A performance modeling approach for networks with QoS guarantees

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BULGARIAN ACADEMY of SCIENCES 1869

1869, 26-30 September
The Bulgarian Learned Society (BLS) was founded in the house of Varvara Hadzhi Veleva in **Braila, Romania.**
On 29th September the first Statutes of the BLS was accepted.

1878, 03 March – Liberation of Bulgaria**.**
1908, 22 September - the 3rd Bulgarian Kingdom is created.

The College was established in *1881* by Decree of the King Alexander I as a State School of Telegraph.

The ***College of Telecommunications and Post*** is a (state owned public) College, has accreditation by the ***National Evaluation and Accreditation Agency***.

The College offers Bachelor degree programmes in the fields of:

- **Telecommunication informatics;**
- **Telecommunication technologies;**
- **Telecommunication networks;**
- **Wireless communications and broadcasting;**
- **Management and informatics in telecommunications and post.**

Institute of Mathematics and Informatics of Bulgarian Academy of Sciences is a research institute and has accreditation by the National Evaluation Agency to educate doctoral students in :

- **all areas of mathematics**
- **all areas of informatics**
- **the methodology of the education in mathematics and informatics**.

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Quality of service

Quality of service (QoS) is: “Totality of characteristics of a telecommunications service that bear on its ability to satisfy stated and implied needs of the user of the service” [ITU-T E.800, 1994].

- This is different from the “network performance”:

Network Performance

Network Performance: The ability of a network or network portion to provide the functions related to communications between users.

NOTE 1 – Network performance applies to the network provider's planning, development, operations and maintenance and is the detailed technical part of QoSO (QoS **O**ffered/planned by service provider).

NOTE 2 – Network performance parameters are meaningful to network providers and are quantifiable at the part of the network which they apply. [ITU-T E.800, 2008].

Our Object of Interest

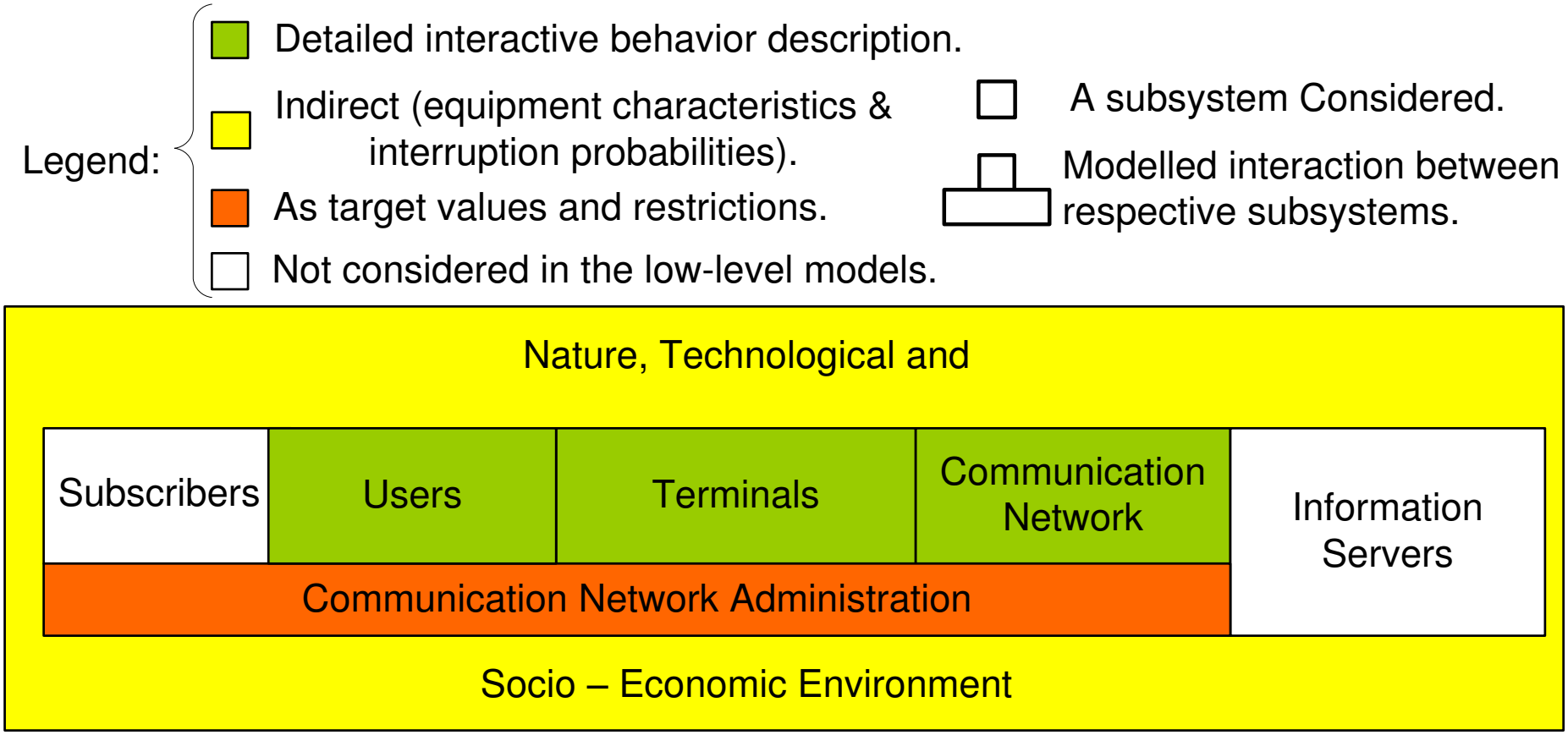


Figure 1. Reference Models on the Overall Telecommunication System Level

The End-to-end Network Approach

In the end-to-end approach, call/connections from a network head-point to a network end-point are considered, usually.

"End-to-End QoS consider the case when a SLA (Service Level Agreement) between an end user and a provider, for a connection passing through several SP (Service Provider) domains, is agreed. [ITU-T E.860, 2002].

”customizable end-to-end QoS services” are discussed in [ITU-T Y.1292, 2008]

“the fundamental challenges to achieving end-to-end QoS are present”, considering users, in [ITU-T Y.1542, 2010].

For end-to-end view of key assumptions in QoS-enabled mobile VoIP service, see [ITU-T Y.2237, 2010].

Based on these and [ITU-T E.800, 2008], [ITU-T Y.2173, 2008] and [ITU-T Y.1541, 2006], **users are indivisible part of end-to-end QoS concept.**

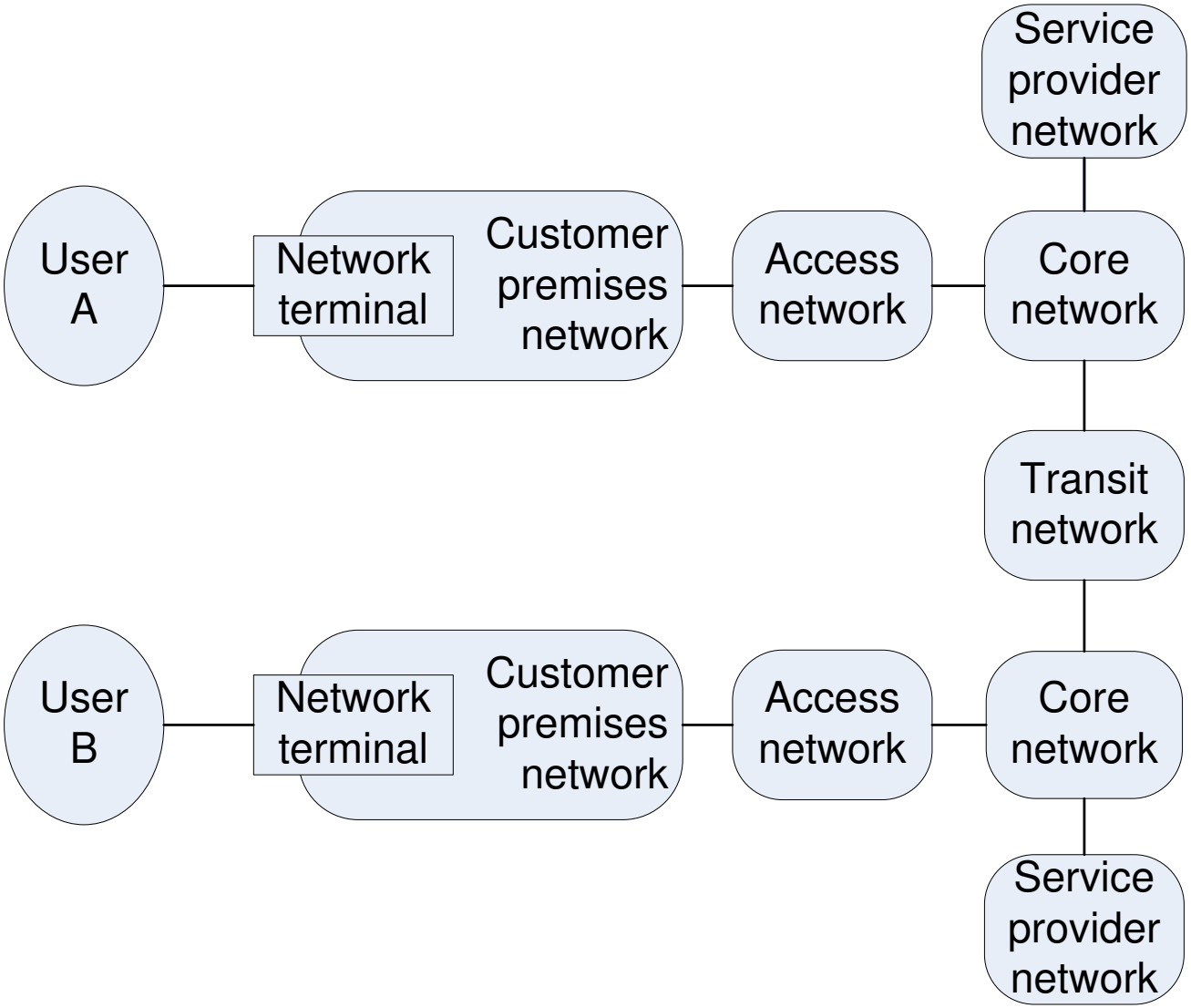


Figure 2. General reference model of contributions to end-to-end QoS.

Overall Telecommunication System Approach

Based on the expression in [ITU-T E.202, 1992]: "In principle, the design of future mobile systems should take into account, the overall end-to-end transmission performance on all realistic connections", we propose the following definition:

Definition: Overall telecommunication network performance includes network performance of all connections' attempts in an overall telecom network, from all access-network-head-points to all access-network-end-points, in the time interval considered.

- In our approach, the overall QoS parameters are aggregation of all end-to-end QoS parameters of all connections in the telecom system, in the considered time interval.

- We propose the following overall telecommunication system performance definition:

Definition: Overall **telecommunication system performance**, in the time interval considered, includes:

- all intended, suppressed and attempted connections, among all users/subscribers through the overall telecommunication network
- all intended, suppressed and attempted connections (not necessary telecommunication connections) between users/subscribers, from one side and network information servers, Network Service Providers and/or Network Administrations, from other side.

Generalized VNET with Overall QoS Guaranties (1/3)

Virtual network (VNET) is: “the set of traffic flows of the same class crossing a link that is governed by a specific set of bandwidth constraints.

VNET is used for the purposes of link bandwidth allocation, constraint-based routing, and admission control.

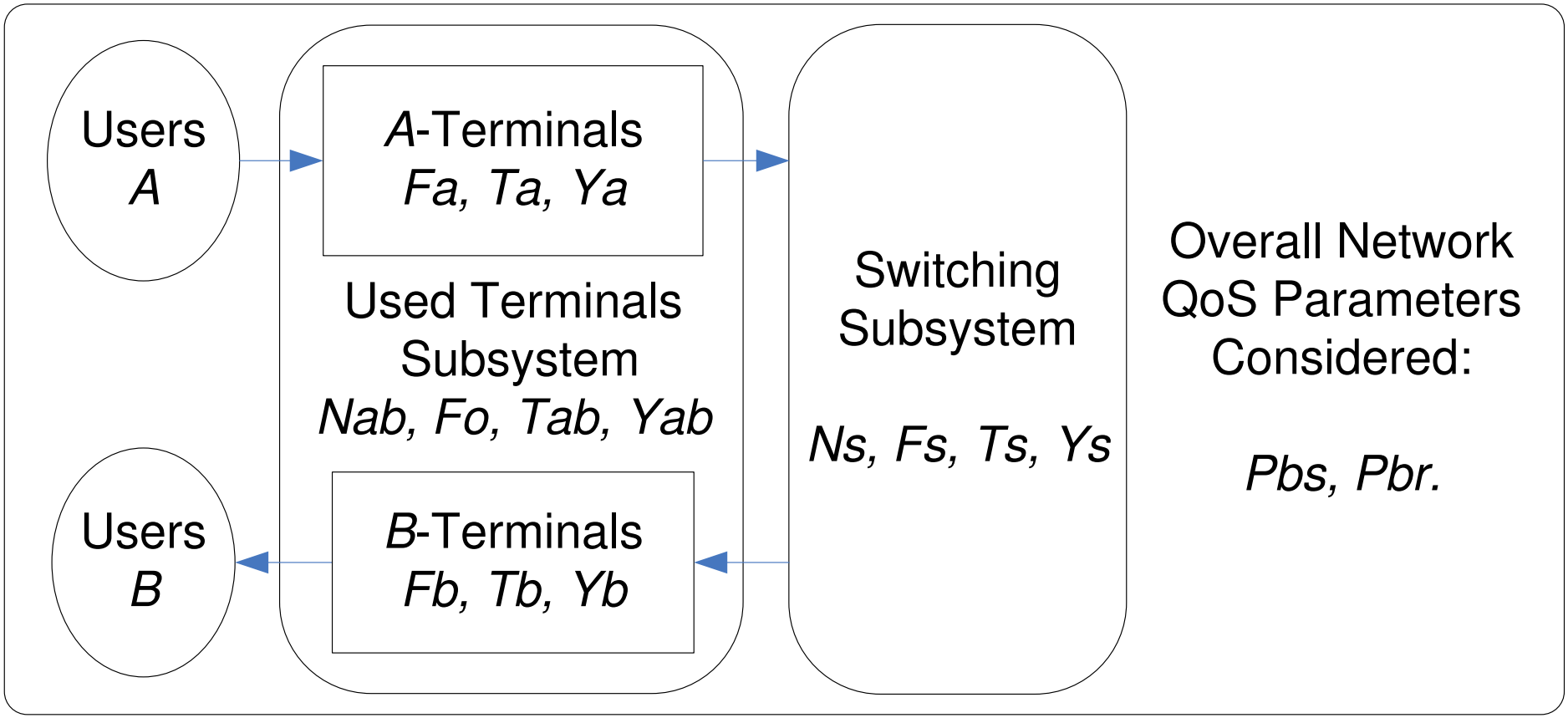
A given flow belongs to the same VNET on all links” [ITU-T E.361, 2003].

Generalized VNET with Overall QoS Guaranties (2/3)

- We consider VNET carrying Class 0 traffic - Real – time, jitter sensitive, high interaction (VoIP, Video Teleconference) [ITU-T Y.1541, 2006].

- The VNET is with virtual channels switching, following the main method for traffic QoS guaranties – resource reservation [ITU-T E.360.1, 2002].

Fig 3. Generalized VNET with Overall QoS Guaranties (3/3)

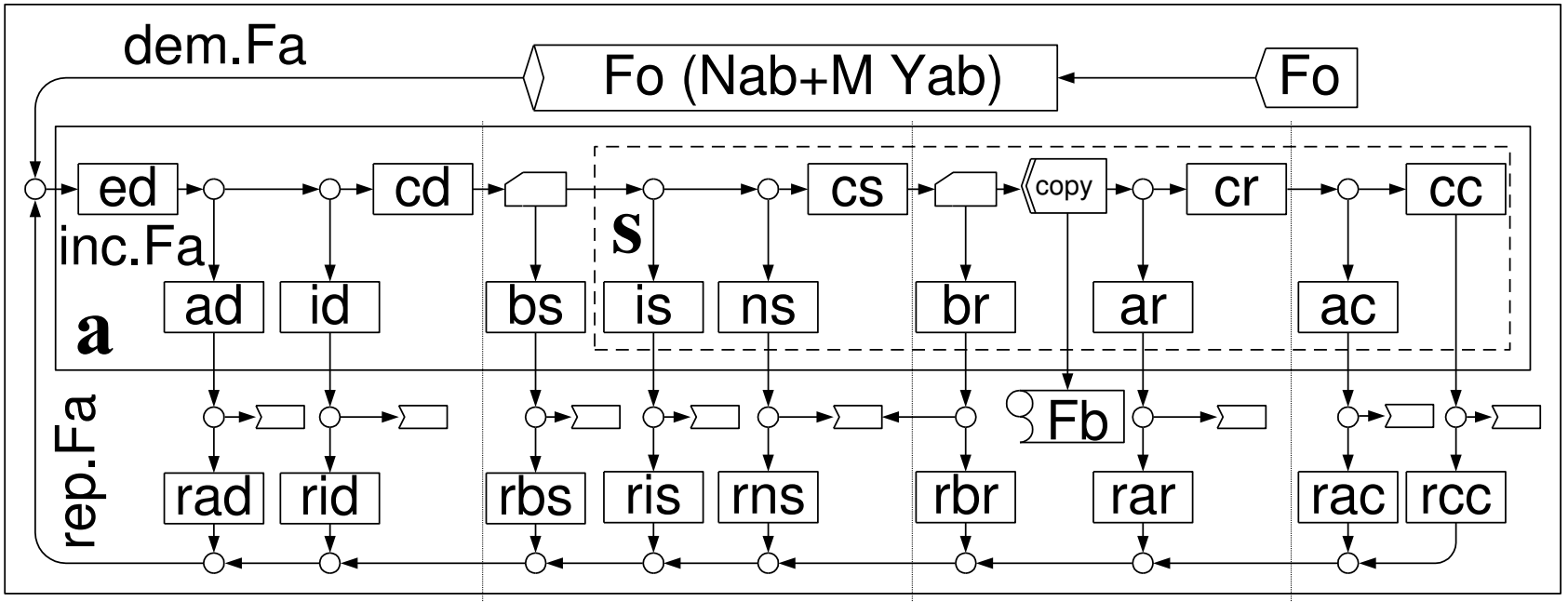


N = number of lines (servers) - capacity of the device;
F = frequency, (rate) of the requests' flow [calls/s];
T = mean service (holding) time [s];
Y = intensity of the device traffic [Erl].

Pbs = probability for blocking due insufficient resources;

Pbr = probability for blocking due busy intent B-terminal.

Fig 4. Detailed Conceptual Model of the system.

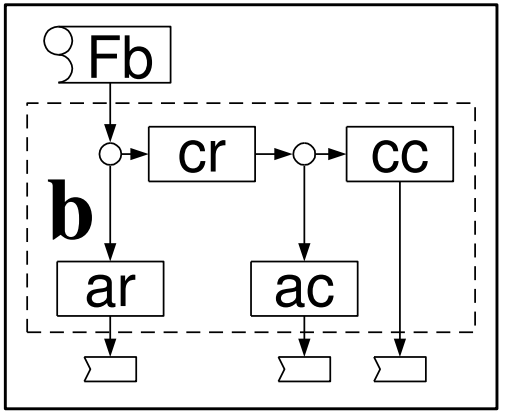


STAGE: **d**ialling; **s**witching; **r**inging; **c**ommunication.

BRANCH EXIT:
r = repeated;
t = terminated
= not considered.

BRANCH:
e = enter
a = abandoned;
b = blocked;
i = interrupted;
n = not available;
c = carried.

Generator;
Terminator;
Modifier;
Server;
Enter Switch;
Switch;
Fb Graphic Connector.



Virtual Device Name = <BRANCH EXIT><BRANCH><STAGE>

The QoS Prediction Task Formulation

After careful analysis and some assumptions (see below) we have chosen a base tuple with 41 parameters.

Values' origination parameters' classification:

1. **Human Behaviour** Parameters are 21: *Fo, Nab, Prad, Tid, Prid, Pris, Tis, Pns , Tns , Prns, Tbs, Prbs, Tbr, Prbr, Par, Tar, Prar, , Tcr, Prac, Tcc, Prcc*;
2. **Technical Characteristics** Parameters are 4: *Pid, Pis, Tcs*, *Ns*;
3. **Mix Factors'** Parameters are 6: *Ted, Pad, Tad, Tcd, Pac, Tac*;
4. **Modeler Chosen** Values Parameter (1): *M (BPP – model)*;
5. **Derived Parameters** from the previous four groups are 9: *Yab*, *Fa, dem.Fa, rep.Fa, Pbs, Pbr, ofr.Fs*, *Ts, ofr.Ys*

The QoS Prediction Task Formulation (cont.)

Static and Dynamic Parameters' Classification

For the static parameters we assume that their values don't depend on the state of the system and correspondingly on the intensity of the input flow.

The 31 static parameters are: *M* ; *Nab*; *Ns*; *Ted*; *Pad, Tad, Prad, Pid, Tid, Prid, Tcd, Tbs, Prbs, Pis, Tis, Pris, Pns, Tns,Tcs, Prns, Tbr, Prbr, Par, Tar, Prar,Tcr, Pac, Tac, Prac, Tcc, Prcc*.

The 10 dynamic parameters, with mutually dependent values are: *Fo Yab, Fa, dem.Fa, rep.Fa, Pbs, Pbr, ofd.Fs, Ts, ofd.Ys*.

FINDING TERMINAL TELETRAFFIC'S PARAMETERS

The QoS Prediction Task formulation: We consider the full telecommunication system conceptual model, presented in Fig. 3. **Parameters with known values** are all the ***P*** (probability for call direction) and ***T*** (holding time) parameters of the base virtual devices, plus values of the intensity of incoming calls flow (***Fa***). **Parameters with unknown values** are those of the comprising devices, except ***Fa*** and ***Nab***.

The task is to find analytically the unknown parameters' values of the devices ***a*** (A-terminals), ***b*** (busy B-terminals), ***ab*** (all the simultaneously busy terminals); ***Pbs*** and ***Pbr***.

The ITU-T offered traffic definitions in force:

ITU-T Recommendation E.600: **offered traffic**: The traffic that would be carried by an infinitely large pool of resources.

ITU-T Recommendation E.501: In the lost call model the **equivalent traffic offered** (*ofr.Ys*) corresponds to the traffic which produces the observed carried traffic (*crr.Ys*) in accordance with the relation (*Pbs* is the call congestion through the part of the network considered, consists of *Ns* (switching) circuits):

$$crr.Ys = ofr.Ys\,[1 - Pbs].$$

$$crr.Ys = ofr.Ys\,[1 - Erl\_b(Ns, ofr.Ys)].$$

Despite computational and value differences, there is no distinguishing of usage between "***equivalent traffic offered***" and *"**traffic offered**"* in ITU-T recommendations, except in [E.501], recommending how to estimate values accordingly the both definitions.

In the analytical models, we use "equivalent traffic offered" definition.

Main Equations (1)

$$Yab = Fa\,[S_1 - S_2\,(1 - Pbs)\;Pbr - S_3\;Pbs],$$

$$Fa \;=\; dem.Fa + \;rep.Fa.$$

$$dem.Fa = Fo\,(Nab + MYab)$$

$$rep.Fa = Fa\,[R_1 + R_2 Pbr\,(1 - Pbs) + R_3 Pbs]$$

$$Pbr = \begin{cases} \dfrac{Yab - 1}{Nab - 1} & , \text{ако} \quad 1 \le Yab \le Nab, \\ 0 & , \text{ако} \quad 0 \le Yab < 1. \end{cases}$$

Main Equations (2)

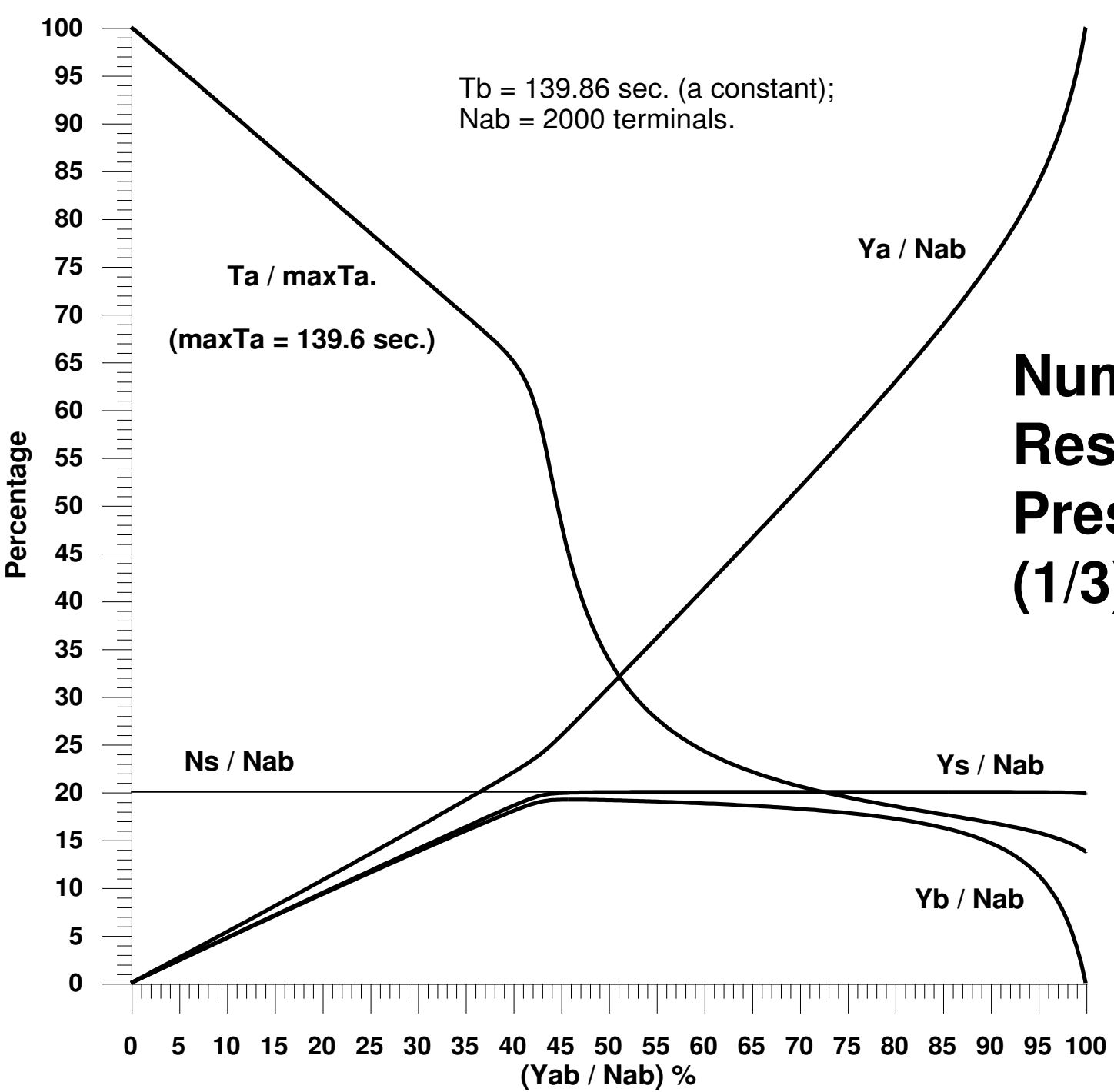
$$Ts = S_{1Z} - S_{2Z}\ Pbr$$

$$ofr.Fs = Fa\,(1 - Pad)(1 - Pid)$$

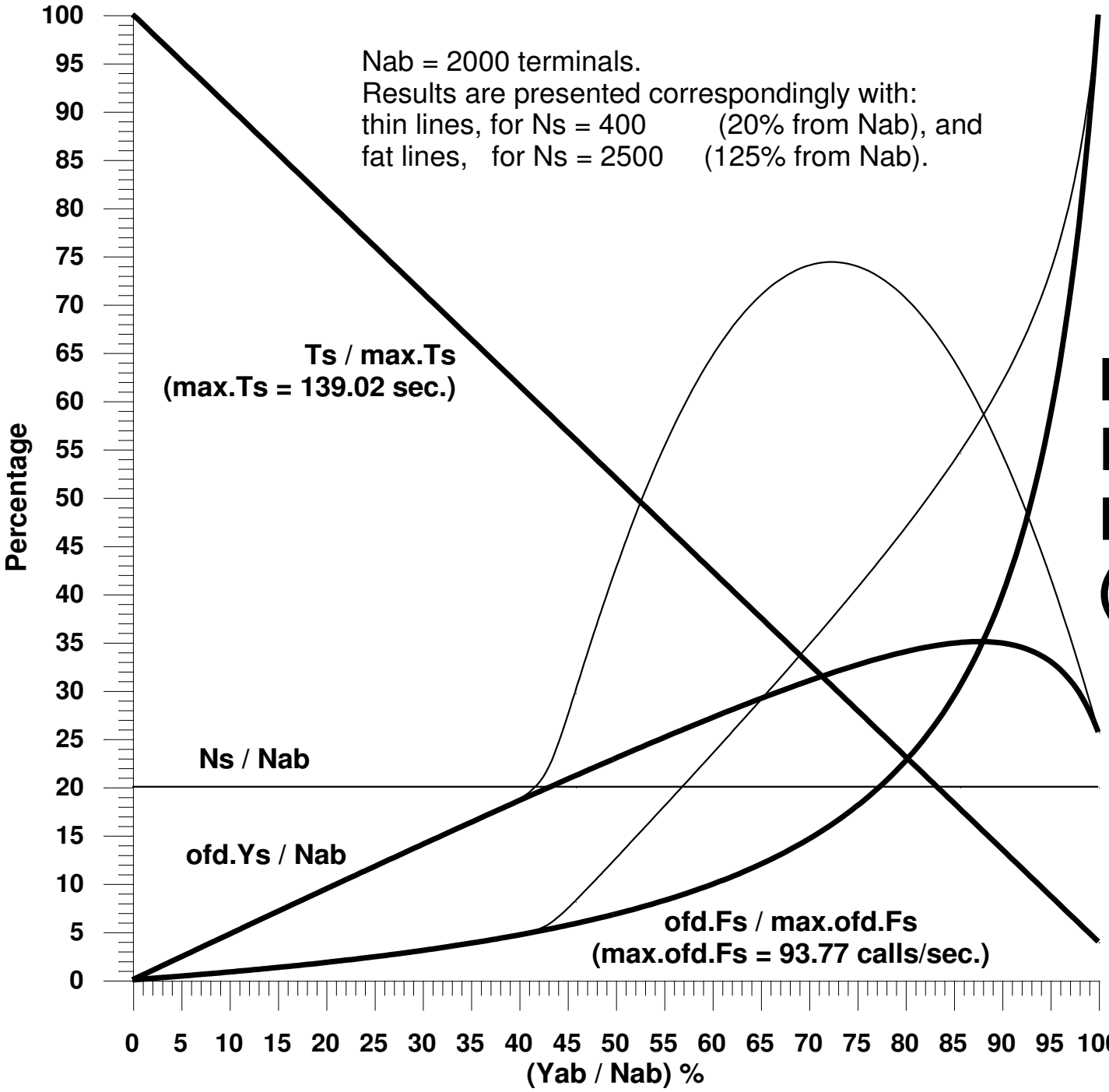
$$ofr.Ys = ofr.Fs\,Ts$$

$$crr.Ys = (1 - Pbs)\ ofr.Ys$$

$$Pbs = Erl\_b(Ns, ofr.Ys) = \frac{\frac{(ofr.Ys)^{Ns}}{Ns!}}{\sum_{j=0}^{Ns} \frac{(ofr.Ys)^{j}}{j!}}$$



Numerical Results Presentation (1/3).



Numerical Results Presentation (3/3).

Conclusions

We have abilities for overall telecommunication network's traffic modelling and prediction, in case of QoS quaranties.

Such models may be useful for:

- Network planning, dimensioning and re-dimensioning;
- Trade-off between prices and traffic load modelling.

THANK YOU

Questions and remarks are welcome

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