ITU Kaleidoscope 2014

Living in a converged world - impossible without standards?

Modelling and Performance Analysis of Pre-emption Based Radio Admission Control Scheme for Video Conferencing over LTE

Ekaterina Markova
Peoples' Friendship University of Russia
emarkova@sci.pfu.edu.ru

Saint Petersburg,
Russian Federation

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Vladimir Y. Borodakiy

JSC "Concern Sistemprom",

Moscow, Russia

bvu@systemprom.ru

http://systemprom.ru

Konstantin E. Samouylov,

Irina A. Gudkova,

Ekaterina V. Markova

Telecommunication Systems Department,

Peoples' Friendship University of Russia,

Moscow, Russia

{ksam,igudkova,emarkova}

@sci.pfu.edu.ru

http://www.telesys.pfu.edu.ru

http://www.rudn.ru/en

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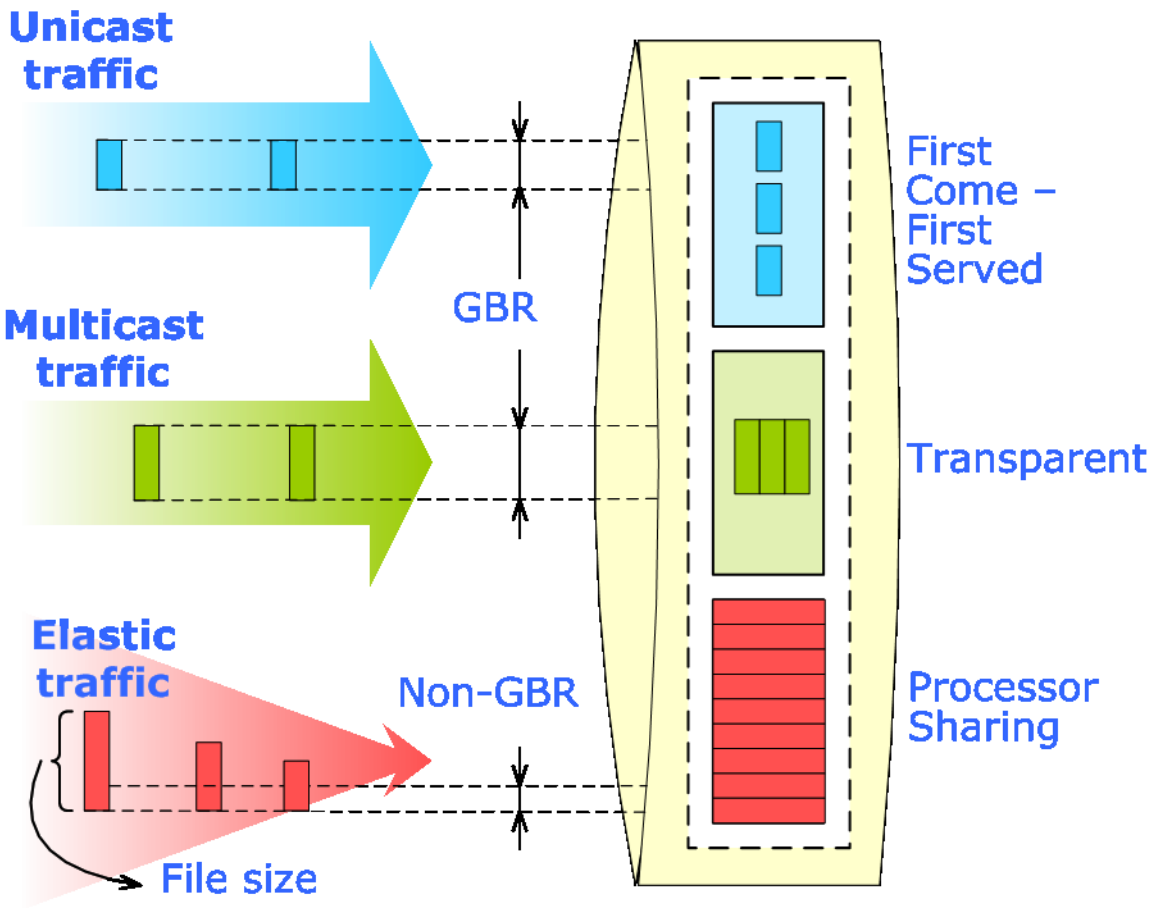
LTE Services and Traffic Types

Bit rate	Priority	Exam
GBR	2	Voic
	4	Vide
	3	Real t gami
	5	Strean vide
Non-GBR	1	Signal
	6,7,8,9	TCP-ba applica



- **3GPP TS 23.203**: Policy and charging control architecture: Release 12. – 2014

Background & Teletraffic of Multiservice Loss Networks

Unicast

- F. Kelly, K. Ross, V. Iversen
- Product form solution
- Kaufman-Roberts recursion

Multicast

- J. Virtamo, O. Martikainen, K. Samouylov, Y. Gaidamaka
- Product form solution
- Recursive algorithm

Elastic

- T. Bonald, M. Logothetis, G. Basharin, I. Gudkova
- Product form solution
- Recursive algorithm

Unicast & Multicast

- K. Boussetta, A.-L. Beylot, J. Virtamo, K. Samouylov, Y. Gaidamaka
- Product form solution
- Recursive algorithm

Unicast & Elastic

- J. Roberts, E. Altman, O. Boxma
- No product form solution
- Approximate methods

Unicast, Multicast & Elastic (Triple Play)

- G. Basharin, K. Samouylov, I. Gudkova
- No product form solution
- Approximate methods

Radio Admission Control in LTE

Higher priority service (*pre-emption capable*) can get resources that were already assigned to lower priority services (*pre-emption vulnerable*)

RAC schemes

- *Partial pre-emption (service degradation)*

Pre-emption capable service partially gets resources assigned to one or more pre-emption vulnerable services (degrades services = lowers its bit rate)

- *Full pre-emption (service interruption)*

Pre-emption capable service fully gets resources assigned to one or more pre-emption vulnerable services (interrupts services)

Teletraffic Models + RAC =
- ***Unicast & Multicast***
  - No product form solution
- ***Unicast & Elastic***
  - Product form solution

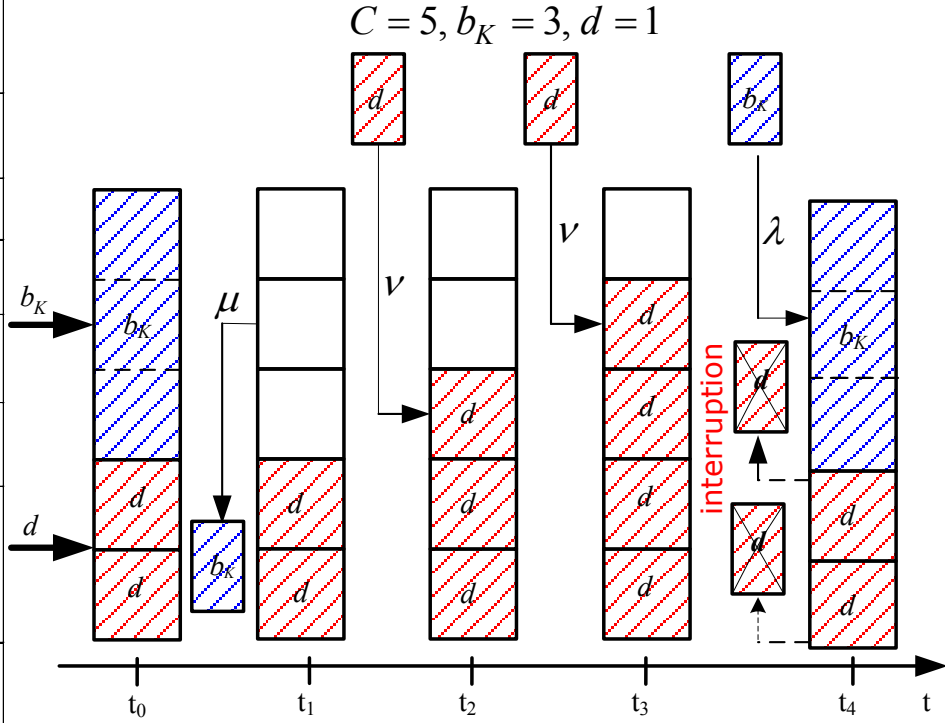
- **3GPP TS 23.203**: Policy and charging control architecture: Release 12. – 2014

RAC Model for Unicast and Multicast Services

	pre-emption capable	*pre-emption vulnerable*
video conference, VC (multicast)	Yes (interrupt VoD)	Yes (degraded by VoD)
video on demand, VoD (unicast)	Yes (degrade VC)	Yes (interrupted by VC)

Notation	Parameter
C	Downlink peak bit rate, bps
λ, ν	Arrival rates of requests for VC and VoD services, 1/s
μ^{-1}, κ^{-1}	VC and VoD service times, s
$d = 1$	Bit rate for VoD service, bps
$b_1 > \ldots$ $\ldots$	Bit rates for VC service, bps
$n \in \{0,1,\ldots,\lfloor C/d \rfloor\}$	Number of VoD users
$\mathbf{m} = (m_1,\ldots,m_k,\ldots,m_K)$	State of a multicast VC session
$m_k = 1$	Session is active - VC service is provided at least to one user on bit rate b_k
$m_k = 0$	Session is not active - VC service is not provided to users on bit rate b_k

Example of service interruption



Performance Measures

State space

$$\mathrm{X} = \left\{ (\mathbf{0}, n), 0 \le n \le C,\ (\mathbf{e}_1, n), 0 \le n \le C - b_1,\ (\mathbf{e}_k, n), C - b_{k-1} < n \le C - b_k, k = \overline{2, K} \right\}$$

Blocking probability for video on demand

$$B = p(\mathbf{0}, C) + p(\mathbf{e}_K, C - b_K)$$

Interruption probability for video on demand

$$\Pi = \sum_{n=C-b_K+1}^{C-1} \frac{\lambda}{\lambda + \nu + n\kappa} \frac{C_{n-1}^{b_K-(C-n)-1}}{C_n^{b_K-(C-n)}} p(\mathbf{0}, n) + \frac{\lambda}{\lambda + C\kappa} \frac{C_{C-1}^{b_K-1}}{C_C^{b_K}} p(\mathbf{0}, C)$$

Mean bit rate for video conference

$$\bar{b} = \frac{b_1 \sum_{n=0}^{C-b_1} p(\mathbf{e}_1, n) + \sum_{k=2}^{K} b_k \sum_{n=C-b_{k-1}+1}^{C-b_k} p(\mathbf{e}_k, n)}{\sum_{n=0}^{C-b_1} p(\mathbf{e}_1, n) + \sum_{k=2}^{K} \sum_{n=C-b_{k-1}+1}^{C-b_k} p(\mathbf{e}_k, n)}$$

Case Study

$C = 50$ Mbps

Video Conference

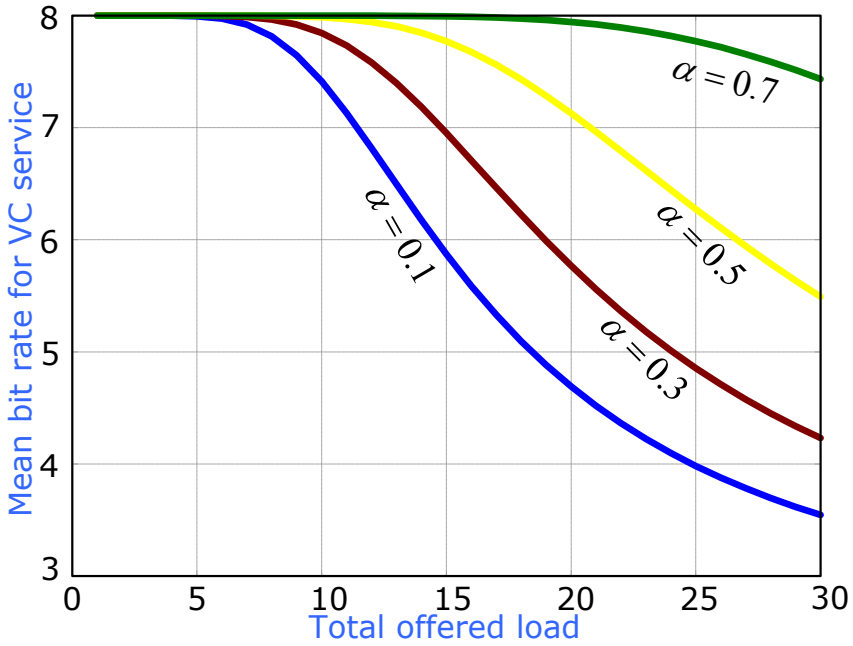
$b_1 = 8$ Mbps, $b_2 = 6$ Mbps,

$b_3 = 4$ Mbps, $b_4 = 2$ Mbps,

$\mu^{-1} = 1$ hour,

$\rho = \lambda / \mu$

$\rho = \alpha *$ **Total offered load**



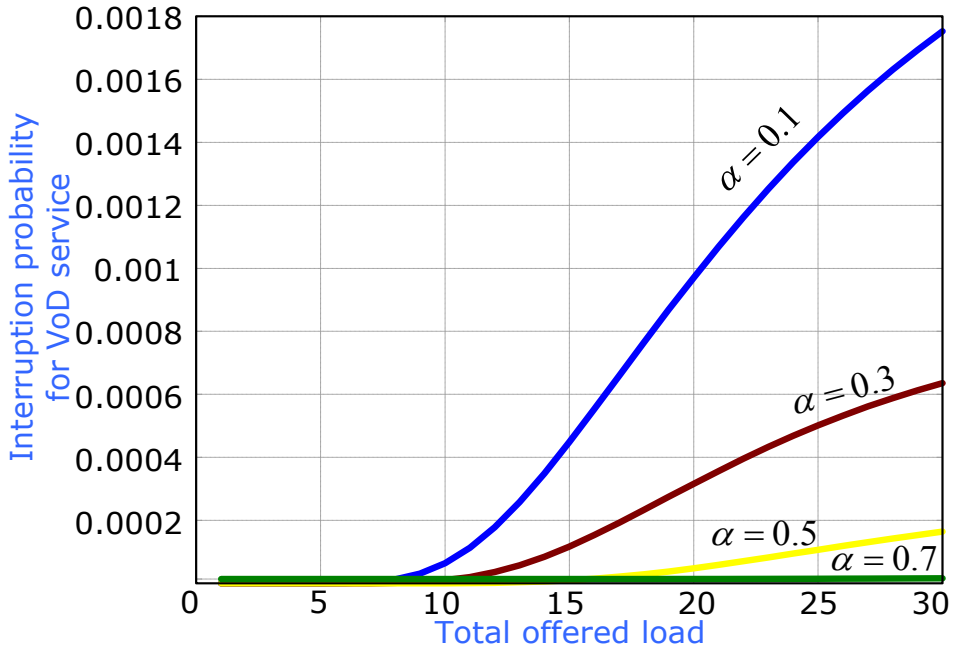
Video on Demand

$d = 2$ Mbps,

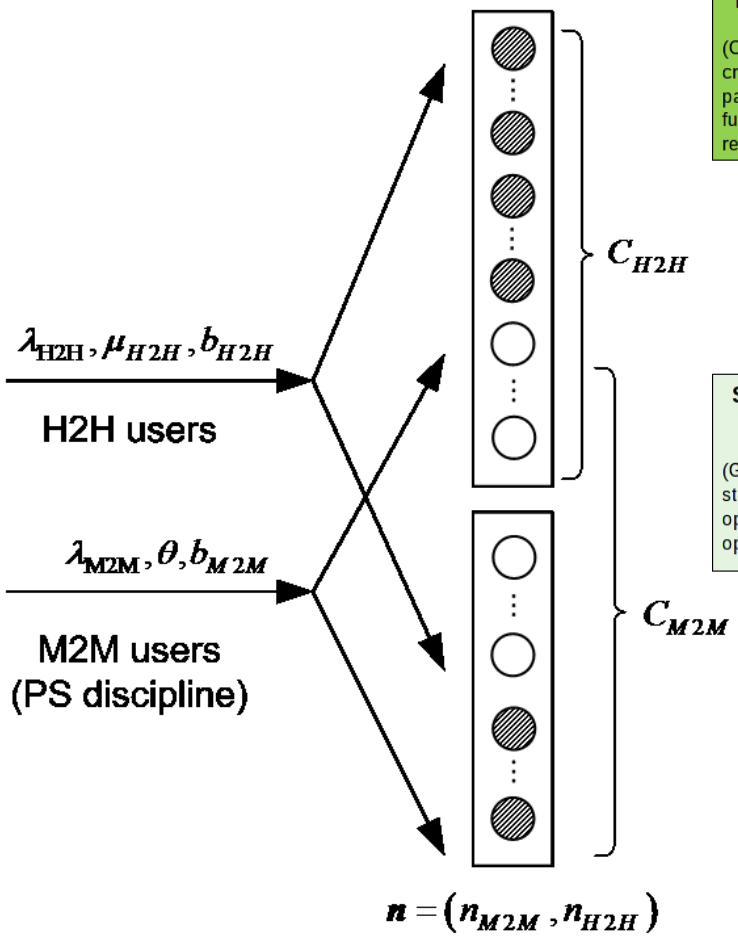
$\kappa^{-1} = 2$ hour,

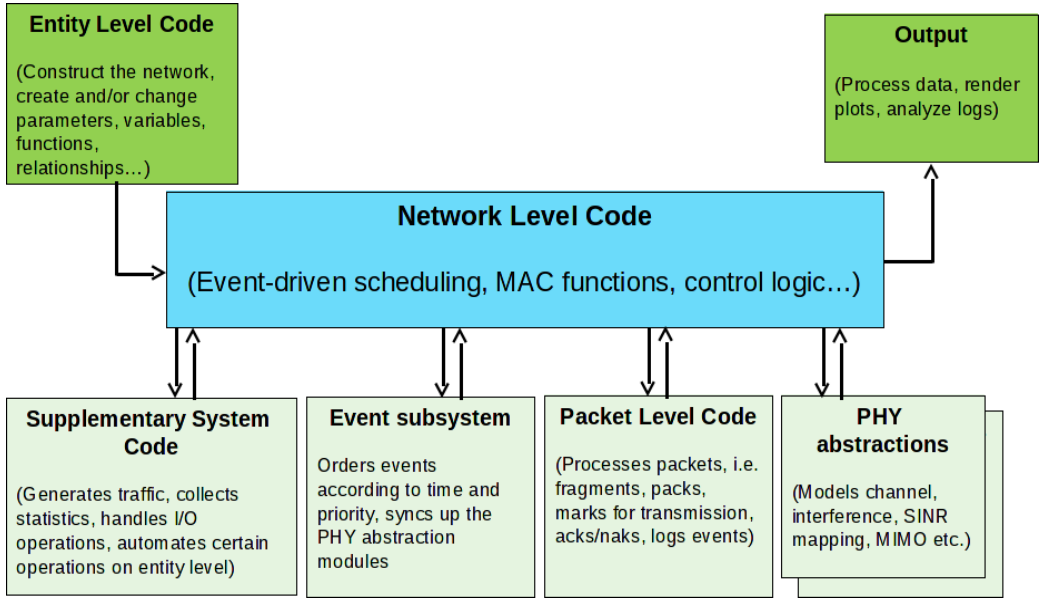
$a = \nu / \kappa$

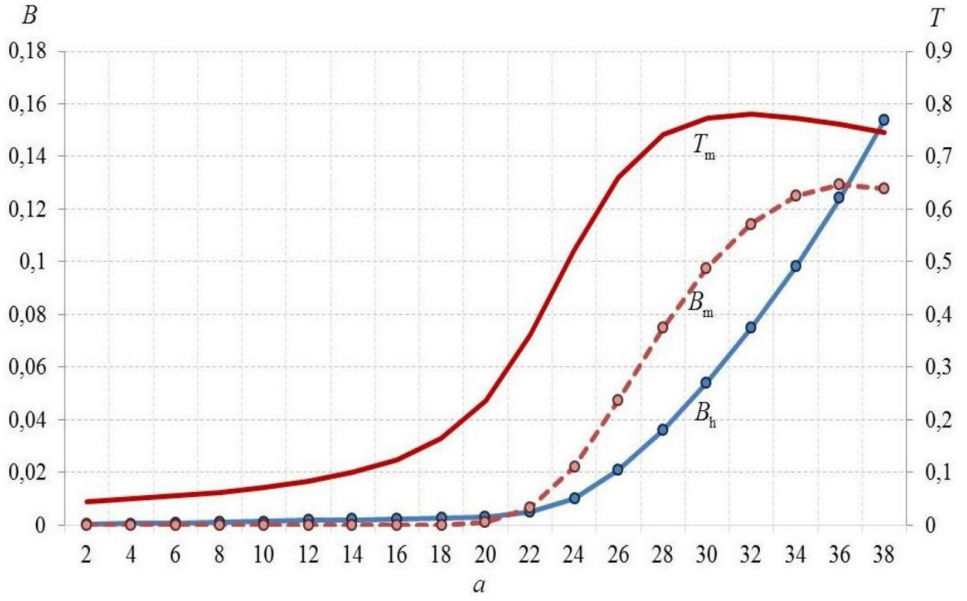
$a = (1 - \alpha) *$ **Total offered load**



RAC Scheme for Unicast and Elastic Services







Gudkova I.A., Samouylov K.E., Buturlin I.A., Borodakiy V.Y., Gerasimenko M., Galinina O., and Andreev S.D. Analyzing impacts of coexistence between M2M and H2H communication on 3GPP LTE system // Lecture Notes in Computer Science. – 2014 Vol. 8458. – P. 162–174

Conclusion

- Multiservice loss network models with unicast, multicast and elastic traffics can be used to describe radio resource allocation techniques in LTE networks
- BUT these teletraffic models should be modified in accordance with radio admission control (RAC)
- RAC transforms the methods for analyzing mathematical models
- Mathematical models verified by simulations are needed to develop RAC schemes realizing different pre-emption algorithms