

***Telecommunication Systems
and Networks
2021/2022***

PART 4

Availability and reliability

- **AVAILABILITY** – the ability to stay in readiness to perform any required function once in a given period of time or continuously during any period in a given range, assuming that all exterior resources that are necessary for this function have been assured.
- **AVAILABILITY** – is PROBABILITY; it is a dimensionless value (or may be in %)
- In practice, when one considers availability, then thinks about two factors:
 - how often the system fails
 - how fast the system may be recovered to be ready to perform the function again
- **RELIABILITY** – the probability that the system will be able to perform its function during a given period.

Availability and reliability – continued

- **Example:** we fly from Łódź to London
- We require the highest **reliability**!! We want the successful start, flight and setting down – the probability that determine the reliability should be as close to 1 as possible.
- The availability may be very low and we perhaps will not know about it .E.g. three hours for maintaining and even some repairs and then three hours for the flight – so the availability value is 0.5 then

Availability

- Systems with high availability are designed in such a way that everything works automatically; all fails are discovered and isolated, alarms sent, backups switched, etc. The rule is that no single fail may cause the service loss (NSPF – no single point of failure)
- We distinguish the element availability (part of a system) and the service availability – e.g. a plane may be equipped with two engines 😊

„Five nines” – „Five-9’s”

- The name is an abbreviation that determines 99.999% of service availability and it results in **5.26 minutes of the system incapacity during one year**
- Telecommunications was one within the first fields where the system of five 9-s was introduced; today some telecommunications' elements achieve higher values, yet.

Erlang

- This value is dimensionless and it is a unit of the telecommunications traffic intensity – IT DOES NOT DEFINE TIME. It describes the part of used ability – i.e. one may use 100% as the maximum; so e.g. when one looks at the system by 10 minutes and the system is used all the time – so we have 1 Erlang. If a surveillance lasts 1 hour – then 1 Erlang means one hour of the total use
- If a surveillance lasts 1 hour and the device is used during 30 minutes – the intensity is 0.5 Erlang

Erlang B

- The formula is recommended by ITU-T in The Recommendation E.520, and allows to calculate the blocking probability
- A - the offered traffic [in Erlangs – so dimensionless]
- N – the number of servers (lines)
- Pb – the blocking probability
- One assumes random incoming calls (in Poisson distribution), the constant period or exponential distribution of lasting of calls, deleting blocked calls

$$Pb = \frac{\frac{A^N}{N!}}{\sum_{X=0}^N \frac{A^X}{X!}}$$

Assumptions to Erlang B Model

- Demands are generated independently (e.g. we do not agree in internet that everyone makes the call exactly at the same time!)
- The time of the call meets the exponential distribution
- FIFO algorithm is used
- Erlang model meets the accuracy, even if incoming demands deviate from Poisson distribution

EXAMPLE – do it at home

- What is the probability to block when $A=0.3$; $N=6$

Insert values to the formula and calculate:

$$P_b = \text{XXXXXXXX}$$

- It means that about xxx% trials will be blocked
- In general one accepts that the optimal phone service should give P_b at least P_b less than 1%

Queuing

- **Queuing** – the service is stopped till the ability returns (e.g. packets are kept in the buffer till they can be sent to the network)
- There are many algorithms for queuing. The simplest ones:
 - **FIFO** – *first in first out* – the one that waits for a longest period will be the first – as in a shop (though there may be also ‘a priority queue’ – for pregnant women)
 - **LIFO** – *last in first out* – one that came as the latest will be served as the first (the memory stack works so)
- Other problems: what actions should be undertaken if the buffer is full – to delete irrecoverably?, to start deleting earlier with some growing intensity?
- If the priority queues exist – the low priorities suffer from ageing. If we have packets very long and very short – maybe it would be better to send the short ones as the first?...

EEB (Extended Erlang B)

- Some blocked calls return to the system (the user tries again)
- The accuracy is better, but one should know how many returned calls met success and how many did not

Model Erlang C

- The demands that have not be served, wait in a queue
- The probability that the demand will wait:

$$P(A, N) = \frac{\frac{A^N N}{N!(N-A)}}{\sum_{x=0}^{N-1} \frac{A^x}{x!} + \frac{A^N N}{N!(N-A)}}$$

Erlang C – continued

- The probability that the demand will wait (the service delay λ) more than t :

h is the average time of a call duration

$$P(\lambda > t) = P(A, N) \bullet \exp\left(\frac{-(N - A)t}{h}\right)$$

- The average delay λ_{av} results:

$$\lambda_{sr} = P(A, N) \bullet \frac{h}{N - A}$$

Holding time – transmission time – sending time

- **Holding Time** – it is the time of the conversation (the realised connection) PLUS the time needed for activities that are necessary for the transmission and for receiving (i.e. **Overhead**).
- Outgoing and incoming connections (uplink and downlink transmissions) may have different times.
- Depending on the destination (also depending on hardware), some elements are covered or not by overheads, for example the time to choose the number, to grant, handshake...
- The overhead time is constant for a given type of connections, so its share is more significant in short connections
- To model it one needs the exponential distribution

From ARPANET to Internet

The US Department of Defense initiated the ARPANET project in late sixties in XX. It was the first wide network with packet switching and the transmission store-and-forward type. Then ARPANET solutions step by step came to civil developments and global Internet 1994

Problems to be solved still

- *Routing*: What track for packets should be chosen?
- *Flow control*: how to avoid overloads in a network?
- *Error correction*: how to do it automatically?
- *Addressing*: how make effective addressing of terminals?
- *Safety*: how to guarantee confidentiality and integrity of the information?
- *Standardising*: how to specify technical aspects of nodes to allow using hardware and software from various producers (neutral market)?
- *Presentation*: how to allow different computers and OS-es to communicate?
- *Management*: how to perform everyday management and how to plan long term development in the network?

Communication Requirements of Different Applications

Transmission Characteristics	Voice	Video	File Transfer	Interactive Media
Bandwidth	Low, fixed	Very high, fixed	High, variable	High, variable
Data loss	Tolerant	Tolerant	Nontolerant	Tolerant or nontolerant
Fixed delay	Low	Tolerant	Tolerant	Low
Jitter	No	No	Tolerant	No
Peak information rate	Fixed	Fixed	High	Very high

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PART 4 – END