Models for a 3G Network's GGSN

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Relation to Thesis

Planned thesis parts

- 1 Investigation of TCP-based video streaming techniques
 - Protocol survey and classification
 - Deriving a model
 - Measurements with the model
- 2 Evaluation of a 3G core network
 - Investigation and evaluation of the control plane
 - Modeling and simulating load
- 3 Measuring video streaming in a 3G network

Presentation based on MMB'14 submission "A PDP Context Load Model and Virtualization Gain for a Mobile Network's GGSN"

Motivation

Mobile network planning and dimensioning today

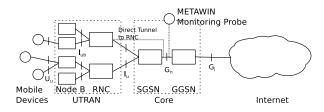
- based on expected user traffic
- good algorithms and tools for placing radio towers and planning radio propagation
- core network and control plane usually not given much consideration

Our approach

- presents queuing models for a GGSN in the core network
- models simulated with data from a real network
- can be used to dimension for control plane
- offers more scaling options



GTP Tunnels and Dataset

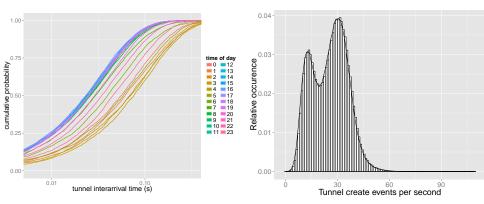


- Any user traffic in a 3G net is encapsulated into tunnels
- GPRS Tunneling Protocol (GTP) used between SGSN and GGSN
- Tunnel state (PDP Context) held at and signaled between core nodes through create/delete/update messages

Recorded dataset

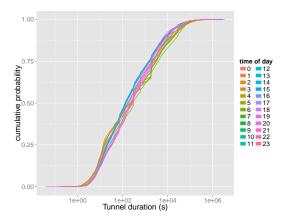
- One week long passive measurements in an operator's core network (METAWIN, April 2011)
- 2.2Bn anonymized user traffic records, 410M GTP tunnel management messages

Tunnel Arrivals



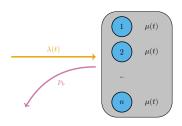
■ Strong time of day dependence with busy hour in the early afternoon

Tunnel Durations



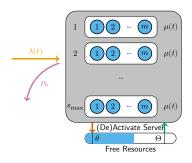
- Only slight dependence on time of day
- Much stronger influence of user device type, OS, or network timers (not shown here)

Monolithic GGSN Queuing Model



- \blacksquare Poisson tunnel arrival process with rate $\lambda(t),$ adjusted for the time of day
- lacktriangle GGSN can serve n tunnels in parallel, limited by network/processing load and signaling/state overhead
- lacktriangle Tunnels have a duration of $\mu(t)$ with a general distribution
- \blacksquare If GGSN is full, reject new tunnels with blocking probability p_b
- ightarrow Non-stationary Erlang loss model $M_t/G/n/0$

Virtualized GGSN Queuing Model

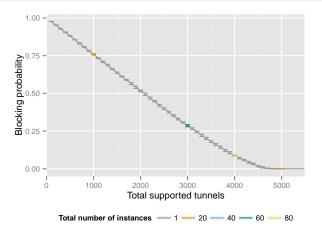


- Same arrival and serving time process, no queue
- \blacksquare Hypervisor distributes tunnels and starts on demand up to s_{max} virtualized GGSN instances, each with capacity m
- Additional blocking when new instances are not switched on fast enough, or instance overhead if not shut down when unused
- System scales up (larger instances) and out (more instances)

Simulating the Model

- \blacksquare No exact mathematical solution available for a $M_t/G/n/0$ model
- Use queuing simulation instead of stationary analysis
- SimPy3 based discrete event simulation¹
- One week simulated period, omitted startup phase, 10 repetitions
- Arrival process with exponential distributions fitted to dataset, four time of day slots ($\lambda = \{10.67, 24.53, 29.25, 23.50\}$ before normalization)
- Tunnel duration CDF fitted with a rational function
- \blacksquare Scenario variable parameters: $n,\ m,\ {\rm and}\ s_{max}$
- Evaluate and compare both models based on
 - Blocking probability
 - resource and instance usage

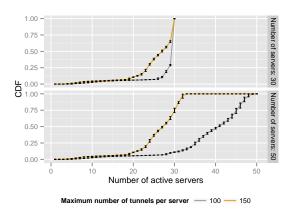
Blocking Probability



- Monolithic and virtualized GGSN scale equally with supported tunnels
- \blacksquare Negligible to no impact on p_B if virtualized model is scaled by tuning s_{max} instead of m

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Virtualized GGSN Resource Usage



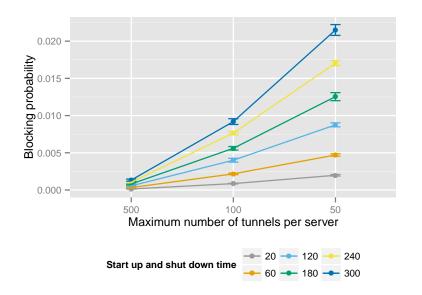
■ Unused instances can be shut down for increased energy efficiency compared to monolithic model

Conclusion

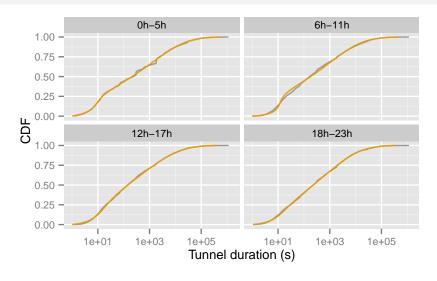
- Investigated tunnel properties in core network dataset
 - Non-stationary Poisson arrivals
 - Tunnel duration with general distribution
- Erlang loss models for tunnel load at a mobile core network's GGSN
 - Monolithic GGSN representing today's makeup
 - Virtualized GGSN proposal with improved scalability and efficiency
- Simulative evaluation of the model
- Enable mobile network dimensioning based on tunnel blocking rate instead of only user traffic volume

Thanks!

Questions?

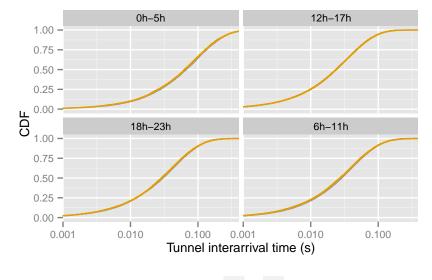


Exponential Arrival Process Fits

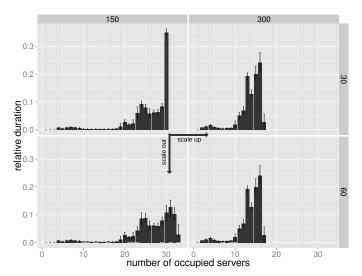


Distribution — Measurement — Fit

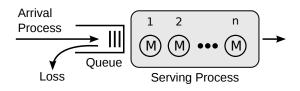
Serving Time Rational Functions Fit



Scaling Up or Out with a Virtualized GGSN



Queuing Models



Described by Kendall's Notation A/S/c/q

- lacktriangle Distribution of the arrival process A
- lacksquare Distribution of the serving time S
- Number of Servers *c*
- Queue Length q
 - $\blacksquare \ q = \infty \ \text{no loss will occur}$
 - 0 loss/blocking system, no queue
- Evaluate
 - Average queue length and server occupation
 - Blocking probability