Engineering Management Methods BMEVITMAK47
Electrical Engineering BSc and MSc Major
Computer Engineering BSc and MSc Major

ENGINEERING MANAGEMENT PRINCIPLES, MODELS AND PROCEDURES

FROM GENERAL TO ICT SPECIFIC TOOLS

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GENERAL MANAGEMENT METHODS

General (engineering) management methods and means

Objective: **to support to exercise the management functions and roles, especially**

- **preparation of of and supporting decisions** (Pareto, PEST, profitability calculation … datamining)
- **communication tasks** (e.g.: presiding a meeting, reasoning)
- **planning and managing strategy** (SWOT, BSC, organization restructuring, development of enterprise culture, etc.)
- **projectmanagement techniques**
- **staff development** (e.g.: working style analysis, performance evaluation)
- **management training** (self assessment, coaching methods, compromizing, managing conflicts)

Simple general management methods:

Pareto method: **classification of activities according to their relevance (priority list for A, B and C):** ***a few*** **relevant A-s, more less relevant B-s, etc.**

STEP/PEST/HEAT method: **structuring the global examination: consideration of social (human, S/H), technical (T), economic (E) and political (administrative, legal, P/A) aspects separately**

Communication, meeting, presiding negotiations

Aspects of the effectiveness:

- Preparation, duration of the meeting, attention to others (opinion), multi-sided approach, structuring, summarizing, determination of next steps, responsible persons, deadlines
- Number, inclusion, motivation, integration of thougths of the participants

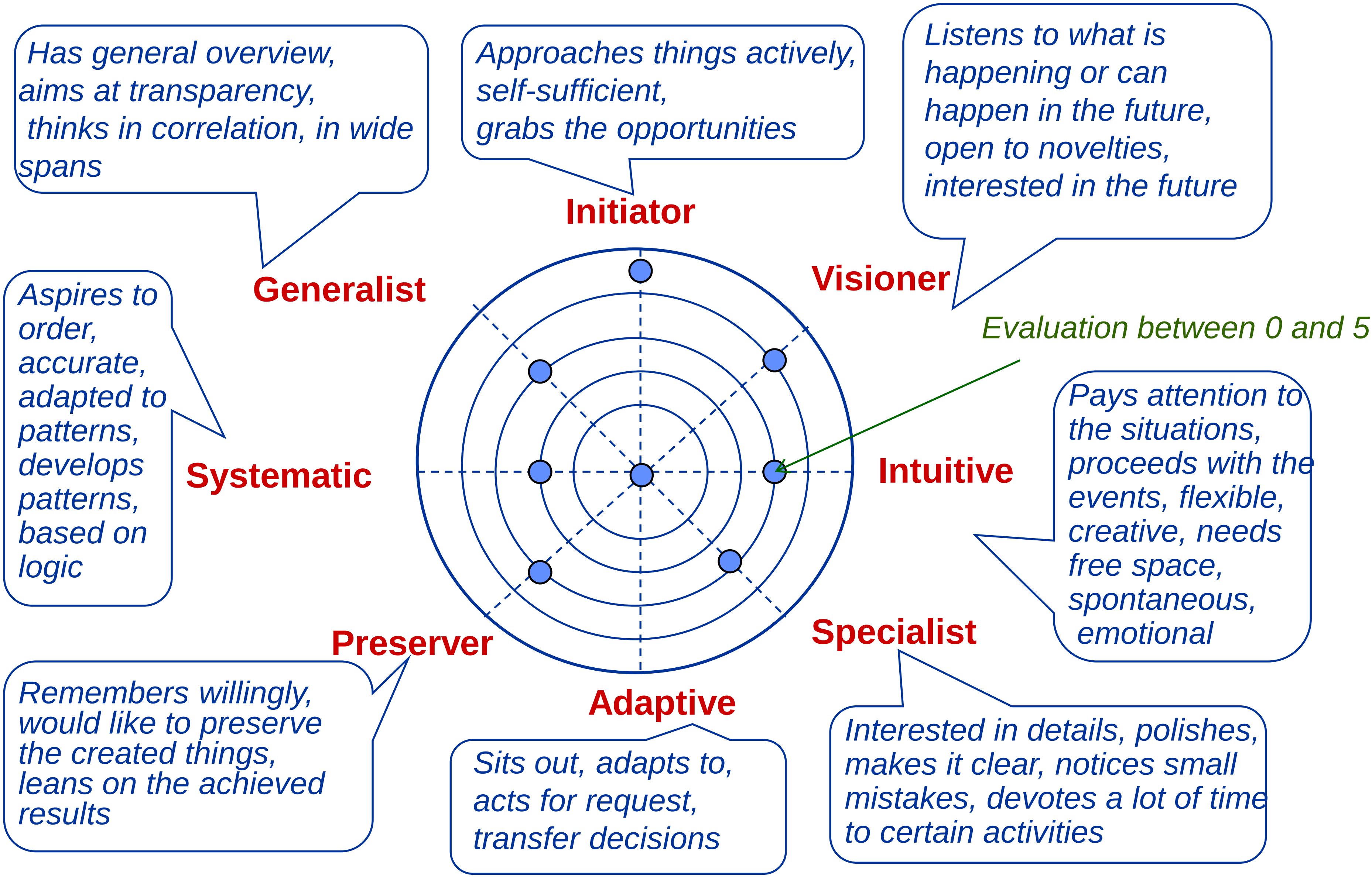
Method of six thinking hats (by Edward de Bono):

  - to manage the bouncing thoughts (approaching aspects)
  - to promote the paralel way of thinking (everyone approaches the same problem from every aspect at the same time) :

- **White hat:** listing up facts, data *without any emotion*
- **Red hat:** feelings, intuitions, *emotional aspect*
- **Green hat:** creativity, collection of ideas, alternatives, opportunities
- **Yellow hat:** looking for *values, advantages*, Why is it good?
- **Black hat:** looking for threats, difficulties, critical approach
- **Blue hat:** comprehensive way of thinking (under one umbrella): goals, compositon, (partial) summary

The order of the hats is not fixed, returns are possible.

Working style analysis: Vogelauer’s method

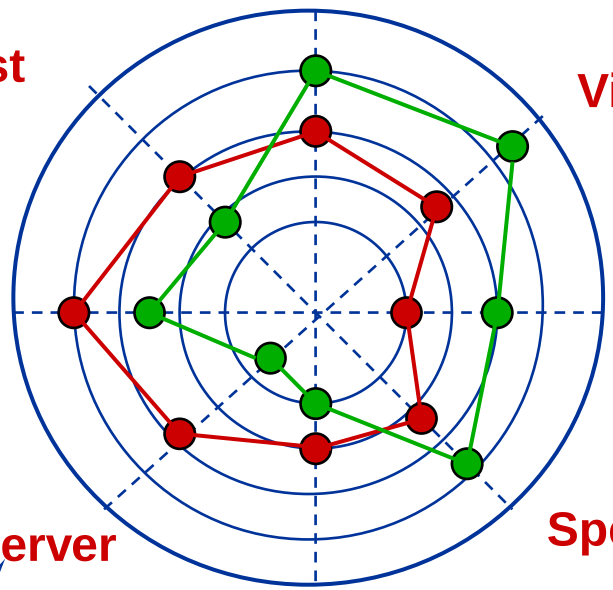


Vogelauer's working style analysis: examples

Has general overview, aims at transparency, thinks in correlation, in wide spans

Approaches actively, self-sufficient, grabs the opportunities

Listens what is happening or can happen in the future, open to novelties, interested in the future



Aspires to order, accurate, adapted to patterns, develops patterns, based on logic

Pays attention to the situations, proceeds with the events, flexible, creative, needs free space, spontaneous, emotional

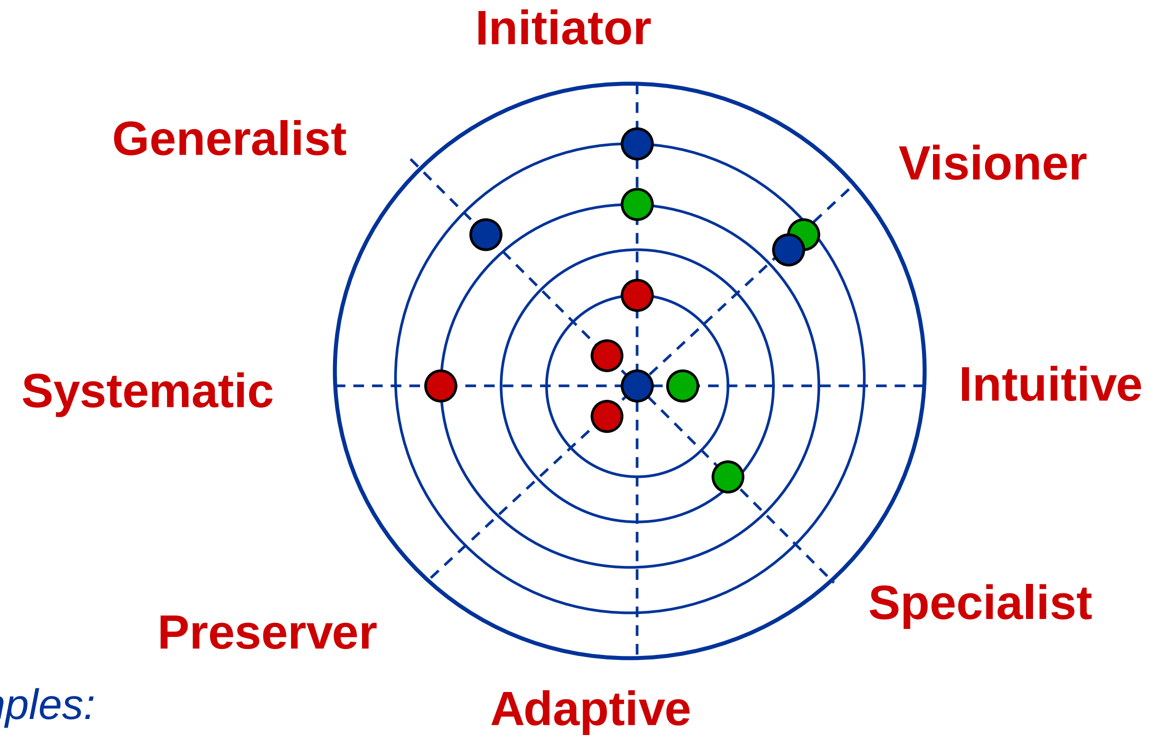
Remembers willingly, would like to preserve the created things, leans on the achieved results

Sits out, adapts to, acts for request, transfer decisions

Interested in details, polishes, makes it clear, notices small mistakes, devotes a lot of time to certain activities

Vogelauer's working style analysis: evaluation

Opposite behaviours in front of each other, measuring *balance and dominancy*.
Extrema: dictator, utopist, chaotic, meticulous, passive, traditionalist, bureaucrat
For also ourselves, colleagues, friends
Purpose: self-recognition (diagnosis) and development, orientation, team building



Examples:

- *Researcher*
- *Project manager*
- *Top manager*

Designation of direction and objectives (SMART)

Management is about **to designate and reach objectives** based upon diagnosis and estimation of the present state.
Types of objectives: performance- and final objectives

SMART objectives (What kind of objectives shall we have?):

- **S**pecific: characteristic to us
- **M**easurable: determination of progress and achievement of objectives
- **A**ttractive: motivation to activity, to challenge
- **R**eal: achievable, upon which we have influence
- **T**imed: setting timing and deadline

Management by Objectives (MbO): management based upon objectives

Stress upon the *performance-objectives* in the systematic performance evaluation system.

Objectives worked out together with the employee:

Key Performance Indicator (KPI): the personalized corporate strategy

Searching for solutions, lateral way of thinking

Exploration of *several alternative possibilities*, options, ideas
to achieve the designated objective/direction, to solve the problem

Approach: to leave the usual aspects, to dare to rethink, partitioning problems, combining different elements of alternative solutions

Brainstorming: exploration of ideas without critisism in a group

- to explore as many ideas as possible without critisism
- to further develop each other's ideas, *chain of thoughts*

Lateral way of thinking (by Edward de Bono): to explore alternative solutions.

„**The practical creativity** can be developed and learnt."

Our brains operate, think in typical, dominant schemes, follow routines. Therefore looking back to creative ideas they seem to be logical. The lateral way of thinking helps the *lateral leaving* of stereotypes (usual patterns):

- **Provocation, shift:** *conscious* throw off stable balance, changing order, stress, emphasis; reversing usual relations, expressing dreams
- **Principle of fans:** creating wider and wider list of objectives – directions of thinking – realisation principles
- **Random input:** proceeding from another/randomly chosen aspect, helping out associations by random words.

OPTIMIZATION OF DEVELOPMENT AND OPERATION

COMPLEX ENGINEERING MANAGEMENT, TECHNO-ECONOMIC APPROACH

In general: Management, operation and development of organizations, companies:

Planning, scheduling, allocation of resources, ordering tasks

Alternative solutions, multilateral aspects

Looking for optimal solution aiming at:

min (costs), max (performance), in general: optimal combination/compromise

Examples:

Production optimization: how many from what to produce versus resources

Transport, distribution problems: among stores and sites

Servicing problems: queuing, congestion, pricing, service planning

Stockpiling: demand models, replacement ordering

Exploitation of equipment, maintenance, scheduling of replacing investment

Alignment, routing: eg. travelling salesman problem, road/route planning

Allocation: eg. allocation of resources among the business units

Location, arrangement problems:

eg. Location and servicing area of a new store, maintenance center, telephone exchange

Managing complex tasks, projects, multi-projects: finding the critical route

Optimum combination of alternatives: planning high-way, telecom network topology and routing

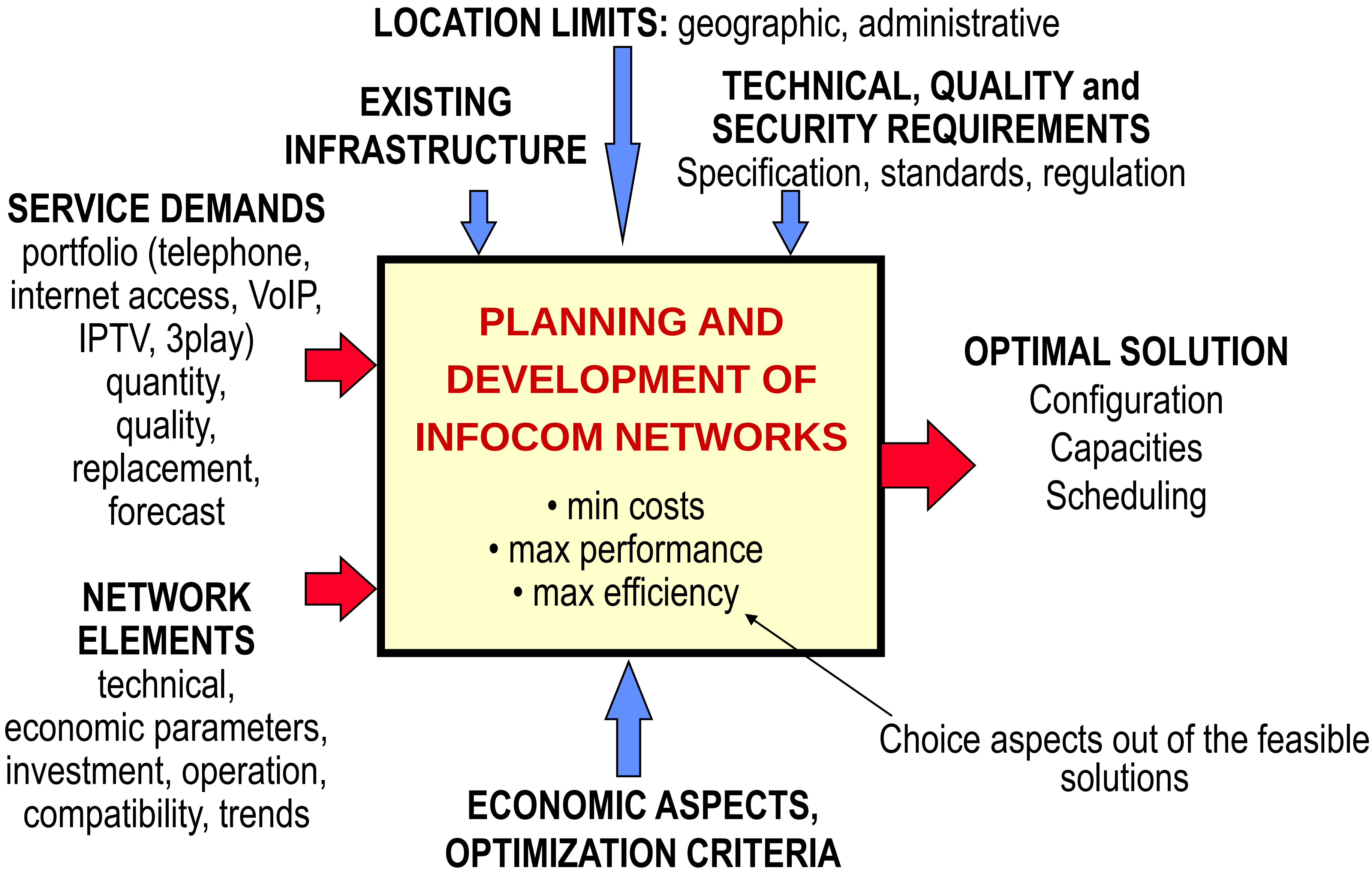
Competitors analysis, calculation of expected decisions, eg. in forming prices (game theory)

Configuration, dimensioning, planning development and operation of complex systems:

eg. nation-wide ICT, information and communication infrastructures, systems,

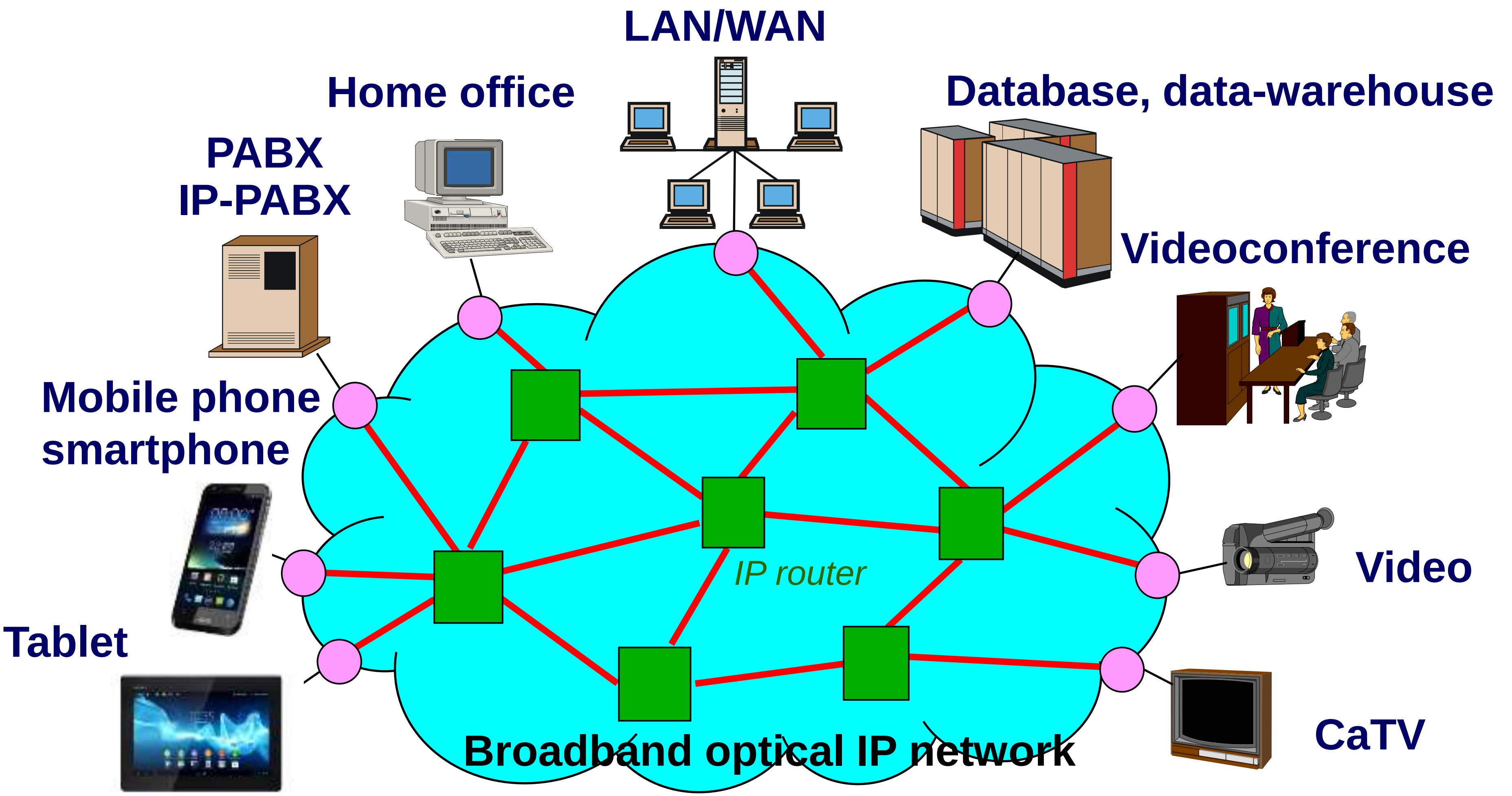
infocom/telecom/internet networks and services (service networks)

Nation-wide information and communication systems, service networks planning



Integrated infocom service network vision

IP based „Next Generation Network/Access” (NGN/NGA)



Planning characteristics of wide-area/nation-wide ICT systems, infrastructures, service networks

Complexity, scheduling, uncertainty, various solutions:

Sophisticated models: consideration of traffic, time and space influences, technical, financial and geographic constraints, modularity

Optimizing network modernization :
gradual deployment, managing the time parameter,
new technologies and services (migration strategy)

Uncertainty: in technology, services, demand/traffic quantity and characteristics

Alternative solutions:

- **Optimization of draft solutions** using a dedicated technology:
  optimal configuration, dimensioning network-elements,
  exploiting network synergies,
  huge savings in total deployment and operational costs!
- **Systematic comparison, multilateral analysis of the solutions:**
  life-time costing, incorporating incomes;
  quality of services, reliability, survivability, sensitivity of optimum with respect to the overload and costs, optimum robustness.

In real tasks the operational research methods are not appropriate!

HEURISTIC MODELS AND METHODS

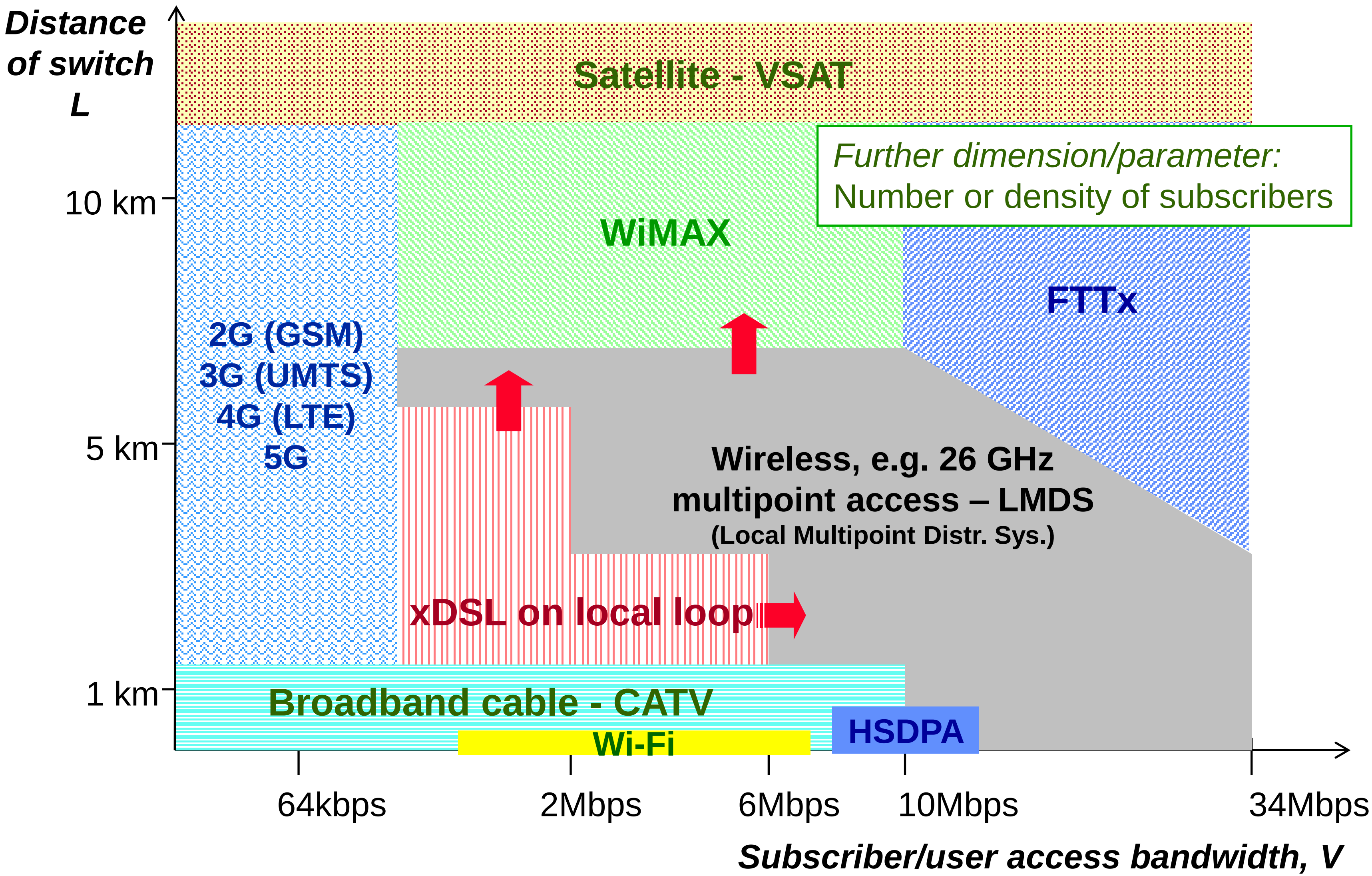
Identification of the internal structure and relationships of the planning problem:

- **segmentation, partitioning of tasks, breaking down to phases**
- **approximate, purpose oriented network development models**
- **planning/optimization segment by segment**
    - **limited use of optimization algorithms**
    - **suboptimal/pragmatic algorithms**
- **interactive iteration**

List of fundamental techniques / procedures:

- **network layers, levels, segments**
- **statistical / aggregate description**
- **present value calculation (discounting)**
- **rolling planning**
- **system/technology/configuration selection diagrams**

Example: Application map of the broadband access technologies: Two-parametric (L, V) system selection diagram



LAYERS OF INTELLIGENT INFRASTRUCTURE OF THE INFORMATION SOCIETY

(planning, operation, regulation of ICT systems, service providing networks)

Media

Inform. Techn.

Telecommunications

Content and applications

Infocom infrastructure

Content
WEB sites (eg. content of e-services), AV content, Video on Demand (VoD), cognitive content (pl. gesture, sensor info)

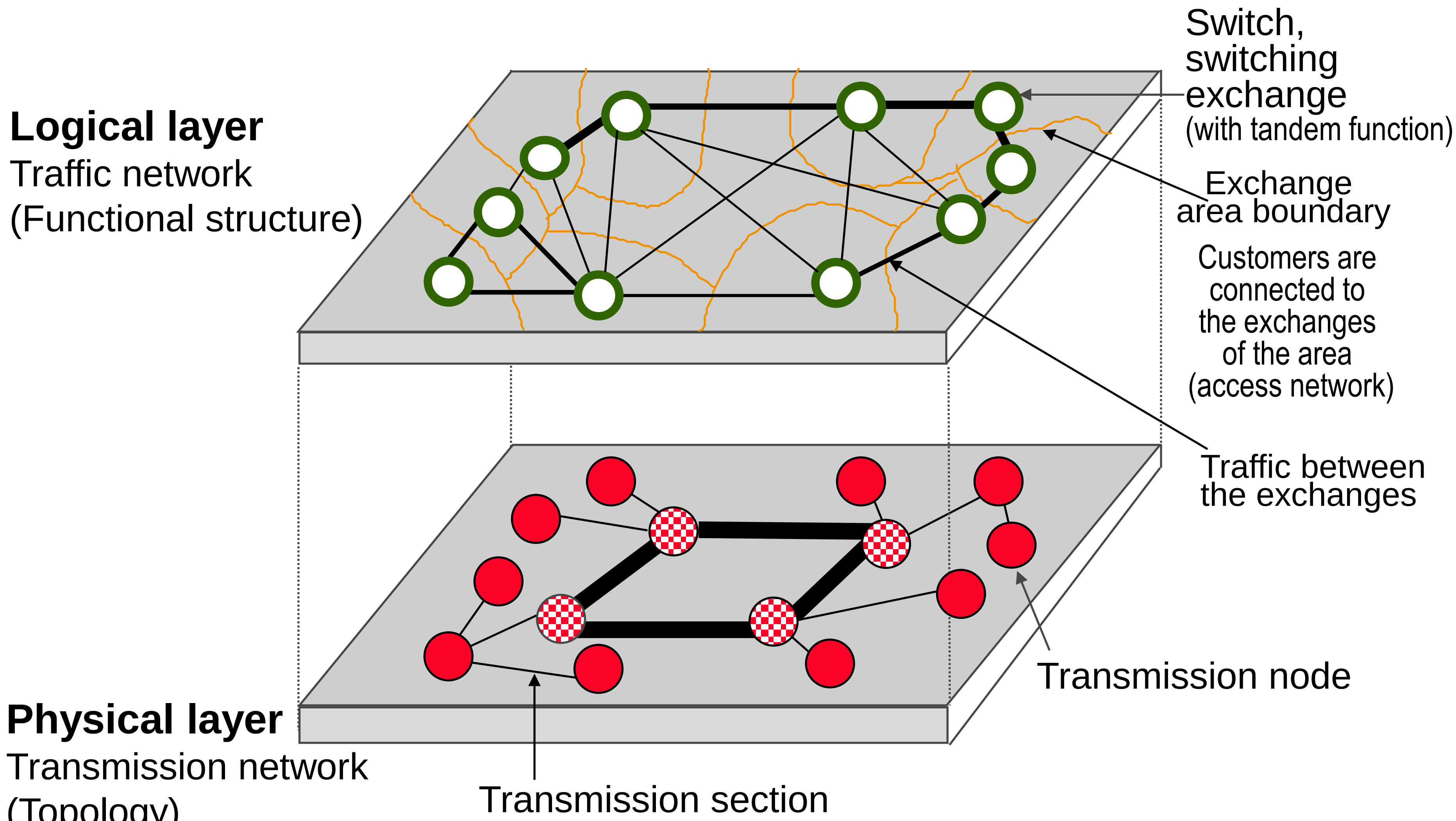
E- content (infosocial) applications
E-services /infocom applications, special systems:
eg. e-commerce, e-government, e-health, AV downloading

E - content (IT) infrastructure
Mediainformatic systems: databases, multimedia, archives, content management and security systems, etc.

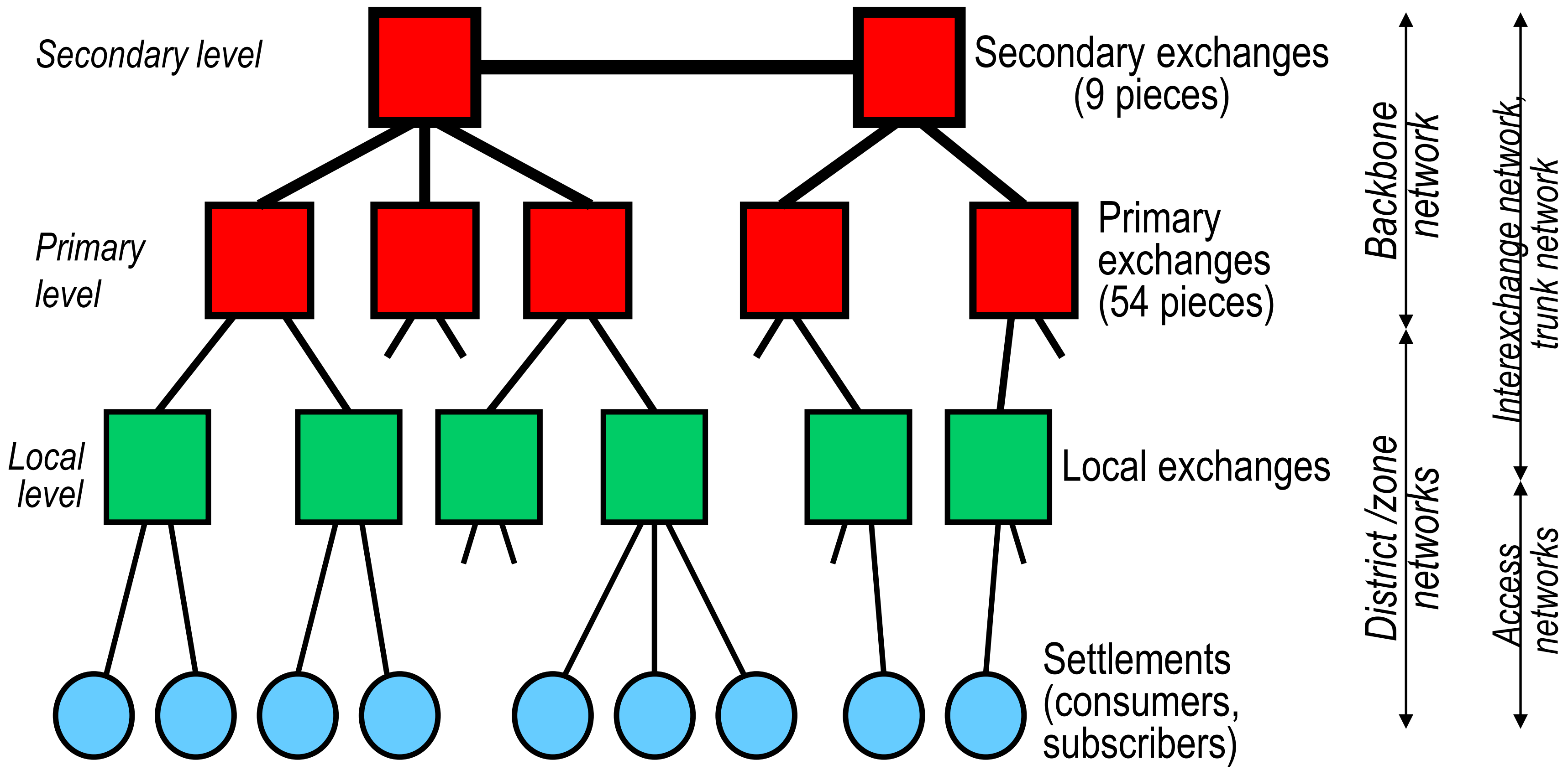
E - communication services (logical layer)
Sevices in the networks, eg:
telephone, fax, datacomm., Internet, VoIP, radio and TV programmes

E - communication networks (physical layer)
Network infrastructure + means of signal transm.: metal and optical wireline, wireless, mobile, satellite, cableTV, broadcasting networks

NETWORK LAYERS
(Service network)



TRAFFIC CONCENTRATION
Hierarchy of the national telephone network (Hungary)

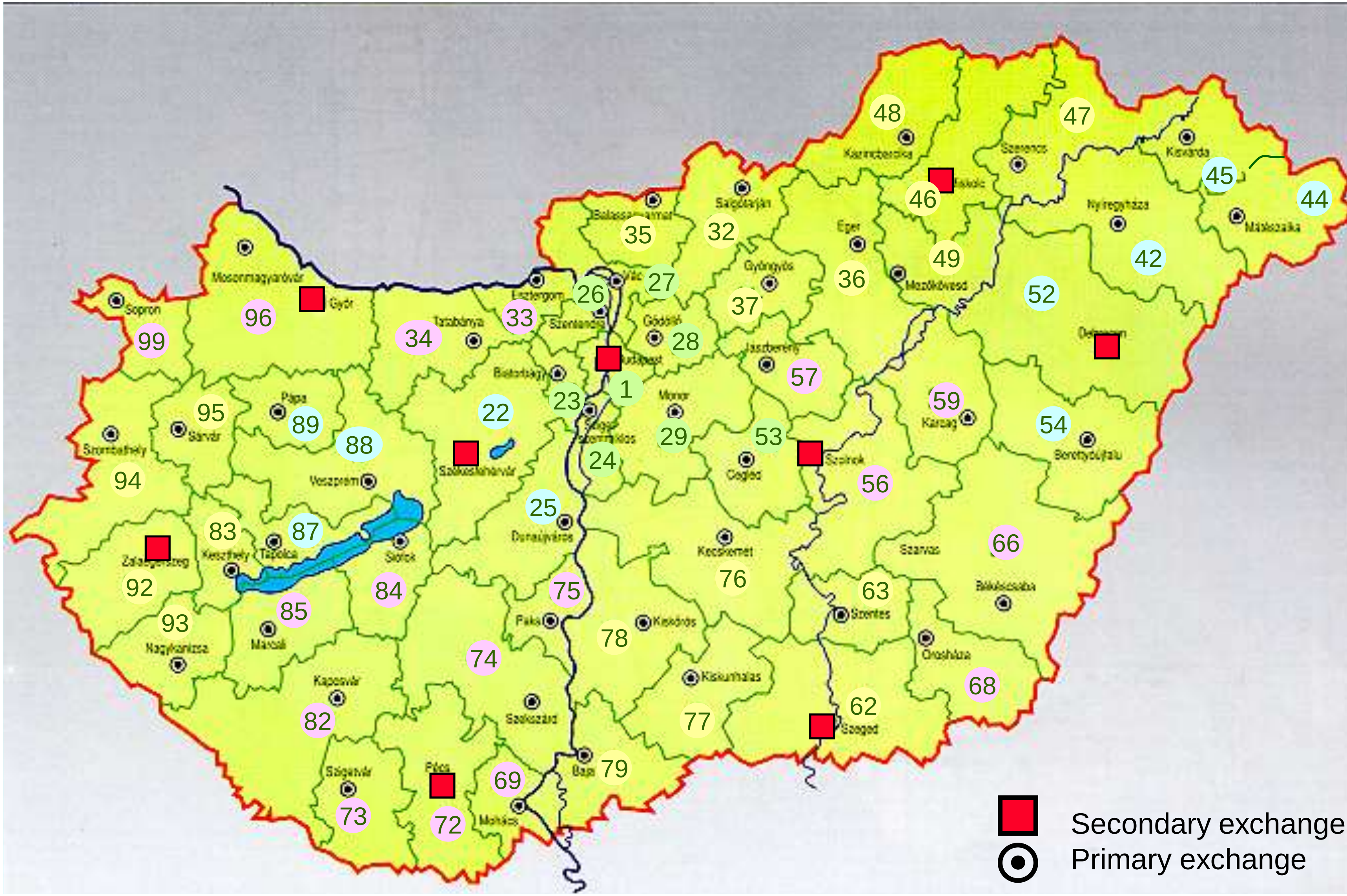


Exploiting the opportunities of digital techniques radical reformation of the national network was needed:

Reduced the number of the hierarchical levels (by 2),
the number of the numbering zones (from 93 to 54),
the number of the local exchanges (>200).

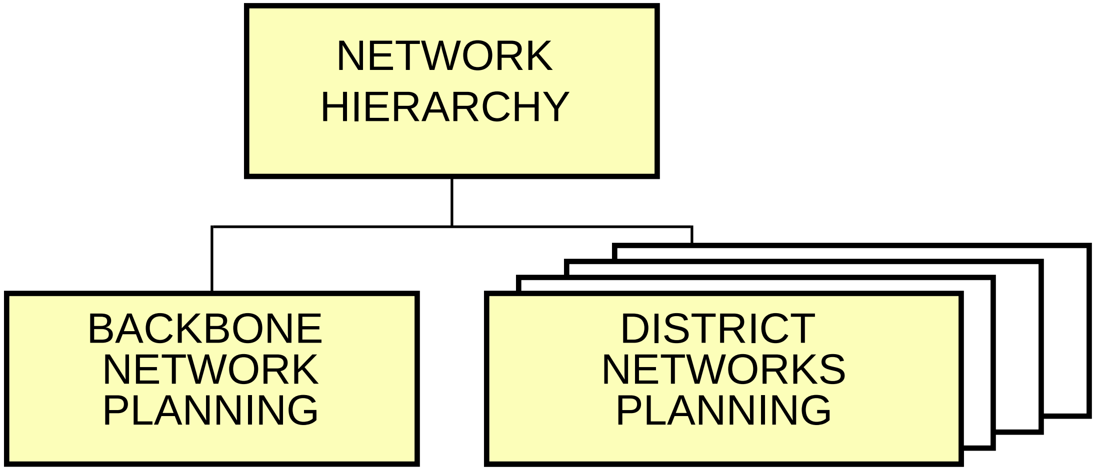
} to interconnect all the domestic settlements (3152)

PRIMARY (NUMBERING) DISTRICTS



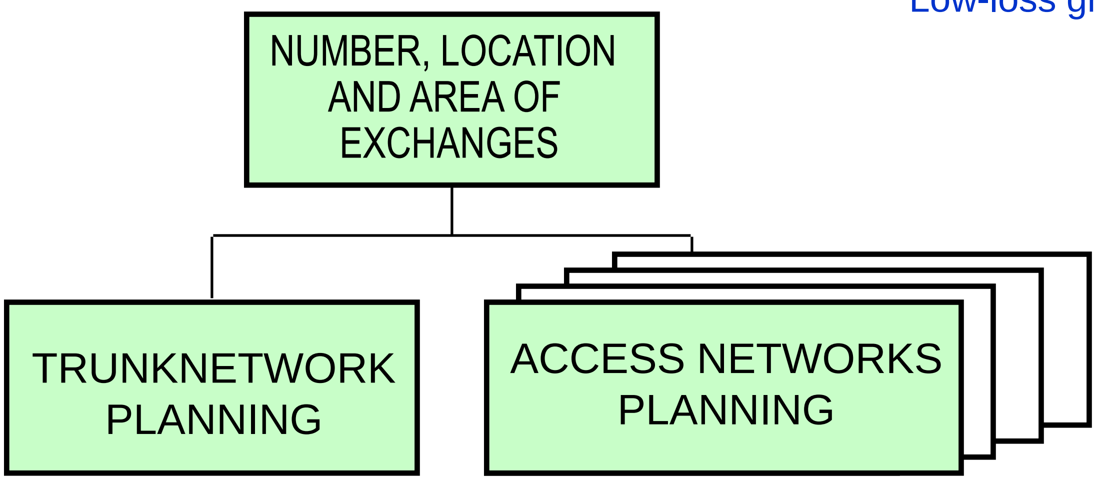
NETWORK SEGMENTS, TRAFFIC ROUTING

National network:

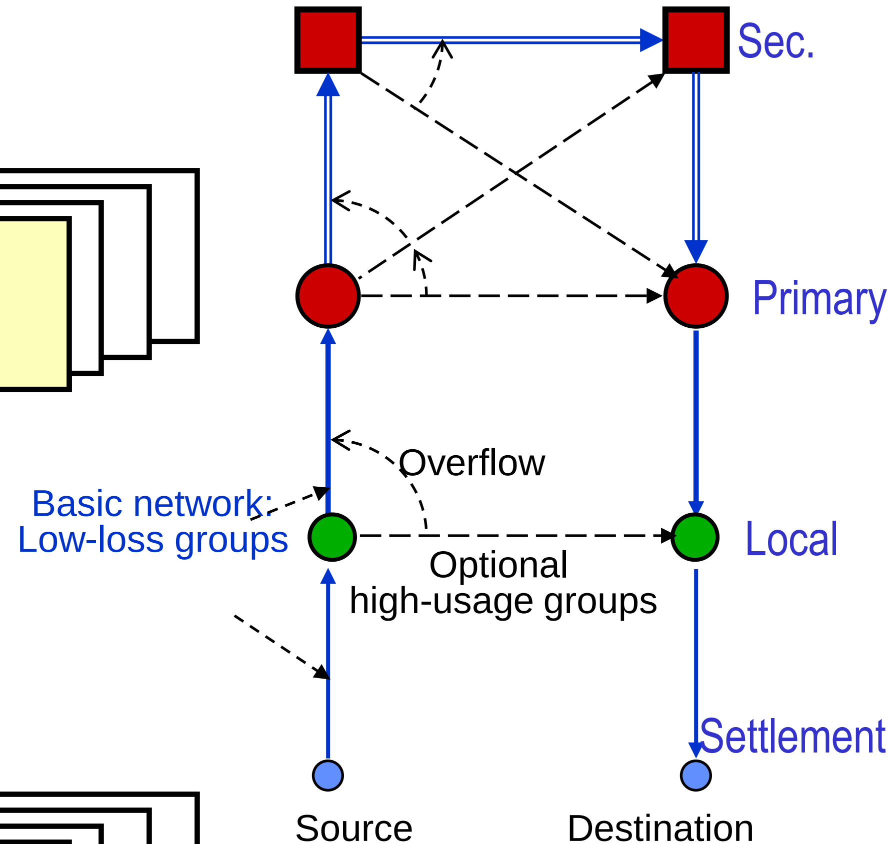


[Inter-primary exchange network]

Metropolitan network (eg. Budapest):

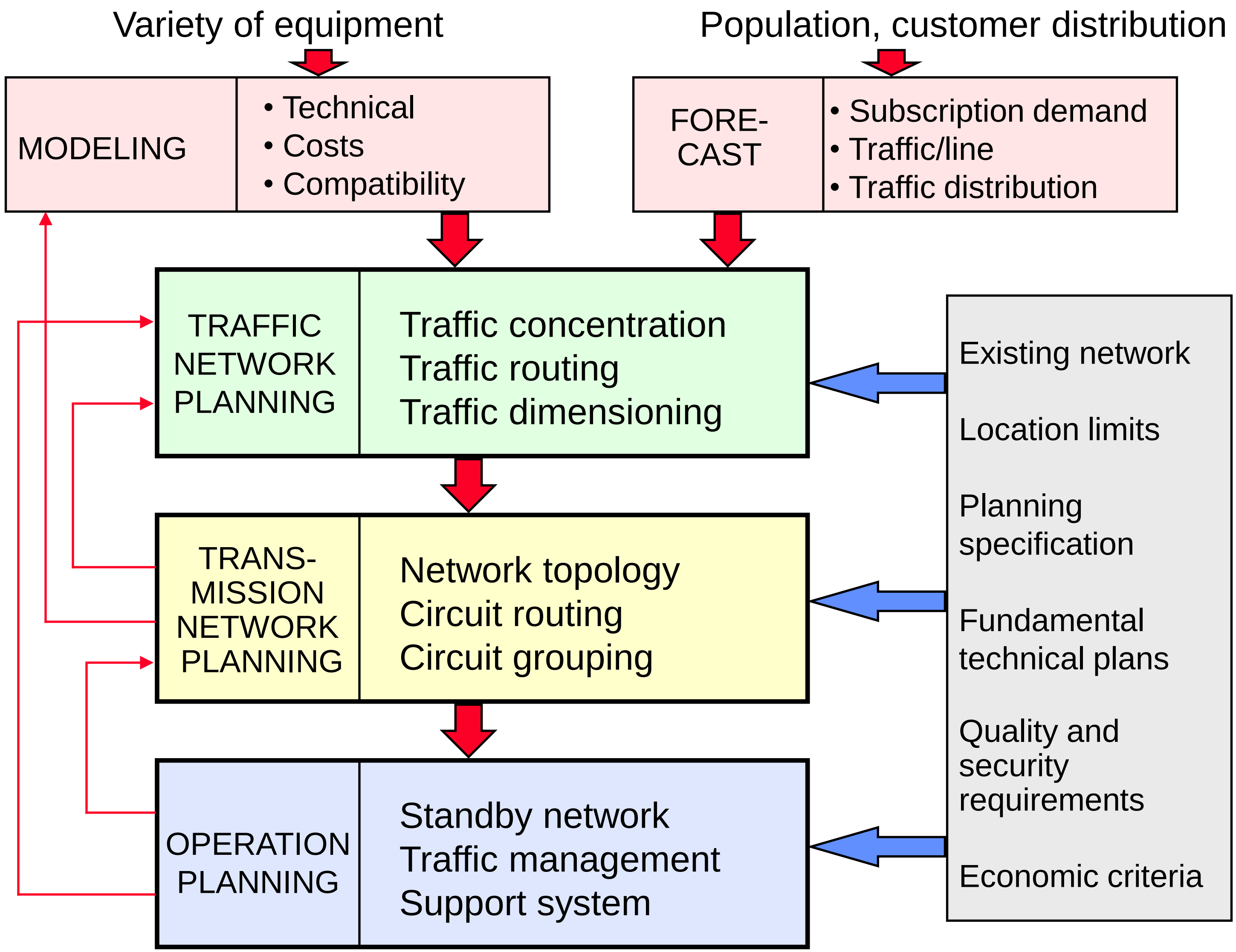


[Interexchange network]



Number of network levels ?
Number of nodes by levels ?
Optional groups ?

PROCESS AND PHASES OF THE NETWORK PLANNING



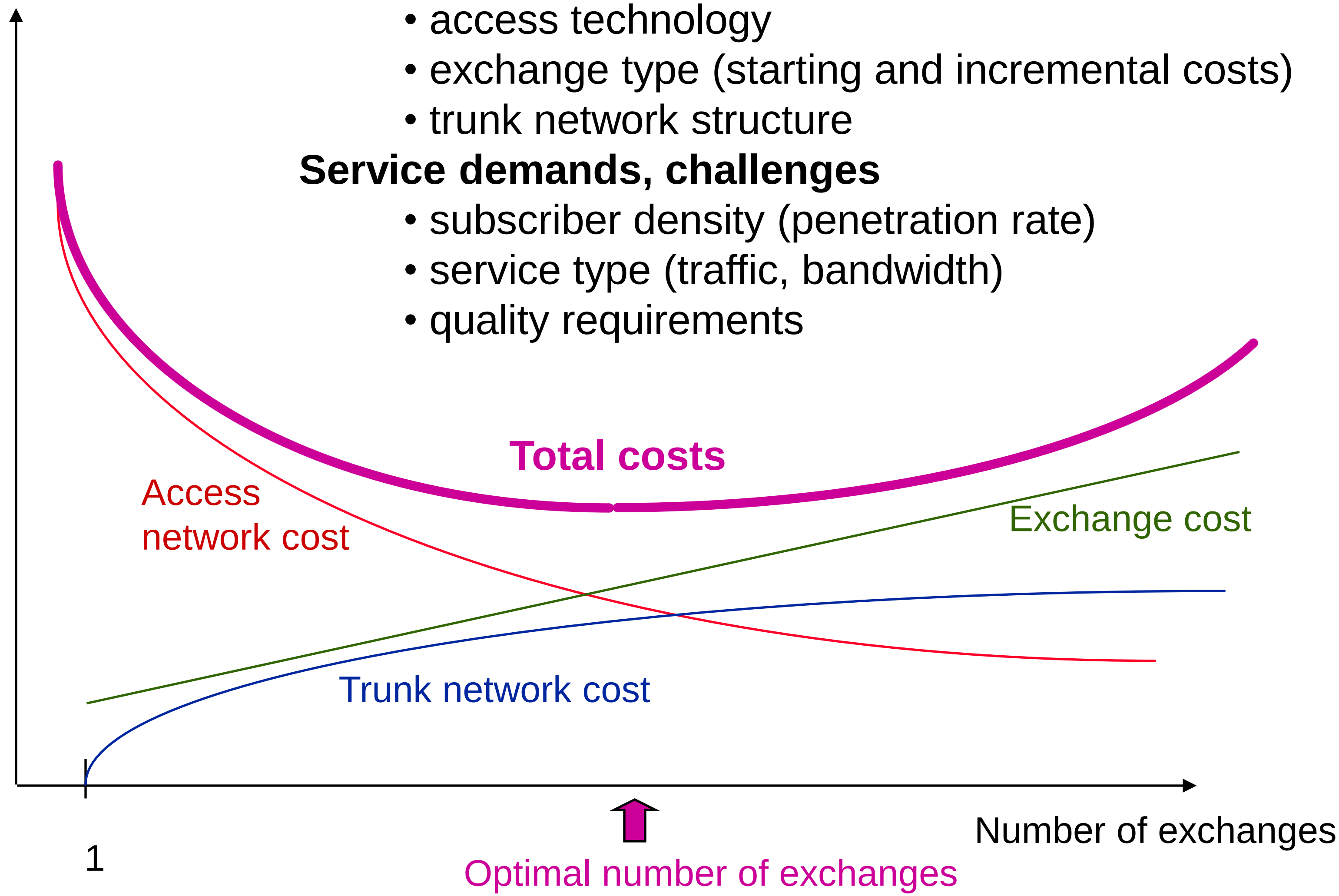
Cost optimization of metropolitan networks with respect to the number of exchanges

Effect of digitalization

- access technology
- exchange type (starting and incremental costs)
- trunk network structure

Service demands, challenges

- subscriber density (penetration rate)
- service type (traffic, bandwidth)
- quality requirements



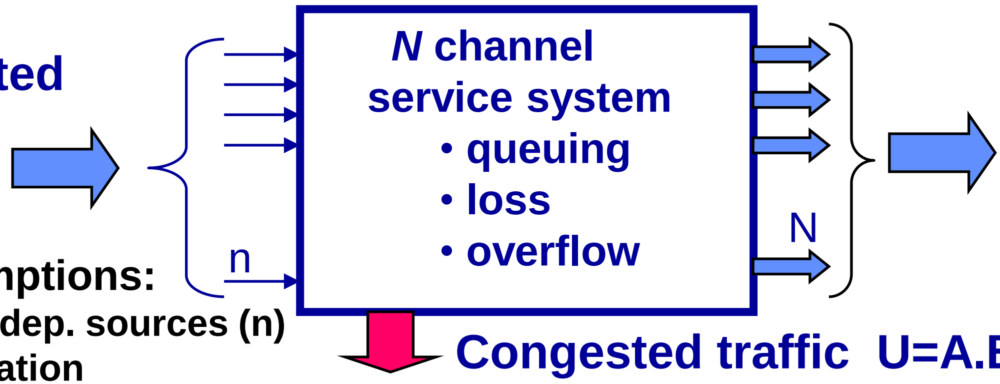
MODELING

Approximations:

- assuming independence and/or symmetry
- simple distributions, statistical parameters
- simple cost, distance and capacity functions
- simplifying the sets of possible states and transitions

MODELING OF SERVICING TELCO TRAFFIC

Offered, generated traffic load
A= n. s /T = n. α



Transmitted, terminated traffic:
average number of the busy channels:

Y= A (1-B) < N

Congested traffic U=A.B

Simplifying assumptions:
- **Large number of indep. sources (n)**
- **Random call generation**
  Expected time interval: T (exp. distr.)
- **Hold time: independent of the elapsed time**
  Expected value: s (exp. distribution)

Congestion: if a call generation is not instantly done: it waits, is lost or overflows.
Congestion probability: B

Specific traffic: average activity of a single source: α= s/T [erlang]
(in the peak hour, typically 10h30..11h30 am)

Eg. Average generated traffic for a business customer: 0,25 erlang
Av. gen. traffic of residential customers: 0,025 erlang, i.e. 1,5 minutes in peak hour

Total traffic load: eg. In case 400 residential customers + 40 business customers: 20 erlangs

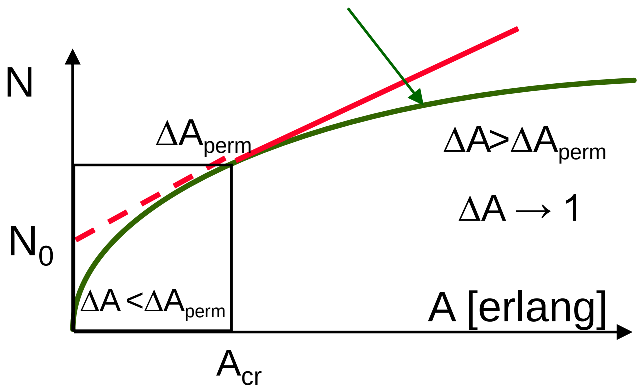
Traffic dimensioning: transmitting/managing traffic load *A* with a congestion *B*, how many channels (*N*) are required?

In case of random traffic and loss system, according to the formula Erlang B:

$$B = E(N, A) = \frac{\dfrac{A^N}{N!}}{\displaystyle\sum_{i=0}^{N} \dfrac{A^i}{i!}}$$

Linear approximation of formula Erlang B ("Erlin"):

Required number of channels *N* for transmitting offered random traffic *A* under permitted congestion *B:*



$A_{cr} \sim$ (22…12) erlang

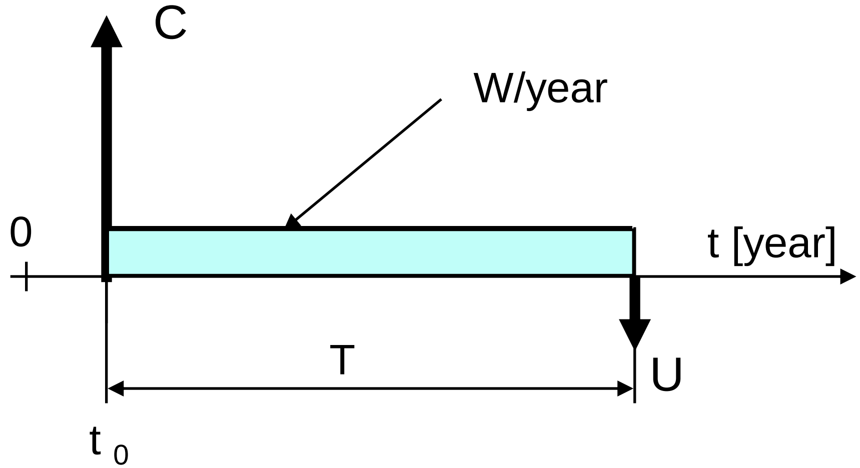
In case of overload τ ($\tau > 1$), the permitted marginal traffic is max $\Delta A_{perm} = 1/\tau$, and

$$N = N_0 + \tau \cdot A \quad \text{if } A > A_{cr}$$

where if nominal congestion B=0,5...1%, and τ = *1.20…*1.25, (*20*…25 %), i.e. ΔA_{perm}=*0.83*...0.80 erlangs, then $\mathbf{N_0 = 6}$

MODELING OF TIME-DEPENDENT COST FUNCTIONS

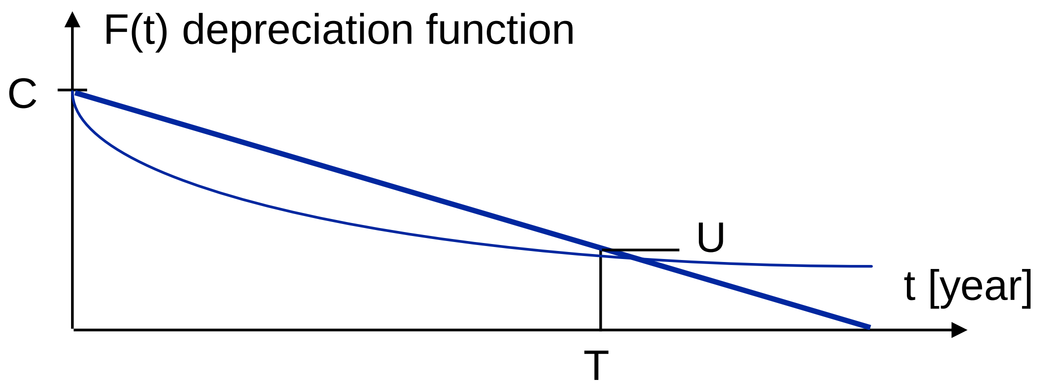
COST/EXPENDITURE FUNCTIONS (C, W, U)



C investment/deployment cost
(non-recurrent/capital expenditure)
W operational cost
(recurrent/continuous expenditure)
T lifetime
U remaining/sink value

Total expenditure:
E = {C + T.W - U}

Describing depreciation (amortization)

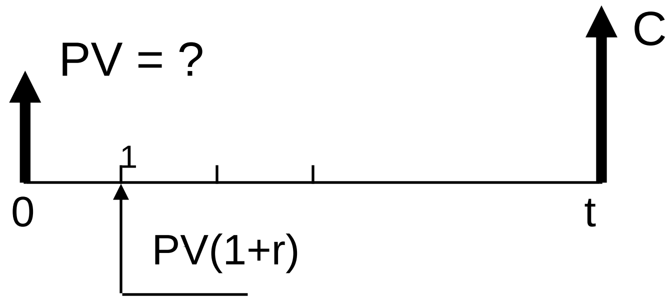


Various depreciation functions: linear, exponential, etc.

PRESENT VALUE CALCULATION (DISCOUNTING)

Costs, expenditures, incomes are emerged in different dates. Summing them we must take the time-dependent value of money into account, both the bank interests and the inflation.

Denoting the effective rate of interest (rate of interest % - rate of inflation %) by *r* , we discount a money value, emerged at *t* into *t=0*, i.e. we calculate its present value, as:



$$C = PV\,(1 + r)^{t}$$

$$PV\,(C) = \frac{1}{(1 + r)^{t}}\,C$$

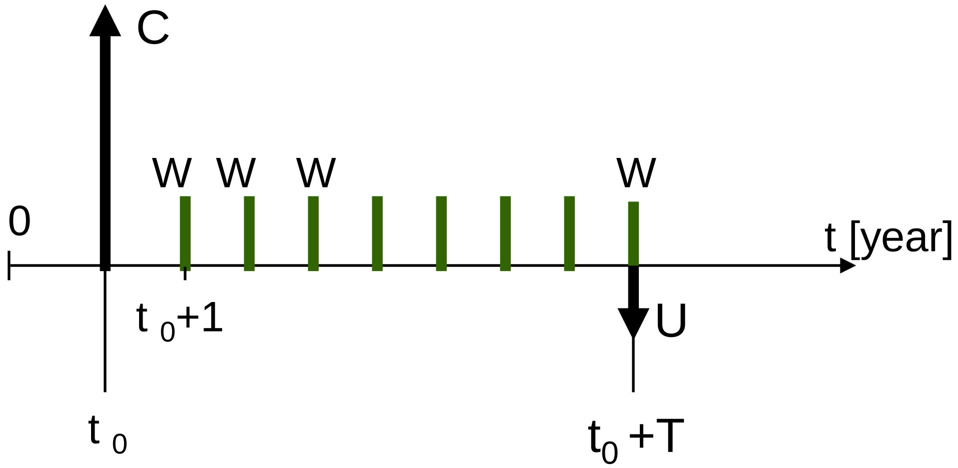
Discounting factor:

$$d\,(t) = (1 + r)^{-t}$$

Present value of total expenditures:

Assuming a uniform annual operational costs W and year-end payment:

$$PV(E) = C\,.d(t_0) + W.[\,d(t_0+1) + d(t_0+2) + d(t_0+3) \ldots + d(t_0+T)\,] - U.\,d(t_0+T)$$



Present value of uniform annual costs:

$$PV(W,T,t_0) = W.d(t_0).[\,d(1) + d(2) + d(3) \ldots + d(T)] = W.\,d(t_0).a(T)$$

where cost series discounting factor (based on the sum of geometric series):

$$\mathbf{a(T)} = \frac{\mathbf{1 - d(T)}}{\mathbf{r}}$$

If $r = 0$, $a(T)=T$; otherwise $a(T) < T$.
If $T \to \infty$, $a(T) \to 1/r$

Present value of annual costs:

Single investment costs (C, U) can be discounted into annual cost uniform in present value, expressing a *uniform annual depreciation (Y)*, as:

If $r=0$ (linear depreciation):

$$C - U = Y^{\circ} . T$$

In general, if $r \geq 0$:

$$C - U . d(T) = Y . a(T),$$

hence:

$$Y = \frac{C - U . d(T)}{a(T)} \geq Y^{\circ}$$

If T is large enough, then **Y = r . C**

Thus the annual total cost of an establishment for T lifetime is **AC = Y + W**.

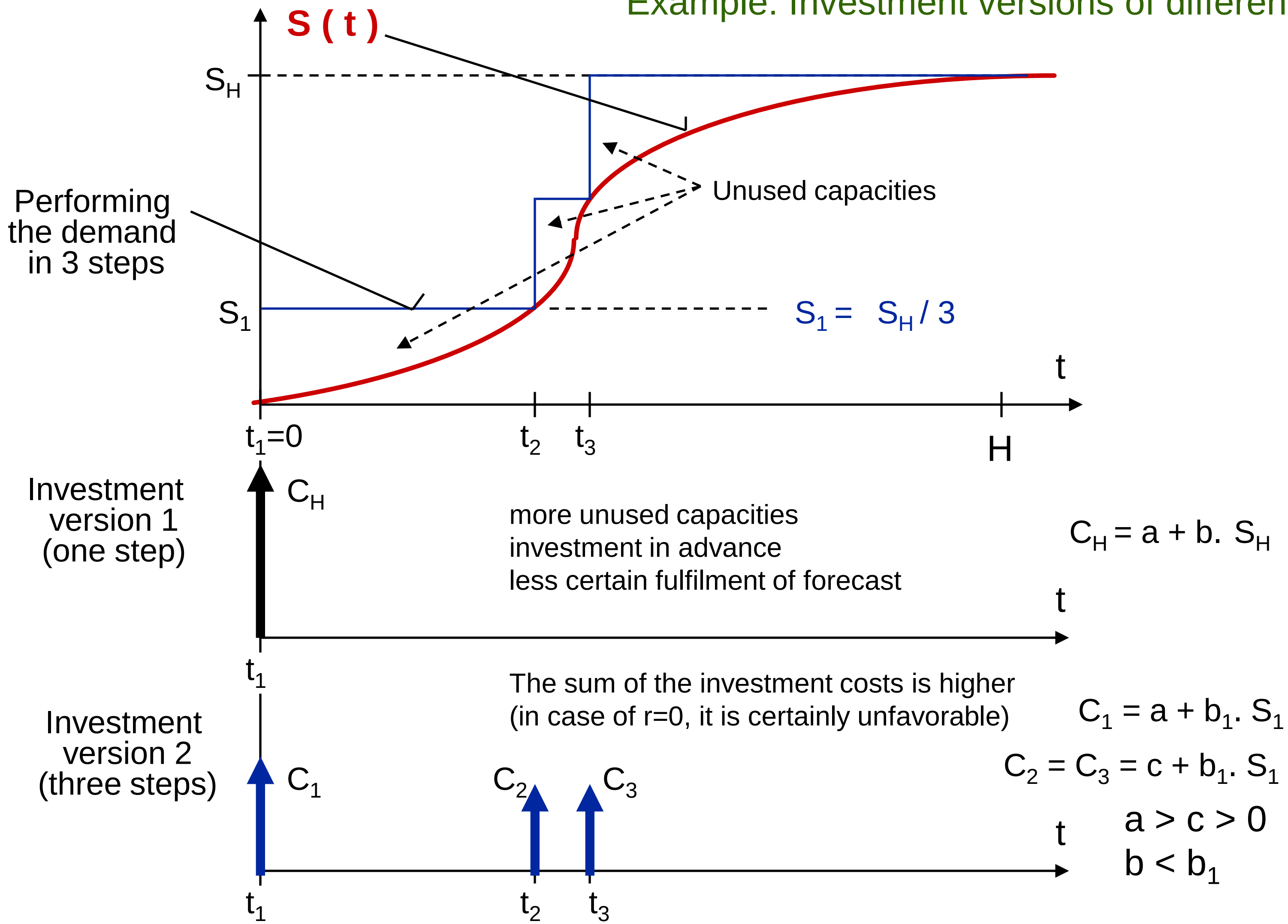
Based on the annual costs Y and W, **the cost effect of an establishment** for a ***planning horizon H*** (5..10..15 years), assuming that its lifetime exceeds the horizon:

$$K = PVAC(E, H, t_0) = (Y + W). d(t_0) . a(H - t_0) = (Y + W). [a(H) - a(t_0)]$$

In case of a multi-component establishment, we sum up the present values of the expenditures of the components $E_1, E_2, ..E_i..$, discounted for the same planning horizon H:

$$K = PVAC(E_1, E_2, ..E_i..; H; t_1, t_2,..t_i..) = \sum_i PVAC(E_i, H, t_i)$$

Example: Investment versions of different steppings



$K1=PVA\ (C_H;\ H;\ 0)$ $K2=PVA\ (C_1,C_2,C_2;\ H;\ 0,\ t_2,t_3\ )$

Remark: the model is insensitive to W, because eg. W is proportional to S(t)

Critical r (r_{crit}) can be defined, where: K1=K2 (If $r < r_{crit}$,, K1<K2)

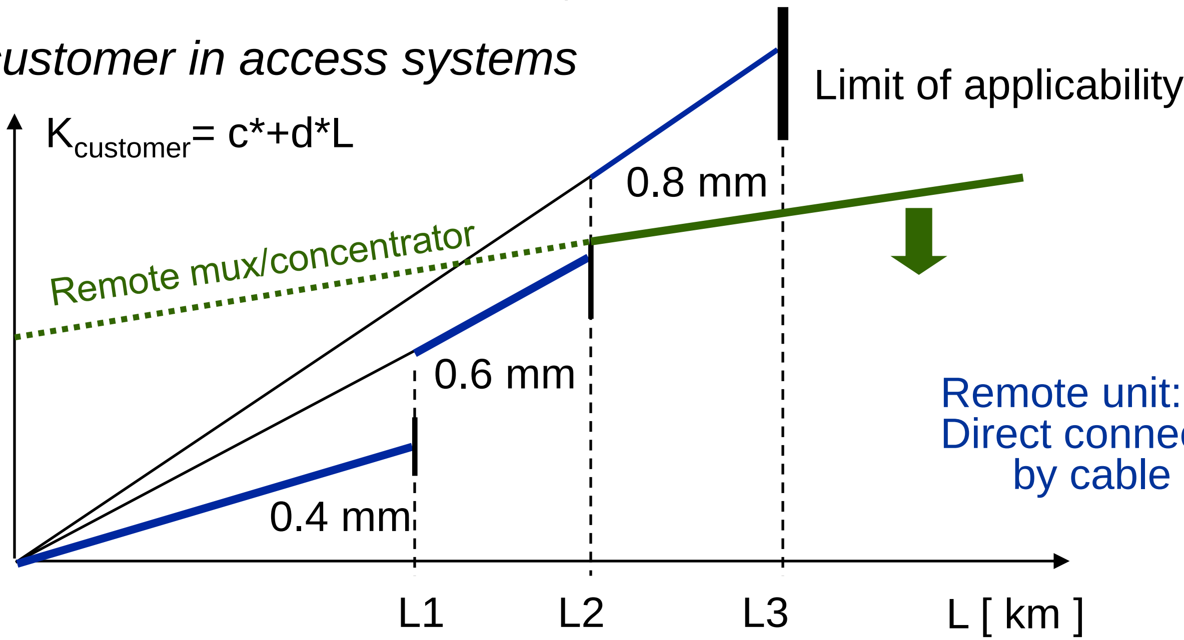
Parametric cost model for a single system: In general the *costs can be linearly approximated in a certain range of the system parameters* (L, M ; eg.: spanned length/distance, number of trunk channels, number of customer lines, transmission speed/bandwidth):

$$K = a + b.L + c.M + d.L.M$$

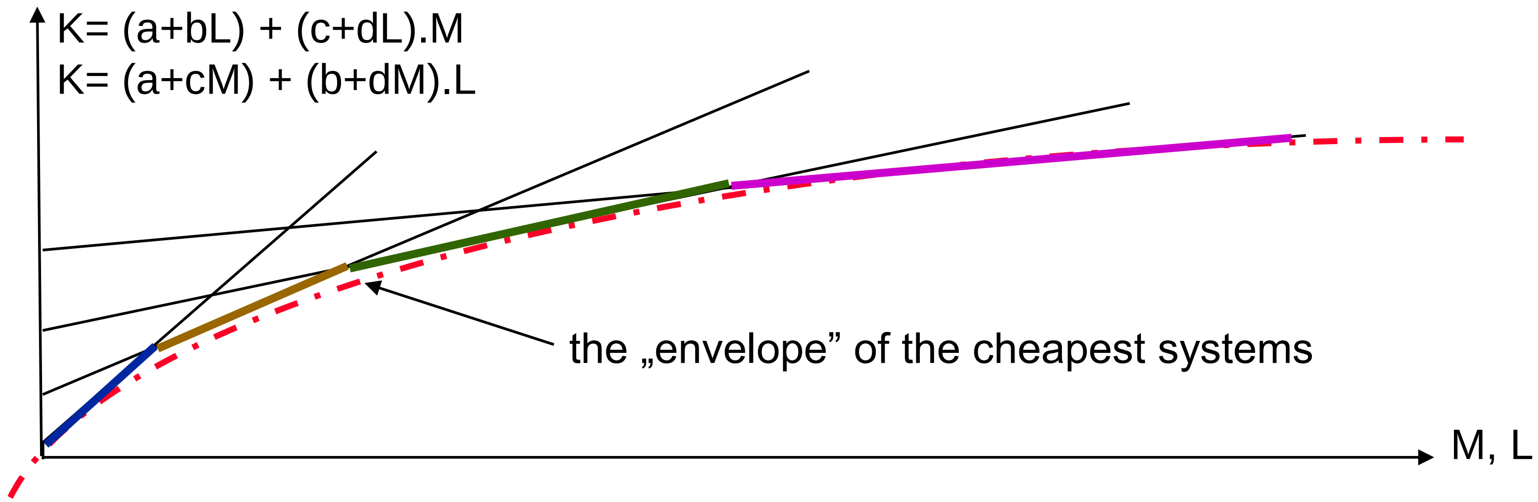
where *a,b,c,d* are appropriate factors (eg. by regression) eg. for a transmission system, a switching system, an access system.

For the full range, multi-range linear approach can also be applied. Thereby some constraints can be built into the cost model, too.

Eg.: Cost per customer in access systems



Parametric cost model for a set of systems performing a given function.
It is defined by the lower envelope of the costs of the optimum implementations.



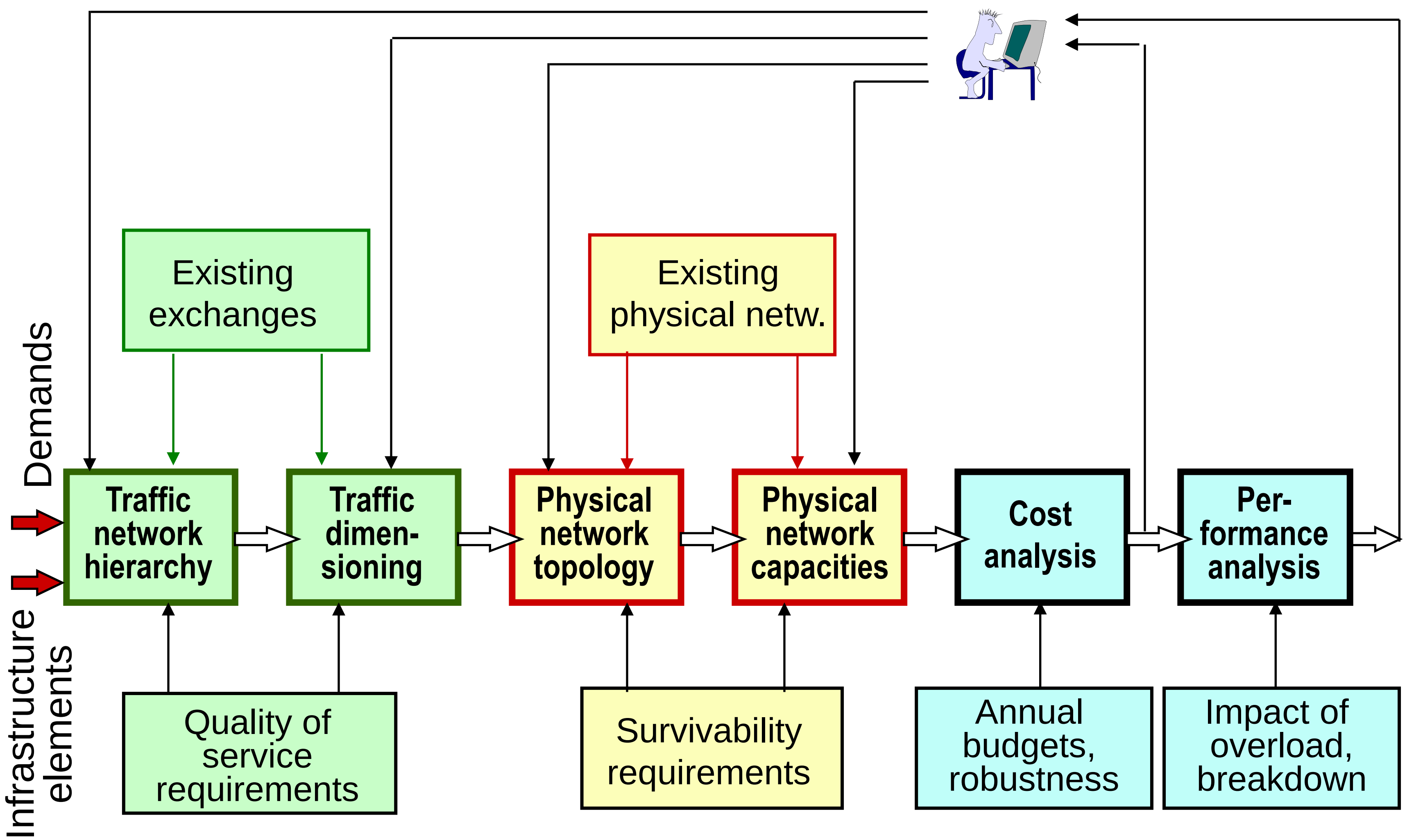
Economy of scale (Grosch's law):
The unit cost of the optimal system is decreasing by increasing the size:

$$K/(L.M) = \frac{k(0.5;0.5)}{\sqrt{L.M}}$$

In general: $\mathbf{K = k(p; q) . L^p . M^q}$ where: $\mathbf{0 < p < 1}$, $\mathbf{0 < q < 1}$.

Grosch's hypothesis: p=q= 0.5.
In practice, constants p, q and k(p,q) are calculated by regression of real costs.
Based on technological trends, p and q are decreasing. It stimulates to construct higher scale systems, concentrate the capacities and a less connected topology.

PLANNING THE DEVELOPMENT OF INFOCOM NETWORKS: MULTI-PHASE HEURISTIC OPTIMIZATION



SUMMARY

ENGINEERING MANAGEMENT PRINCIPLES, MODELS, PROCEDURES

GENERAL ENGINEERING MANAGEMENT METHODS

- **Pareto, STEP, de Bono, Vogelauer, SMART objectives, …**

SOLUTION OF COMPLEX ENGINEERING PROBLEMS

(Planning the development of ICT networks)

- **Heuristic optimization**
- **Layering, segmenting the tasks**
- **Harmonized techno - economic system modeling**
- **Present value calculation (discounting)**
- **Economy of scale (concentrating traffic loads and capacities)**
- **Quality, overload, security**
- **Interactive planning**