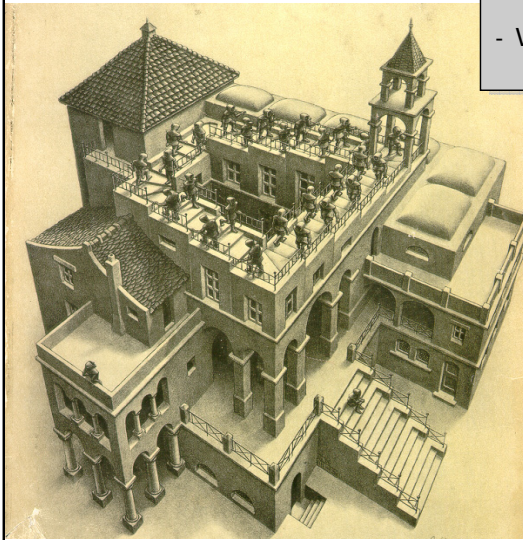


Nachrichtenverkehrstheorie

Kap.3.2

- Weitere Betrachtungen in Verlustsystemen-



Universität Hannover
Institut für Allgemeine Nachrichtentechnik
Kommunikationsnetze
Prof. Dr.-Ing. K. Jobmann

13.1.1

Literatur:

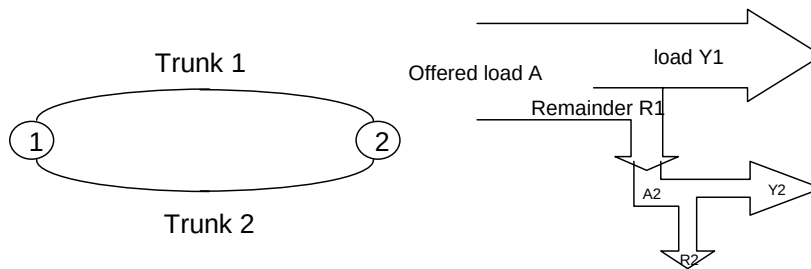
[schw88] Mischa Schwartz, Telecommunication Networks, Protocols, Modelling and Analysis, Addison Wesley Publishing Company, 1988, ISBN 0-201-16423-X

[Klei75] Leonard Kleinrock, Queuing Systems, Volume I, Volume II, John Wiley & Sons, New York...,1975, ISBN 0-471-49110-1

Outline

- Overflow traffic
- Limited accessibility
- Cloß Arrangement
- Grading
- Simulation of loss systems

Loss Systems with overflow traffic

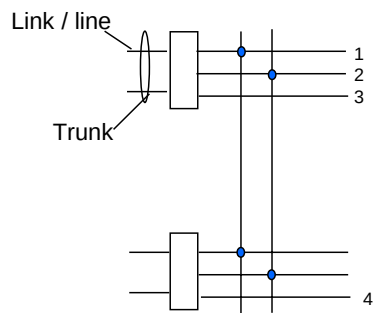


- Incoming traffic is first offered to trunk 1. If trunk 1 is fully loaded, it is offered to trunk 2 (alternative traffic routing)
- Note that the incoming traffic for trunk 2 is not anymore poisson distributed!

Overflowing traffic

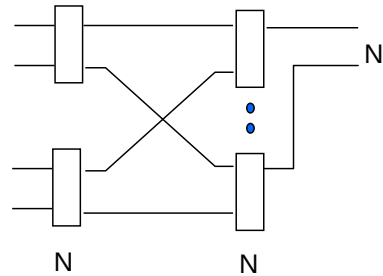
- Overflowing traffic is not poisson distributed
 - ⇒ Remember: Splitting of Poisson traffic remains poisson if and only if the allocation of traffic to different traffic streams happens randomly
 - ⇒ Overflow traffic allocates traffic to trunk 2 depending on the state of trunk 1 → not anymore random
- Whenever the statistics of arrivals or service processes are not Poisson, we additionally need to take into account the variance of the distribution (see M/G/1 system)

Trunk with limited accessibility



accessability: $k=3$
Outgoing links: $N=4$

Incomplete trunk with
limited accessibility



Incomplete trunk with
variable accessibility

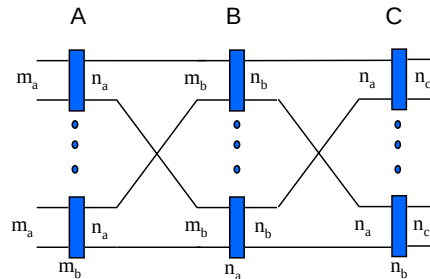
13.1.5

accessability (Source: NTG recommendation 0903):

Number of links in an outgoing trunk which can be tested by an incoming link for its occupancy state (free or busy)

Cloß configuration

We are now talking about switching networks (Koppelnetze). Assume that every single switching network can route any incoming line to any outgoing line.



Requirement for no losses

$$n_a \geq \begin{cases} 2 \cdot m_a - 1; & m_b = n_b \text{ and } m_a = n_c \\ m_a + n_c - 1; & m_b = n_b \end{cases}$$

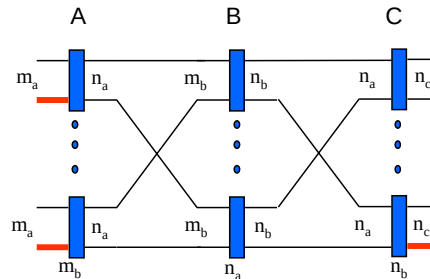
13.1.6

The arrangement above consists of three levels of switching networks. It is built such that we can reach any of the switching networks of the second stage from any of the switching networks (SN) of the first stage (left). We have m_b SNs in the first and n_a SNs in the second stage. Therefore, we need n_a outgoing lines for each SN in the first stage. The same is true for the second and the third stage, see n_b .

Note that a three-stage arrangement is the minimum that is required to enable any incoming trunk to reach any (free) outgoing line. Assume for this purpose that a call arrives at any SN in stage 1. The arrangement shall be designed such that any FREE outgoing line of stage 3 can be reached. The required number of SNs in the second stage are indicated at the lower end of the slide. We are going to derive this requirement in the following slides

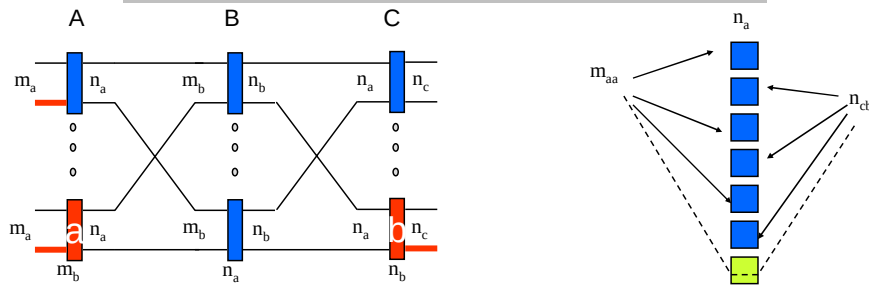
Cloß arrangement

We are searching for the 3-stage SN arrangement without inner blocking at minimum effort



The most critical case is, when at each SN in stage A exactly one incoming line is still free and there is only one free line in stage C left. We want to make sure that this outgoing line can be reached from every incoming line.

Cloß (original)



Observations at incoming stage A:

Red SN a: $m_a - 1$ incoming links busy, hence $m_a - 1$ SNs in stage 2 busy.

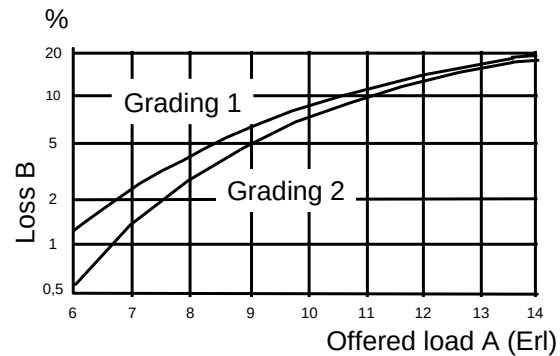
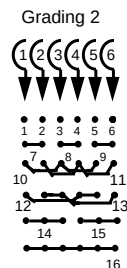
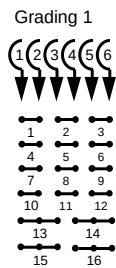
Red SN b: $n_c - 1$ incoming links in backward direction busy, hence $n_c - 1$ SNs in stage 2 busy. The worst case would be, if no connection can be found between SN a and SN b. Hence, we need at least one additional SN in stage 2:

$$n_a \geq (m_a - 1) + n_c - 1 + 1 = m_a + n_c - 1$$

Outline

- Overflow traffic
- Limited accessability
- Cloß Arrangement
- **Grading**
- Simulation of loss systems

Quality of the grading



The blocking probability does not only depend on the number of available outgoing lines but also on which outgoing lines are connected with each other.

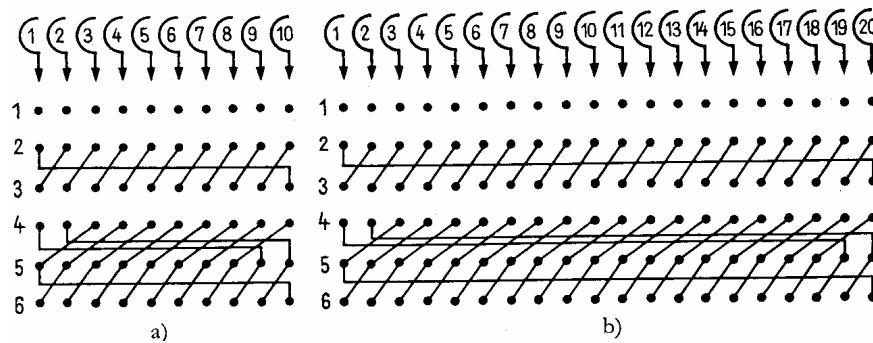
13.1.10

Grading – Mischung

Interconnecting number – Mischungsverhältnis

Interconnecting number Q is defined as follows: Assume a switching network with g offering trunks, each with k links to the route considered. If N outgoing links are connected to these $g \cdot k$ links, the mean interconnecting number is defined as $Q = (g \cdot k) / N$

Simplified standard grading



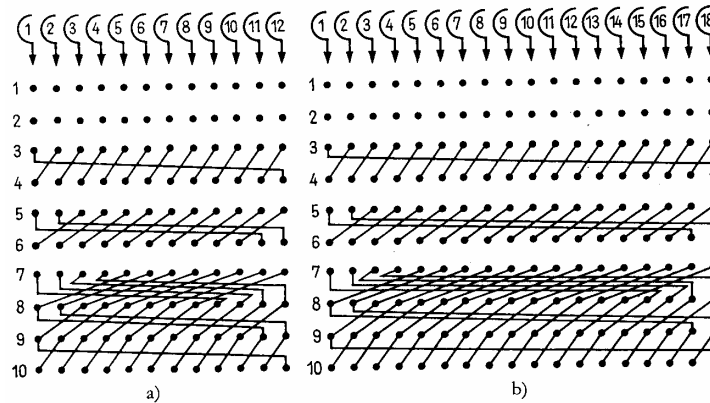
accessability $k=6$, mean interconnection number $Q=2$:

- a) $g=10$ offering links, $N=30$ outgoing lines
- b) $g=20$ offering links, $N=60$ outgoing lines

13.1.11

Simplified standard grading was the standard grading of e.g. Deutsche Bundespost in the 60s of the 20th century

Simplified standard grading



accessability $k=10$, mean interconnection number $Q=2$:

- a) $g=12$ offering links, $N=60$ outgoing lines
- b) $g=18$ offering links, $N=90$ outgoing lines

13.1.12

Simplified standard grading was the standard grading of e.g. Deutsche Bundespost in the 60s of the 20th century

Limited accessibility

- Blocking when the outgoing trunk is not entirely busy but still cannot be reached from an incoming trunk
- The smaller the accessibility, the bigger the blocking probability
- For variable accessibility, we need to base our calculation on an equivalent accessibility:
 - ⇒ The equivalent accessibility is the accessibility which causes the same loss for the same offered load in a single-stage switching network and the same number of outgoing lines

Modified Palm Jacobaeus Formula (MPJ)

$$B = \frac{E_N(A_0)}{E_{N-k}(A_0)}$$

B:= loss probability

N:= number of outgoing links

k:= accessibility

A_0 := equivalent offered load which would cause the same load on a complete tr

$E_N(A_0)$:= Erlang loss for N outgoing links for offered load A_0

$E_{N-k}(A_0)$:= Erlang loss for N-k outgoing links for offered load A_0

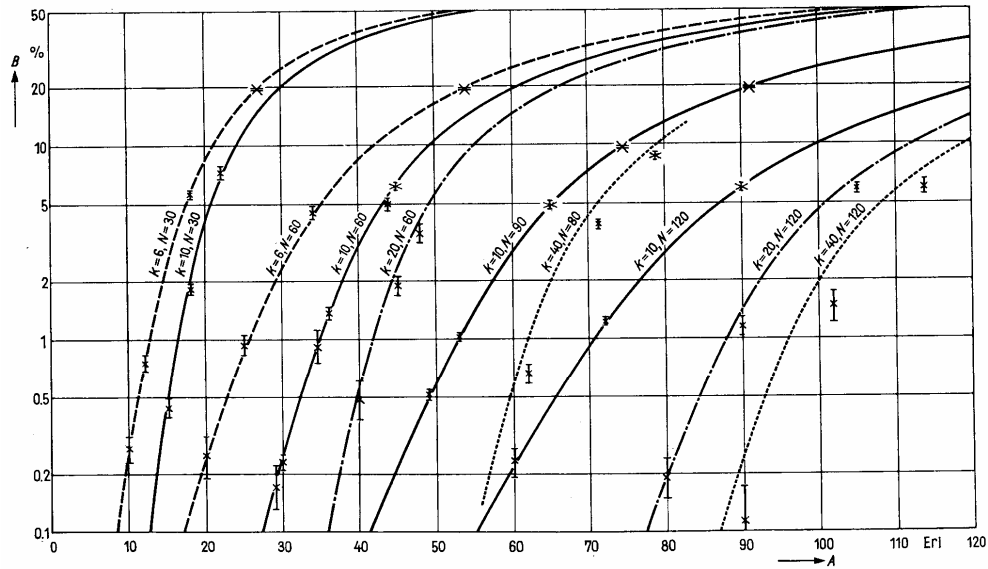
Adapted modified Palm Jacobaeus formula (MPJ)

$$A_{\text{admitted}} = A_{\text{MPJ}} + \Delta A$$

$$\Delta A = F \cdot \left(\frac{N}{k} - 1\right)^2 \frac{(k-2)(1-B)}{(60+4k)(1+kB^2)}$$

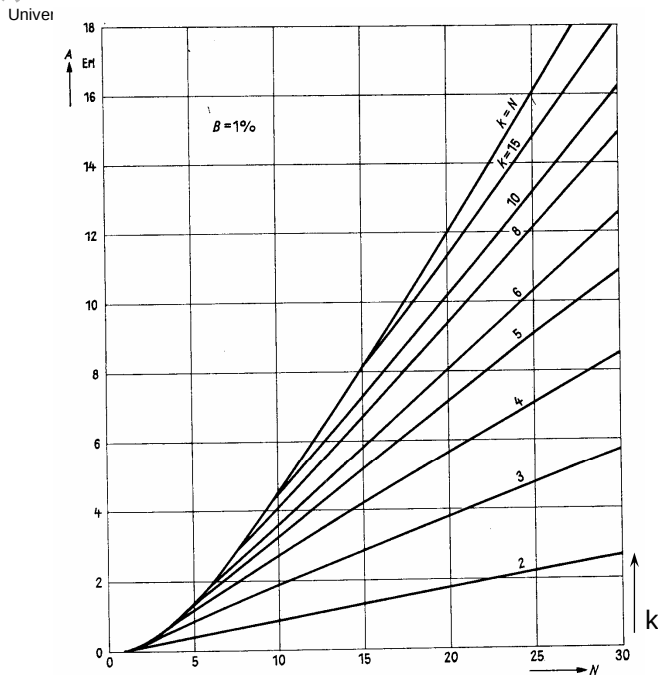
F - adaptation factor ($F = -3$ für simplified standard grading)

Development of adapted modified MPJ



13.1.16

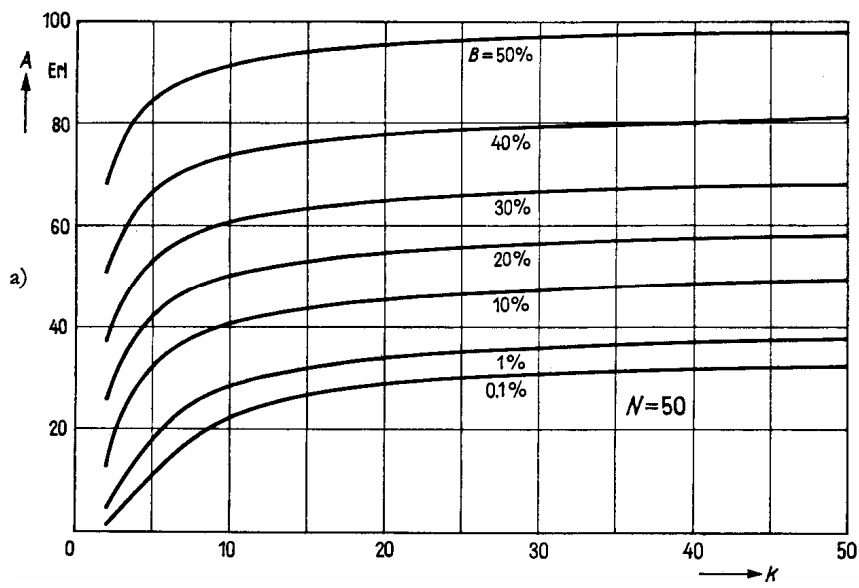
The adapted modified MPJ is an empirical formula. It was derived by a huge number of simulations by a working group at the University of Stuttgart. The figure above shows the simulation results compared to the calculated curves. The dots are simulated values with confidence interval (95%)



Adapted
 modified Palm
 Jacobaeus
 formula (MPJ)

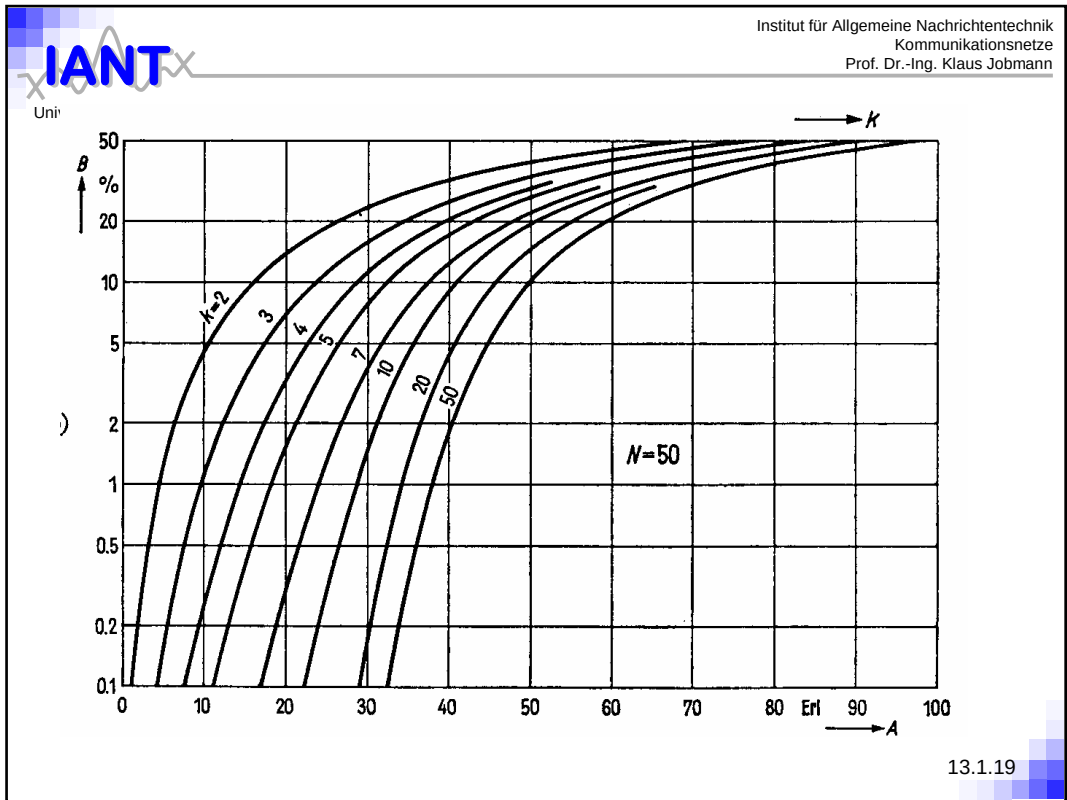
13.1.17

Admittable offered load A versus the number of outgoing links with the accessibility k as parameter for an allowed loss of 1% (for simplified standard grading)



13.1.18

The admissible offered load A versus k for $N=50$ with the loss probability B as parameter



Loss probability B versus admissible offered load A for $N=50$ outgoing lines and with k as parameter

Simulations

Application:

too complex calculations

Network too big for calculation,

Development of analytical formulae too expensive

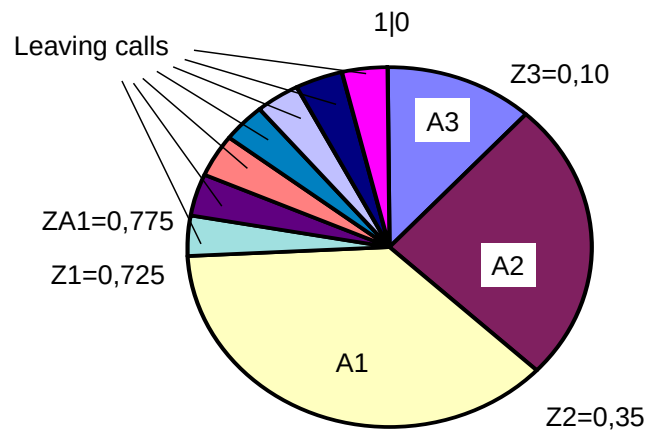
Control for analytical calculations

13.1.20

Ereignisgenerator

- Random number generator with numbers between 0 and 1
- A_n intervals result in arriving calls, Z_n intervals in leaving customers
- Size of the A share:
 - $\Rightarrow Z_{An} = A_n / (\sum A + \sum N)$
 - $\Rightarrow A :=$ offered load, $N :=$ outgoing lines
- The remainder is equally distributed for leaving customers

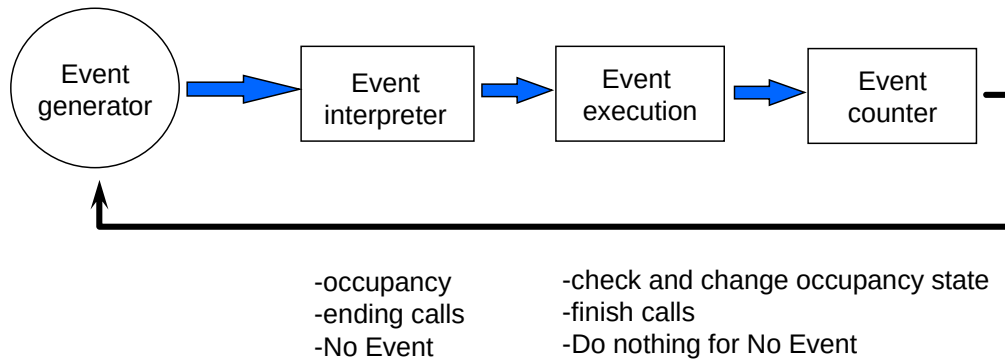
Event generator



13.1.22

The event generator creates one event per time interval. The arriving and end of calls are Poisson processes due to the fact that any event can happen with a certain probability in every time interval.

Simulation model



13.1.23