant loss measurement

In the OJSC "MTT" network, we measured the repeated calls to initial ones ratio dependence of losses. Indirect result of this measurement is the finding of the subscriber persistence and those losses component which does not case repeated calls. The volume of aggregation was generated by 1000 initial calls. A call was accepted as the repeated call if it was an unsuccessful call that observed from the same A-number to the same B-number not later than in 10 minutes after the previous one.



Pic. 4. $k(q)$ dependence for the Uzbekistan mobile (+99893*) destination

Measurement results for Uzbekistan mobile (+99893*) destination are shown in the picture 4. In this example, the subscriber persistence estimation $H = 0.8$ and the losses component estimation $p_c = 0.5$. The next example for Yakutiya fixed (+7411*) destination gives $H = 0.64$ and $p_c = 0.1$ (see picture 5).



Pic. 5. $k(q)$ dependence for the Yakutiya fixed (+7411*) destination

Conclusions

For any measurement in the telecommunication network, we should avoid those points of measurement where the equipment initiated repeated calls exists. Man-initiated repeated calls should be taken into account if we want to estimate the real QoS from the subscriber point of view. Modern telecommunication networks have so many alternatives for a subscriber that this parameter estimation is hardly important to keep clients of service.

The repeated calls to initial ones ratio dependence of the network measured loss is expressed by equation (5). This dependence is obtained theoretically and it is in accordance with the practice. The subscriber persistence and the constant component of loss may differ for different destinations.

The dependence $k(q)$ is nonlinear one. By this reason the measured QoS parameters are distorted by repeated calls. The more losses are the more this distortion is. Taking the dependence form into consideration allowed us to create the operator choice algorithm based on the QoS parameters "cleaned" of repeated calls for OJSC "MTT" traffic management system.

Other important application of the results obtained is in network management and optimization: values of $k(q)$ and H are important input for network redimensioning and operative resource assignment.

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