Price/quality integrated modelling of cloud-based composite services performance

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Content

Service Networks (SNs)

- Service-centric webs emerging through the composition of cross-organizational applications
- Steady, but open set of complementary and interchangeable services, which can be composed to form ad-hoc demand-driven complex services.
- Allow reusability of loosely coupled services in transparent compositions
- With distributed administrative control across different service providers (SPs)
- Possibilities for composing a complex service on the basis of existing services offered by different SPs
  - Services with <u>matching</u> input and output parameters can be combined in more complex service compositions
  - Services with <u>equal</u> input and output parameters can be interchanged and are considered as competitors in the network.

Modelling approaches

- In the **context** of a SN with multiple service consumers and multiple SPs interacting via a web-based Software-as-a-Service (SaaS) platform with multiple applications.
- 3 types:
  - business-oriented
  - technical
  - integrated

Business-oriented modelling approaches

- Focus on the business domain, including disciplines like marketing or organizational studies.
- Mainly interested in analysing the value generation resulting from the provisioning of value-added business capabilities.
- Main focus: economically motivated collaboration between legally independent business entities used for the purpose of calculating the profit from a business collaboration on the process level.

Technical modelling approaches

- SN is an open set of interconnected services.
- Main goal: support for proper encapsulation of the application logic into highly reusable and composite services on the infrastructure level.
- Analysis of interactions between the services on the service level is of highest relevance.

Integrated modelling approaches

- Consider the value-creation process in SNs as the result of the balanced collaboration between business and technical entities.
- Highest priority: understanding the relations between a business entity on the business level and its technical match on the service level.

Existing models

	Business				Technical		Integrated		
	A	B	C	D	E	F	G	H	I
Stakeholder perspectives	0	-	-	-	-	-	-	+	-
Heterogeneous entities	-	0	+	+	-	0	+	+	+
Heterogeneous relationships	0	0	+	0	+	+	+	+	-
Technology independent orientation	+	+	+	+	+	+	-	-	-
Model customization	-	-	+	-	-	-	-	+	-
Human and machine processing	-	-	-	+	+	-	-	-	-

- A (*Allee*)
- B (*Gordijn*)
- C (*Danylevych*)
- D (*Scholten*)
- E (Cardoso)
- F (*Blau*)
- G (*Schulz)*
- H (*Liu*)
- I (*Wang*)

Source: “Service Network Modeling Approaches: Overview, Classification, and Analysis” by A. Kabzeva, J. Gotze, and P. Muller, presented at 2014 40th Euromicro Conference on Software Engineering and Advanced Applications.

Existing models (cont.)

	Business				Technical		Integrated		
	A	B	C	D	E	F	G	H	I
Consumer-oriented	o	-	-	-	-	+	-	+	-
Provider-oriented	o	-	-	-	-	-	-	+	-
Operator-oriented	-	-	-	+	-	-	+	+	-

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Existing models (cont.)

	Business				Technical		Integrated		
	A	B	C	D	E	F	G	H	I
Physical entity	+	+	+	+	-	+	-	+	0
Business process	-	-	-	-	-	-	-	-	0
Business task	-	+	+	-	-	-	-	-	0
Contract	-	-	+	-	-	-	+	-	-
Lifecycle activity	-	-	-	+	-	-	-	-	-
Service	-	-	-	-	+	+	+	+	+
Service composition	-	-	-	-	-	0	+	-	0

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2. Considered Service System – Top Level Conceptual Model

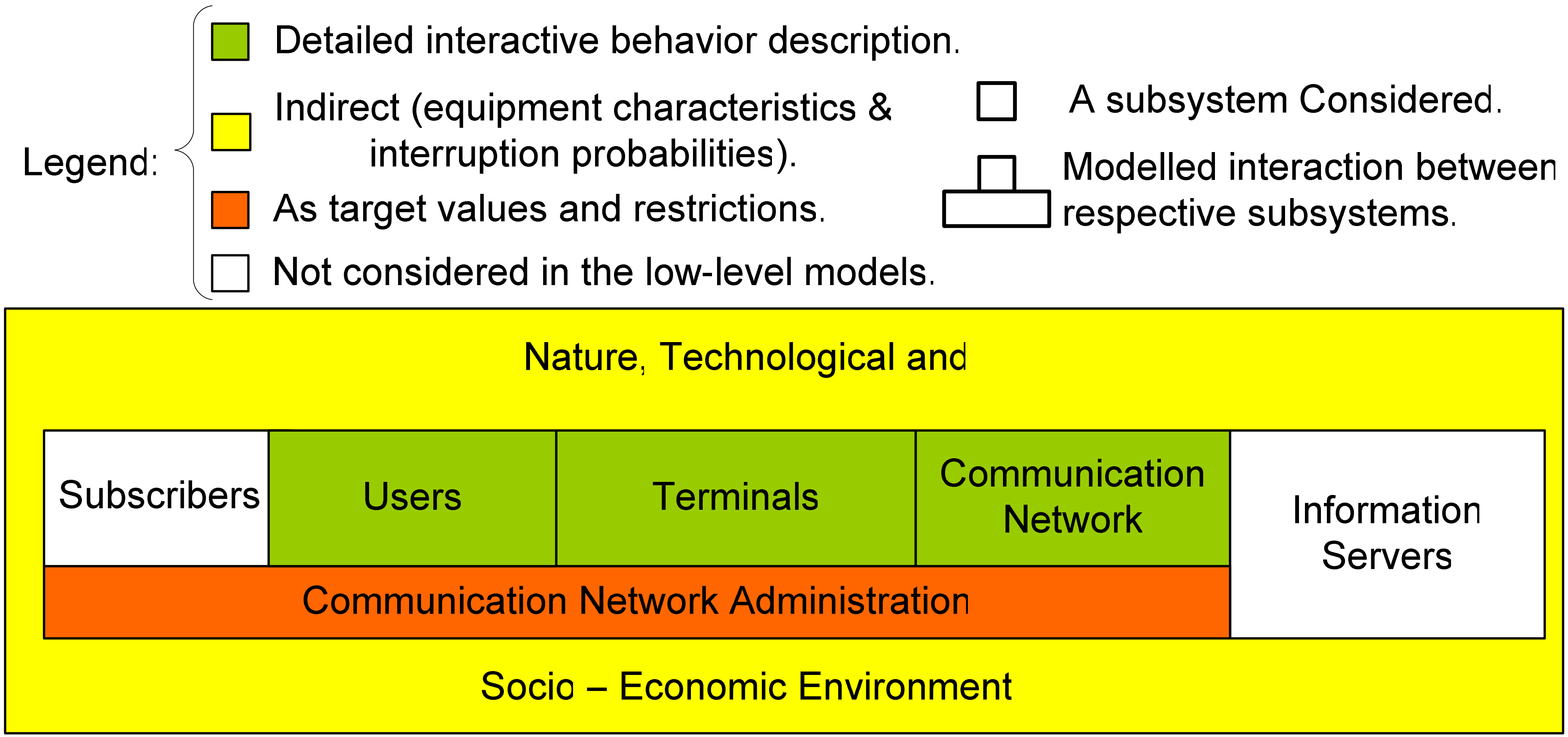


Figure 1. Reference Models on the Overall Telecommunication System Level

3.Overall versus end-to-end approach (1/2)

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].

3. Overall versus end-to-end approach (2/2)

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

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.**

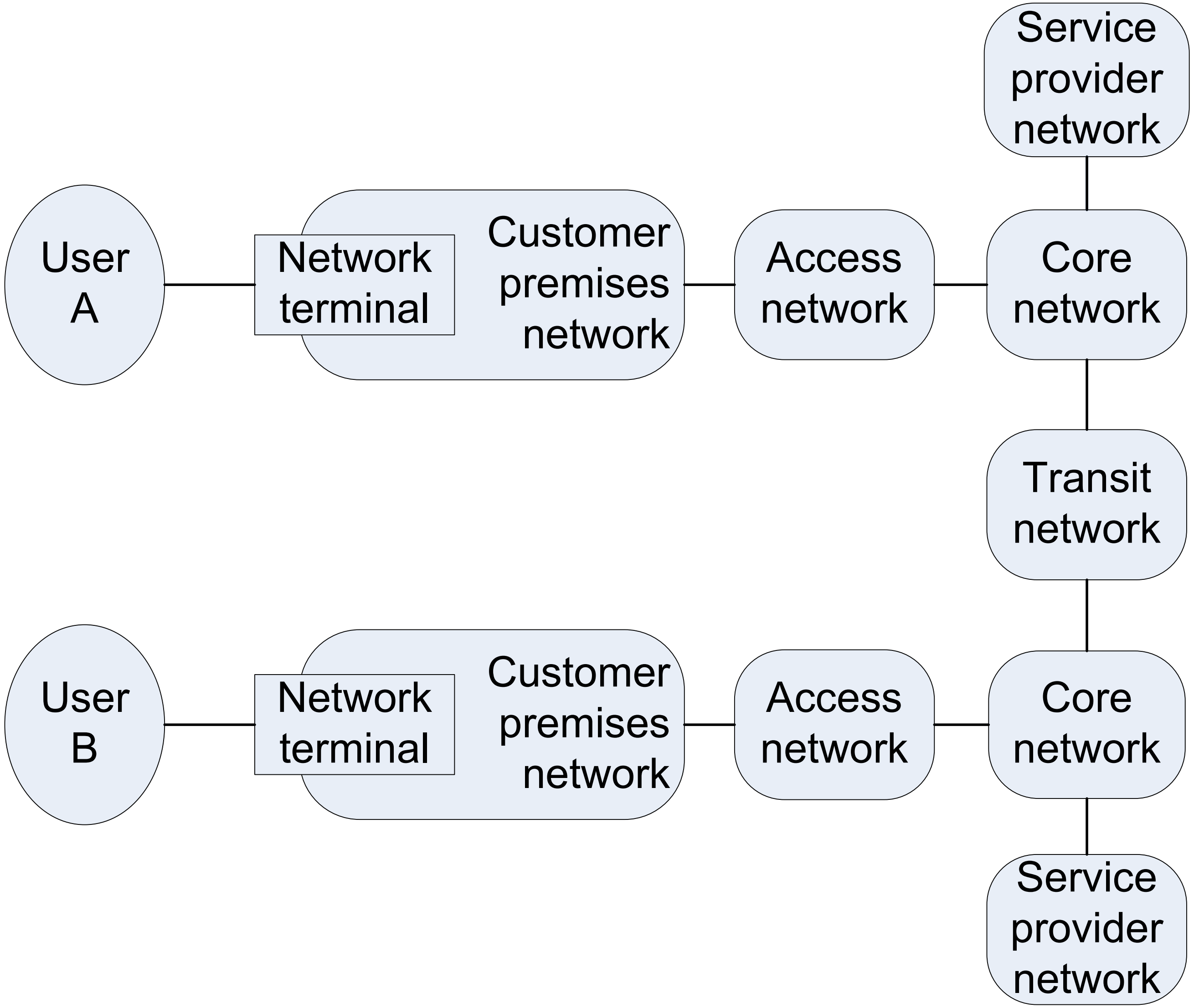


Figure 2. General reference model of contributions to end-to-end QoS [Poryazov, Saranova, 2011] .

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.

Overall Telecommunication System Approach

- 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:

[Poryazov, Saranova, 2011] S. Poryazov, E. Saranova. Overall QoS Referencing in Telecommunication Systems – Some Current Concepts and Open Issues. Int.J. “Information Technologies and Knowledge” , Vol.5, No.4, ITHEA, 2011, pp. 424-452.ISSN: 1313-0455

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

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

4. Generalized VNET with Overall QoS Guaranties (1/2)

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].

4. Generalized VNET with Overall QoS Guaranties (2/2)

- 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].
- We consider parameter values of a system in stationary state (observed interval duration: from 15 min to 1 hour).

5. Overall Service Network Performance Prediction Model: General Input-Output (1/2)

General Input 1: Users Behavior Parameters

- Number of Users;
- Calls frequency from a user;
- Probability for call attempt abandoning;
- Probability for unsuccessful call attempt repetition;
- Probability of B-party absence;
- Durations of communication, signals reception, etc.

General Input 2: Technical Characteristics

- Network Capacity;
- Duration of switching;
- Probability of Interruption, etc.

5. Overall Service Network Performance Prediction Model: General Input-Output (2/2)

General Output 1: Predicted QoS Parameters

- Probability of Call Attempt Blocking (Pbs), due to insufficient Network Capacity;
- Probability of Call Attempt Blocking, due to B-terminal busy;
- Network Call Efficiency (Ec);
- Network Time Efficiency;
- Network Traffic Efficiency.

General Output 2: Predicted Relative Financial Indicators

- Relative Primary Price of Network Traffic Intensity (new);
- Cost/Quality Ratio (new).

6. QoS – QoE Indicator Conversion Function (1/2)

•For each indicator, we use specific Conversion Function with input: the Indicator Value, and output: predicted Perceived Quality Value.

•Conversion Function uses Weber-Fechner's Law in the form:

$$P = A + B\,Log(S+C),$$

where *P* is perception, *S* - stimulus, *A, B* and *C* are constants.

6. QoS – QoE Indicator Conversion Function (2/2)

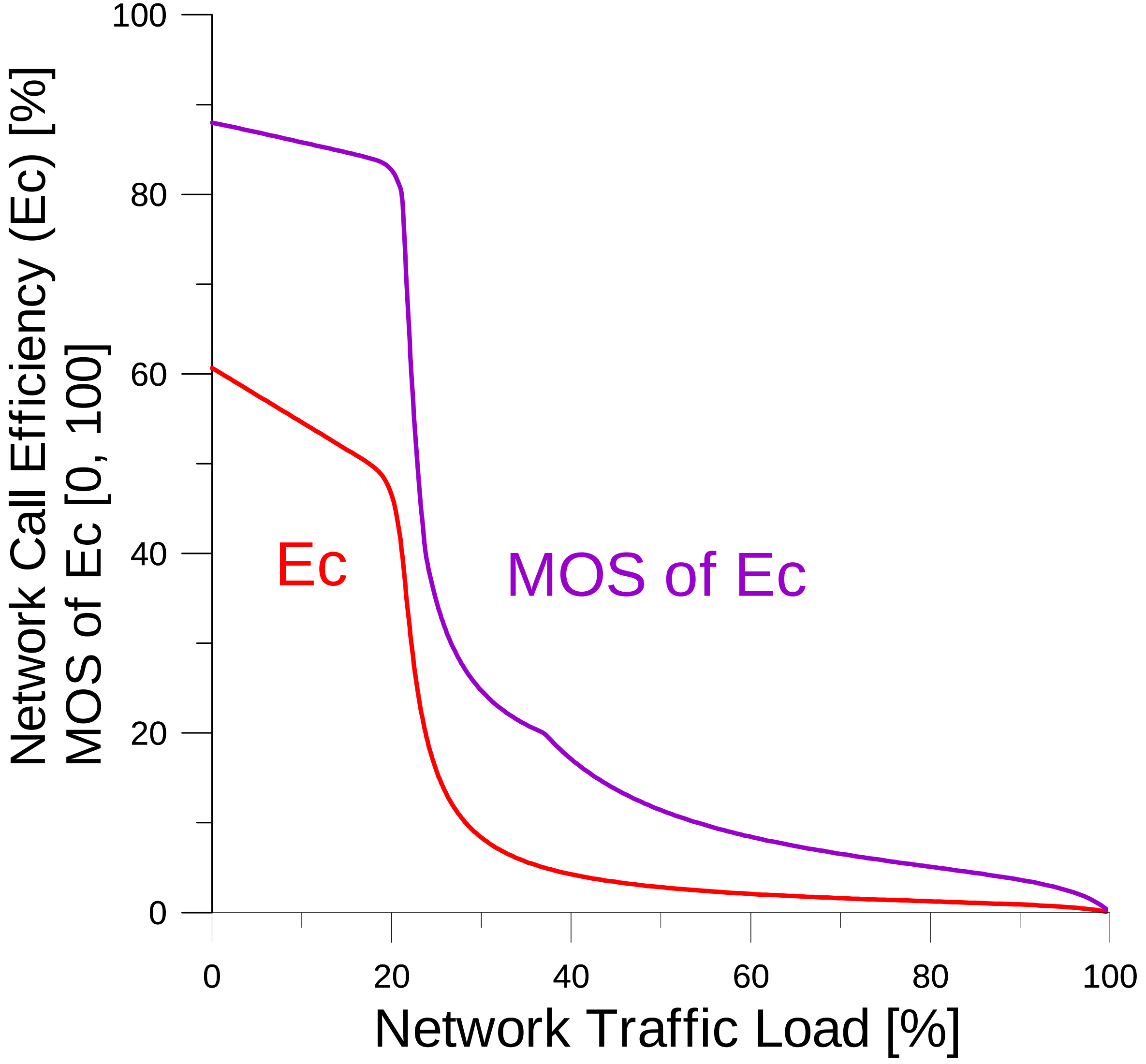
- Predicted Perception is in extended MOS values :

Norm. MOS Value	Ext. MOS Value	Quality
100	5	Excellent
80	4	Good
60	3	Fair
40	2	Poor
20	1	Bad
0	0	No Service

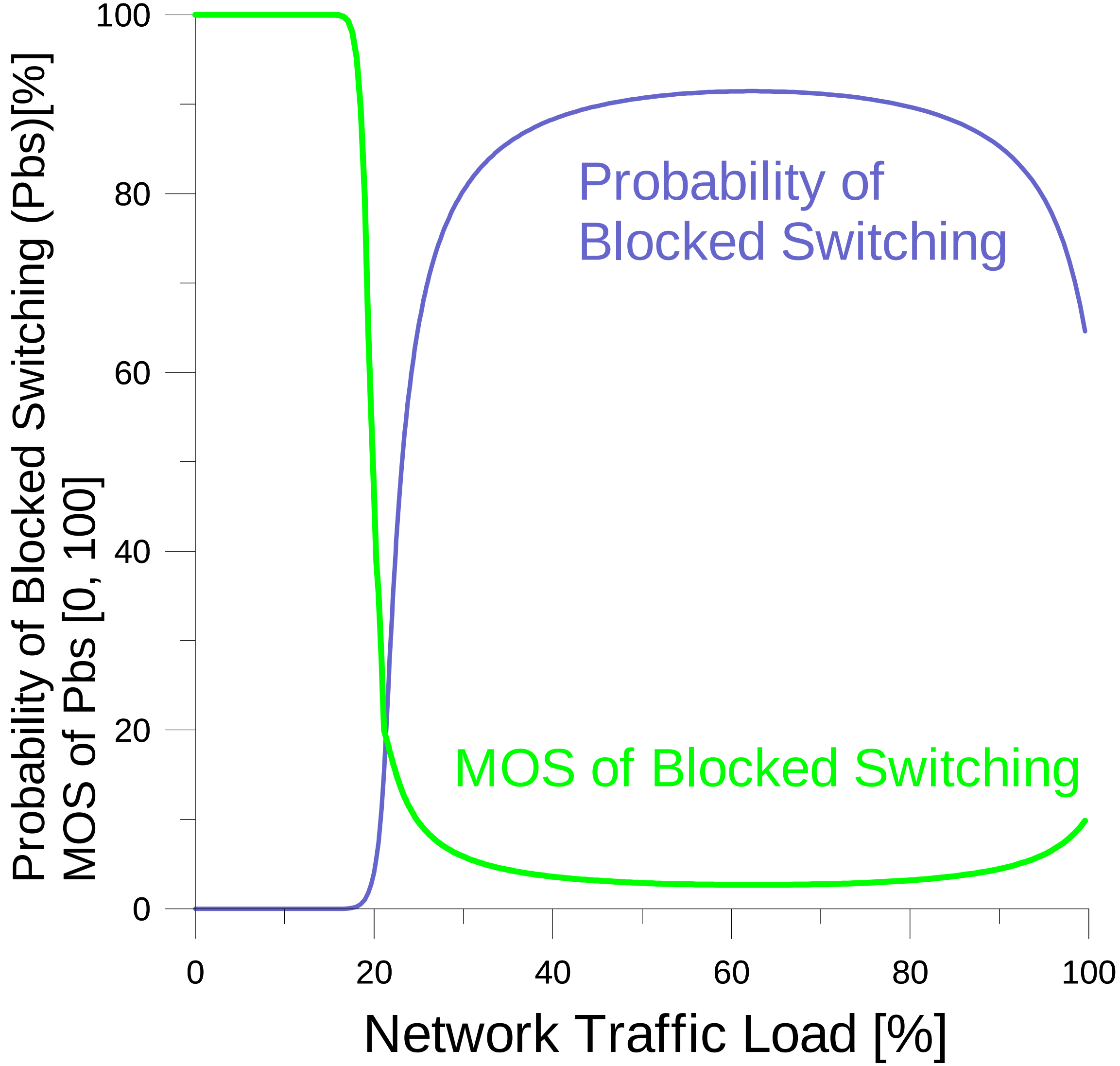
[Wang at al 2014] Zhengyou Wang, Liying Li, Wan Wang, Zheng Wan, Yuming Fang, Cong Cai. A Study on QoS/QoE Correlation Model in Wireless-network. 978-616-361-823-8 © 2014 APSIPA

- The Predicted MOS values are continuous;
- The normalization of the Predicted Perception in [0, 100] allows it's presentation together with QoS indicators.

Network Call Efficiency and its MOS



Blocked Switching (Pbs) and MOS of Pbs



7. Relative Primary Price of Network Traffic Intensity (1/3)

Network Costs Intensity = NCI

$$NCI = \frac{Mean\ Network\ Full\ Cost}{Mean\ Interval\ Between\ Payments}$$

Network Traffic Intensity Primary Price = NTIPP

$$NTIPP = \frac{Network\ Costs\ Intensity\ (NCI)\ [Euro]}{Paid\ Network\ Traffic\ \ Intensity\ [Erlang]}$$

7. Relative Primary Price of Network Traffic Intensity (2/3)

$$NTIPP = \frac{Network\ Costs\ Intensity\ (NCI)\ [Euro]}{Paid\ Network\ Traffic\ \ Intensity\ [Erlang]}$$

$$\frac{NTIPP}{NCI} = \frac{1}{paid.Y} = RPPNT$$

RPPNT = Relative Primary Price of Network Traffic Intensity

7. Relative Primary Price of Network Traffic Intensity (3/3)

RPPNT = Relative Primary Price of Network Traffic Intensity

- RPPNT means : The primary price of one paid erlang, as a part of the Network Cost Intensity (*NCI*).

- It is independent from the absolute Service Provider's expenditures;

- It depends of Network Performance and Network Administration Policy.

8. Cost/Quality Ratio

Cost/Quality = RPPNT / Ec,

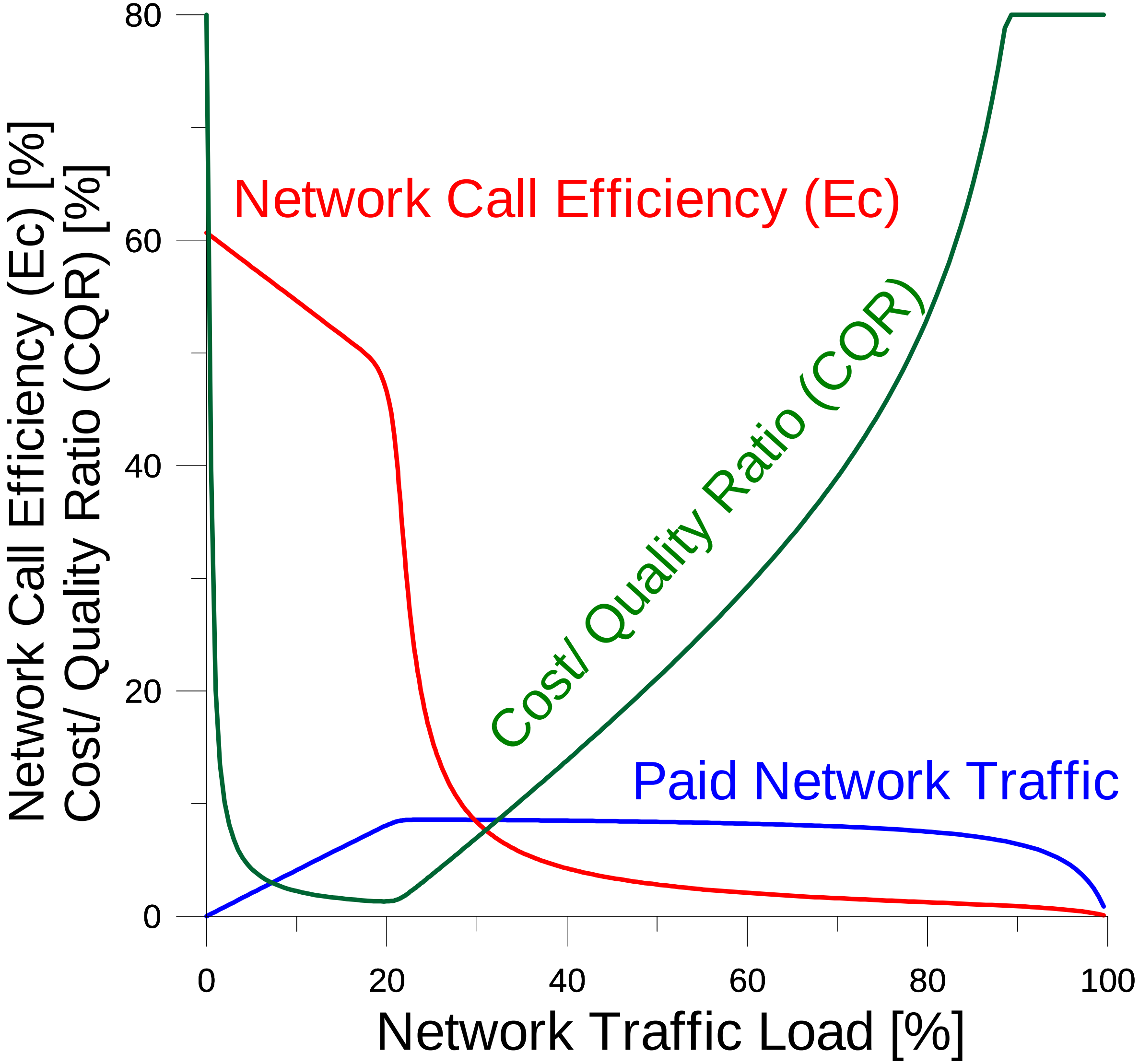
Ec = Network Call Efficiency =
successful call attempts/ all call attempts.

Ec = (1-Pad)(1-Pid)(1-Pbs)(1-Pis)(1-Pns)(1-Pbr)(1-Par)(1-Pac).

(An example QoS of service composition!)

In the following numerical examples, paid traffic is the Successful Communication Traffic (of the A-party, paid B-traffic and the price of the transferred information are not considered).

Cost/ Quality Ratio



Conclusion and Open Issues

1. An integrated Network Performance Model, including human factors and technical characteristics, and allowing prediction of QoS and QoE values of key indicators is proposed;

2. The results allow prediction of quality of the Service Network, providing composite services;

Conclusion and Open Issues

3. The predicted values include:

- Primary Price of the one paid erlang, from Service Providers' point of view;
- Cost/Quality Ratio;
- MOS of the main QoS indicators, from the users' point of view.

4. Some QoS indicators are not monotonic functions from the network load.

Conclusion and Open Issues

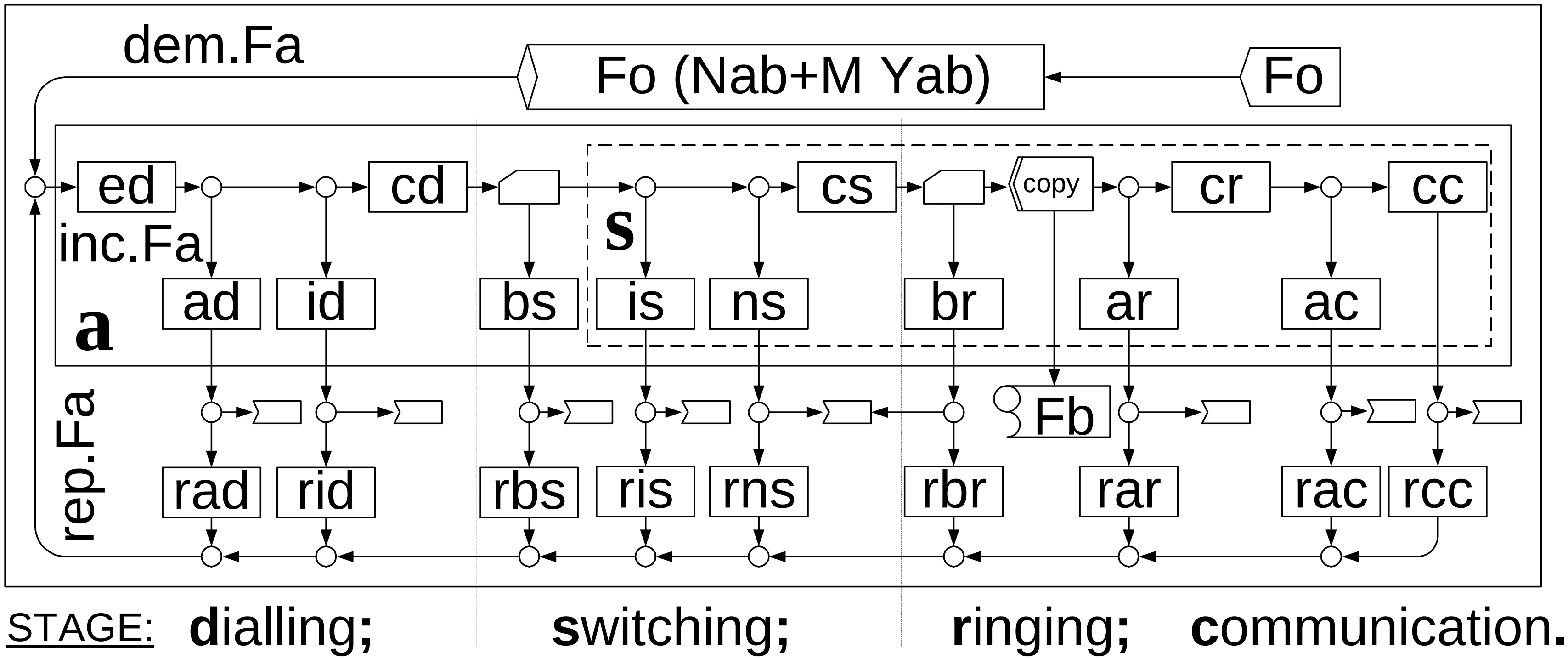
5. Quality of composite services depends from time-space service structure, as well as from service importance;

6. The influence of QoE on the QoS is for further study, because it depends from many not-formalized factors, e.g. local culture, advertising etc.

THANK YOU

Questions and remarks are welcome

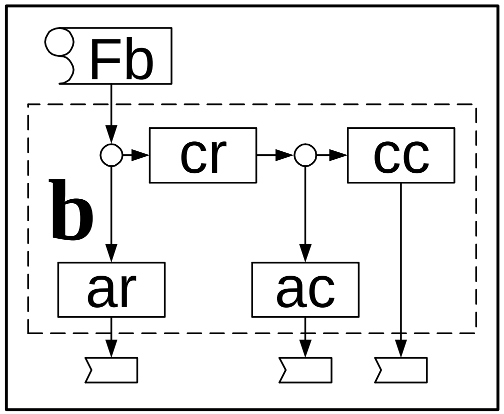
Detailed Conceptual Model of the system.



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*.

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 <u>of the base virtual devices</u>, 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***.

Main Equations (1)

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

$$Fa = dem.Fa + rep.Fa.$$

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

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

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

Main Equations (2)

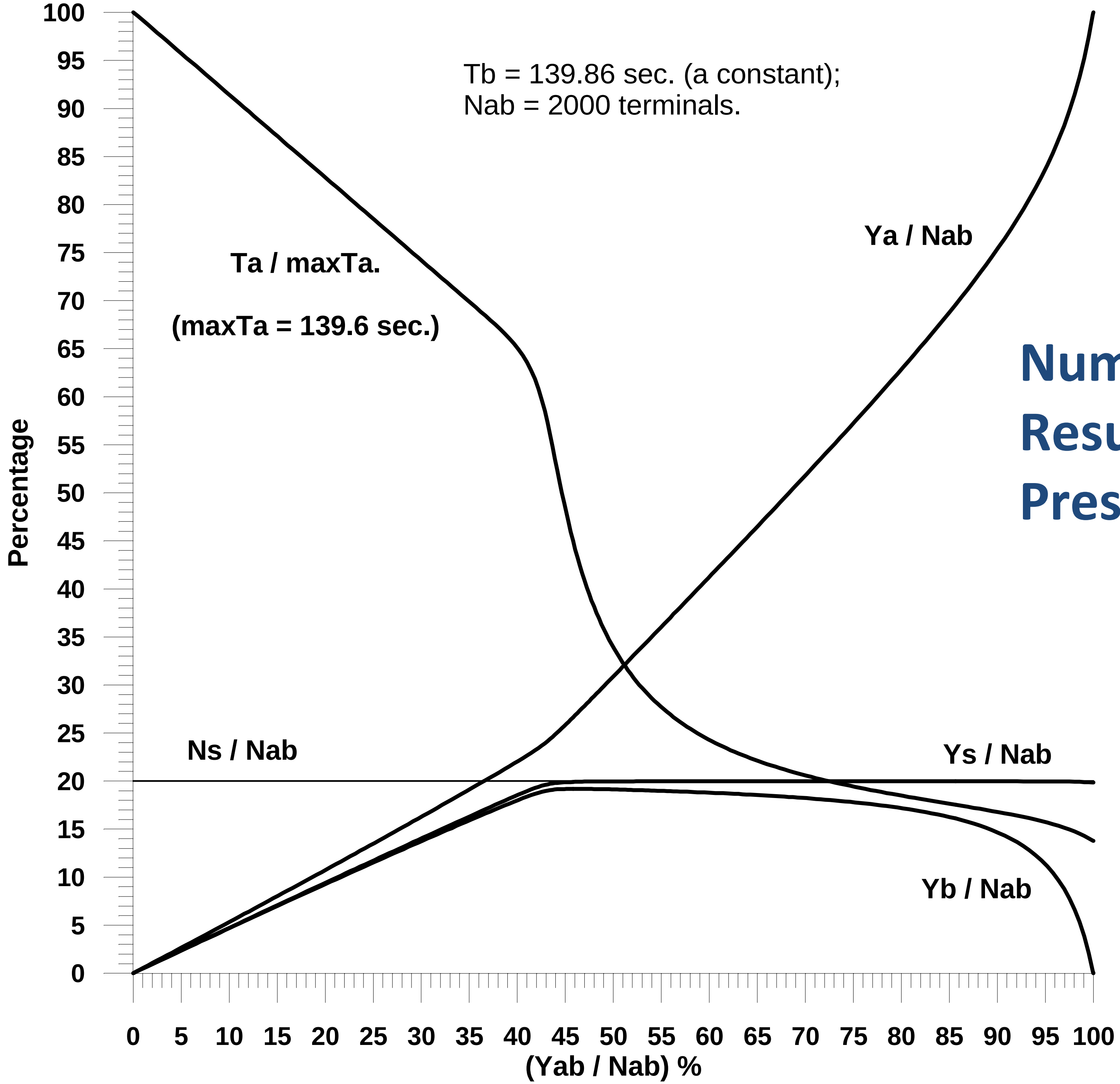
$$Ts = S_{1Z} - S_{2Z}\ Pbr$$

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

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

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

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



Numerical Results Presentation.