Analysing Efficiency of New Load Distribution Algorithm with Horizontal Scaling

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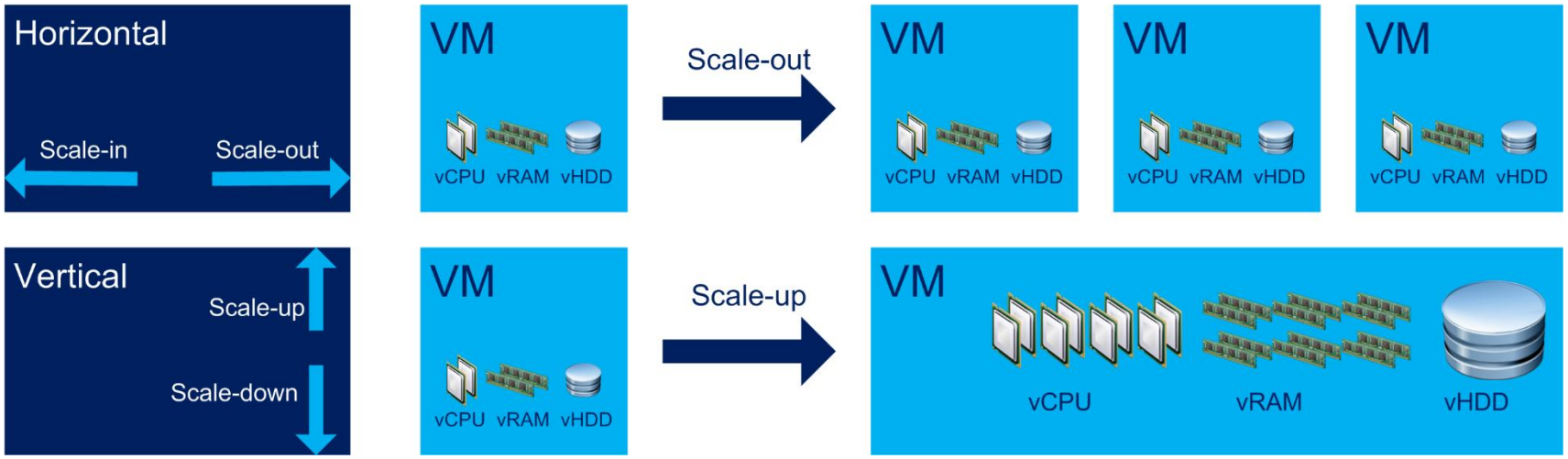
Introduction
Distributed systems and scaling

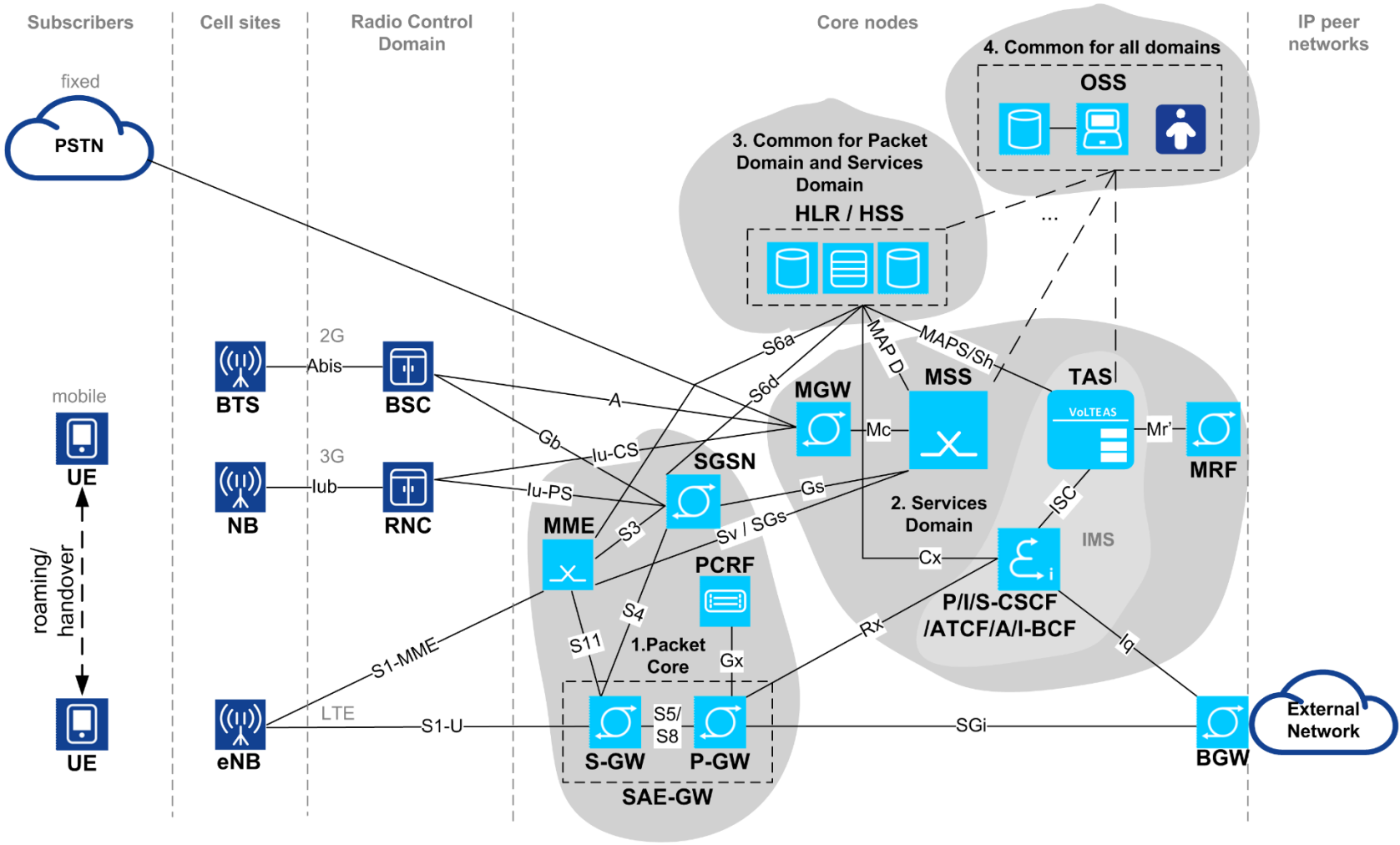
- In most systems there are many tasks that can be processed independently
- Therefore the system load can be handled by multiple *functional units*
- If the system load varies through time, the amount of required resources is not constant
- The total system resource amount can be changed via scaling; horizontal or vertical
- In this paper we consider only horizontal scaling
- In this paper the modelled system will be a telecommunication network element



Load distribution in telecommunication network elements

Network functions in Cloud environment

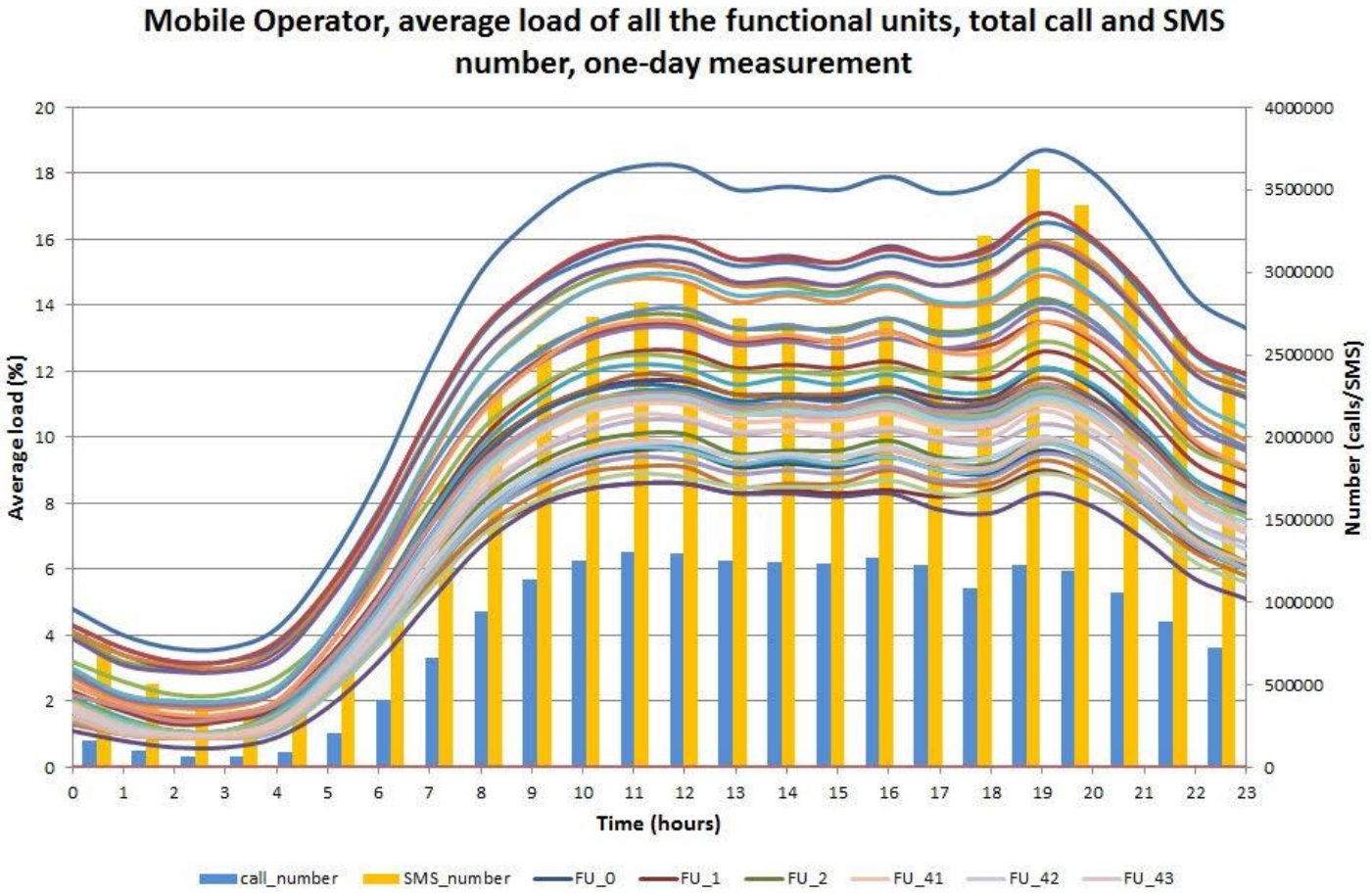
- Traditional solution is static load distribution i.e. the method does not change with the changes of the load
- In virtualized network functions [3] the possibility of dynamic scaling [1], [2] appears
- Our modelling target is the signaling part of the core network



Problem with load distribution and load balancing

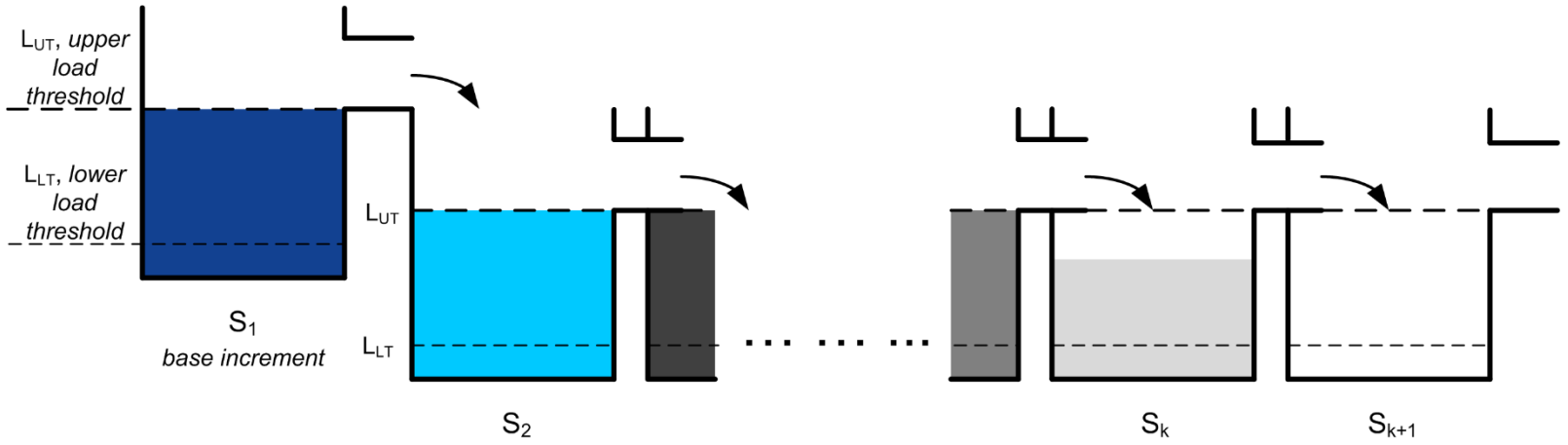
Challenges of current solutions

- The goal of current solutions is to distribute requests evenly
- Instead of load, requests are distributed, although there is a strong correlation
- Static system topology is designed to handle the maximum design load
- Typical operation handles less load
- Load distribution can be modelled with the Round-Robin algorithm



New load distribution algorithm
Requirements for the new logic

- Be able to handle groups of functional units (sets) to achieve a bigger scaling step
- Set load thresholds to limit the maximal load of active sets
- Instead of even distribution allow one set (lower order) to be less loaded and assign the design load to the other active (higher order) sets
- The changes of the system load will appear on the lower order set, allowing better scalability
- Randomize call distribution between the functional units



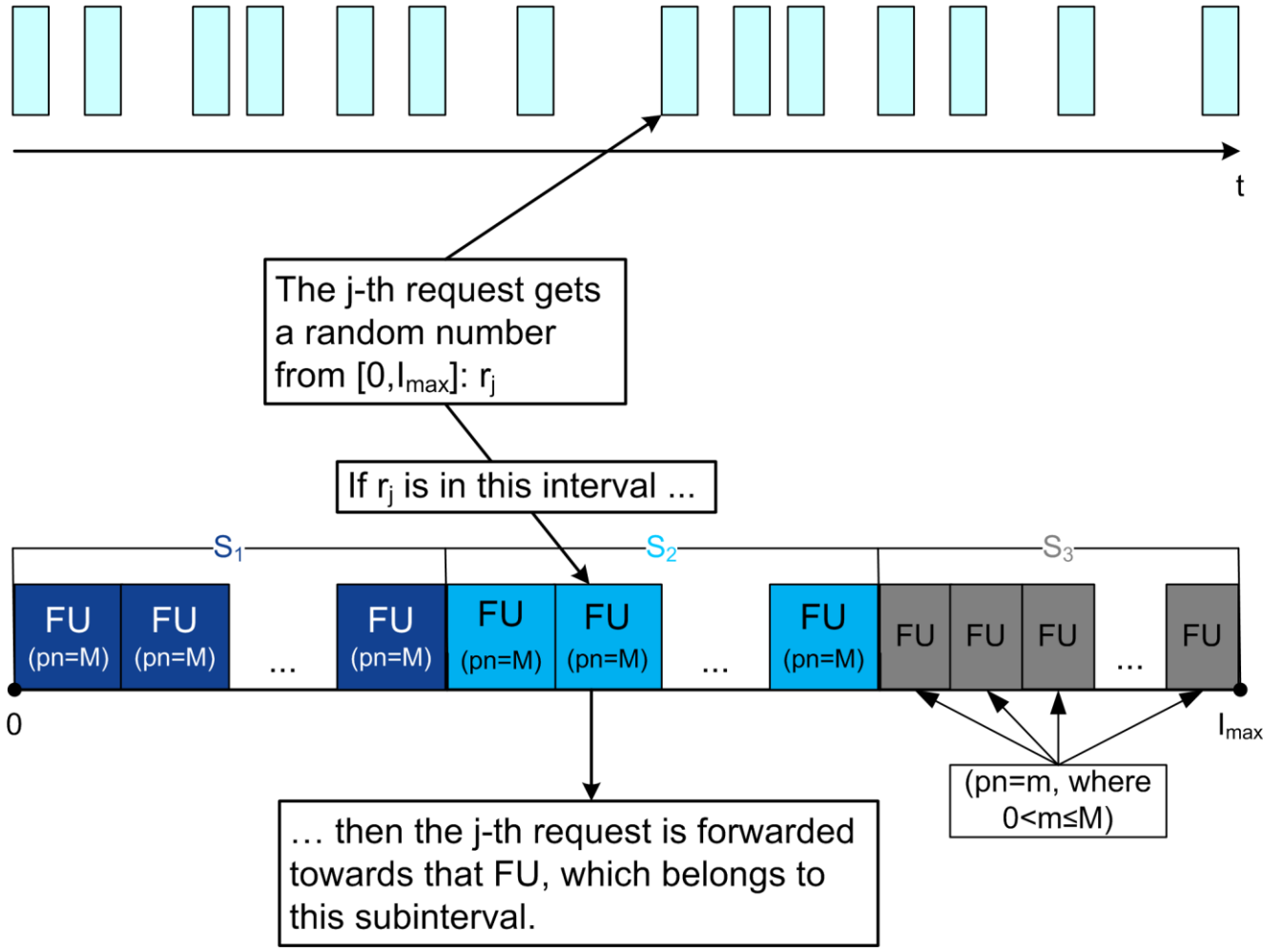
New load distribution algorithm
Solution proposal

- Assign priority numbers to the sets
- Represent sets (and units) with corresponding intervals on the real line
- Assign interval lengths:

$$L_{FU_k} = P_{FU_k} \times F_{FU_k}$$

where P is the priority number, F is the free capacity of the functional unit

- For every call generate a random number with uniform distribution on the union of the intervals $[0, I_{max}]$
- Assign the request to the unit that corresponds to the interval *"hit"* by the random number

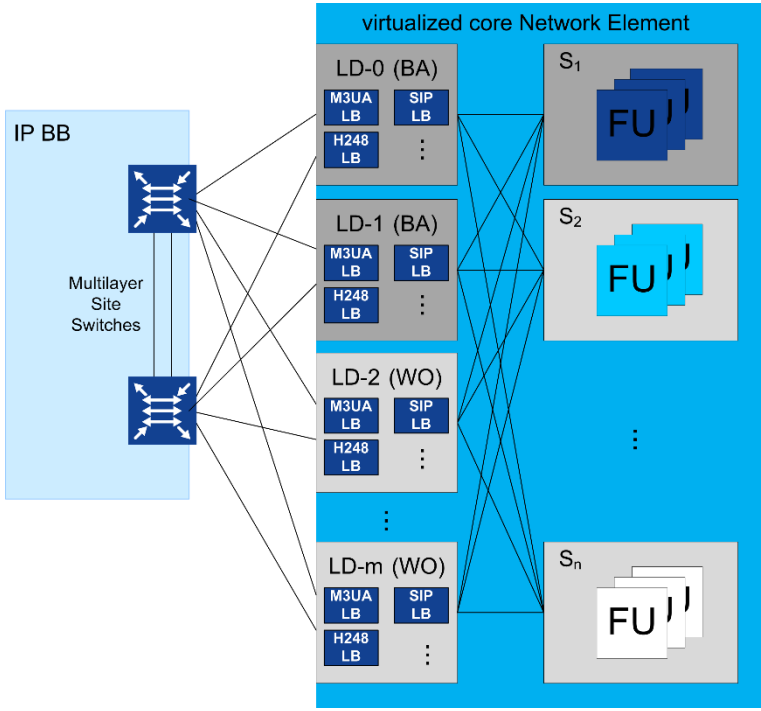


Comparing models for existing and the new method
Efficiency of load distribution

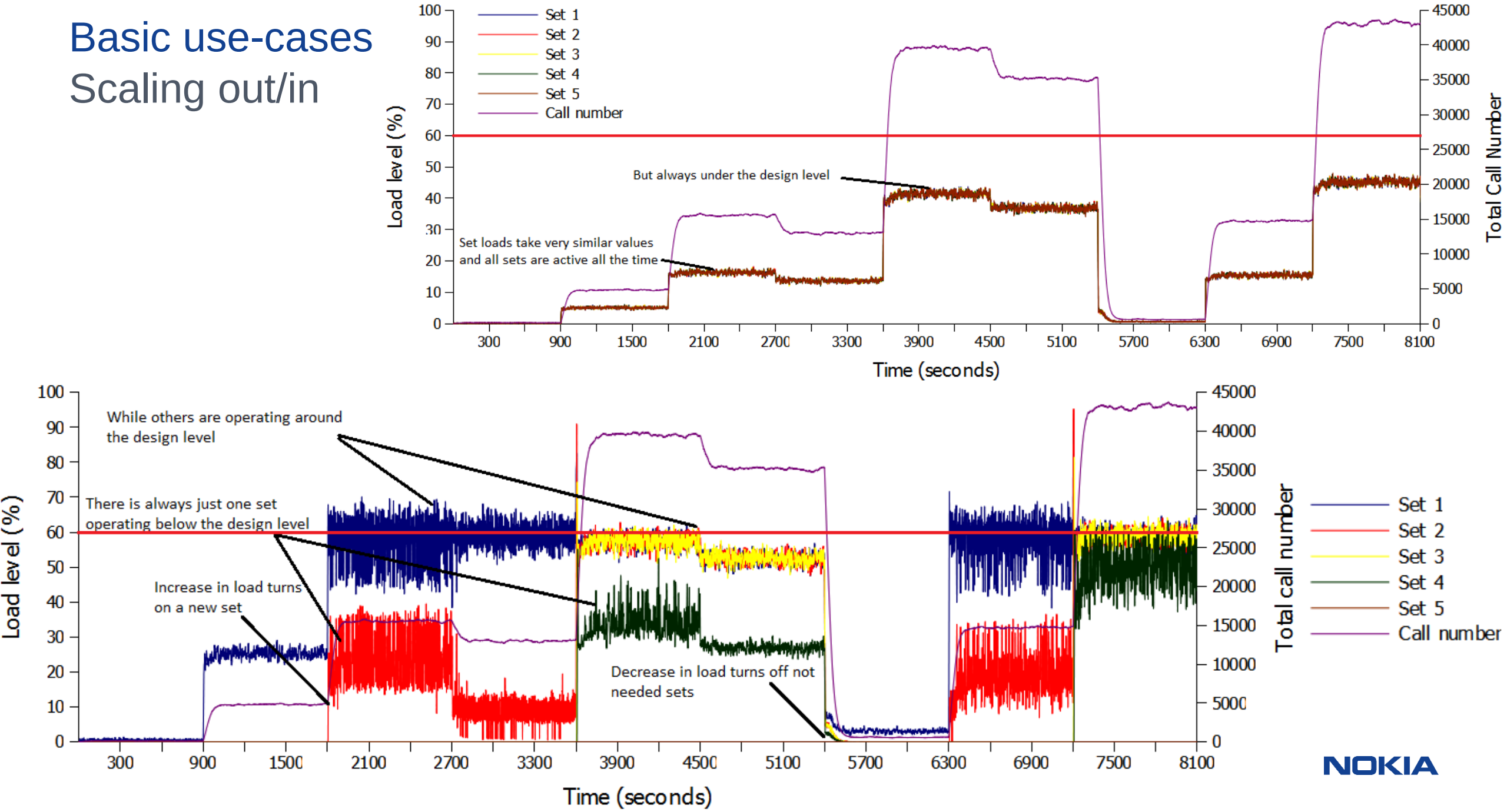
- The existing solution is modelled with Round-Robin
- The new solution is described in [5], called the Horizontal Scaling Algorithm (HSA)
- Simulation is required for both, algorithm logic and call traffic both have to be simulated
- Call arrival model is an inhomogeneous Poisson process
- Call length models are more challenging [4], for simple simulations exponential and log-normal distributions can be used
- Rate-function of the Poisson process can be created based on traffic measurements
- Rate function is piecewise constant (measurement granularity), definition can be improved by spline interpolation
- Goal is to keep as many sets in gracefully shut down (GRSD) state as possible

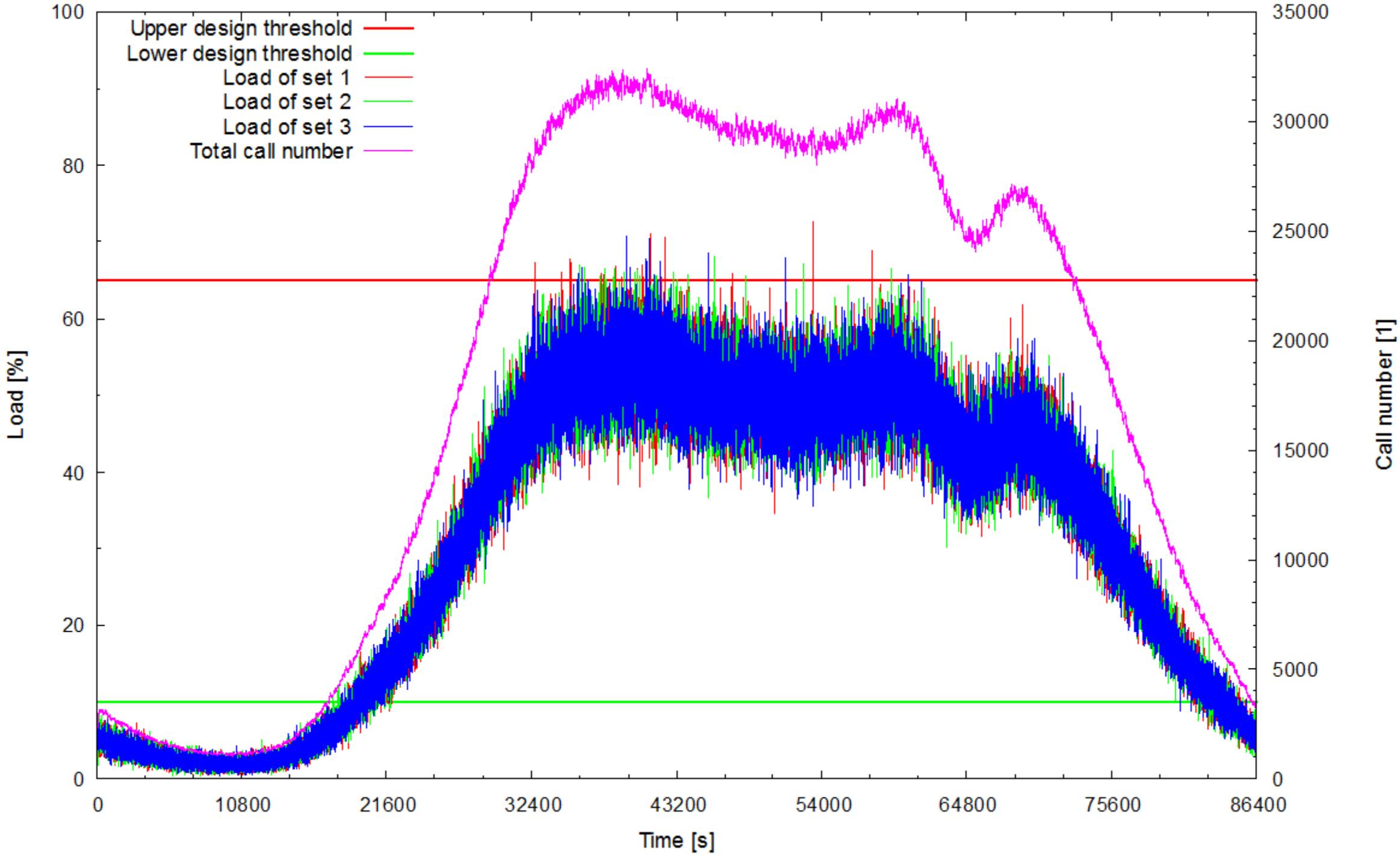
Simulation
Program for comparing models

- Simulation was written in c++ with object models for calls, units, sets etc.
- Call length distribution was log-normal with 90 seconds expected value and 50 seconds standard deviation
- Both algorithms (RR and HSA) used the same simulated call set
- First simulations were to determine the different behaviour of the models in prepared use-cases (when scaling was required)
- Later simulations aimed at simulating real traffic profiles
- One day simulation with measured (re-scaled) traffic profile and system capacity based on real network design were created



Basic use-cases
Scaling out/in




Upper design threshold
Lower design threshold
Load of set 1
Load of set 2
Load of set 3
Total call number
Load [%]
Call number [1]
Time [s]
0
20
40
60
80
100
0
5000
10000
15000
20000
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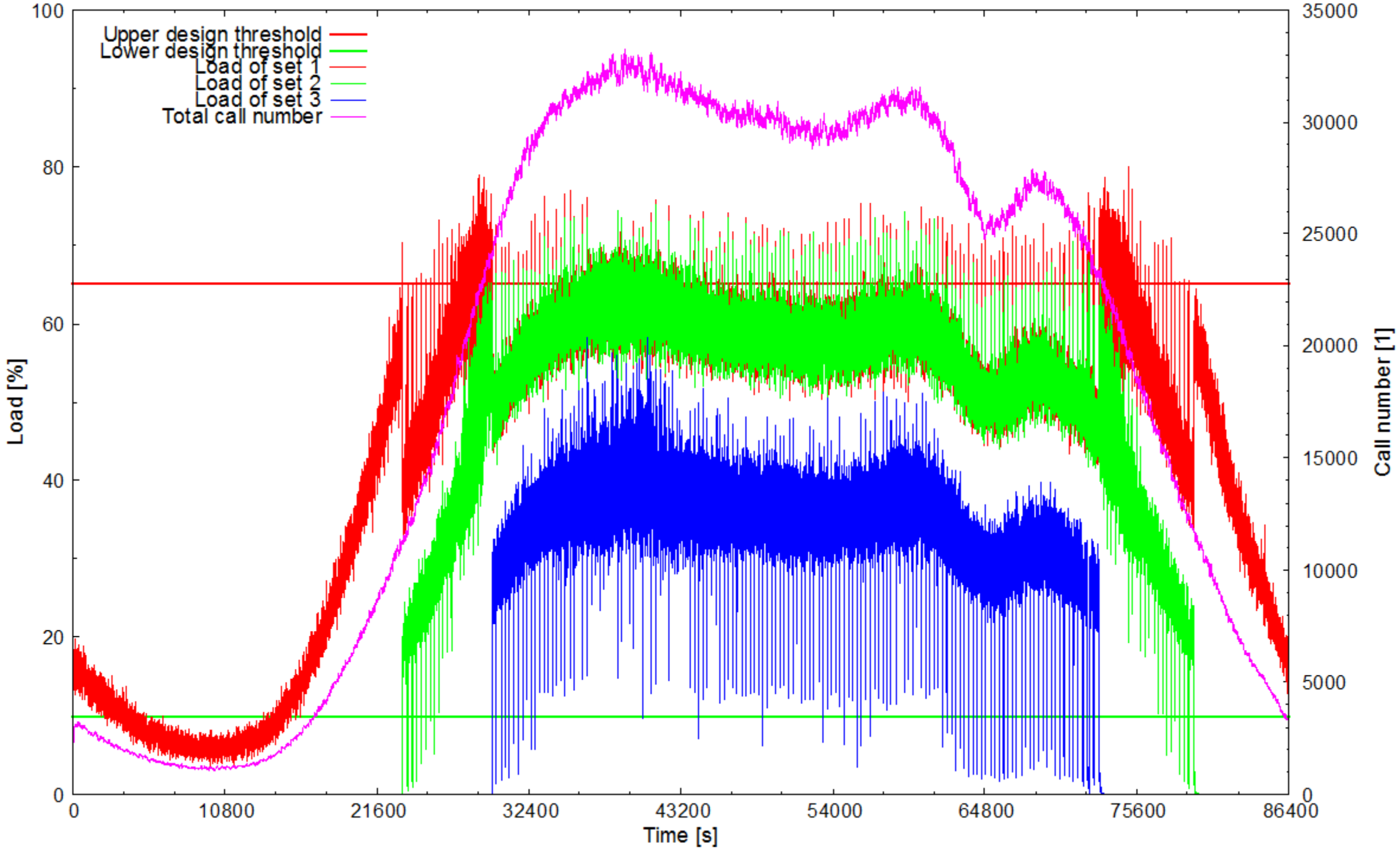
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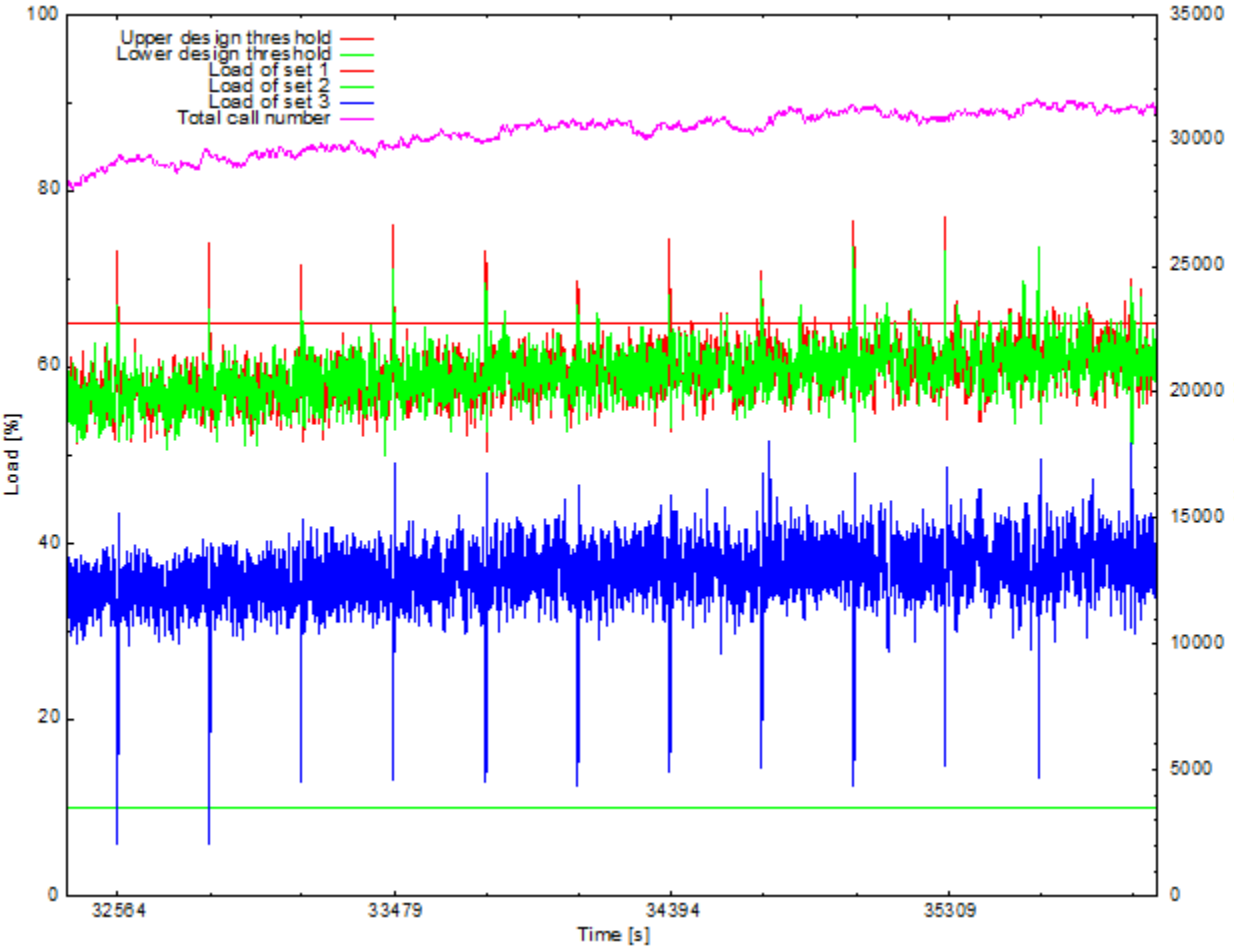
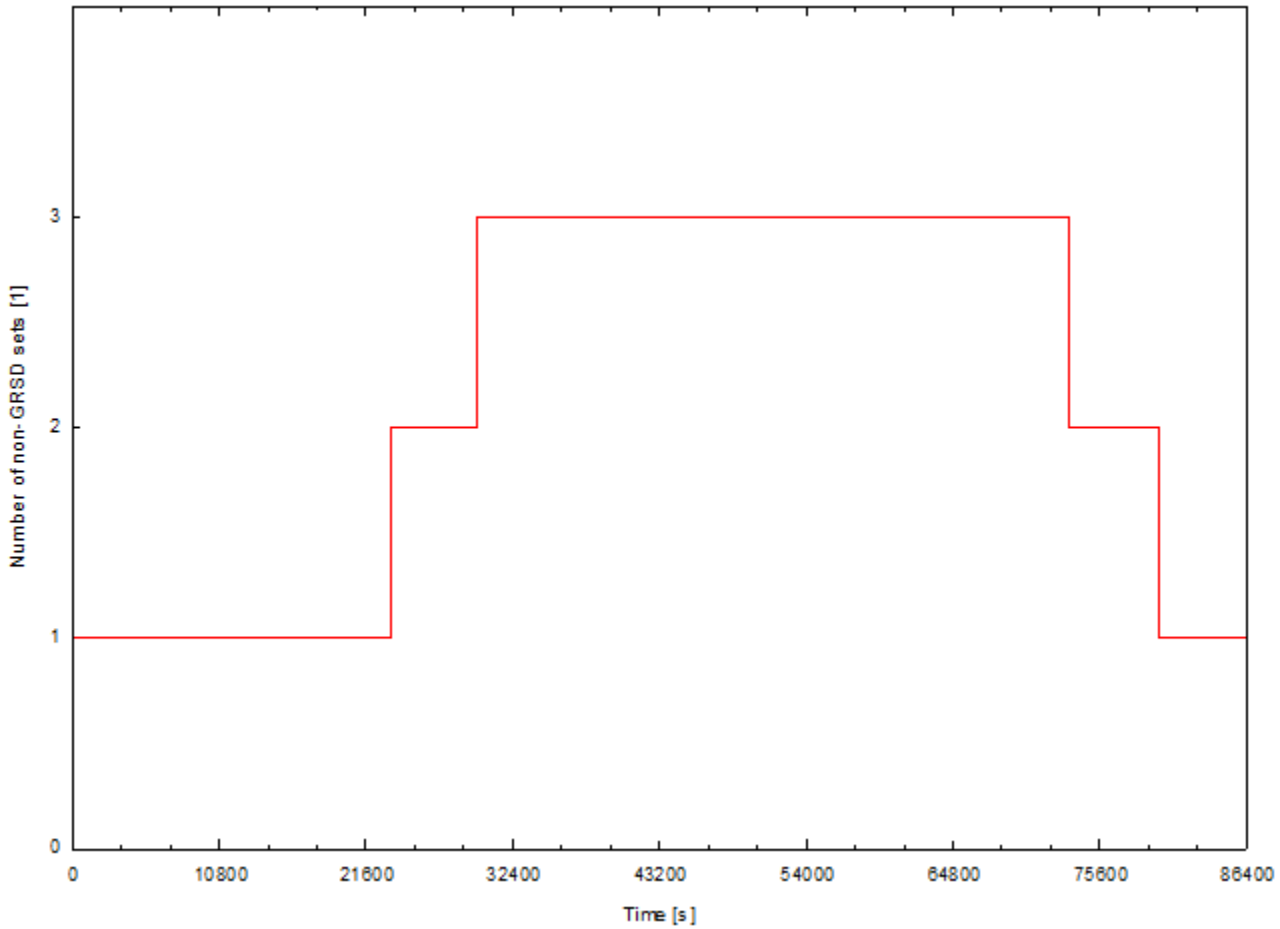
Challenges of the simulation
Unnecessary switching and GRSD state





Conclusions

Results so far and further possibilities

- Load distribution algorithm was patented [5]
- Simulations show that efficiency can be improved by scaling
- HSA supports graceful shutdown of units / sets effectively
- Decreased capacity – during periods of low load – does not create service degradation at load increase
- Multiple – allowing / strict – thresholds and sliding window averages could improve the algorithm
- Analysis of the effect of parameter values on efficiency and quality could be performed
- The overload handling of HSA could have a modified logic to improve the overload handling
- Call length modelling could be enhanced to reflect real traffic profiles better

[1] Sagar Dhakal, Majeed M. Hayat, Jorge E. Pezoa, Cundong Yang, David A. Bader: ”Dynamic Load Balancing in Distributed Systems in the Presence of Delays: A Regeneration-Theory Approach”, IEEE TRANSACTIONS ON PARALLEL AND DISTRIBUTED SYSTEMS, VOL. 18, NO. 4, Apr. 2007.

[2] Parveen Jain, Daya Gupta: ”An Algorithm for Dynamic Load Balancing in Distributed Systems with Multiple Supporting Nodes by Exploiting the Interrupt Service”, International Journal of Recent Trends in Engineering, Vol 1, No. 1, May 2009.

[3] ETSI GS NFV 002, Network Functions Virtualisation (NFV), Architectural Framework, V1.1.1, Oct. 2013. http://www.etsi.org/deliver/etsi gs/NFV/001 099/002/01.01.01 60/gs NFV002v010101p.pdf

[4] Pedro O.S. Vaz de Melo, Leman Akoglu, Christos Faloutsos, Antonio A.F. Loureiro: ”Surprising Patterns for the Call Duration Distribution of Mobile Phone Users”, Machine Learning and Knowledge Discovery in Databases, Lecture Notes in Computer Science Volume 6323, pp 354-369, 2010.

[5] István Bakos, Gyula Bódog, Attila Hilt, László Jánosi, Gábor Járó: ”Optimized resource management in core network element on Cloud based environment”, Patent PCT/EP2014/075539, Nov. 2014

Thank you for your attention

Q&A

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