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THE OVERLAYING FREE TERMINAL STATES CONCEPT

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Summary:

A detailed conceptual and a corresponding analytical traffic models of an overall (virtual) circuit switching telecommunication system is used. The models are relatively close to real-life communication systems with homogeneous terminals. The overlaying free terminal states concept is proposed and argued. Systems of equations including life cycle states of requests occupying calling (A) and called (B) terminals are derived. The proposed definitions and results obtained are useful for overall network teletraffic modeling and are applicable for the most telecommunication system.

***AMS 2000 Subject Classification**: 60K30 Applications (congestion, allocation, storage, traffic, etc.); 68M10 Network design and communication; 90B20 Traffic problems*

1. Introduction

The users in a mobile network cell are relative little number, and if we want to dimension or re-dimension the base station, we have to use the Engset’s formulae [Engset 1918] instead of the Erlang’s one, because the Erlang’s formulae is valid for unlimited number of sources.

Here “number of sources” includes the number ($Ya.o$) of busy (occupied) calling (A) terminals as well as the number of empty (free) ones ($Ya.e$), which are potential calling (A) terminals. Hence we have to determine the number ($Yb.o$) of occupied called (B) terminals and number ($Yb.e$) of potential B-terminals, which are empty.

We consider term “request” as a generalization of terms “empty request” (occupying an empty (free) terminal, e.g. see “call intent” and “suppressed call” in [ITU E.600]), and “occupying request” – occupying a terminal, e.g. see “call demand”, “call attempt” in [ITU E.600]. In this meaning, Request Life Cycle consists of two states of a request: empty request and occupied request.

In [Poryazov, Kharkevich 2008] Request Life Cycles for all (calling (A) called (B) and free) terminals are defined and corresponding equations are derived.

A telecommunication terminal, in circuit switching mode, has two mutual exclusive states: busy and free (empty). But if a terminal is free, in general, it may be a free A-terminal and simultaneously a free B-terminal. So the free states of A and B-terminals are overlaying completely.

In this paper, [Poryazov, Kharkevich 2008] is expanded with detailed request life cycles consideration of A and B terminals.

2. State of the art

Models of Request Life Cycles, in Overall Network Teletraffic Theory are not known. The expression “Request Life Cycle States” was find by Google in four documents only – two by Cisco [Cisco 2003], one in [Three Olive Solutions 2008]. In [Cisco 2003] there is a general quantitative block-schema of “Change Request Life Cycle States” without direct traffic correspondence.

Google has found 37 documents for "overlaying states" and 1 document for: telecommunication OR telecommunications "overlaying states".

3. Request Life Cycle Concept

The all used and not defined in these paper notations, and general assumptions are explained in details in [Poryazov, Saranova 2006].

We’ll consider the number of all occupied (*Yab.o*) and all empty (*Yab.e*) terminals in the investigated telecommunication system. The durations of the empty and occupied states of the terminals are *Tab.e* and *Tab.o* respectively. In Fig. 1 is graphically shown explicitly the Request Life Cycle in a telecommunication system in stationary state. *Fab.o* and *Fab.e* are rates (frequency) of occupying and emptying call attempts, respectively.

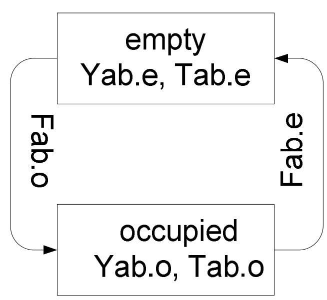

Figure 1. Closed Cycle (Explicit presentation of the Empty Block).

In Fig. 2 is shown open Request Life Cycle in a telecommunication system – the Empty Block is hidden. This is the usual approach, used in Teletraffic Theory e.g. [Iversen 2008]. The first block is a Generator and the last block is a Terminator of requests.

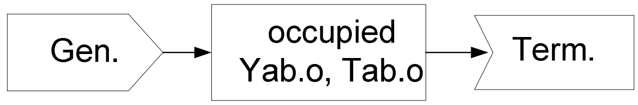

Figure 2. Open Cycle (Hidden Empty Block, substituted from Generate and Terminate blocks)

In [Poryazov 2005] and [Poryazov, Saranova 2006] is used mixed request life cycle presentation, following the necessity of presentation the repeated calls, between attempts.

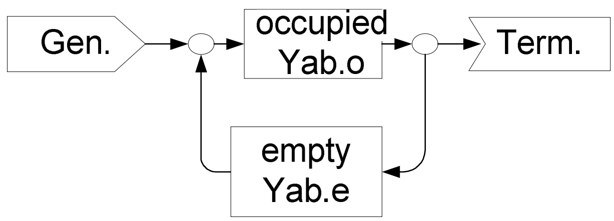

Figure 3. Mixed Life Cycle Presentation (Open and closed blocks are presented).

4. Main Request Life Cycle Equations for all occupied terminals in Terminal Traffic Theory

Obviously, the sum of occupied A ($Ya.o$) and B-terminals ($Yb.o$) equals to the number of all occupied terminals ($Yab.o$):

$$Yab.o = Ya.o + Yb.o \qquad (1)$$

The number of all occupied terminals ($Yab.o$) is less or equal to the number of all active terminals in the system (Nab):

$$0 \le Yab \le Nab \qquad (2)$$

In stationary state, flow frequency of occupying and releasing requests equals:

$$Fab = Fab.e = Fab.e \qquad (3)$$

Following the Little's formulae and notations for durations of the empty and occupied states - $Tab.e$ and $Tab.o$ respectively, we obtain:

$$Fab\,(Tab.e + Tab.o) = Nab. \qquad (4)$$

The duration of the Request Life Cycle (*Tab.c*) is:

$$Tab.e + Tab.o = Tab.c = \frac{Nab}{Fab} \qquad (5)$$

From (4) follows directly:

$$Yab.e + Yab.o = Nab \qquad (6)$$

We know the values of *Yab.o, Tab.o*, *Fab.o* [Poryazov, Saranova 2006] and consequently the mean traffic (*Yab.e*) of the empty terminals is:

$$Yab.e = Nab - Yab.o. \qquad (7)$$

Therefore, we obtain the mean free time (*Tab.e*) of the requests:

$$Tab.e = \frac{Nab - Yab.o}{Fab} \qquad (8)$$

5. Request Life Cycle Equations for A and B-terminals

A telecommunication terminal has two mutual exclusive states: busy or free (empty). Following terminals homogeneity, if a terminal is free, it may be a free A-terminal and simultaneously a free B-terminal.

Main Assumption: Free states of A and B-terminals, in circuit switching mode, are overlaying completely.

Therefore the mean numbers of simultaneously free A (*Ya.e*), B (*Yb.e*) and all free AB (*Yab.e*) terminals are equal:

$$Ya.e = Yb.e = Yab.e \qquad (9)$$

From the Theorem of Little and (9), for the mean free time of the A-terminals (*Ta.e*) follows:

$$Ta.e = \frac{Ya.e}{Fa} = \frac{Yab.e}{Fa} \qquad (10)$$

Fa is the rate (frequency) of attempts occupying (and leaving, in stationary state) A-terminals.

Let *Tb.e* is the mean free time of the B-terminals and *Fb* is the rate (frequency) of attempts occupying B-terminals. Analogously of the (10), for empty B-terminals we have:

$$Tb.e = \frac{Yb.e}{Fb} = \frac{Yab.e}{Fb} \quad (11)$$

Let the number of active (busy or empty) A-terminals is *Na* and the number of active B-terminals is *Nb*. Active A-terminals are occupied A-terminals and empty A-terminals. In other words, active A-terminals are all terminals that are not occupied B-terminals:

$$Na = Nab - Yb.o \quad (12)$$

Following (1), (7) and (12) we receive:

$$Na = Yab.e + Ya.o \quad (13)$$

Analogously:

$$Nb = Nab - Ya.o = Yab.e + Yb.o \quad (14)$$

An important consequence from (12), (14), (7) and (1):

$$Na + Nb = 2Nab - Yb.o - Ya.o = Nab + Yab.e = Yab.o + 2Yab.e \quad (15)$$

A comparison with (7) gives:

$$Yab.e = 2Yab.e \quad (16)$$

This discrepancy is a direct consequence of the main assumption (A and B-terminals free states overlaying), and means that we have to use union instead of numerical summation, adding free states of A and B-terminals.

The duration of the Request Life Cycle of the A-terminals (*Ta.c*), following (13), is:

$$Ta.c = \frac{Na}{Fa} = \frac{Nab - Yb.o}{Fa} = \frac{Yab.e + Ya.o}{Fa} \quad (17)$$

Analogously, the duration of the Request Life Cycle of the B-terminals (*Tb.c*), following (14), is:

$$Tb.c = \frac{Nb}{Fb} = \frac{Nab - Ya.o}{Fb} = \frac{Yab.e + Yb.o}{Fb} \quad (18)$$

6. Conclusions:

1. Detailed normalized conceptual and correspondent analytical traffic models of an overall (virtual) circuit switching telecommunication system (like PSTN and GSM) [Poryazov, Saranova 2006] is used;
2. The Request Life Cycle States Concept in the Terminal Teletraffic Theory is developed, introducing the overlaying free states of A and B-terminals separately.
3. Equations for mean values of Request's Incoming Rates, Free Times and Traffic Intensity of empty A and B-terminals terminals in the telecommunication system are derived.
4. The durations of the Request Life Cycles of the A and B-terminals are determined.
5. The results may help application of the Engset formulae to cell network dimensioning.

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Концепцията за припокриващи се свободни състояния на терминалите

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Резюме:

Използван е детайлен концептуален и съответстващ аналитичен модел на цялостния трафик в телекомуникационни системи с комутация на виртуални канали. Моделът е сравнително близък до реалните системи с хомогенни терминали. Предложена и обоснована е концепцията за припокриващите се свободни състояния на терминалите. Изведени са системи от уравнения, включително за състоянията на цикъла на живот на заявките на викащите (A) и виканите (B) терминали. Получените резултати могат да бъдат полезни при моделиране на цялостния мрежови трафик, в системи с малък брой източници.