Embedded Systems Innovation BY TNO

Reliability in Telecom

Design for ‘carrier grade’ service level

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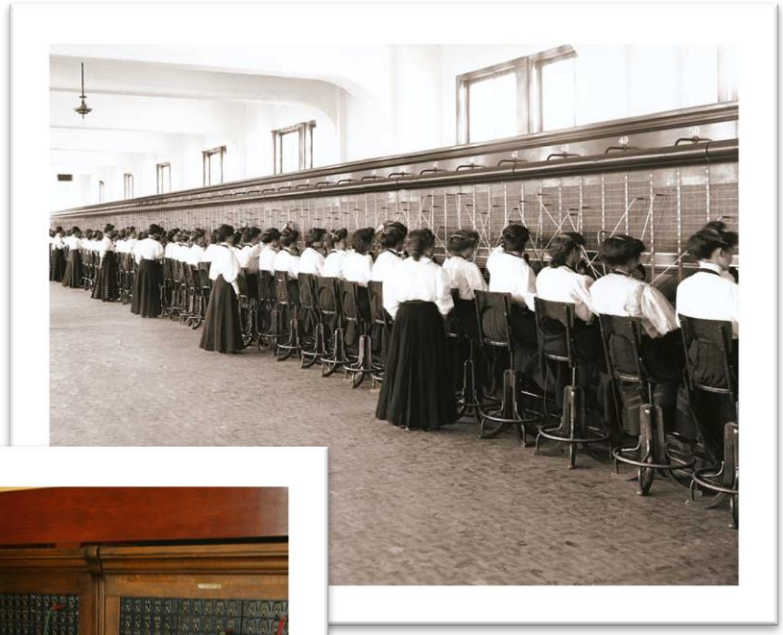
Outlook

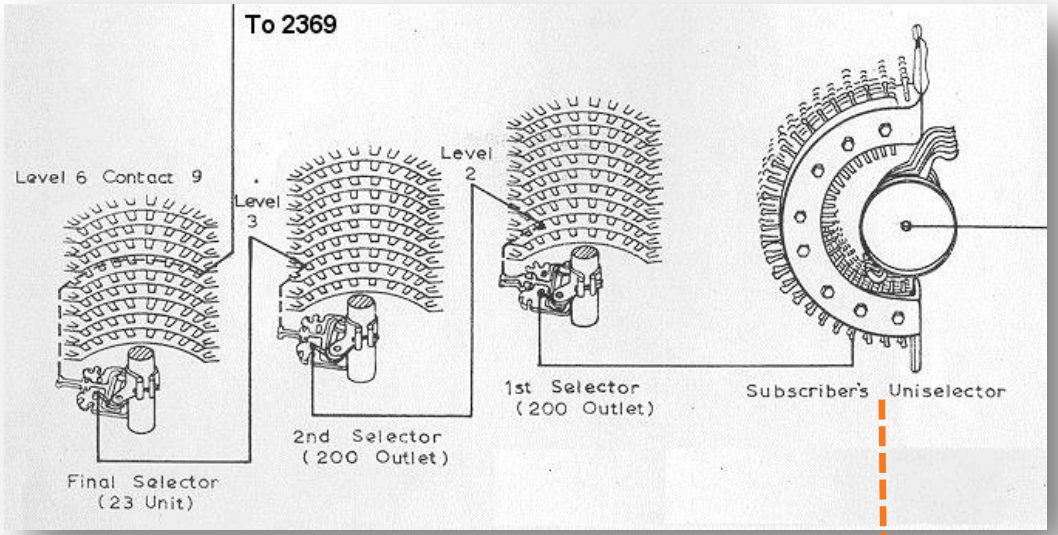
- Telecom networks
  - fast forward introduction to the evolution of switching and services
- Major contributors for the non-functionals
  - legacy aspects
  - the ‘carrier grade’ reference model
  - industry trends
- Architecting for reliability
- Solutions to achieve ‘carrier grade’ compliancy
- Wrap up

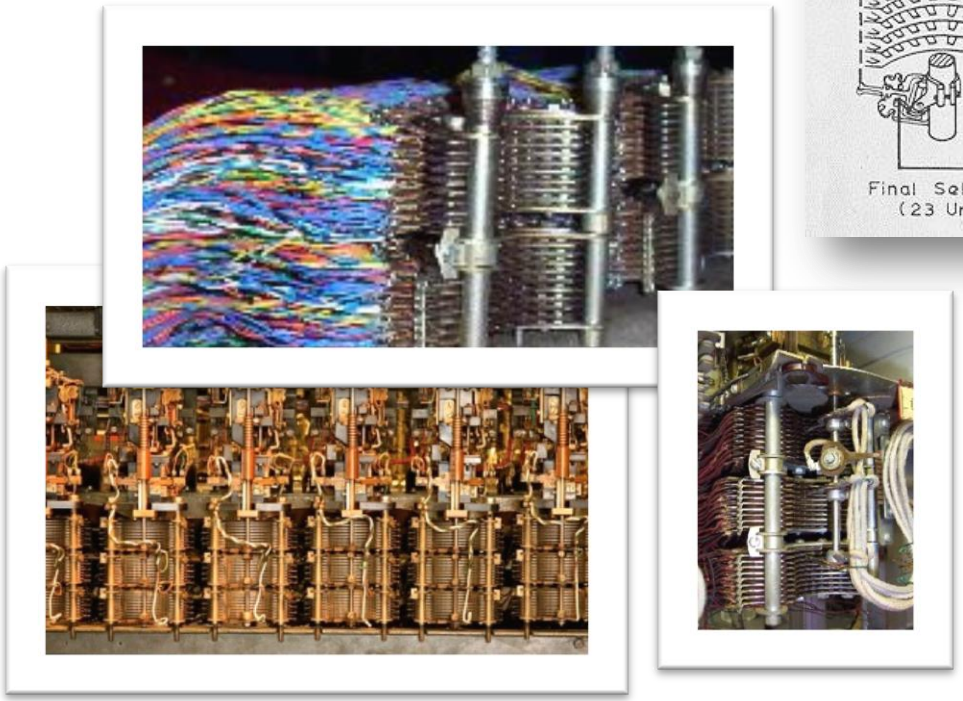
Circuit Switched telecom networks

manual operated switchboards



Automatic electro-mechanical step-by-step switches

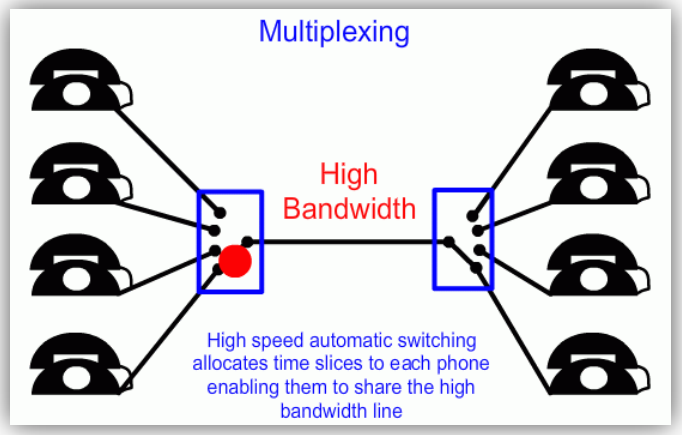


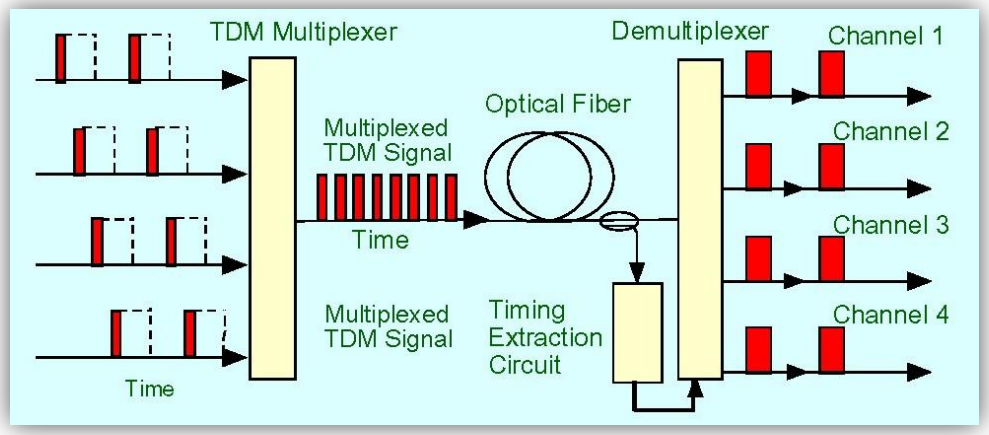


From Circuit Switched to Packet Switched

increasing capacity, decreasing physical wiring

TDM (time-division multiplexing) *multiplexing in which two or more bit streams or signals are transferred appearing simultaneously as sub-channels in one communication channel, but are physically taking turns on the channel. The time domain is divided into several recurrent time slots of fixed length, one for each sub-channel.*

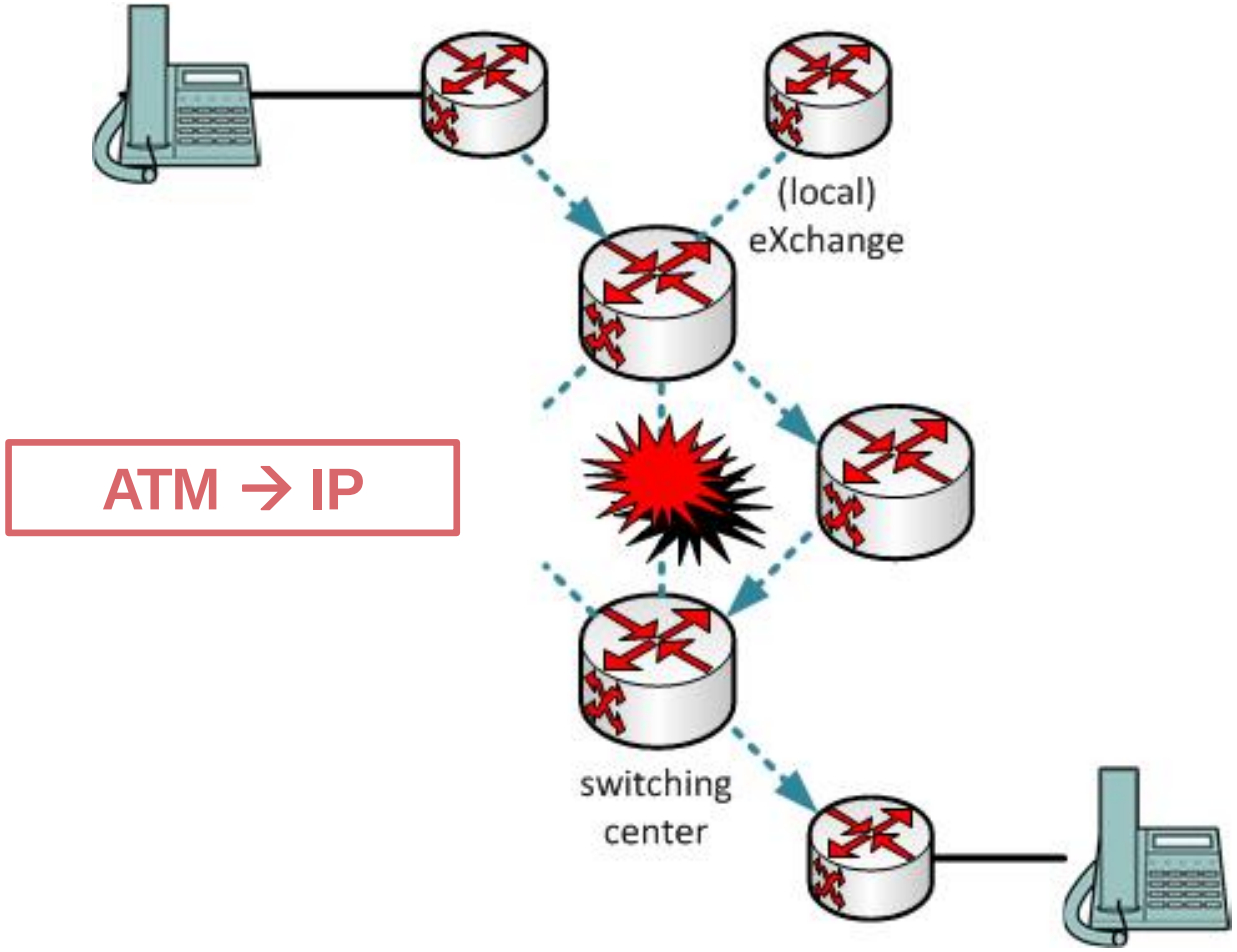




- traditional voice: 64 kbit/sec per channel (8 bit per sample, 8k samples/sec)
- TDM guarantees QoS

Automatic Routing

Packet Switched



ATM → IP

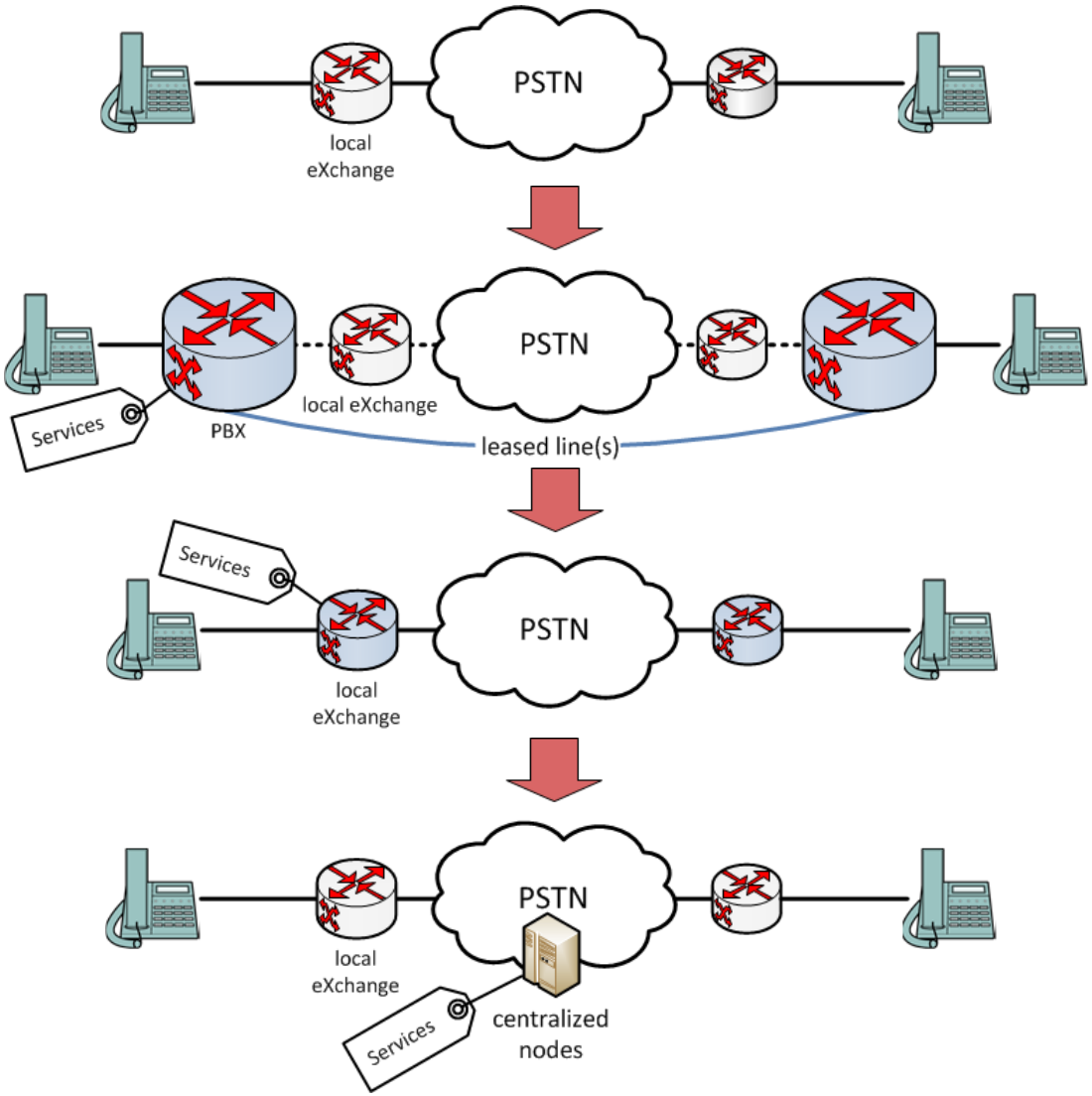
Services domain

e.g. diverged charging / pre-paid

leased connections

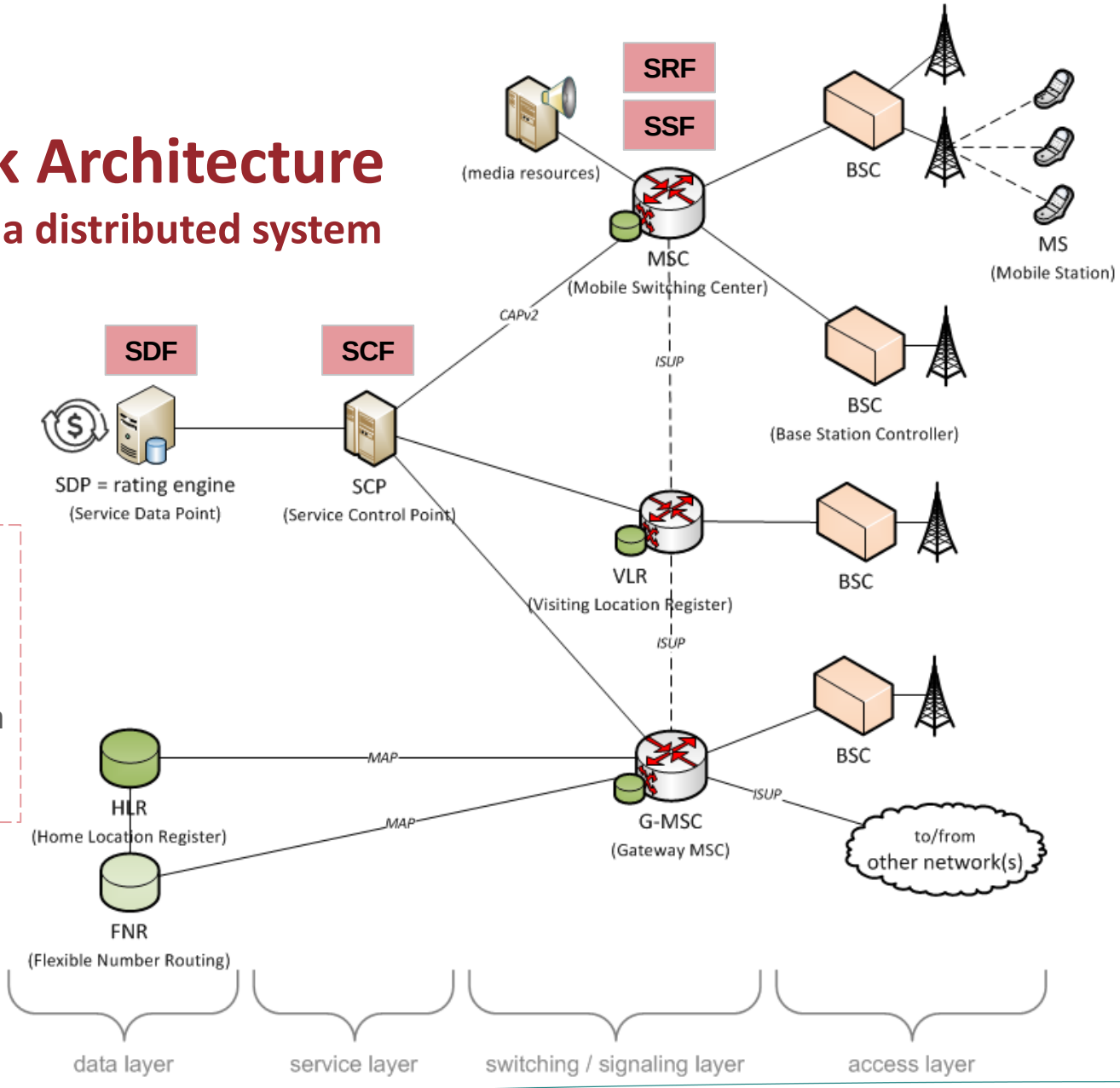
“centrex” solutions

“Intelligent Networks”



Mobile Network Architecture

the telecom network is a distributed system



Functions

SCF: Service Control Function
SSF: Service Switching Function
SRF: Specialized Resource Function
SDF: Service Data Function
…

Legacy aspects

Already since the beginning of previous century telecommunication is perceived as **critical utility function for society**. Nevertheless the telecom industry has been one characterized by of lack of openness and constant frustration of the interoperability standardization process by network equipment vendors.

As result governments have stepped in and become a key driver for non functional requirements; telecommunication nowadays is firmly anchored into **legalization**.

Examples of **regulatory requirements**:

- Availability
  - guaranteed availability of communication services at all times
  - guaranteed reachability of mission critical communication services such as emergency calls
- QoS
  - regulation of charging: tariffs, toll-free calls, differentiation schemas, ..
  - guaranteed interrupt free calls

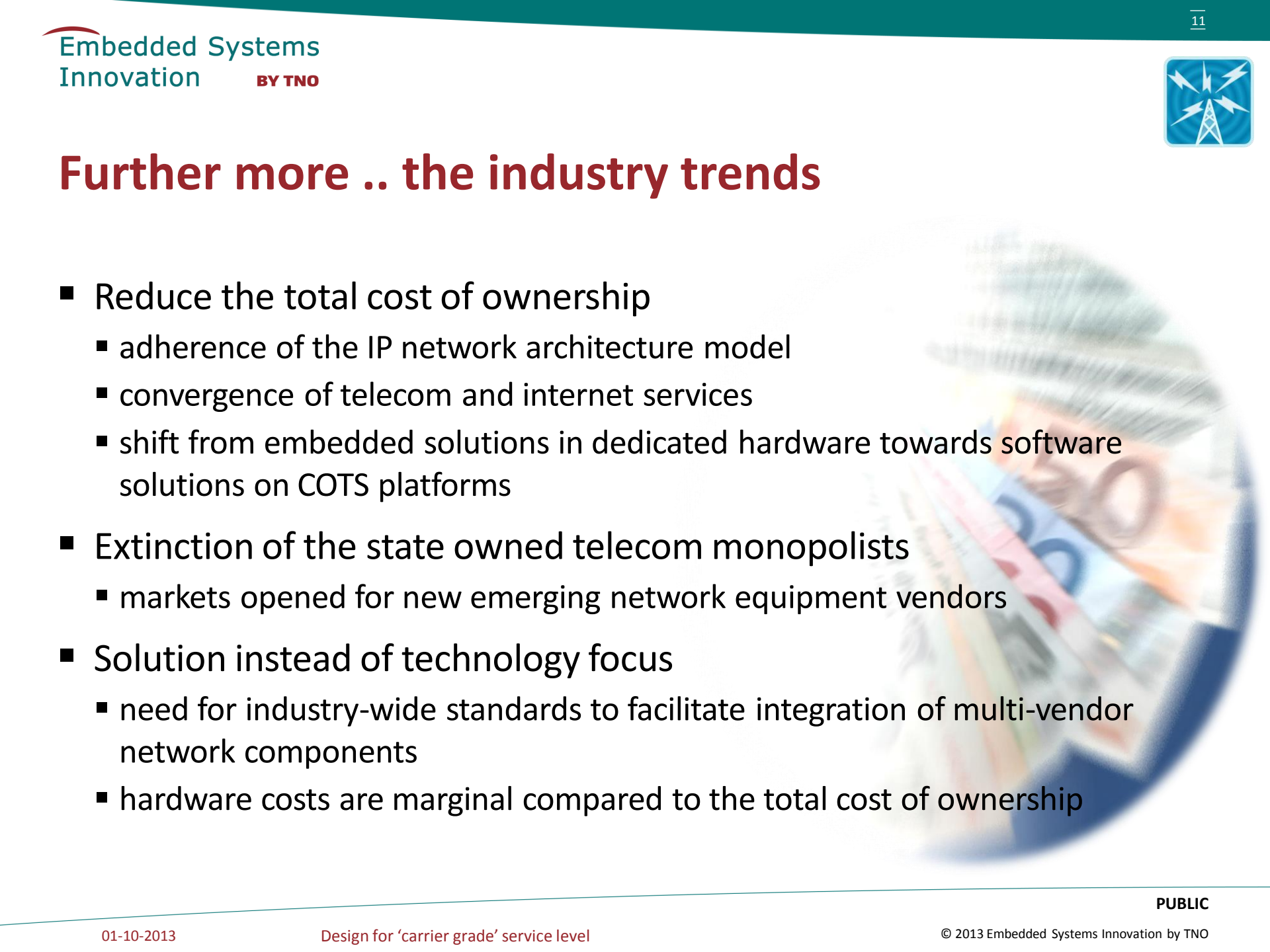
The ‘carrier grade’ reference model

some key non-functionals, International Telecommunication Union (ITU)

- Very **high performance**, support for large number of simultaneous session / transactions per time unit (thousands per seconds)
- Very **high availability**, at least **99.999%** uptime with predictable response times including overload situations
  - acceptable downtime is less than 5 minutes 26 seconds per year
  - load regulation & protection mechanism required
- **Real-time responsiveness**
- **Scalable** (non disruptive) network configurations
- Hardware and software **upgrade without service interruption**
- **Controlled life cycle of utilized resources**
- **Automated fault escalation & recovery**
- High level of **security**
- ..

Further more .. the industry trends

- Reduce the total cost of ownership
  - adherence of the IP network architecture model
  - convergence of telecom and internet services
  - shift from embedded solutions in dedicated hardware towards software solutions on COTS platforms
- Extinction of the state owned telecom monopolists
  - markets opened for new emerging network equipment vendors
- Solution instead of technology focus
  - need for industry-wide standards to facilitate integration of multi-vendor network components
  - hardware costs are marginal compared to the total cost of ownership



Reliability, network (node) architecting impact

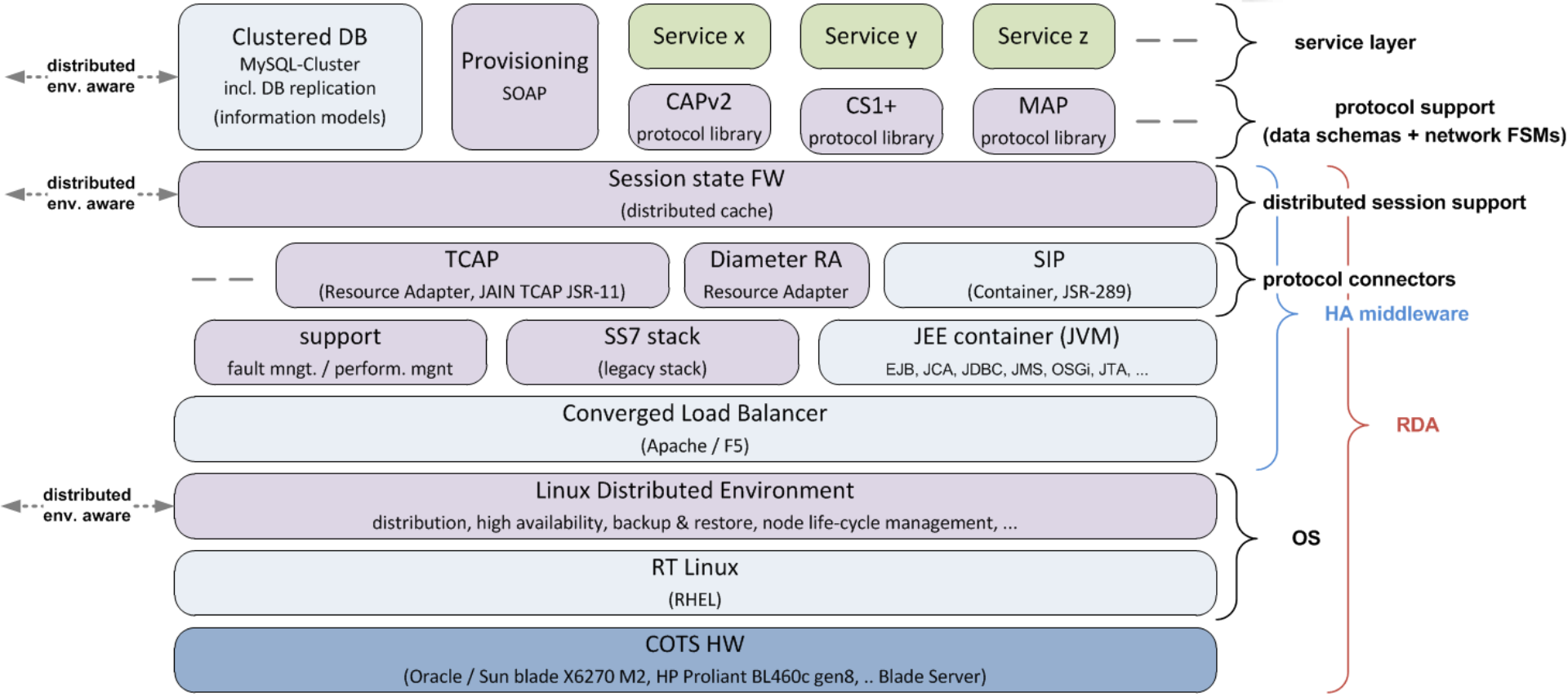
Required: **reliable** hardware and software agnostic blueprint for telecom services.
Focus is on availability, low failure rate and robustness.

Key solutions for reliable & robust networks architecting:

- **COTS** hardware & software stacks
  - use industry-wide proven technology and design
  - clusters instead of single-points-of-failure
- Scalable **redundancy** where it is cost effective
  - standby functions take over operation in case of failure
  - session data /state replication & distribution
  - automatic availability management using active & (hot/warm / cold) standby nodes
- **Robust interfaces** and checkpointing ensuring non-interrupted QoS
  - strong decoupling of network and service models allowing for “graceful degradation”
  - seamless software (& hardware) upgrade mechanisms
- **Over-dimensioning** to ensure RT responsiveness

COTS hardware & software stack

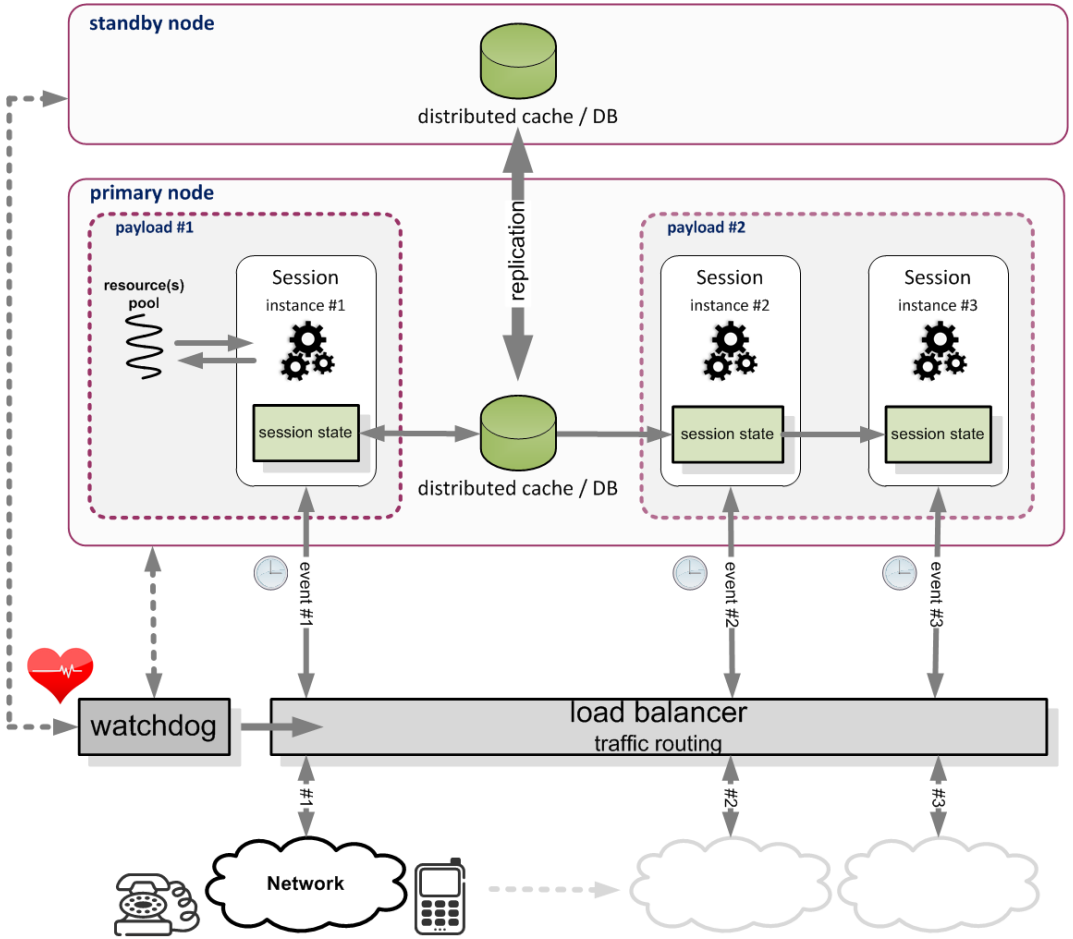
example: SCP node (configuration blueprint for single payload)



Everywhere redundancy

.. and redundancy, redundancy ..

- Session processing (execution threads) and session state are decoupled.
- Sessions states are stored temporary between events, resources are pooled.
- Session states are replicated over the payloads, every payload can process the next session's event (session retention).
- Critical data (incl. session states) is replicated to the backup node, that one can immediately process the next session's event.
- System's self healing capability: watchdogs (and timers) monitor and actively verify the payloads and nodes health, switchover or reconfiguration automatic initiated.
- Redundancy: typically N+1 (or 2N).



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Design for failure proof

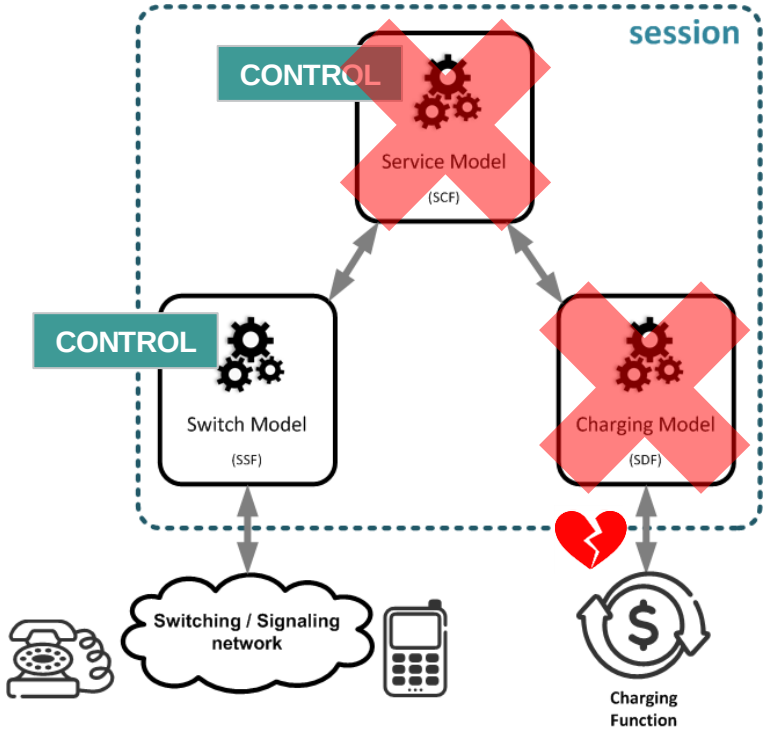
robust interfacing allowing for “graceful degradation”

Design functional models so that failures (think of lost events) are not fatal but are recoverable, so service can still be continued on some degraded level.

For example a missed event can result in failure of the service model (*online charged call*), but by discontinuation of a sub-service (*charge control*) and shifting the session control to a lower level (*call control* only) the overall service can still be finished successfully more or less (as a *toll-free call*).

Design techniques:

- Checkpointing to detect / enforce unexpected state changes.
- Hearthbeats + activity timers to monitor on connection health.
- Decoupling service from network models, all extended with failure scenarios.
- Introduce / manage the notion of session control.



Upgradeability

Make use of the system redundancy & checkpointing, so the capacity of the system to survive / recover from a failing session, payload or node.

Software upgrade strategies:

better, but more complex

- **split-mode upgrade** use the (redundant) standby node
  Decouple system, re-install node 1, couple up + sync data, switch over traffic primary to standby, temporal transition period , decouple, re-install node 2, ..
- **rolling upgrade** upgrade one payload at the time
  Use standard (*nix) upgrade technology, but quite complex to realize for distributed components (especially distributed caches).
- **seamless (smooth) upgrade** use of a new dynamic binding (class-loader) next to the old binding
  New sessions are loaded in the new binding, old sessions are finished in the old binding, during the upgrade window both bindings are supported.
  This requires that upgraded code is backwards compatible with not-yet-upgraded DB schemas, and old code is forward compatible with already-upgraded DB schemas.

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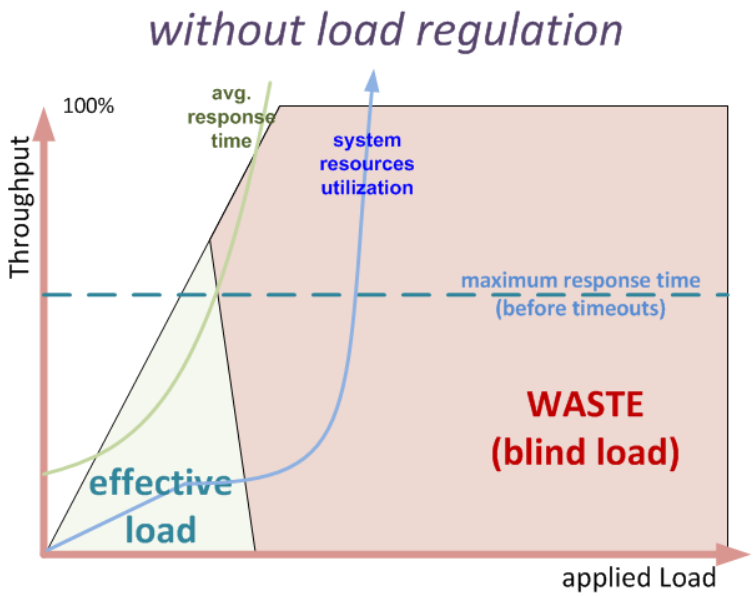
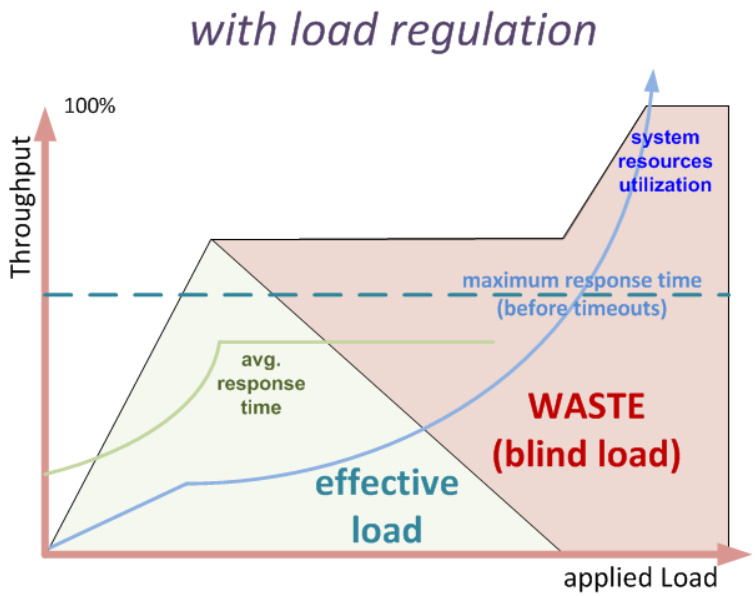
Load protection & load regulation

system over-dimensioning to achieve reliability

"Always" **reject session initiation** (call setup) when **load is above a certain threshold** (typical 25%-40%).

- Protect critical system resources, ensures that the system remains in service.
- Secures high throughput at sustained high load, as response times are kept artificially low.
- Prevent applications are wasting resources as their activities are, under high load, discarded anyway.





Wrap up

- Reliability is critical for telecom networks
  .. focus is on availability, low failure rate and robustness.

- Telecom architectures are strongly characterized by redundancy
  .. enabling system self-healing capabilities, upgradeability, resource utilization.

- Heavy over-dimensioning is acceptable to achieve reliability
  .. as the telecom realm is heavily solution oriented so hardware costs are negligible.

Questions