



Novel Availability Metrics for Network Topologies

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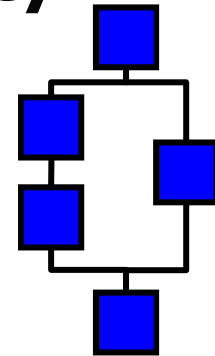
Motivation

- **Equipment availabilities are well defined**
 - Hardware are sold with their Mean Time Between Failure (MTBF) values
 - Widely investigated
 - Originally for military purposes
- **Can we define **network availability**?**
 - „five-nine network”
- **High-availability network design**
 - To **compare** different network designs, topologies, routing mechanisms, protection options from the viewpoint of availability



Network availability

- **The probability of the hardware failures can be evaluated**
 - Given MTBF, MTTR values
- **We can evaluate the connection availability**
 - Reliability Block Diagram (RBD)
 - Series-parallel approach
- **When is the network unavailable?**
 - if **any element/connection** is unavailable
 - Very low availability values
- **Minimum and average end-to-end availability values**
 - ... but not all the connections are equally important





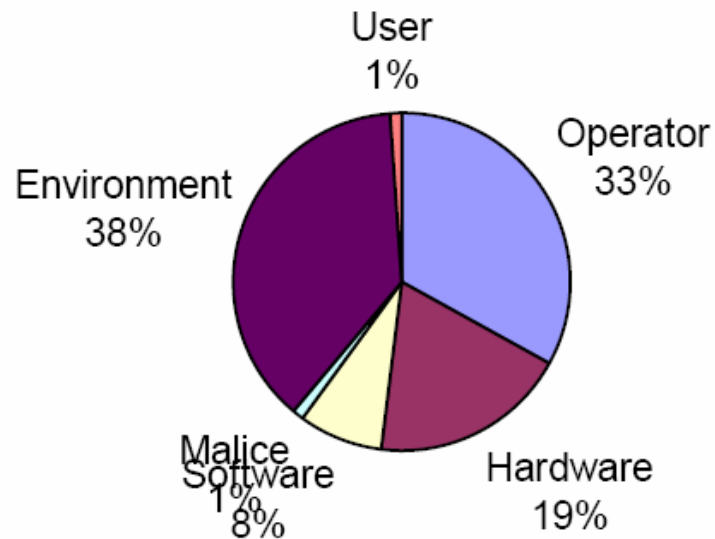
Some more proposals

- **Weighted sum of the connection availability values**
 - ... but what about the connections using common elements?
 - the effect of critical common elements as being single point of failures.
- **Service Disruption Time/Frequency**
 - ... but users are compensated according to the experienced data loss
- **Loss of Traffic**
 - Total Expected Loss of Traffic (TELT)
 - the amount of traffic that is lost in the network in a year
 - ... but a failure at night does not result in high amount of data loss, however a fraction of users will not have the potential to access emergency services
 - Average Expected Loss of Traffic
 - the ratio of TELT and the total traffic demand in the network



Federal Communications Commission (FCC)

- **US PSTN operators have to report outages to the FCC if the problem affected a certain amount of population**
 - 30000 customers or persisting for at least 30 minutes
 - ignore outages affecting small number



Relative fault cause statistics of the US PSTN (downtime-type in customerminutes) according to

P. Enriquez, et al.: "Lessons from the PSTN for dependable computing", In. Proc of SHAMAN, New York, NY, June **2002**



Our approach for characterizing network availability in IP networks

- A network (PSTN, IP) is down, if these are passed:

Population threshold

E.g. 20% of total population

Duration threshold

E.g. 10seconds

- Time to re-dial
- ITU-T Recommendation G.821: unavailable state means at least 10 consecutive severely errored seconds.

Performance threshold

E.g. 5% packet loss ratio (non-elastic flows)

- The 5% is taken for VoIP applications



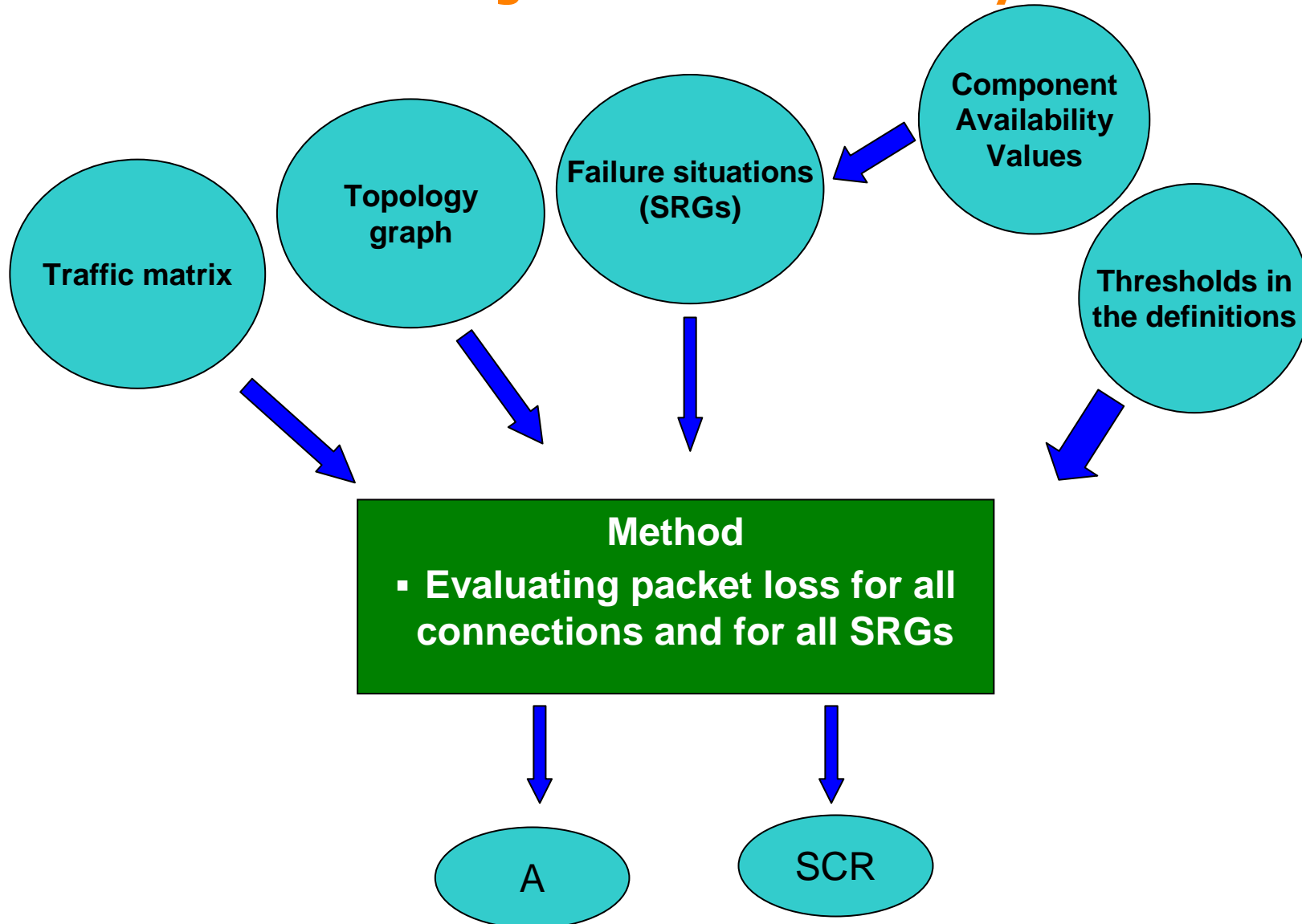
Proposed network availability definitions

- **Operator-centric view: Network availability**
 - The probability that the network is in „up” state
 - **Definition 1: The network is unavailable („down” state) if there is no connectivity or there is only poor performance for at least a 20% of subscribers for at least 10 seconds.**
 - Poor performance is described by a packet loss ratio more than 5%
- **A user-centric view: Session Completion Ratio**

$$SCR = \frac{\# \text{completed connections}}{\# \text{attempted connections}}$$

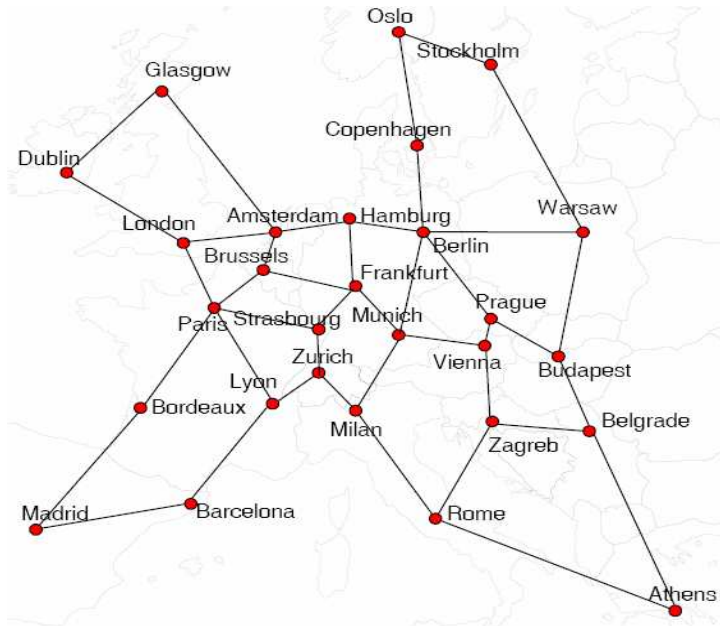


A method for evaluating network availability and SCR





Comparing topologies



Results by single link failure-tolerant design:

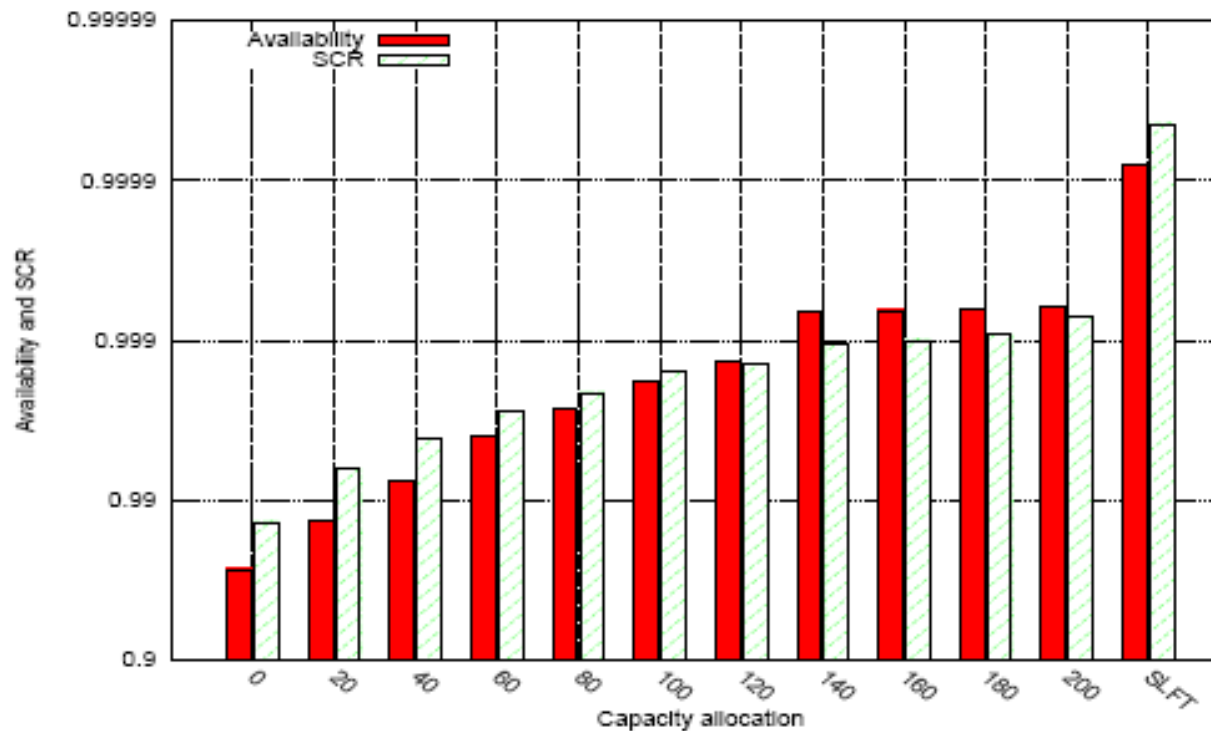
Topology	Availability	SCR	Extra capacity*
NOBEL-EU	0.999921	0.999956	91.1%
NOBEL-US	0.999386	0.999737	72.3%

* Compared to the average capacity requirement



Comparison of different capacity allocation approaches

Capacities set to the average demand vs. X% overprovisioning vs. single link failure-tolerant design

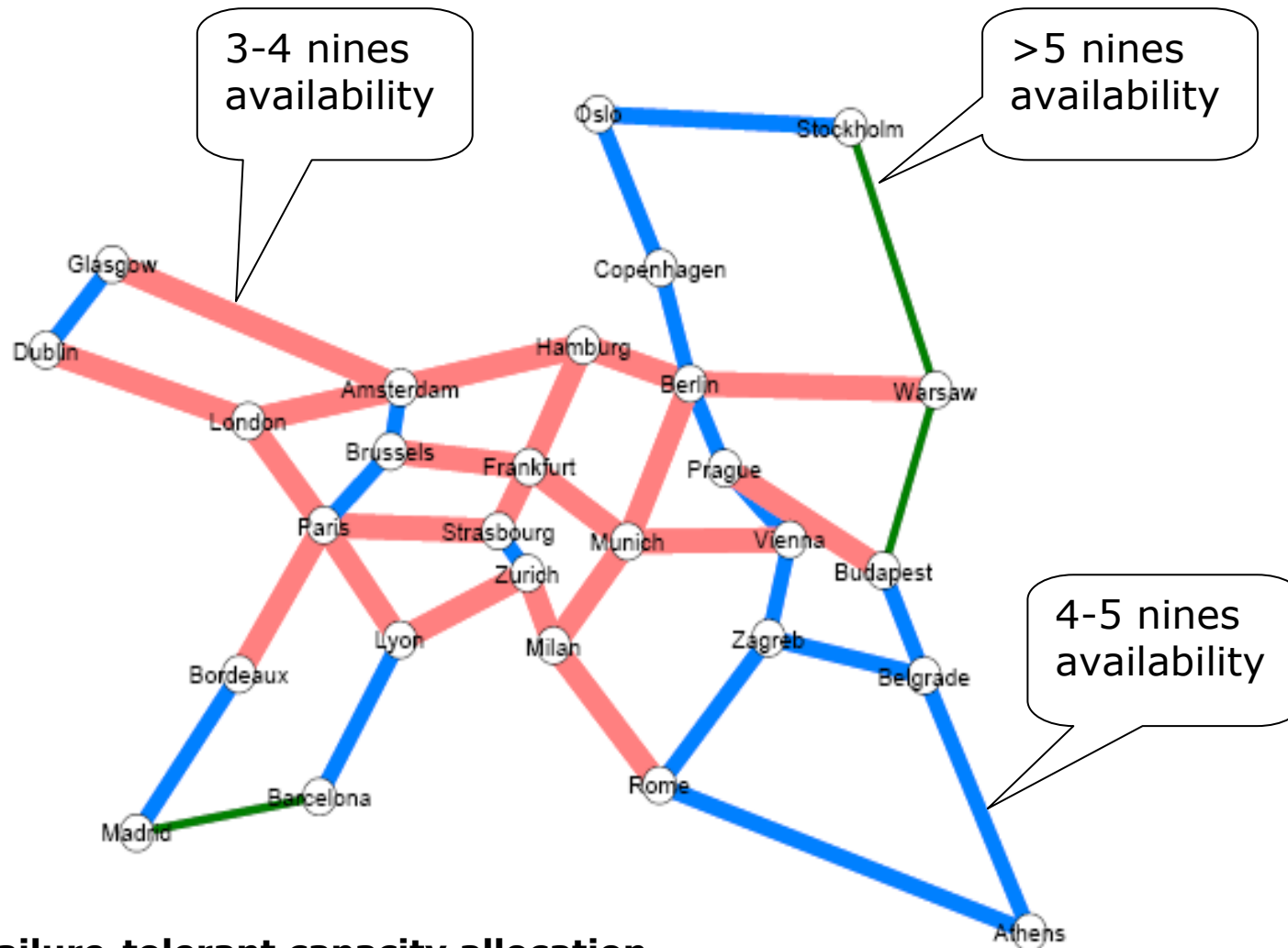


- NOBEL-EU network
- 20% population threshold
- 5% packet loss ratio threshold



Case study – Weak points of the network

**Overall
availability:
0.999921**



Single link failure-tolerant capacity allocation



Conclusions

- **General Network availability definition**
 - "five nine availability,,
- **The network is unavailable if there is no connectivity or there is only poor performance (packet loss ratio more than 5%) for at least a 20% of subscribers for at least 10 seconds.**
- **Topology analysis**
 - **Extra capacity allocation strategies analysis**
 - **Verifies the single link failure-tolerant network design**



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