

Tutorial Human Side of Systems Architecting

by *Gerrit Muller* University of South-Eastern Norway-NISE

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Abstract

Architects play a crucial role in creating systems that fit well in the human needs. The creation of these systems requires many human interactions between all stakeholders. The background of architects, however, is completely different, mostly technical. We bring insight in the human aspects of systems architecting and we provide an approach with related tools to address the human aspects.

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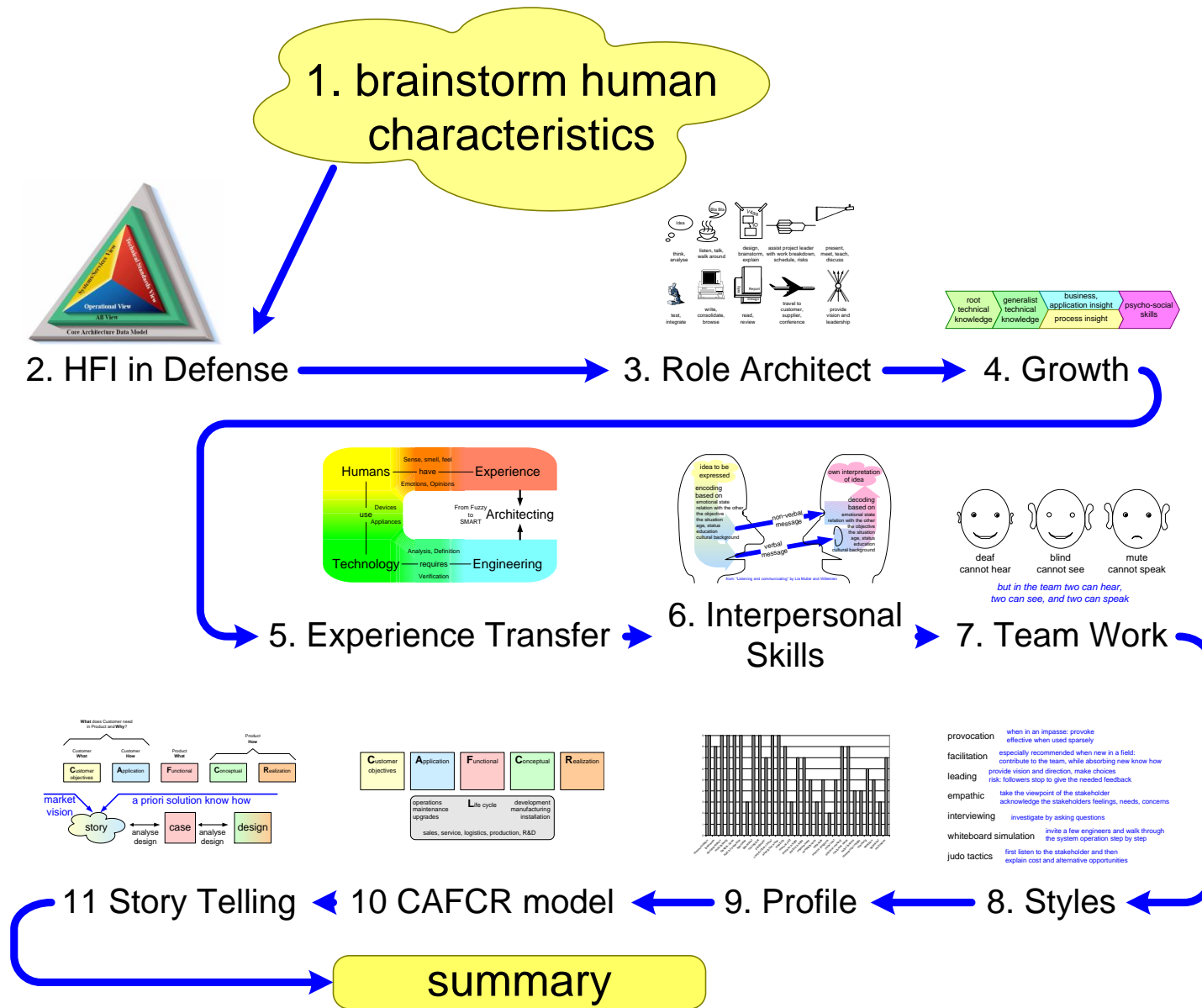
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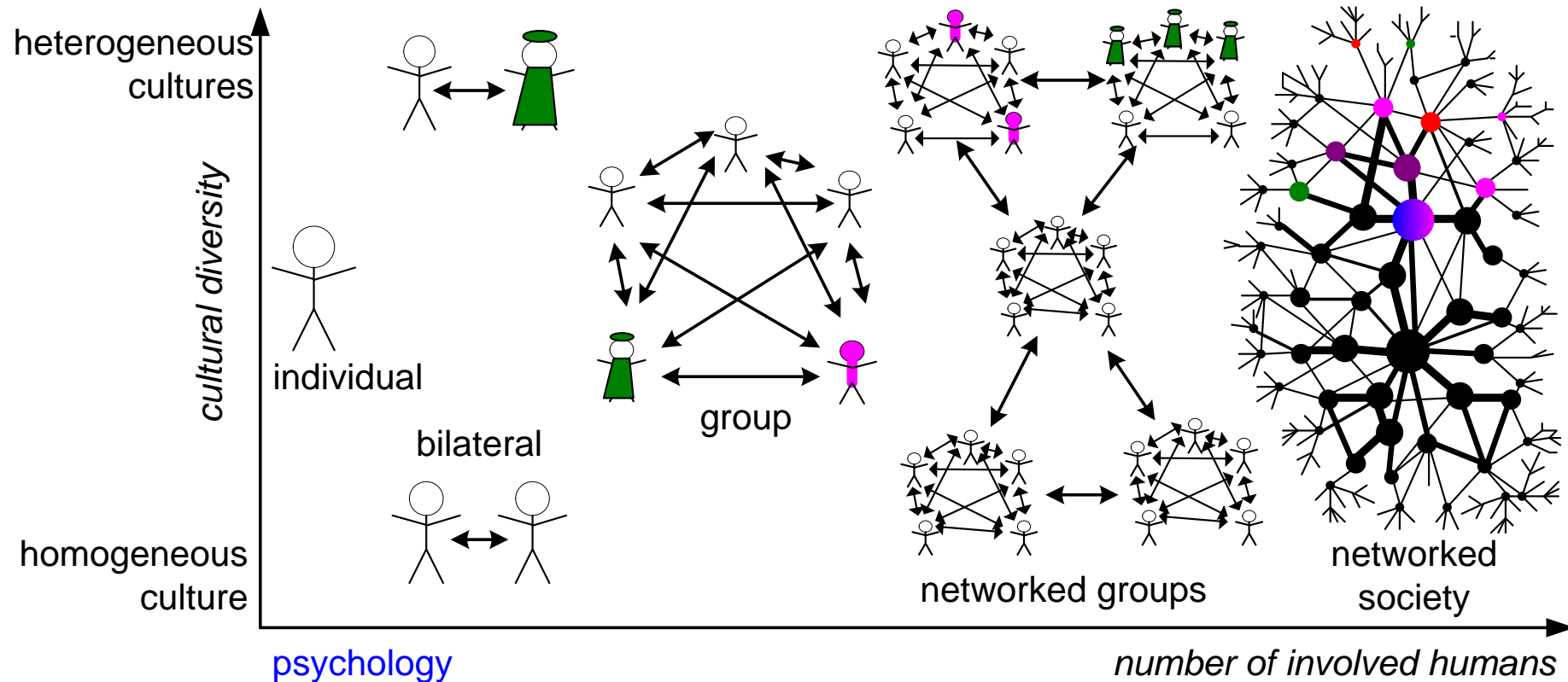


Figure Of Contents™



What human characteristics
do you know
that impact the
use, specification and design
of systems?

Overview of Human Aspects



psychology

number of involved humans

psychiatry

group dynamics

cultural anthropology

physiology pedagogy

didactics

political science

ergonomics

sociology

criminology

medicine

Human Factors in Defense

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Abstract

The defense industry has recognized the importance of human factors for system design. Some processes and procedures are available to address these needs. In this paper we provide a brief overview of ongoing *Human Factors* or *Human Systems Integration* activities in Defense.

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draft
version: 0.1



Human Systems Integration DoD Acquisition



Human Systems Integration in DoD Acquisition by Ms. Nancy Dolan CNO N125
<https://acc.dau.mil/GetAttachment.aspx?id=25755&pname=file&aid=3181&lang=en-US>

Human Engineering from Naval Perspective

1. Mission Analysis
2. Requirements Analysis
3. Function Analysis
4. Function Allocation
5. Task Design and Analysis
6. Human Interface and Team Development
7. Performance, Workload, and Training Level Estimation
8. User and Requirements Reviews

from ONR (Office of Naval Research)/SC-21 Manning Affordability Initiative
[www.hf.faa.gov/docs/508/docs/Human_System_Engineering_\(NSWC\).pdf](http://www.hf.faa.gov/docs/508/docs/Human_System_Engineering_(NSWC).pdf)

HV-A: Personnel Availability

HV-B: Quality Objectives and Metrics

HV-C: Human Interaction Structure

HV-D: Organisation

HV-E: Human Functions and Tasks

HV-F: Roles and Competencies

HV-G: Dynamic Drivers of Human Behaviour

from The Human View Handbook for MODAF
[www.hfidtc.com/MoDAF/HV Handbook First Issue.pdf](http://www.hfidtc.com/MoDAF/HV_Handbook_First_Issue.pdf)

The Role and Task of the System Architect

by *Gerrit Muller* USN-SE

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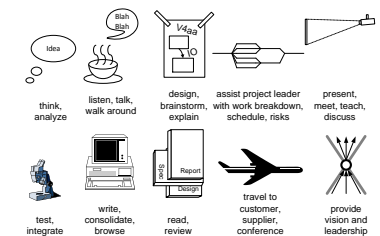
Abstract

The role of the system architect is described from three viewpoints: deliverables, responsibilities and activities. This description shows the inherent tension in this role: a small set of hard deliverables, covering a fuzzy set of responsibilities, hiding an enormous amount of barely visible day-to-day work.

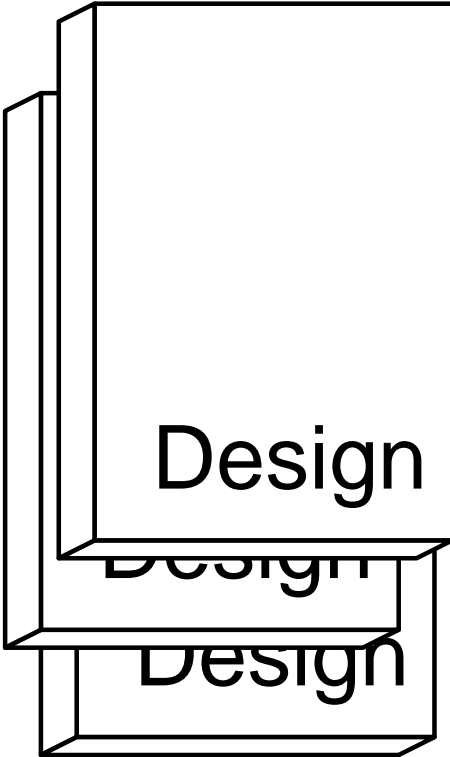
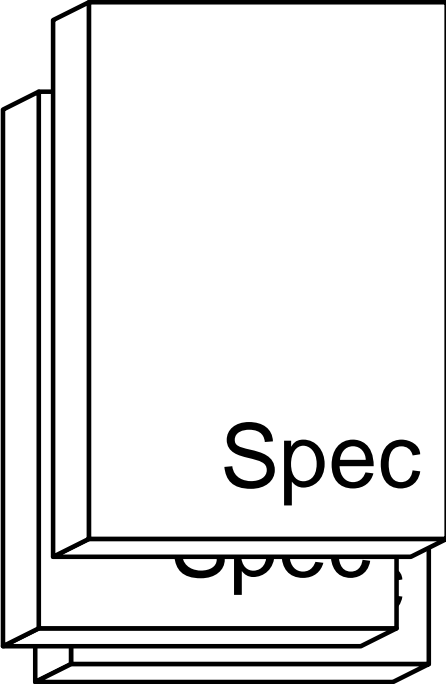
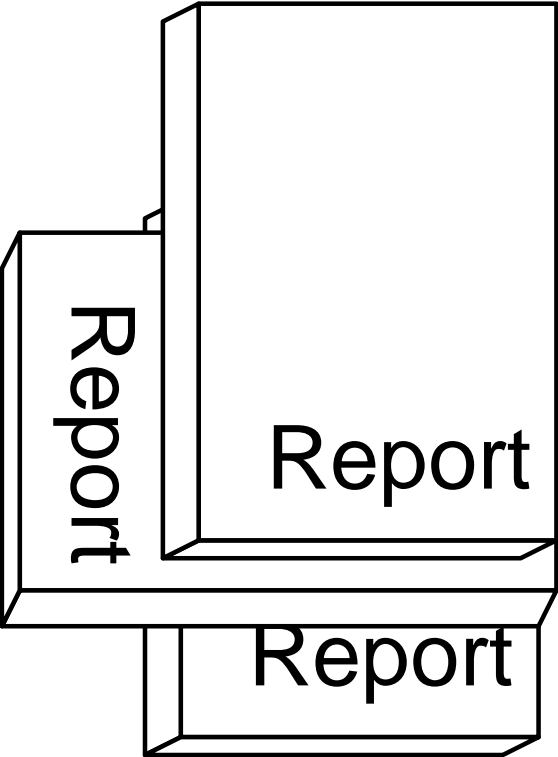
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Deliverables of the System Architect



List of Deliverables

Customer and Life-Cycle Needs (*what is needed*)

System Specification (*what will be realized*)

Design Specification (*how the system will be realized*)

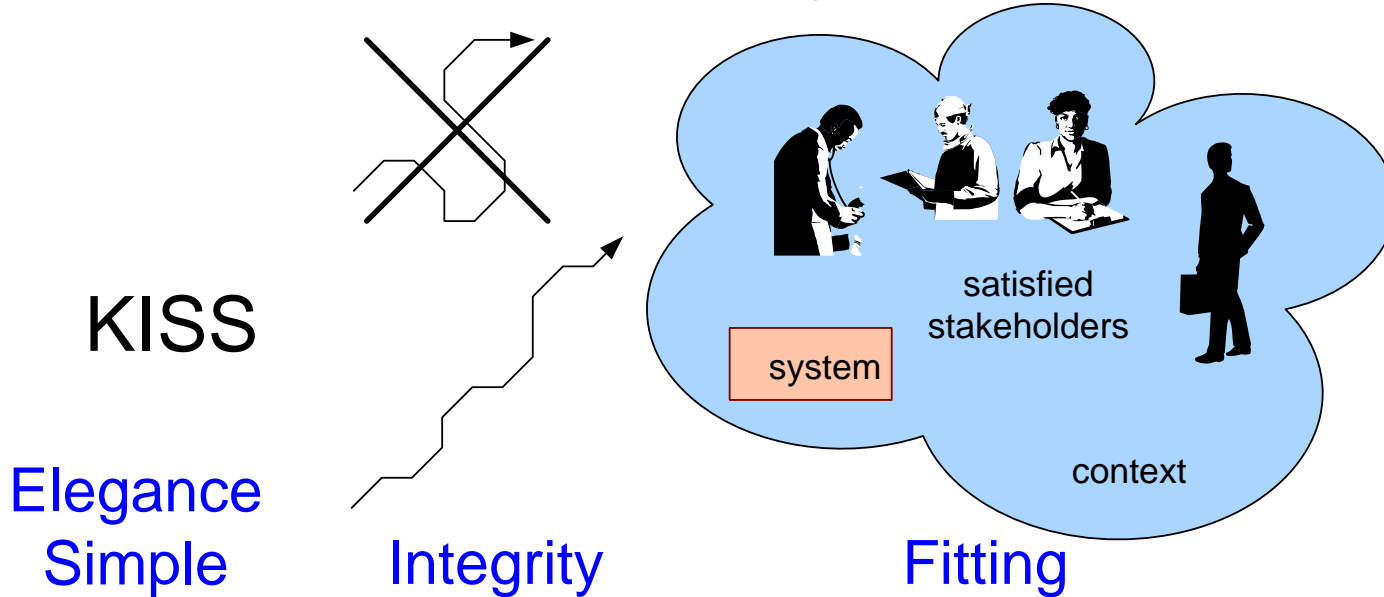
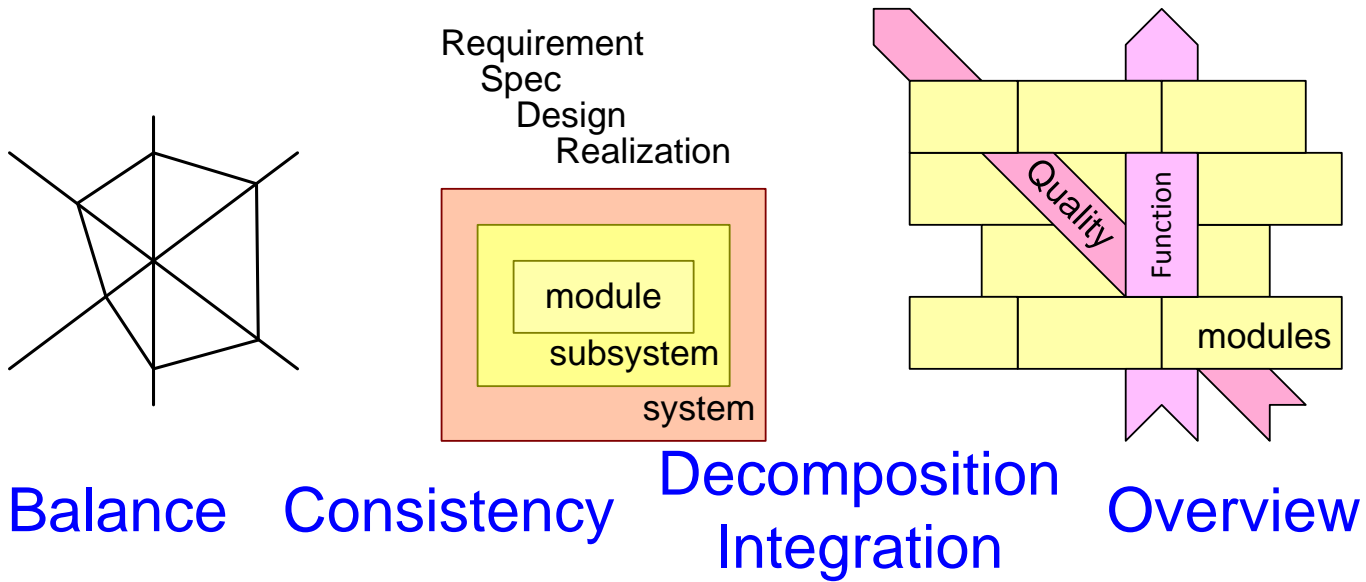
Verification Specification (*how the system will be verified*)

Verification Report (*the result of the verification*)

Feasibility Report (*the results of a feasibility study*)

Roadmap

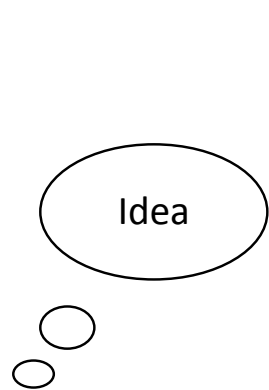
Responsibilities of the System Architect



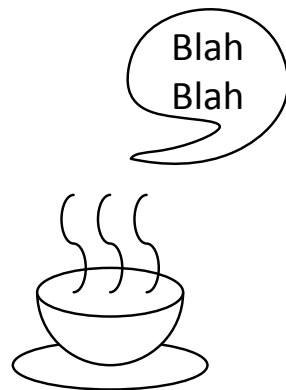
Examples of Secondary Responsibilities

responsibility	primary owner
business plan, profit	business manager
schedule, resources	project leader
market, saleability	marketing manager
technology	technology manager
process, people	line manager
detailed designs	engineers

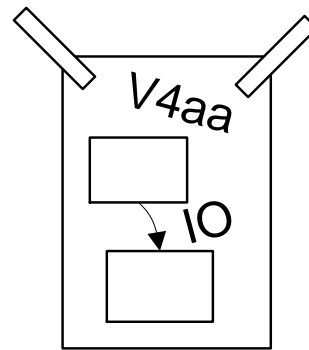
What does the System Architect do?



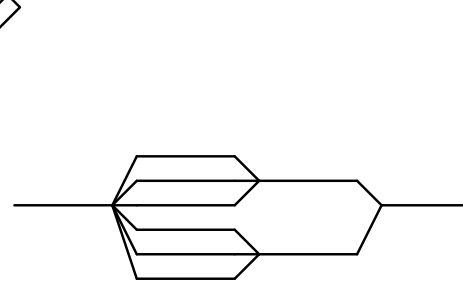
think,
analyze



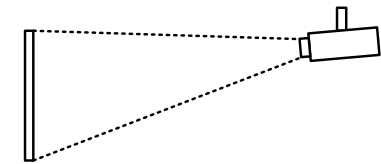
listen, talk,
walk around



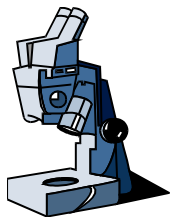
design,
brainstorm,
explain



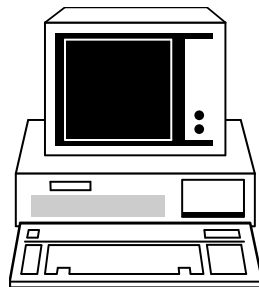
assist project leader
with work breakdown,
schedule, risks



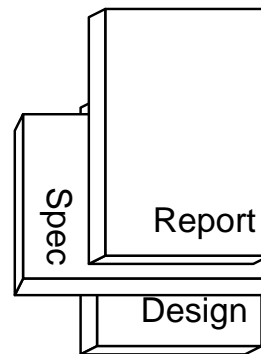
present,
meet, teach,
discuss



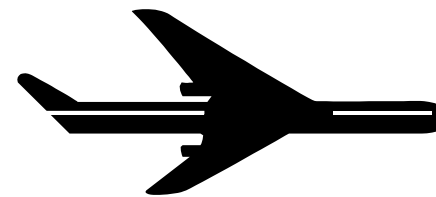
test,
integrate



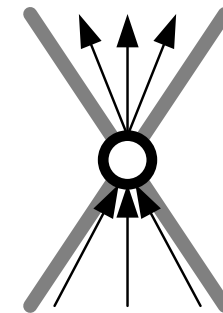
write,
consolidate,
browse



read,
review



travel to
customer,
supplier,
conference



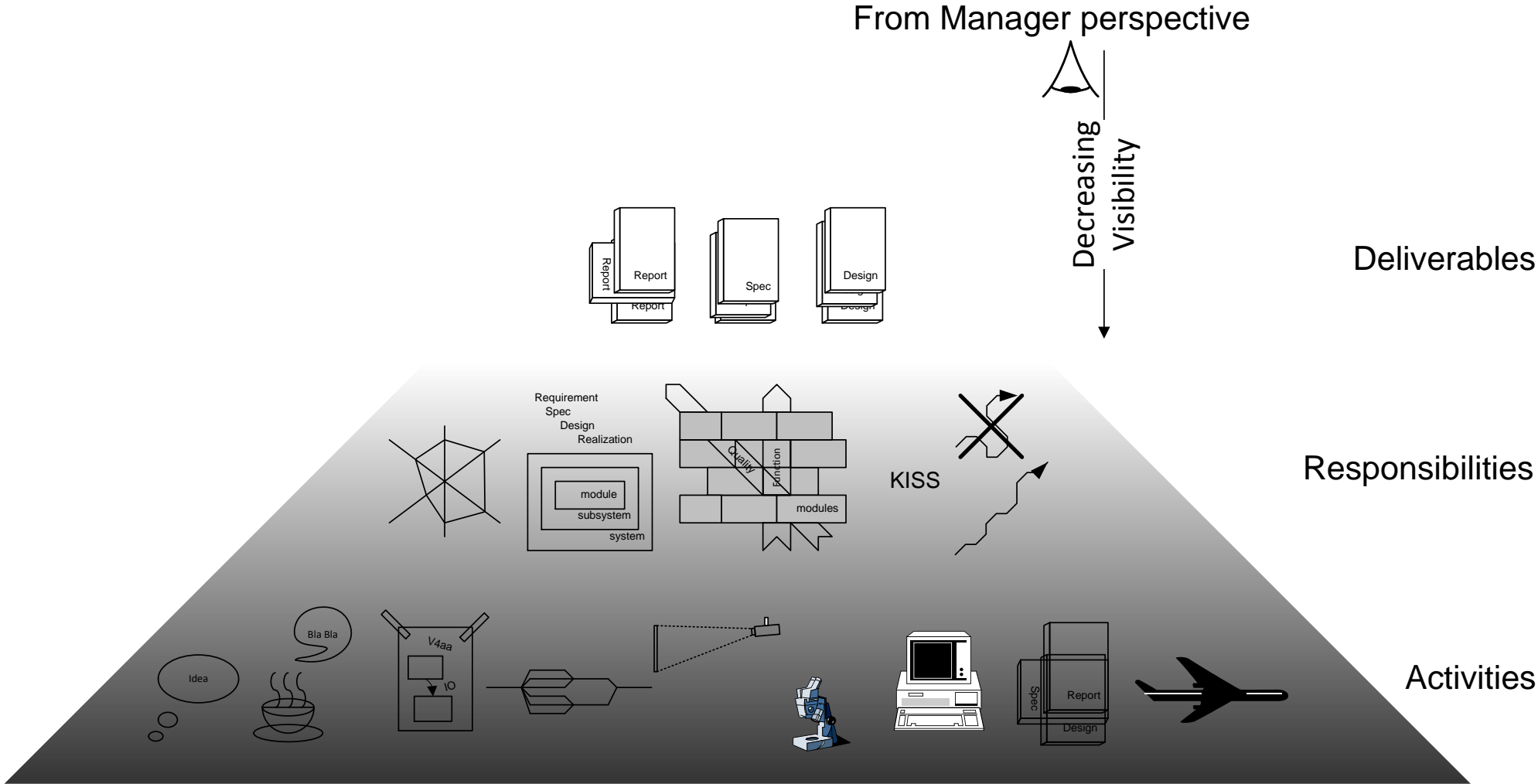
provide
vision and
leadership

From Detail to Overview

	Quantity per year (order-of- magnitude)	architect time per item
consolidation in deliverables	10	100 h
meetings	10 ²	1 h
informal contacts	10 ⁴	0.5 – 10 min
sampling scanning	10 ⁵ – 10 ⁶	0.1 – 1 sec
product details	10 ⁷ – 10 ¹⁰	
real-world facts	infinite	

Abstractions only exist for concrete facts.

Visible Output versus Invisible Work



The Awakening of a System Architect

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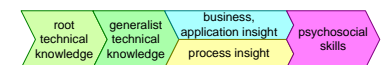
Abstract

The typical phases of a system architect development are described, beginning at the fundamental technology knowledge, with a later broadening in technology and in business aspects. Finally the subtlety of individual human beings is taken into account.

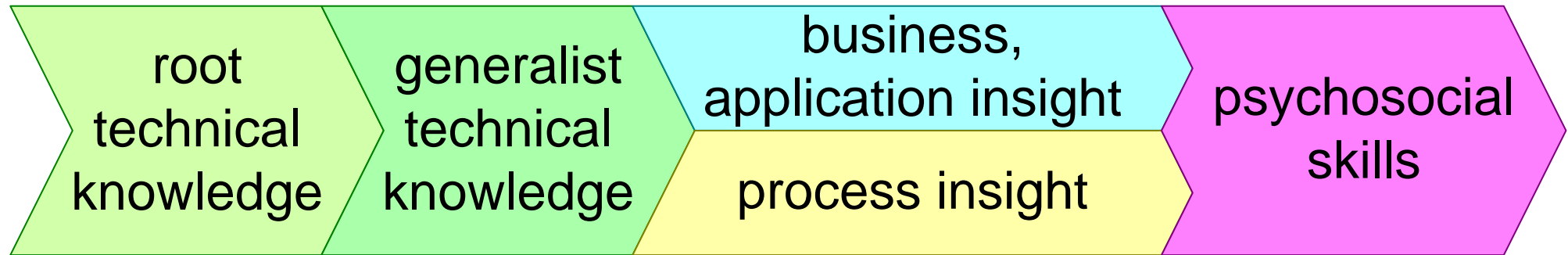
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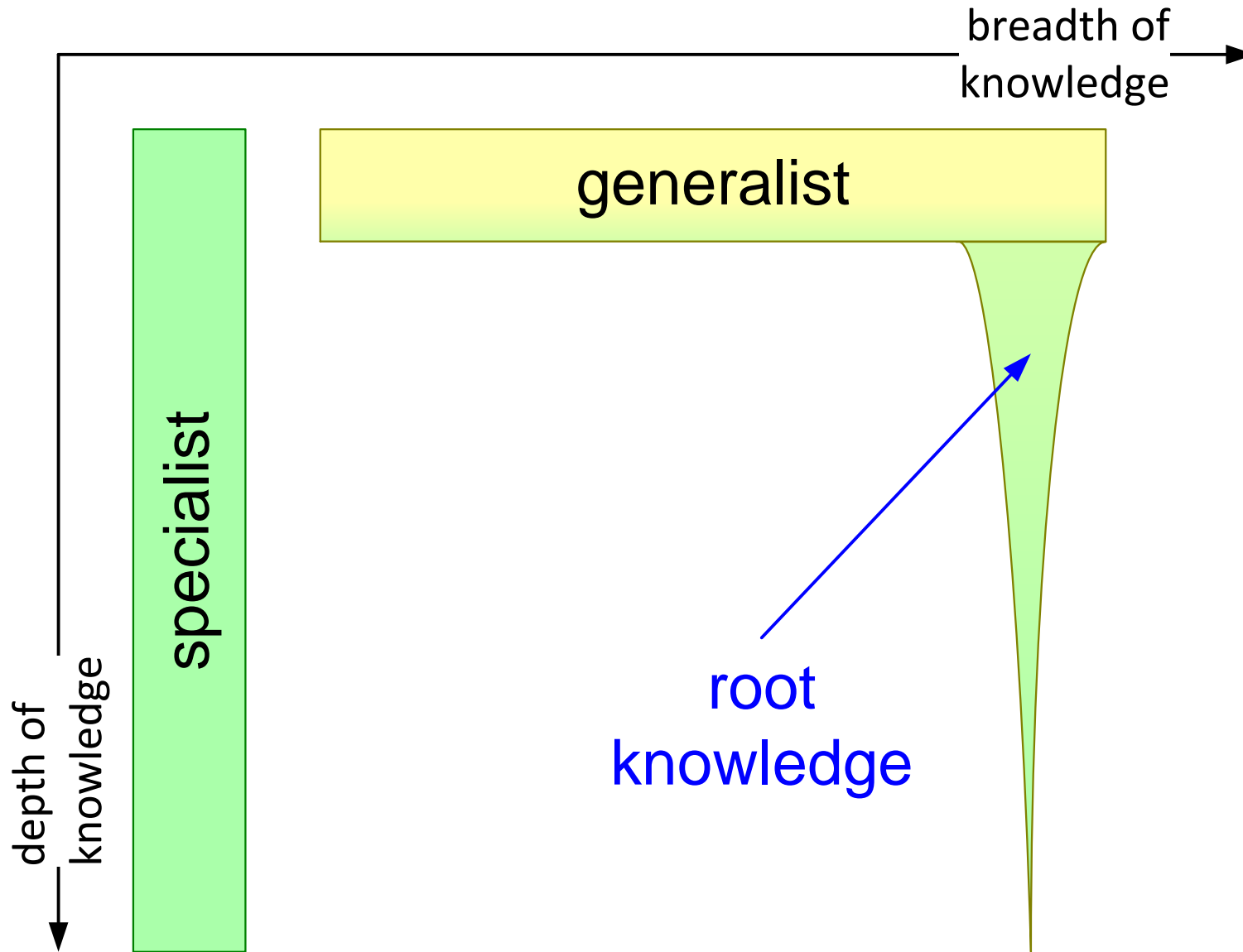
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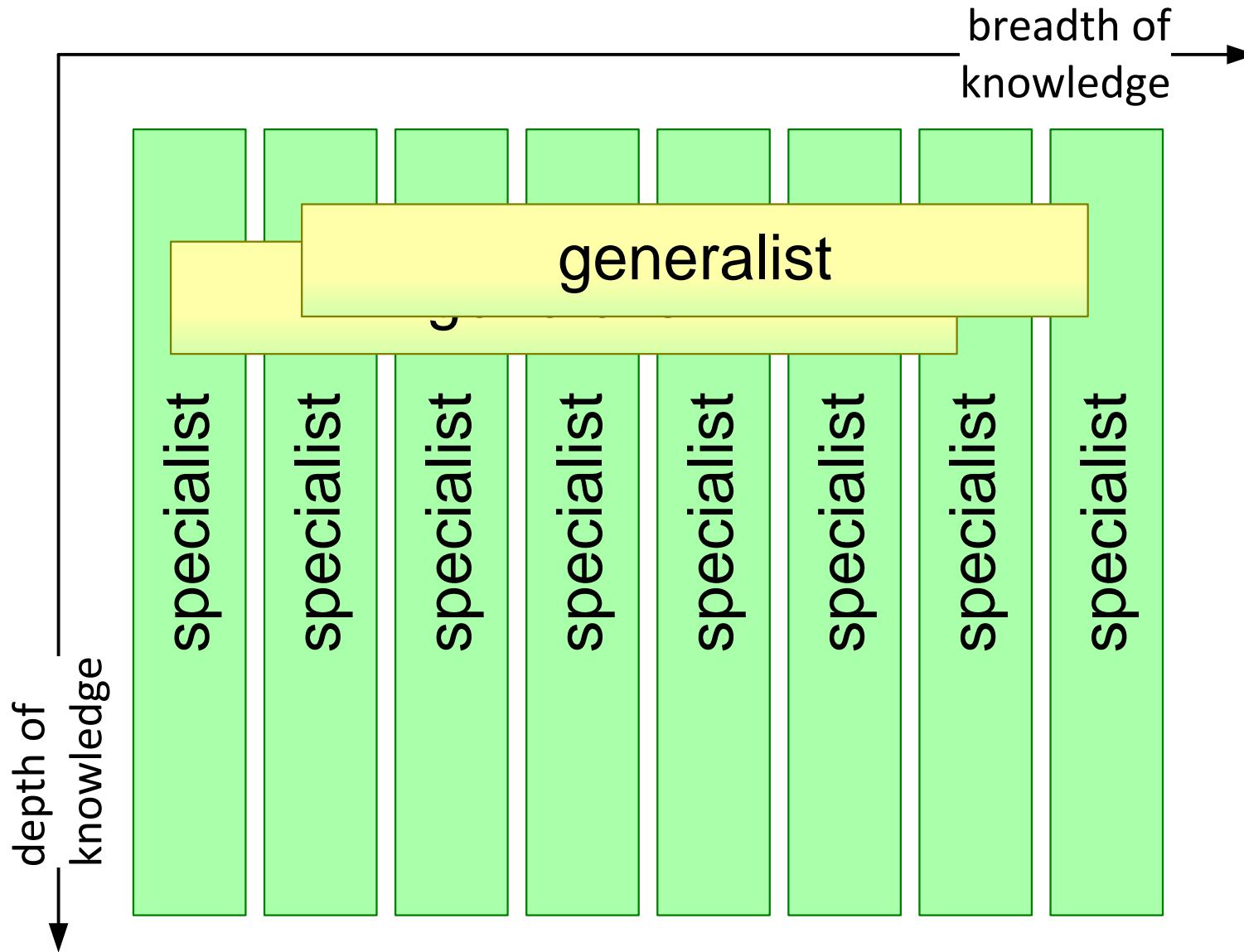
Typical Growth of a System Architect



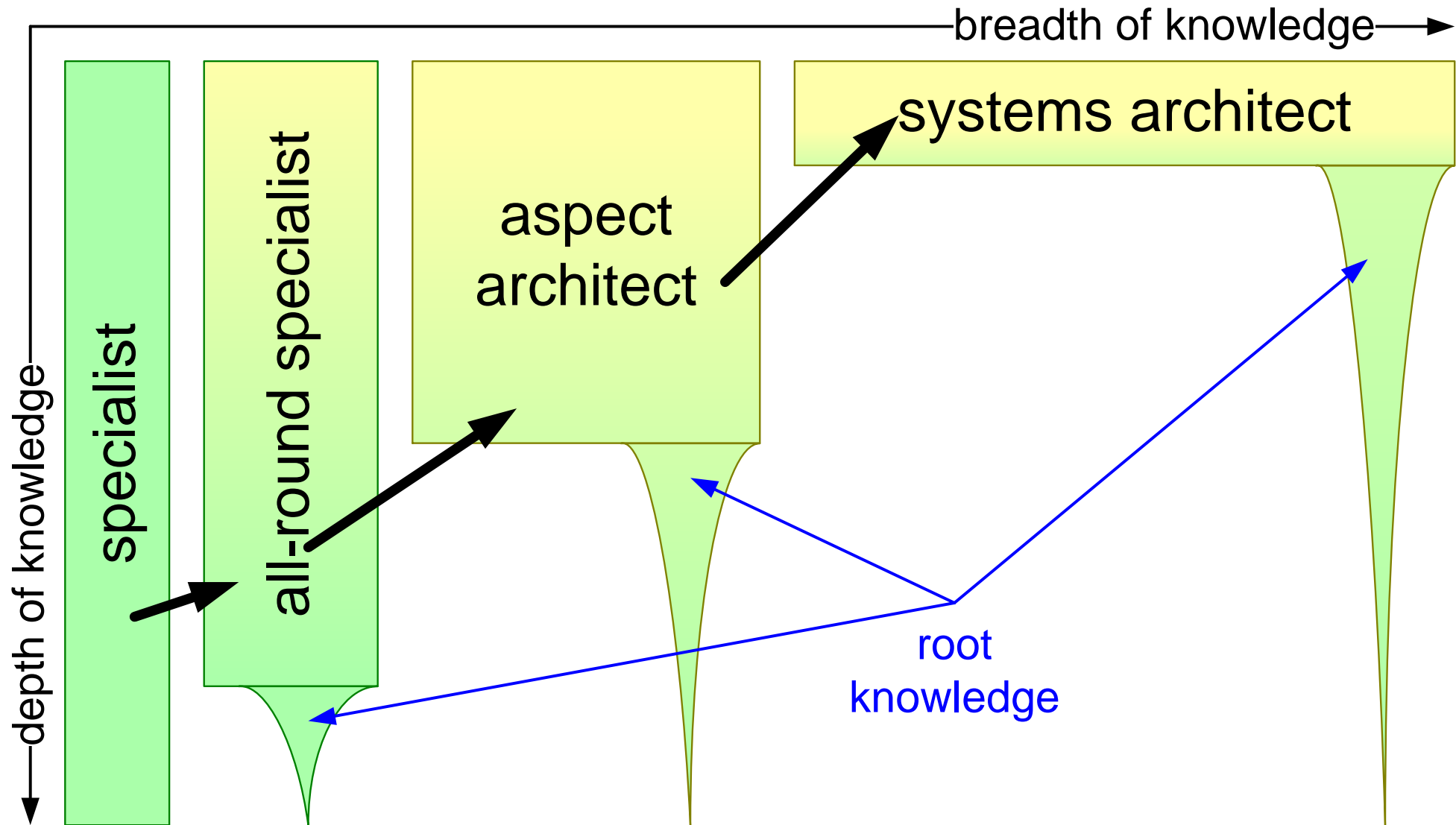
Generalist versus Specialist



Generalists and Specialists are Complementary



Spectrum from Specialist to System Architect



Did you ever program a VCR or PVR?

A



depressed

B



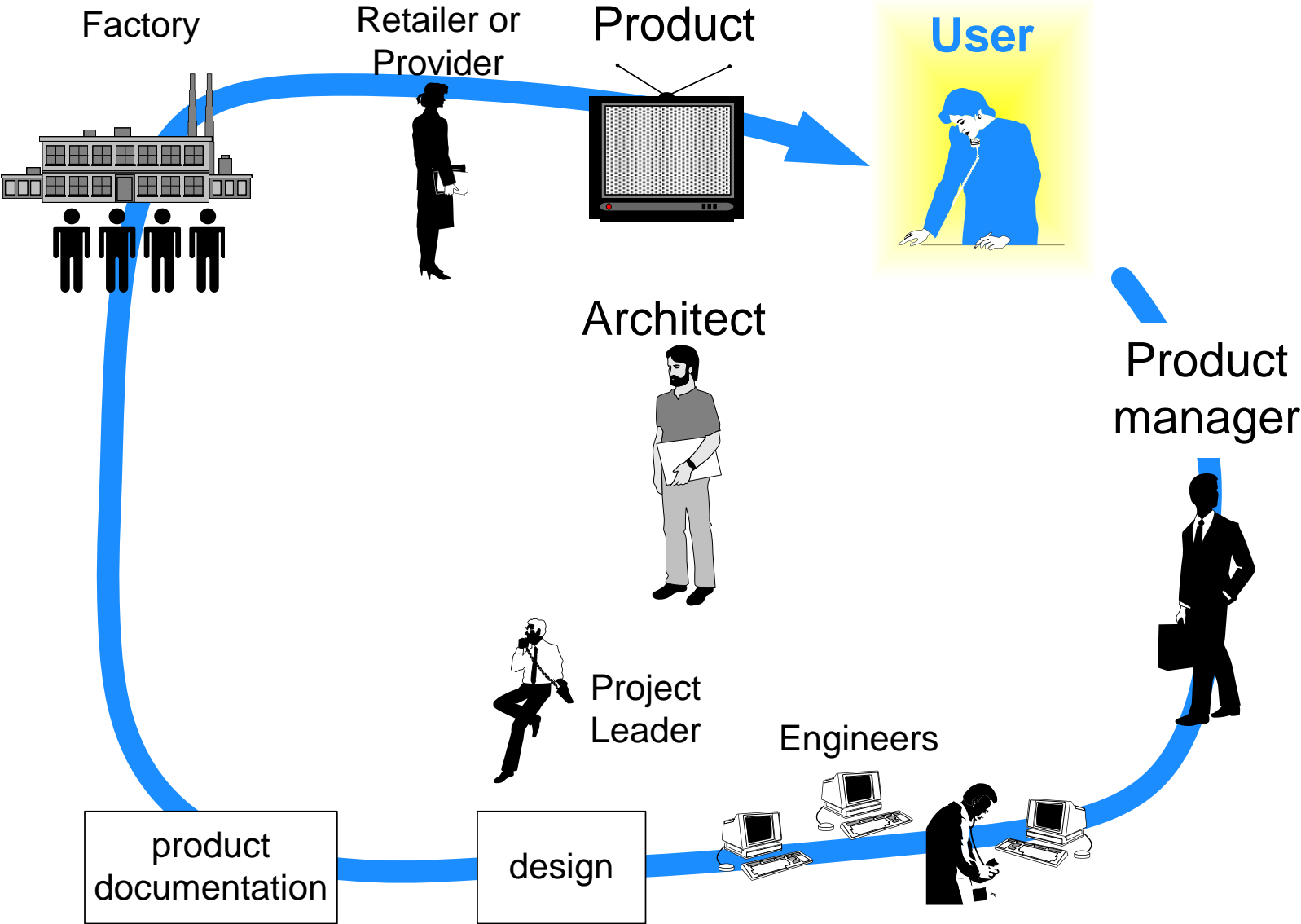
desperate

C

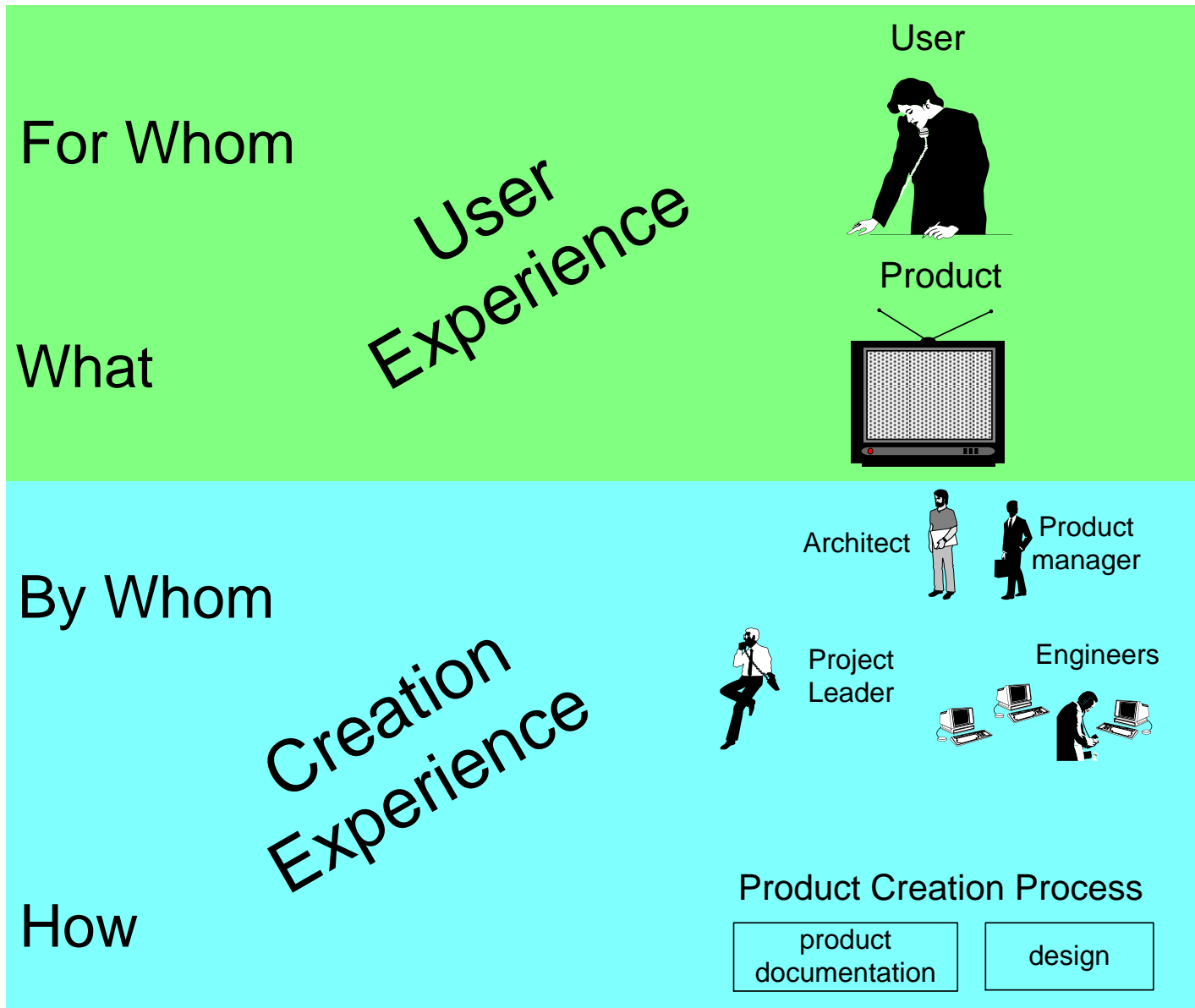


hysteric

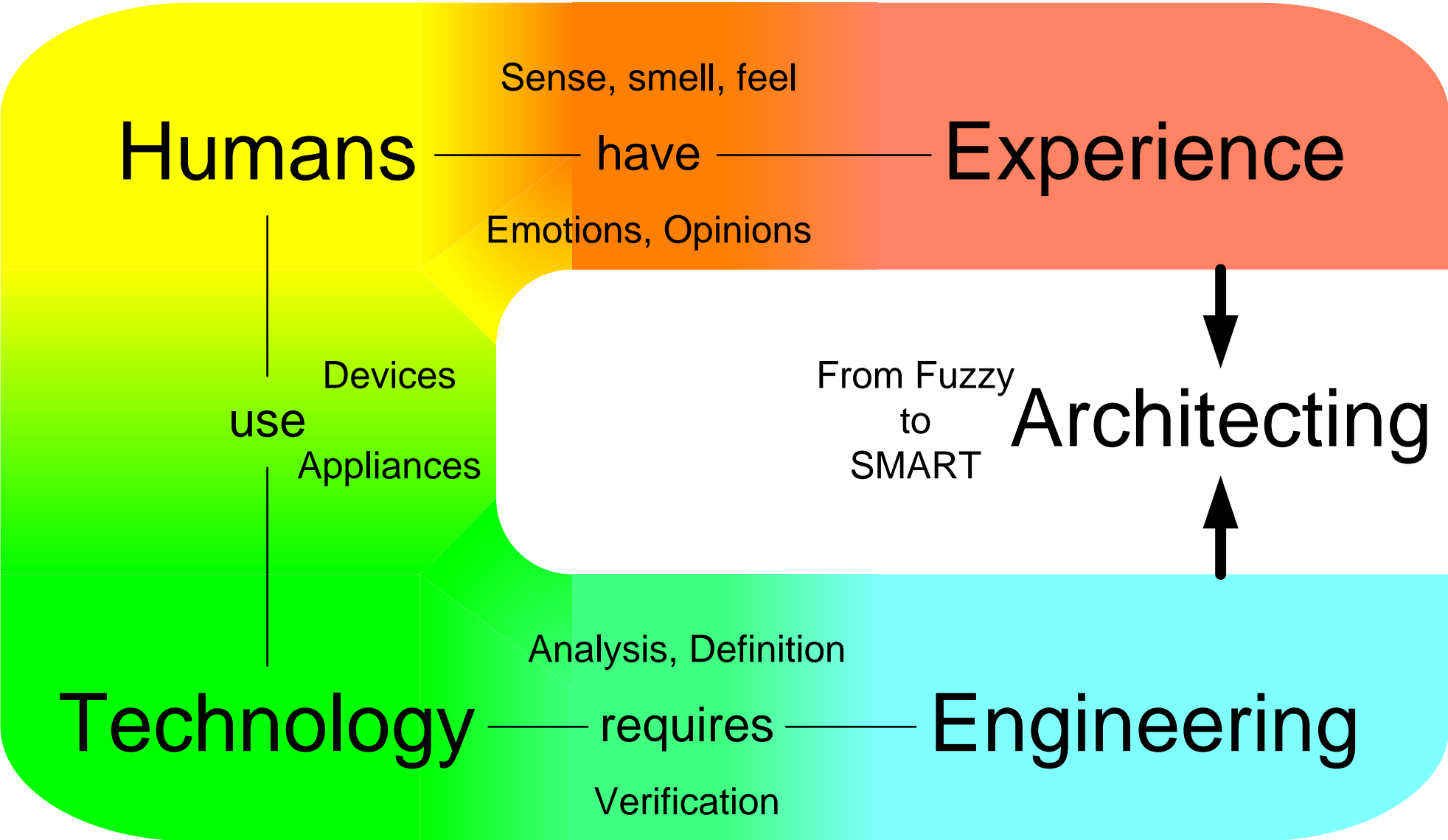
Product Creation Cycle



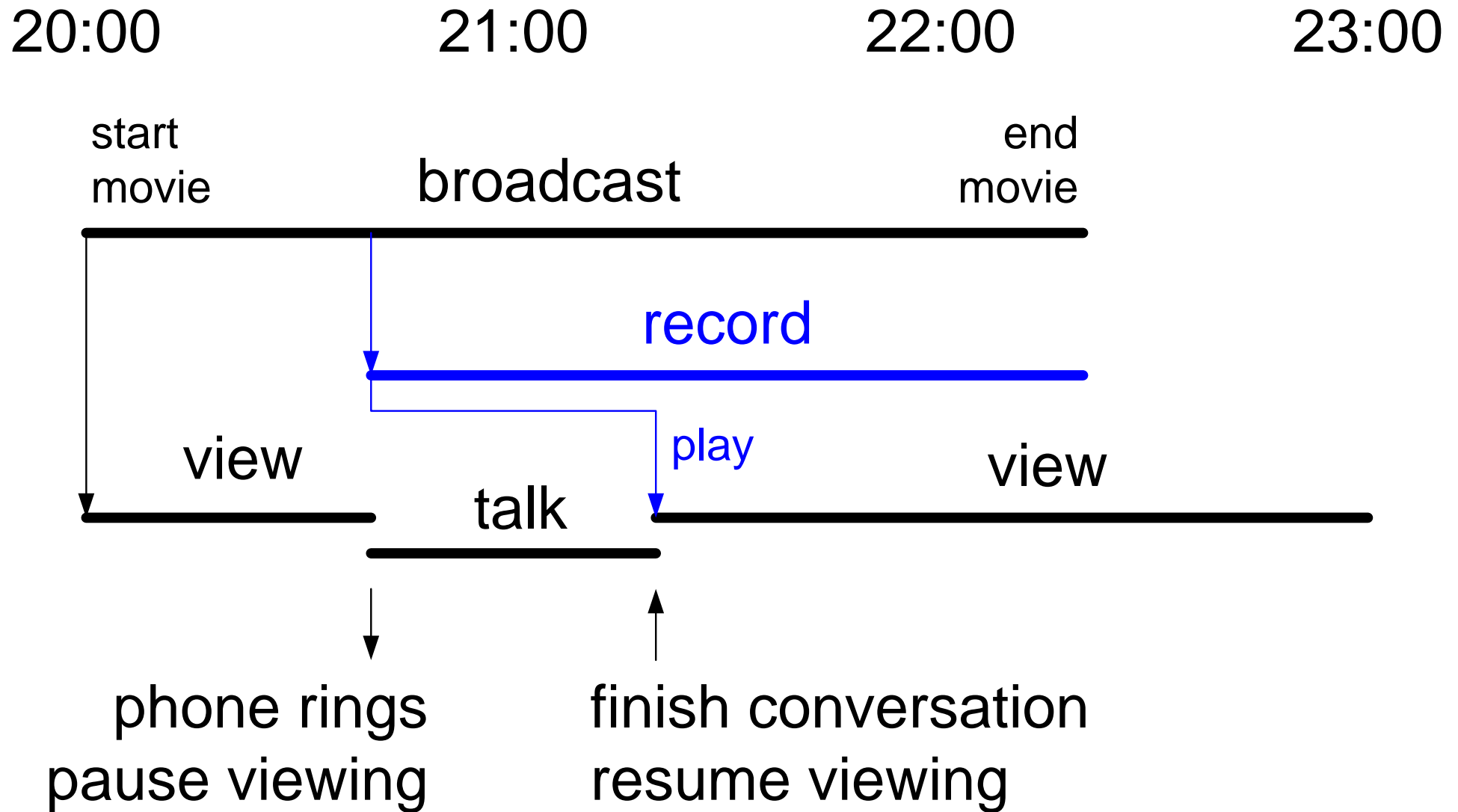
2 Levels of Experience



Bridging the gap between Experience and Engineering



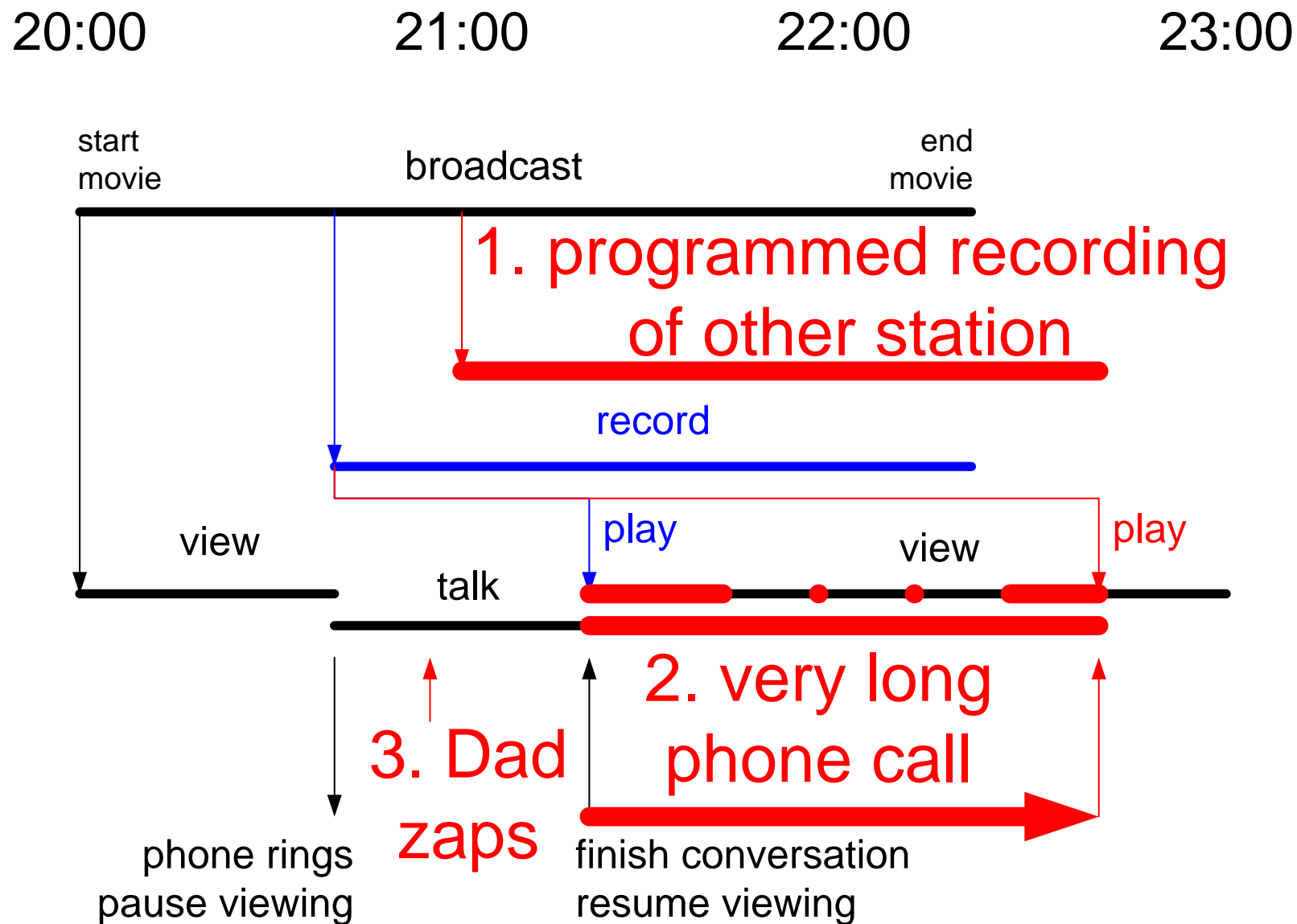
Example Time Shift recording



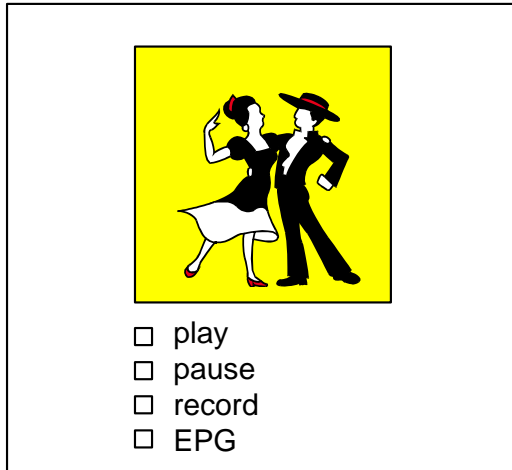
Construction limits intrude in Experience

- number of tuners
- number of simultaneous streams (recording and playing)
- amount of available storage
- management strategy of storage space

What if?



Visual Basic Prototype:
enables "experiencing"

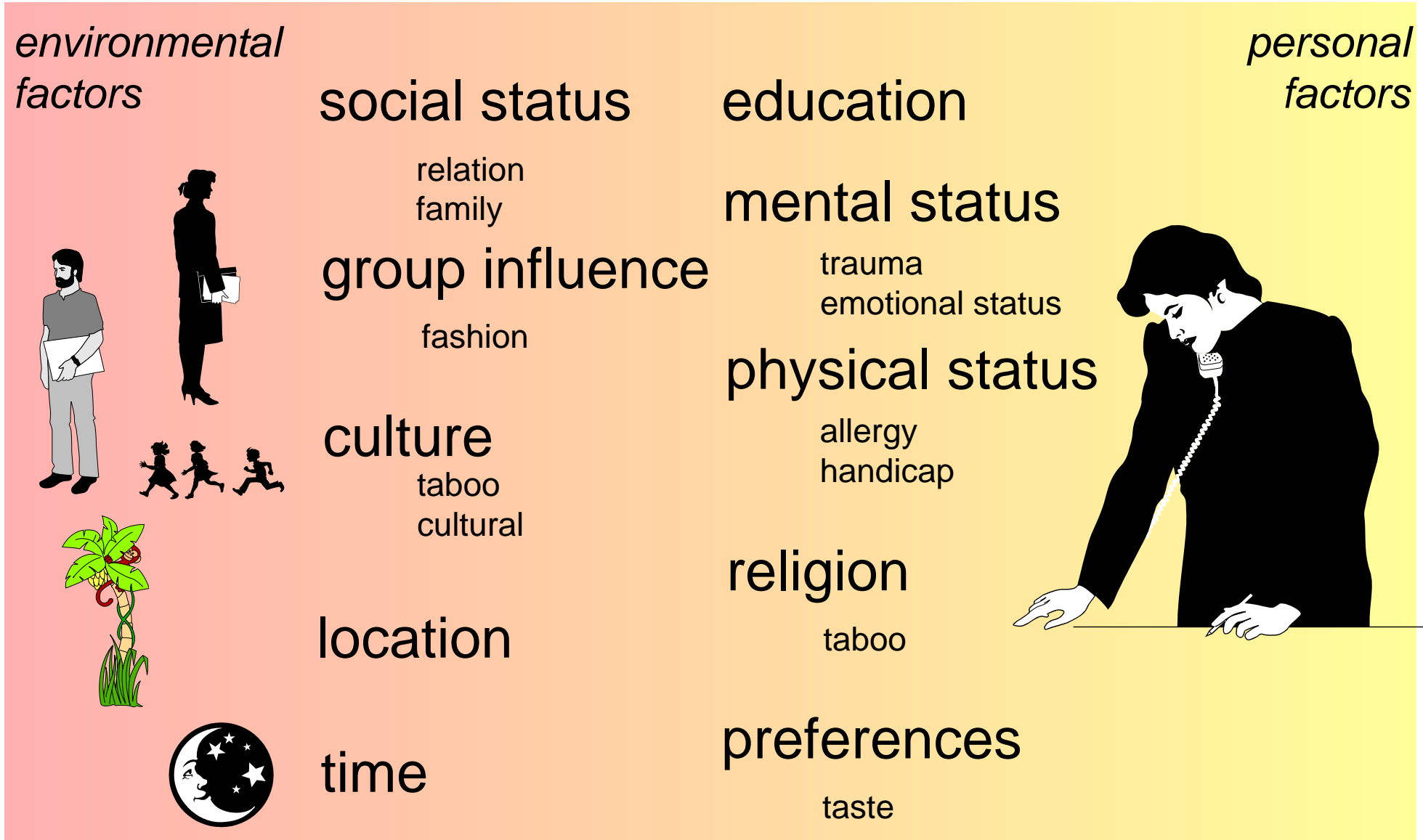


Requirements specification
Many tables, mostly addressing details

- 2.1.1 Real-time data requirements
- 2.1.2 Implementation detail
- 2.1.3 Non-real time data requirements

1.1 Software Requirements	
1.1.1 Real-time data requirements	<p>1.1.1.1 Access to the non-real-time data must be done in such a way that it does not interfere with the real-time data</p> <p>1.1.1.2 There must be no disruptions in output of video signal during the operation of VCR</p> <p>1.1.1.3 Responsiveness for non real-time data is less than 150ms (the time for writing a block on HDD) for 2KB of non-video data</p>
1.1.2 Implementation detail	<p>1.1.2.1 Management of HDD content must only be possible through the TOC in order to prevent unauthorized access to content of HDD</p> <p>1.1.2.2 Visual feedback is provided to the user via On-Screen Display</p> <p>1.1.2.3 User input is provided via the RC</p>
1.1.3 Non-real time data requirements	<p>1.1.3.1 User must be able to pause and unpaue a title, played from HDD, while (s)he is watching it</p> <p>1.1.3.2 User can jump forward and backward in a title, from HDD, during watching of this title</p> <p>1.1.3.3 Names of titles should be derived from the information from the EPG (name of the program to be recorded, time and date of registration)</p>

Factors influencing the User Experience



How to "SMART"en Experience?

- define
- measure
- predict
- verify

Infinite Experience Space

People	Number of People on earth	$O(10^9)$
		*
Time	Human lifespan in seconds	$O(10^9)$
		*
Location	Square meters of planet earth	$O(10^{14})$
		*
...

Size of experience space

∞

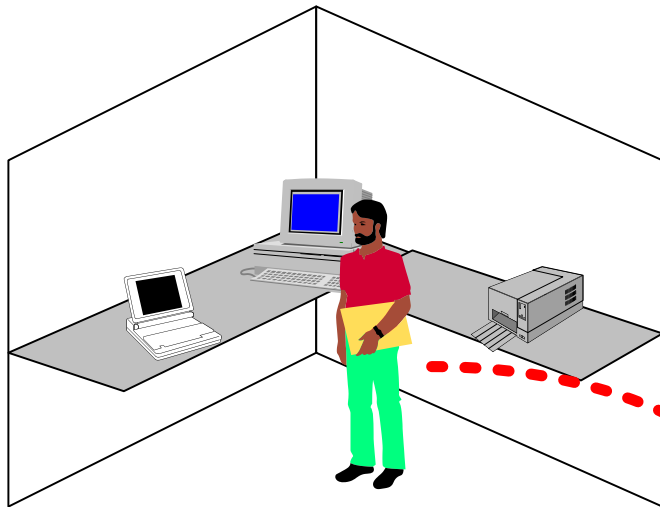
It is not that bad :-)

Many nice and successful products exist!

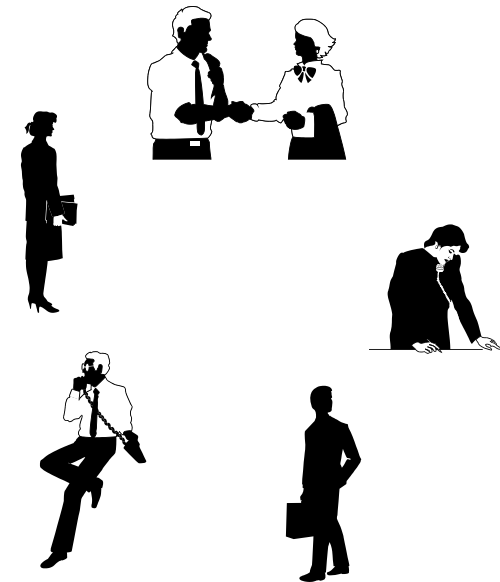
Key Success Factor: Feedback

Obtain feedback from real users:

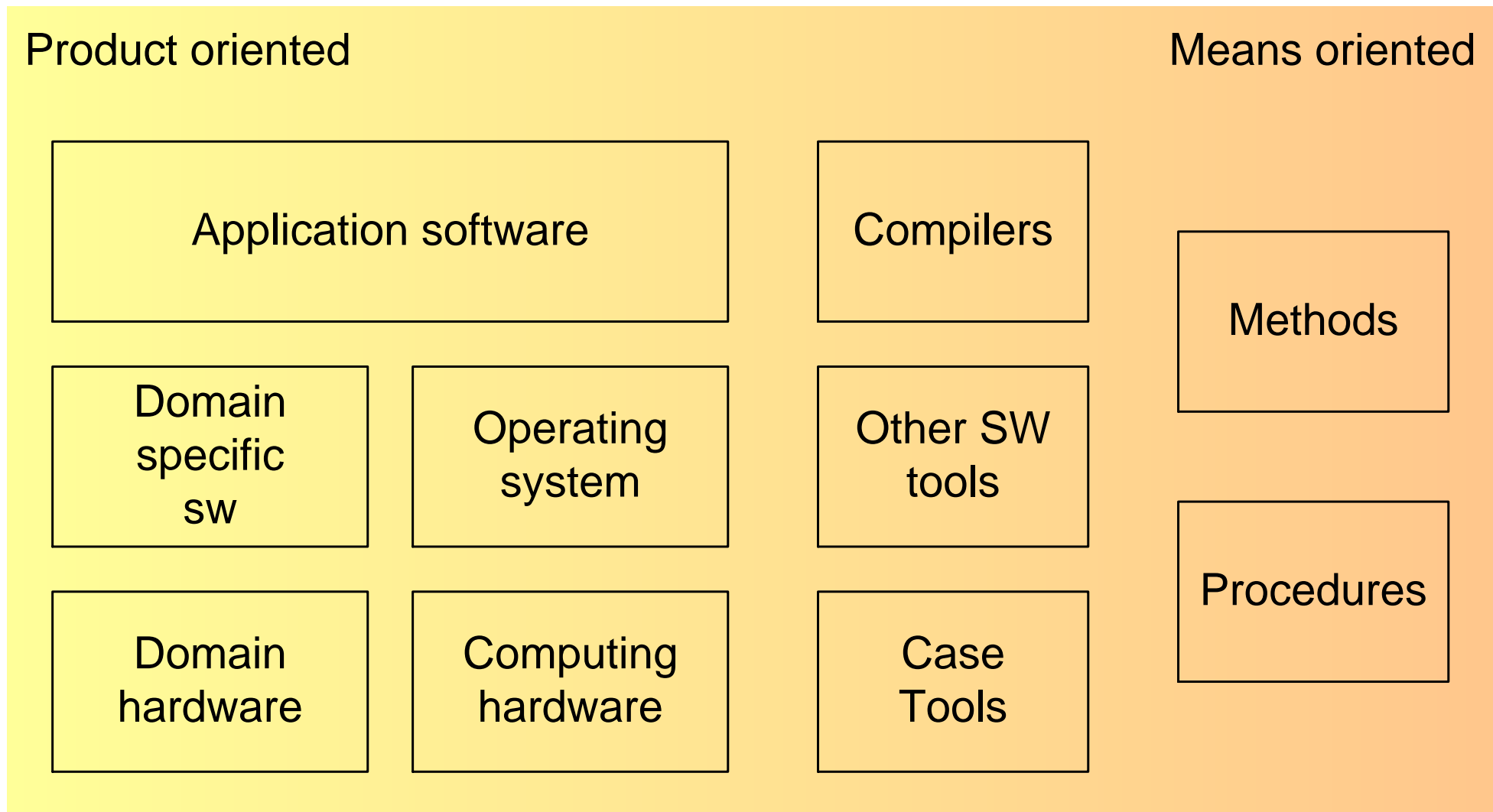
- Observe
- (Dare to) Listen
- Experiment
- Use short development cycles



Don't stay in the development lab



The world of the construction



Engineers are educated in construction disciplines

- Programming languages
- Operating systems
- Algorithms
- Data structures
- Formal specification and verification techniques
- Analysis, simulation techniques

Product Creation is much more than Engineering

Product Creation = Engineering + Creativity

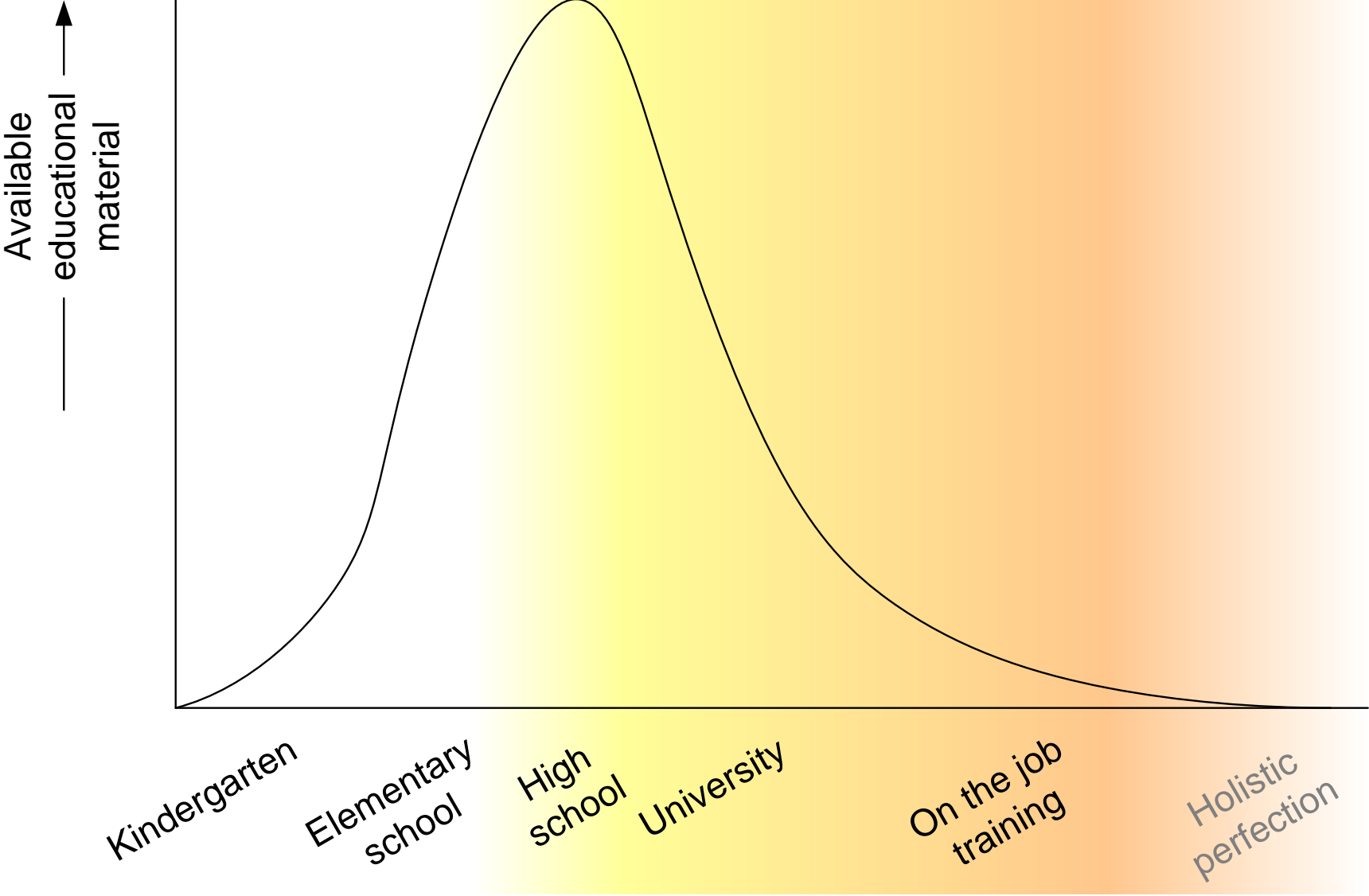
Known:

- Facts
- Notations
- Methods
- Tools
- Patterns

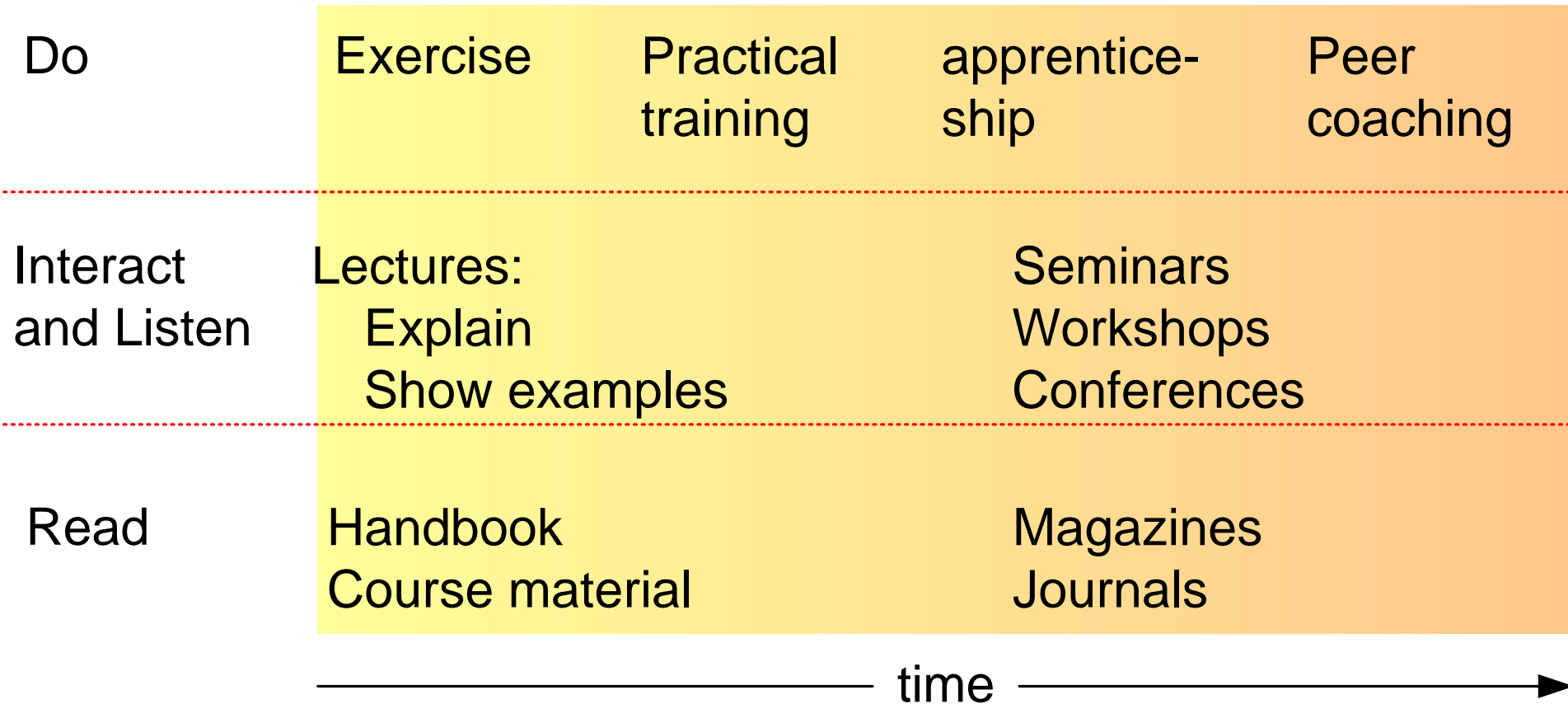
- Intuition
- Observation
- Trial and error
- Lateral thinking
- Collection of references

Education ↔ Experience

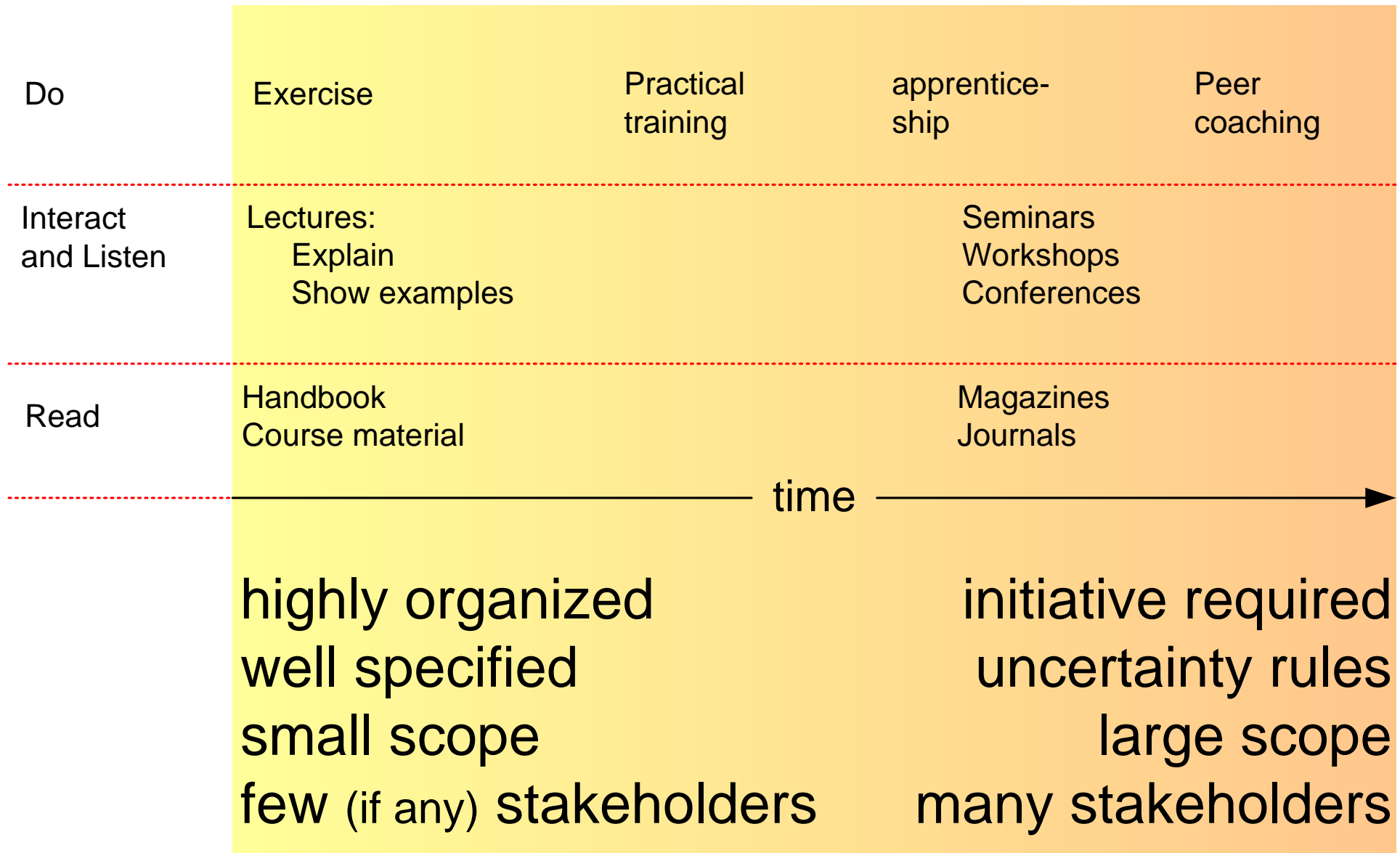
Educational Material per education stage



Changing Education model in time







Increasing Initiative required



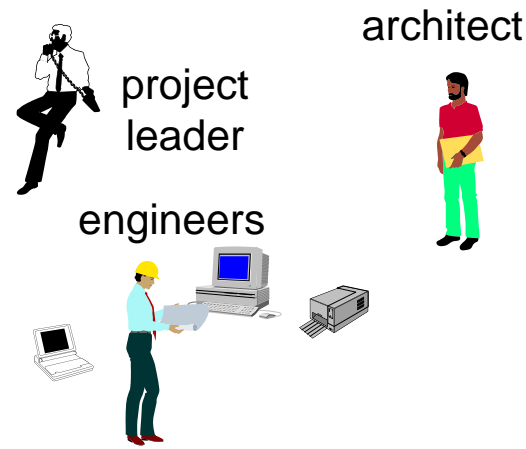
Prerequisites for continuous successful product creation

- Awareness of engineers of human aspects
- Active personal development drive of engineers
- Awareness of managers of education models
- Active motivation by managers

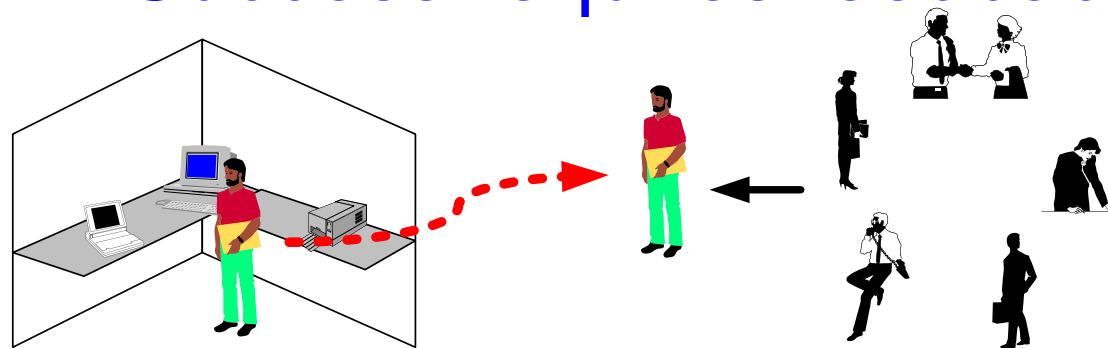
To create an User Experience

- A 
- B 
- C 
- D 

Design Experience is needed



Success requires feedback



Experience is not predictable and never guaranteed

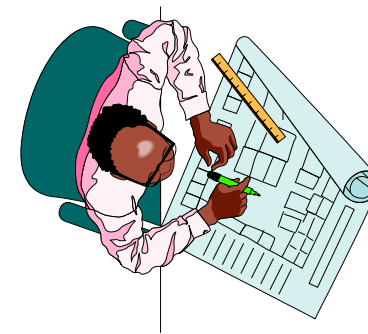
Design experience is not transferable education is no substitute



Regular education =
Transfer of Engineering methods
+ Training

Transfer is approximated by personal development

Personal Development =
On the job training
+ feedback
+ continuous personal education



Human Side: Interpersonal Skills

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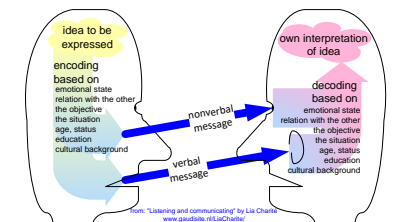
Abstract

We discuss in this paper a set of skills and techniques to cooperate effectively between two individuals. We show the wonders of communication and then we address techniques such as investigation and acknowledgement, constructive feedback, conflict management, appraisal, good practices in a conversation, searching for ideas.

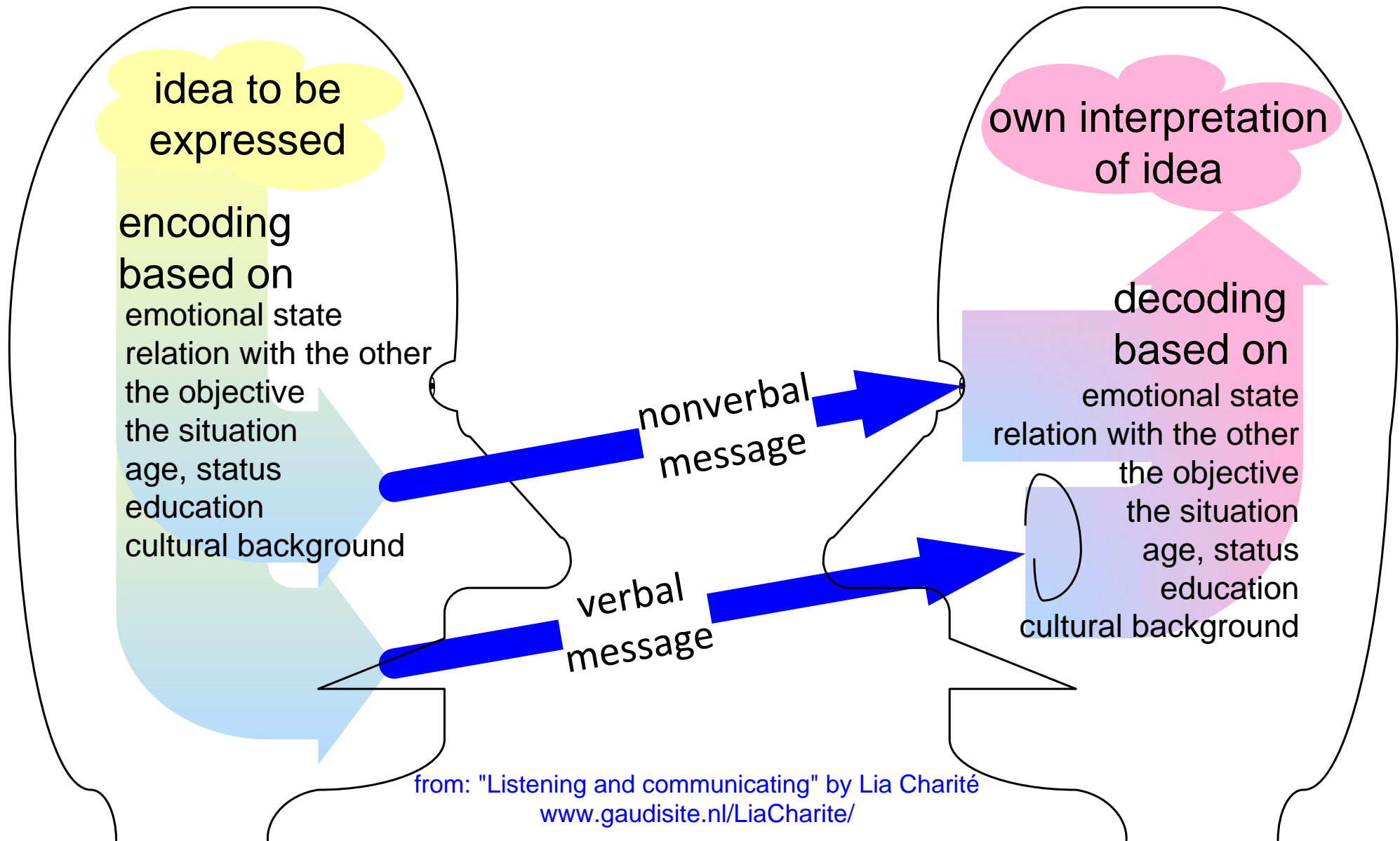
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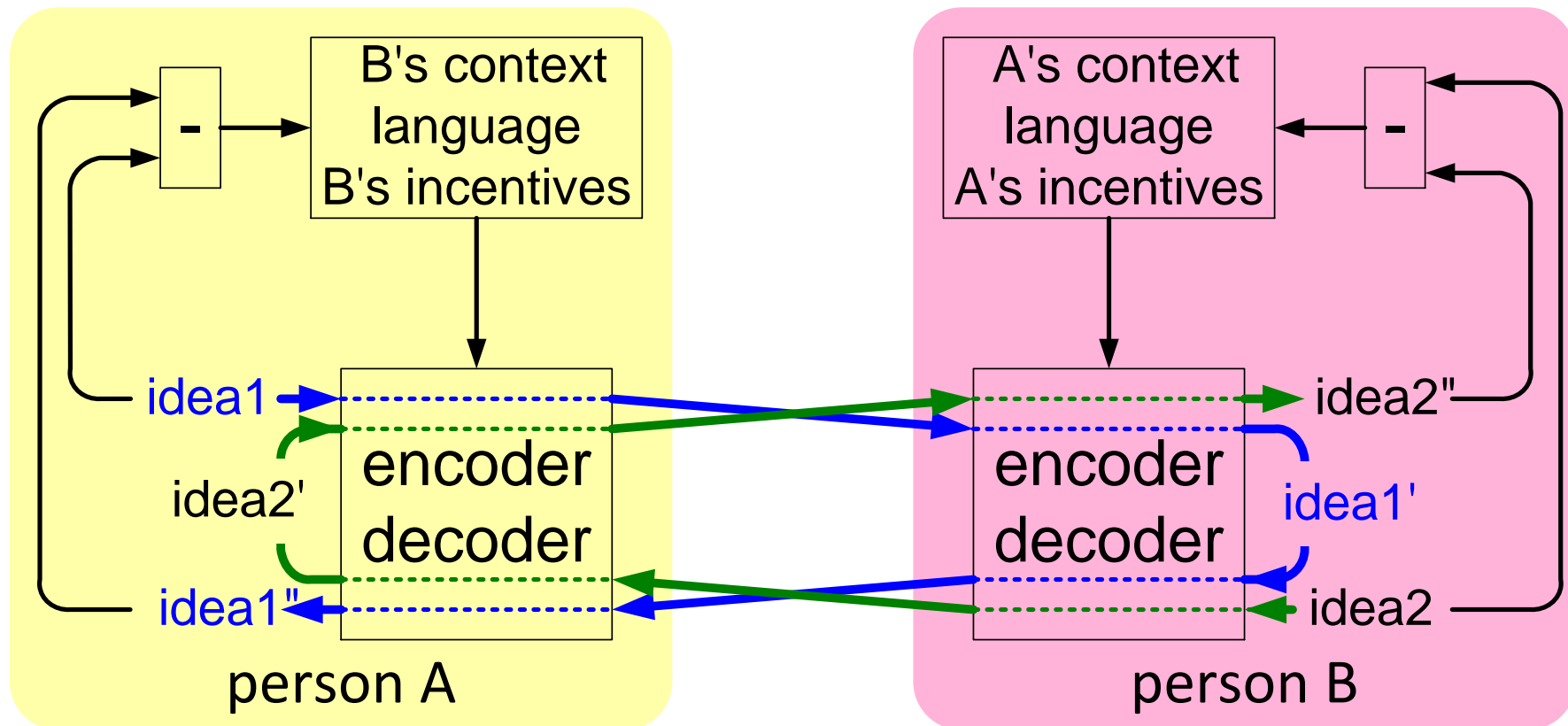


Active listening: the art of the receiver to decode the message

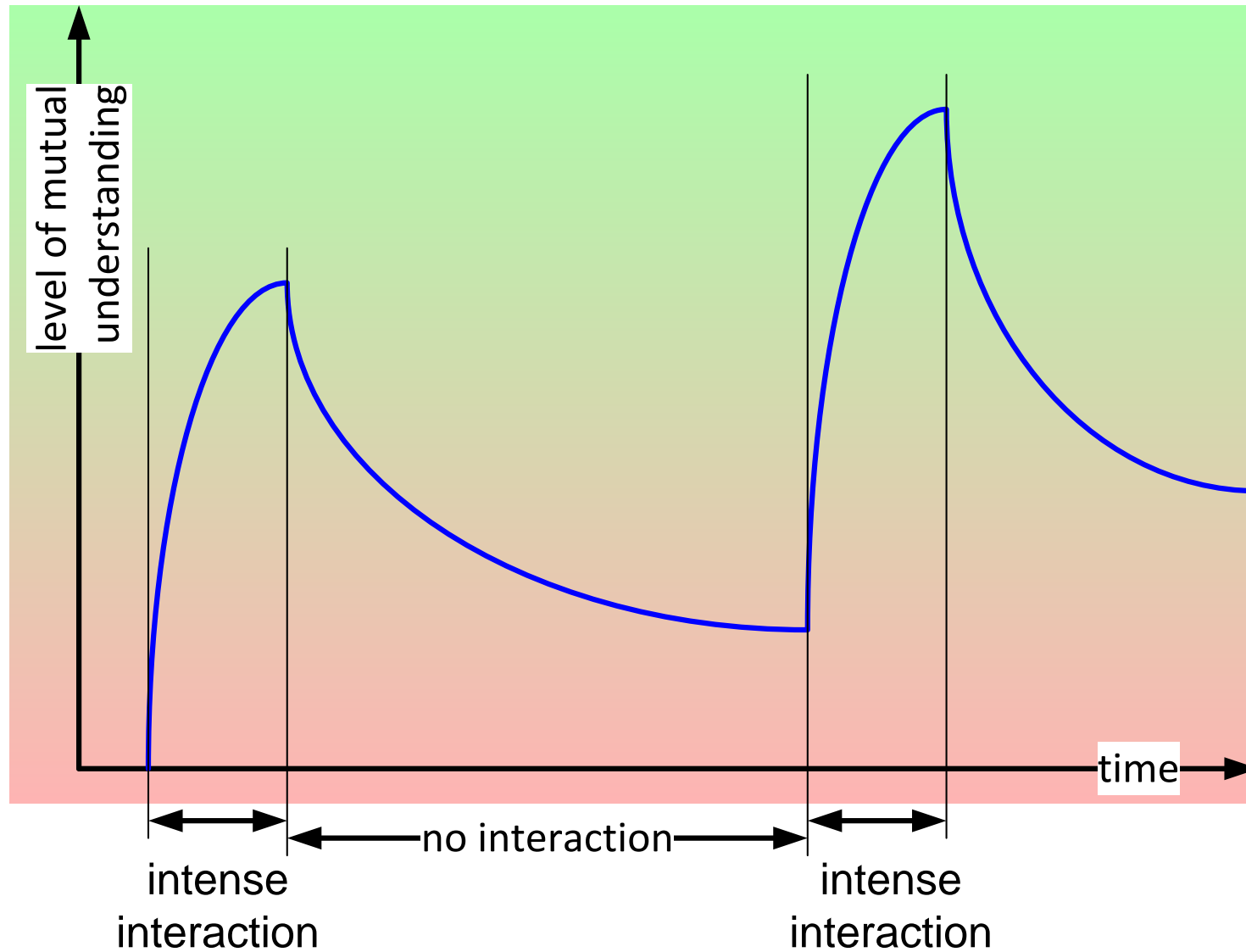


Intense interaction needed for mutual understanding

to calibrate:
repeat many times with different
examples, illustrations, and explanations

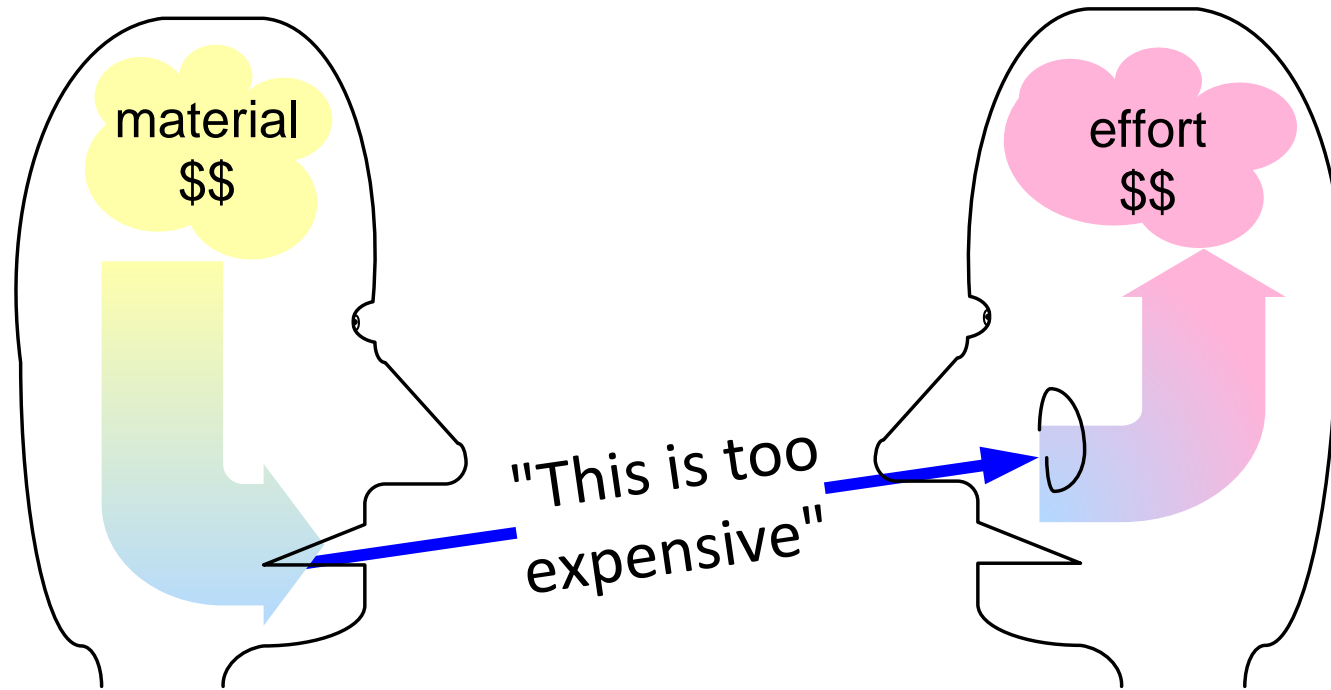


Mutual understanding as function of time



The material for interpersonal skills
is based on a set of techniques
from a course
"Interpersonal Management Skills"
by
Hay Management Consultants
in 1998

Investigate and Acknowledge



investigate:

What has been said and why?

acknowledge:

Paraphrase what has been said and why?

i.e. use your own words

When a decision will be taken or an action will be started on the basis of exchanged information, opinions or suggestions
or
when the first reaction is to reject, ignore or contradict what you just heard.

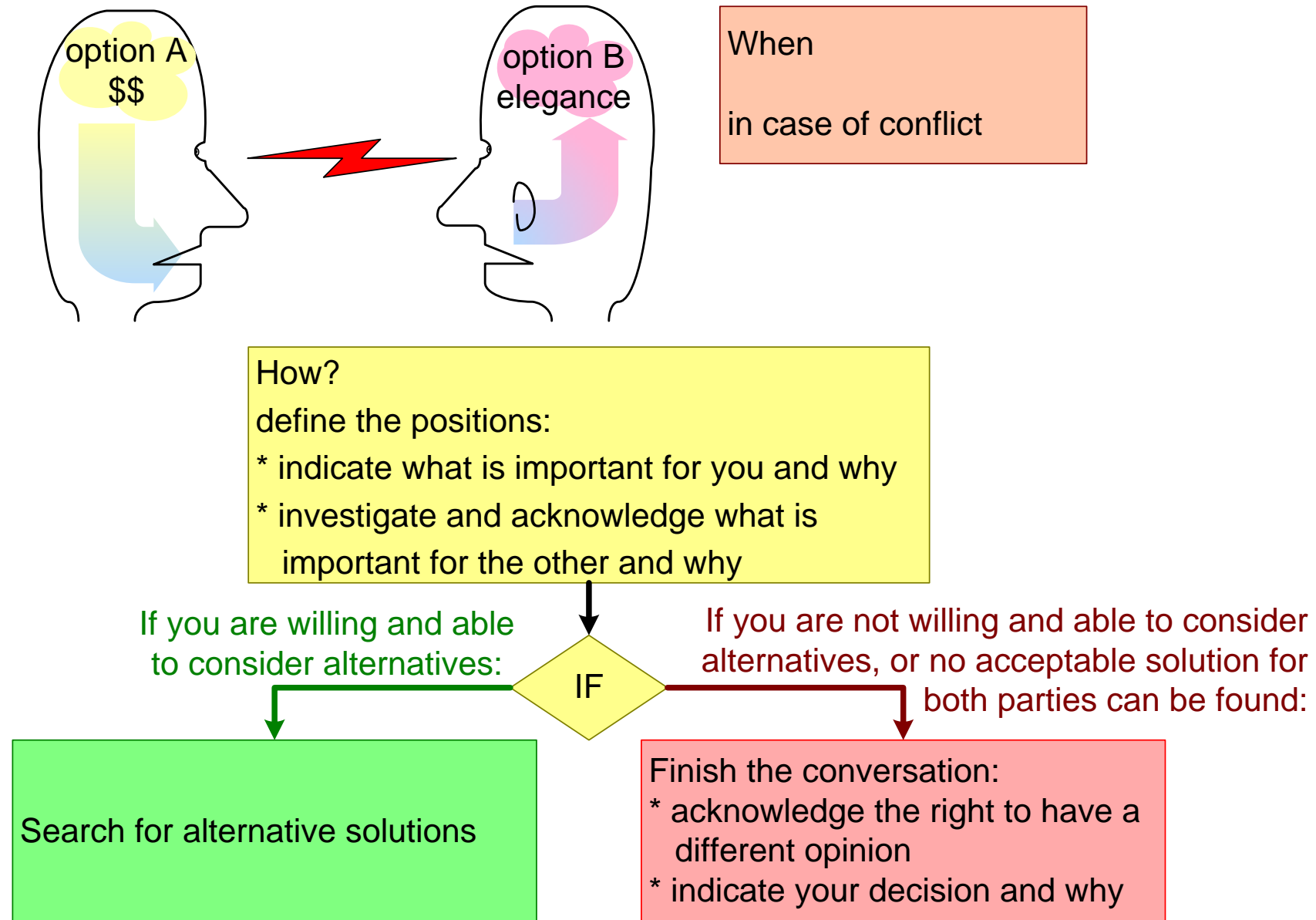
How

- + Indicate the strong points to be kept
- + Indicate the points to be improved
- + Search for solutions which build upon the strong points and improve the weak points

When

You want to facilitate someone to improve his/her performance

Conflict Management



When

Someone's performance is important for you

- * exceeding the expectations
- * meets expectations continuously
- * meets expectations, which exceed the normal performance level of this person

Appraise only when authentic!

How

- + Mention the performance very specific.
- + Mention the personal qualities which lead to this performance.
- + Describe which advantages arise for you, the department or the organization.

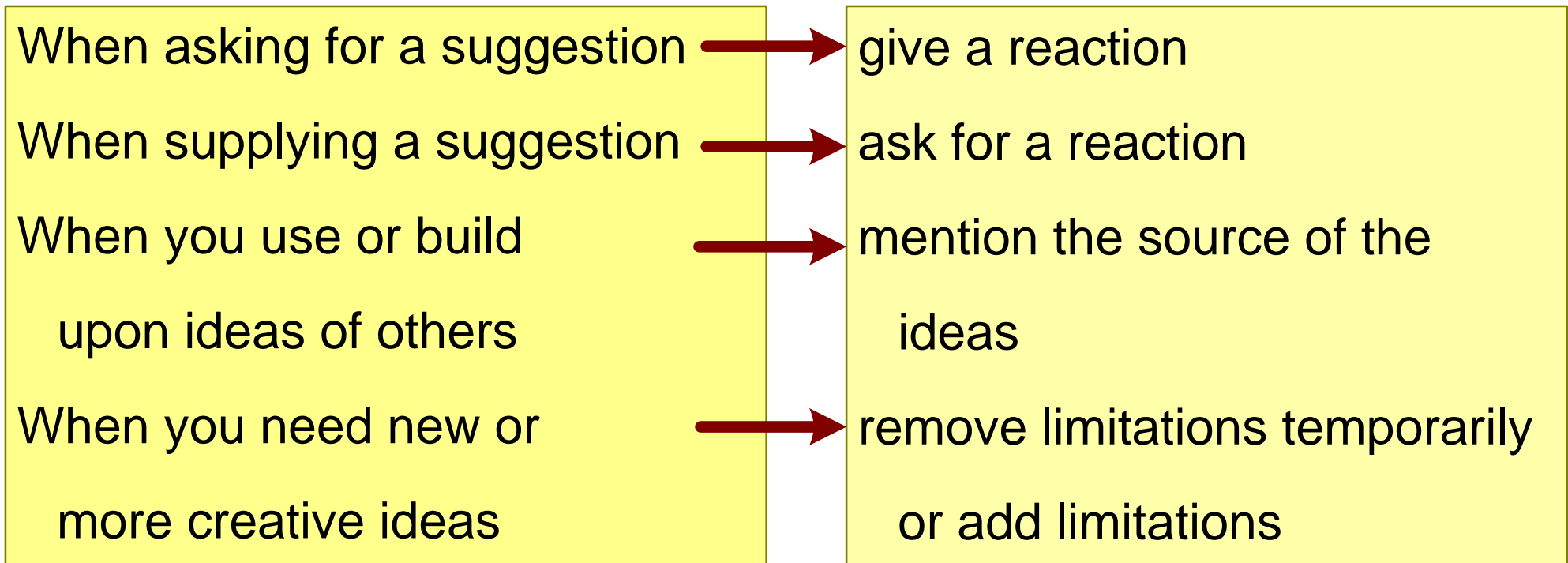
When you open a conversation

formulate the purpose

When you finish the conversation

summarize the agreements and the actionplan

Searching for Ideas



Human Side: Team Work

by *Gerrit Muller* USN-SE

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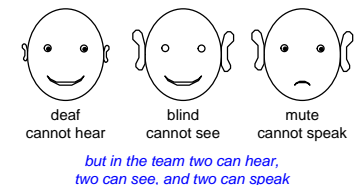
Abstract

The creation of products requires many different people to cooperate. The work is often organized in teams. The team members have complimentary skills and knowledge. In many management courses the need to design teams is emphasized. Unfortunately, often these recommendations are ignored. We re-iterate in this paper the rationale for teams and the recommendations for designing the team itself.

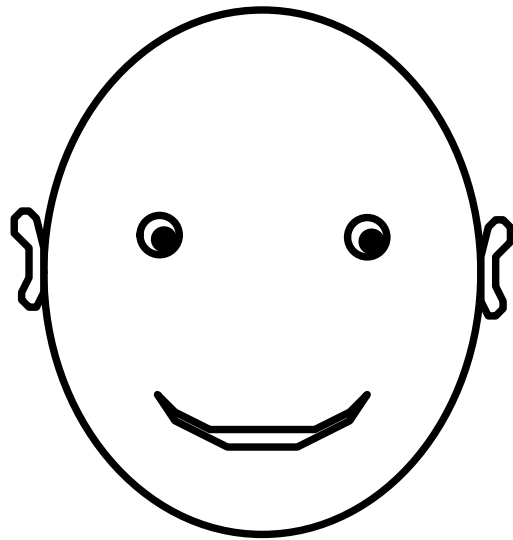
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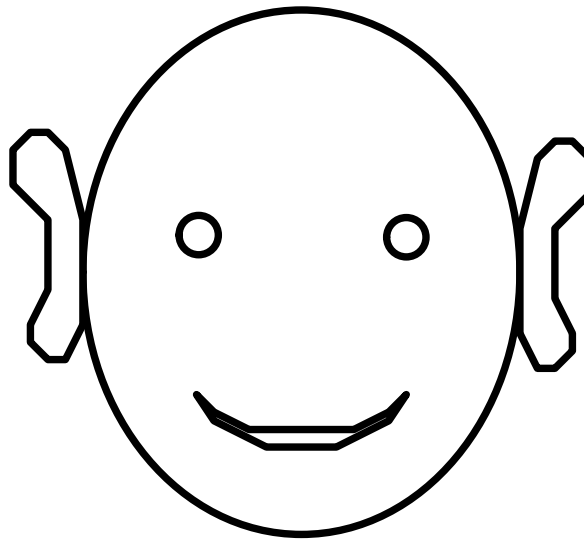


Teams consist of complementary people



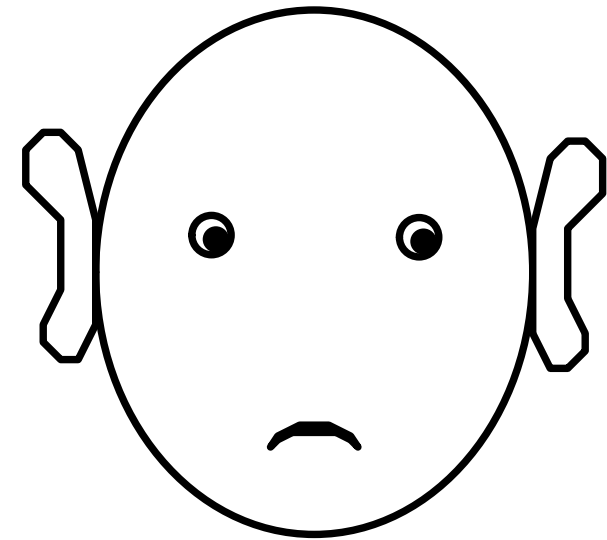
deaf

cannot hear



blind

cannot see

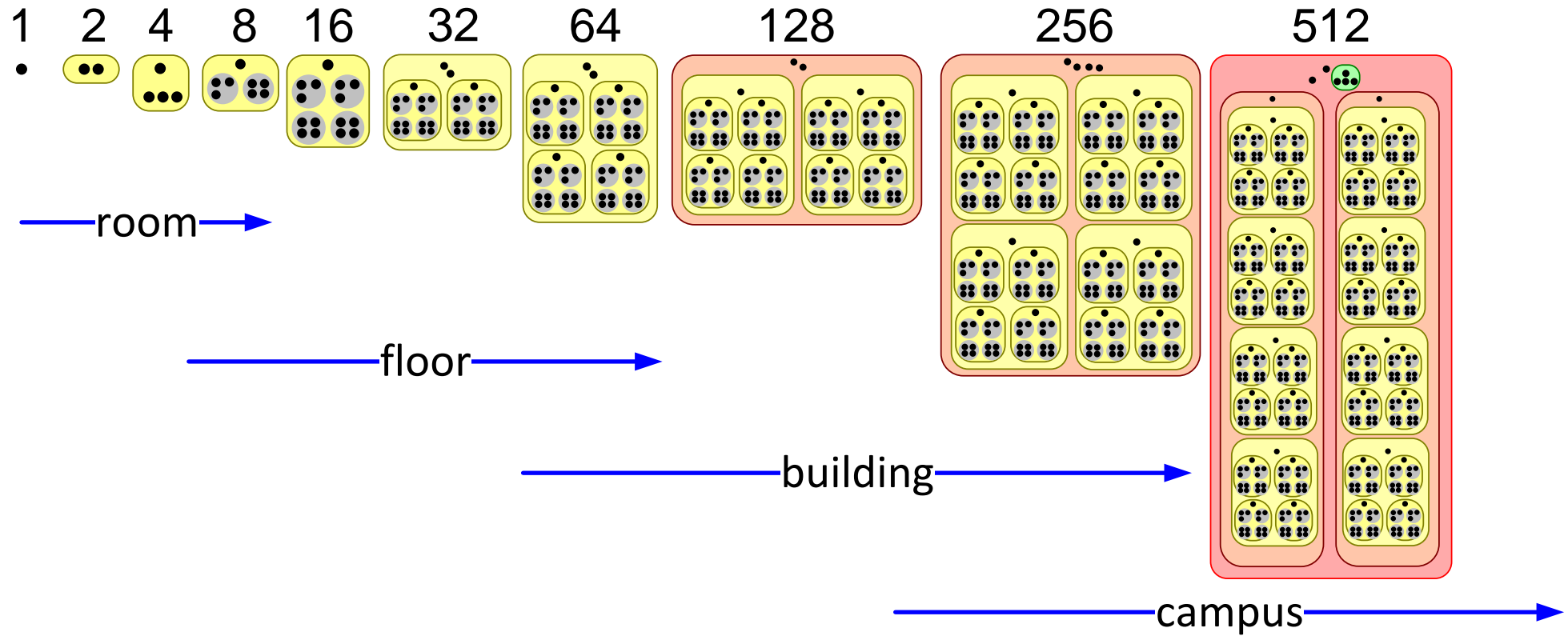


mute

cannot speak

*but in the team two can hear,
two can see, and two can speak*

Organization size and teams

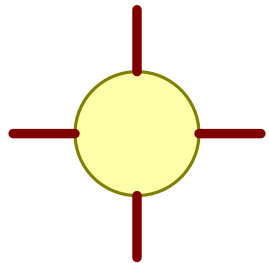


Very simplistic team model

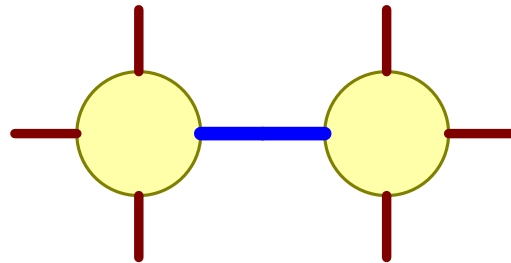
legend

— productive work

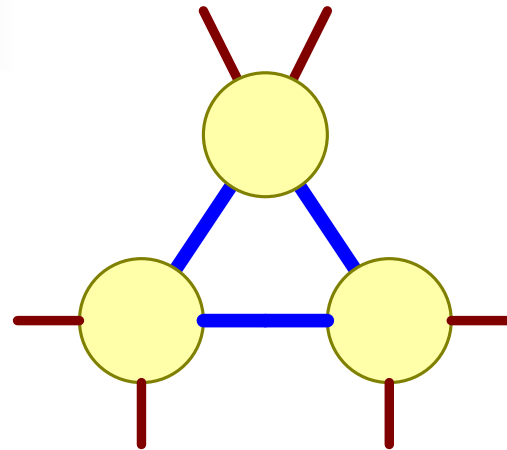
— communication



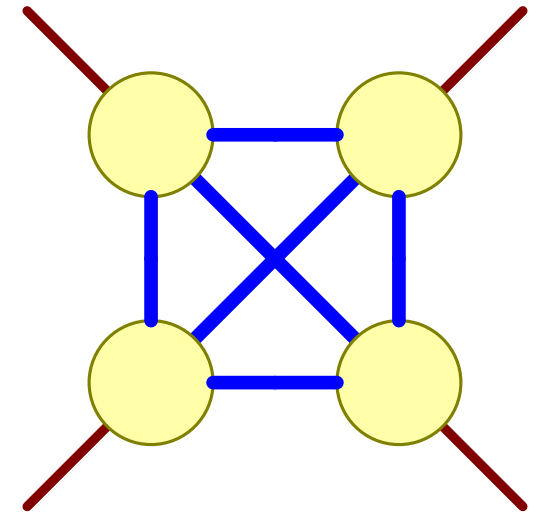
1-person
team
eff = 100%



2-person
team
eff = 75%



3-person
team
eff = 50%



4-person
team
eff = 25%

Hierarchical simplistic team model

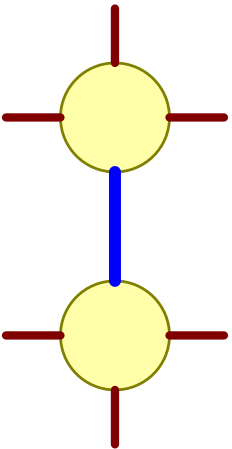
legend



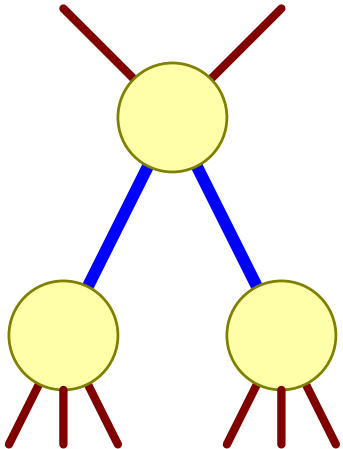
productive work



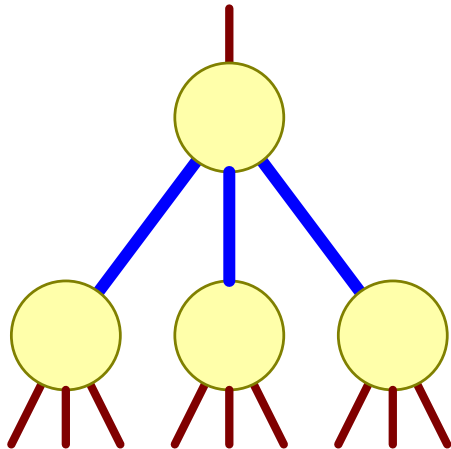
communication



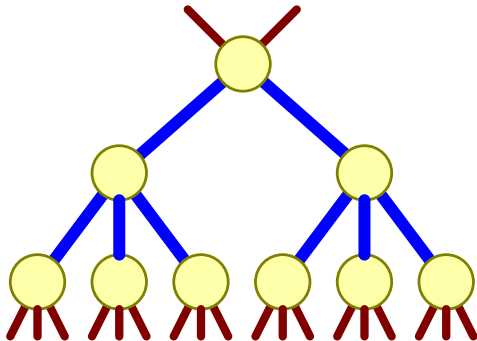
2-person team
eff = 75%



3-person team
eff = 66%

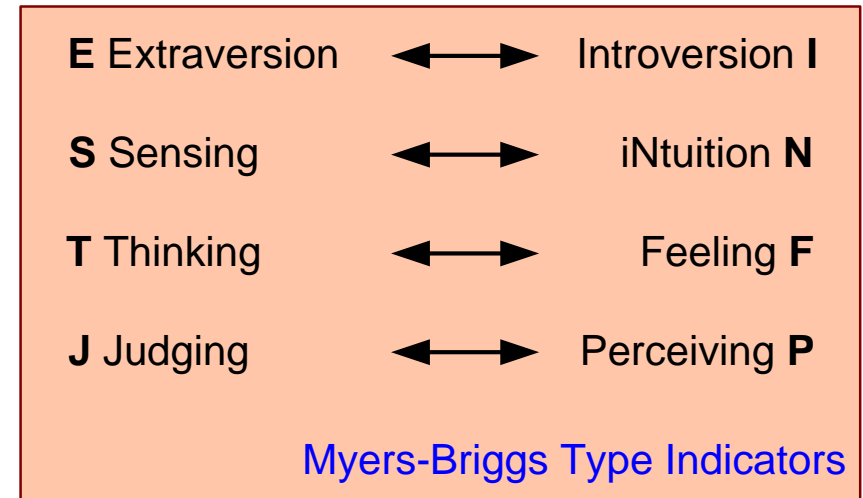
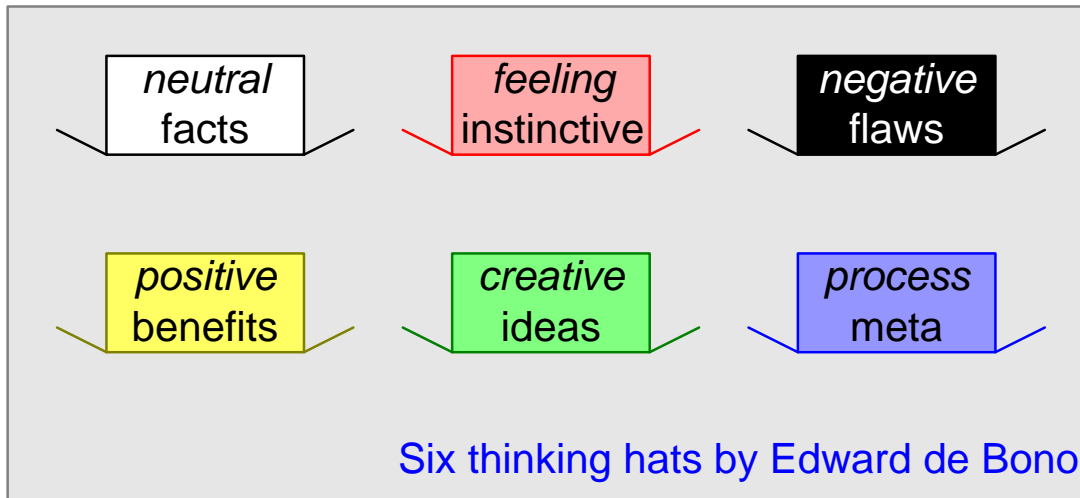


4-person team
eff = 62.5%



9-person team
eff ~ = 56%

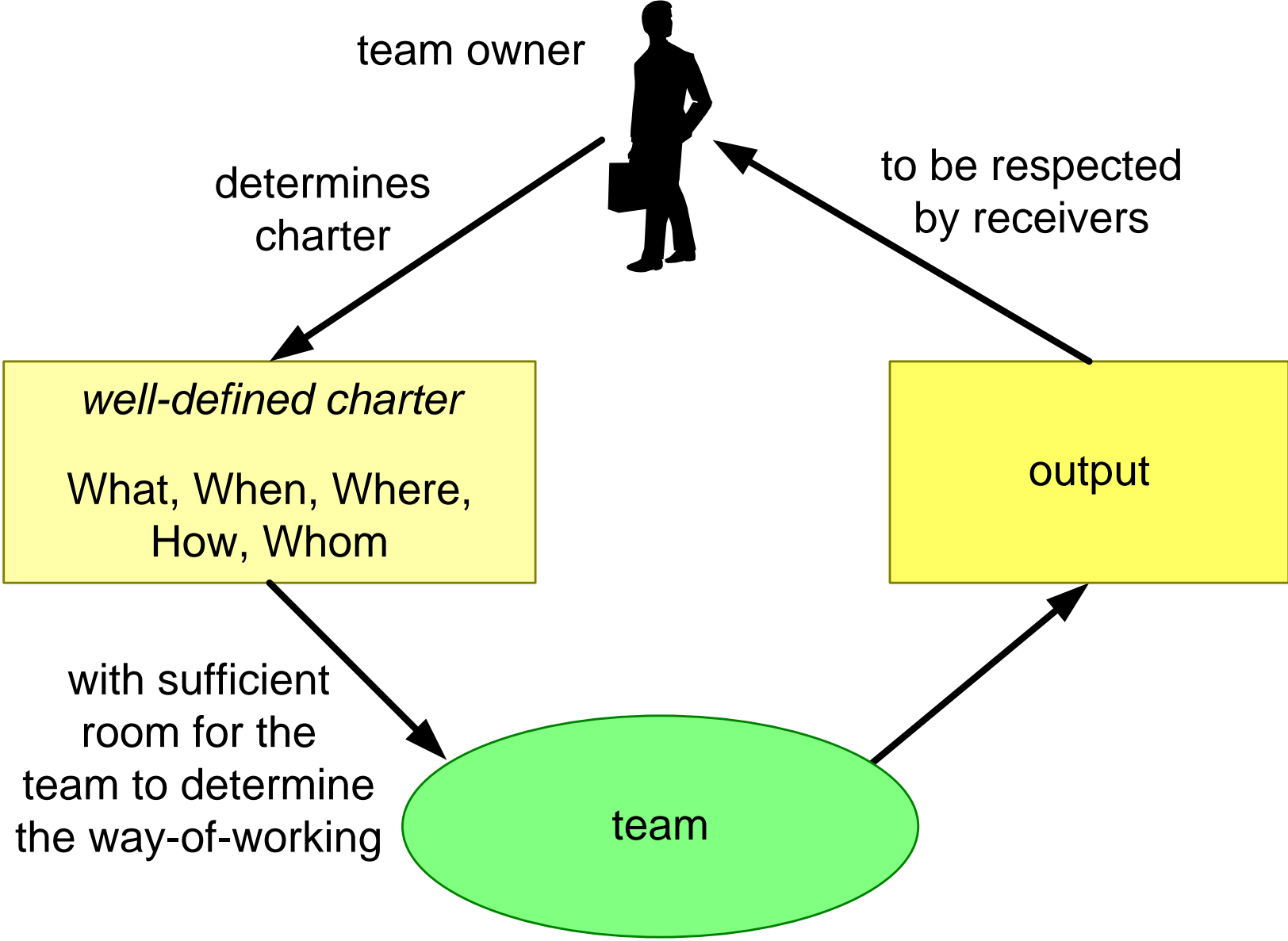
Many personality and role models are available



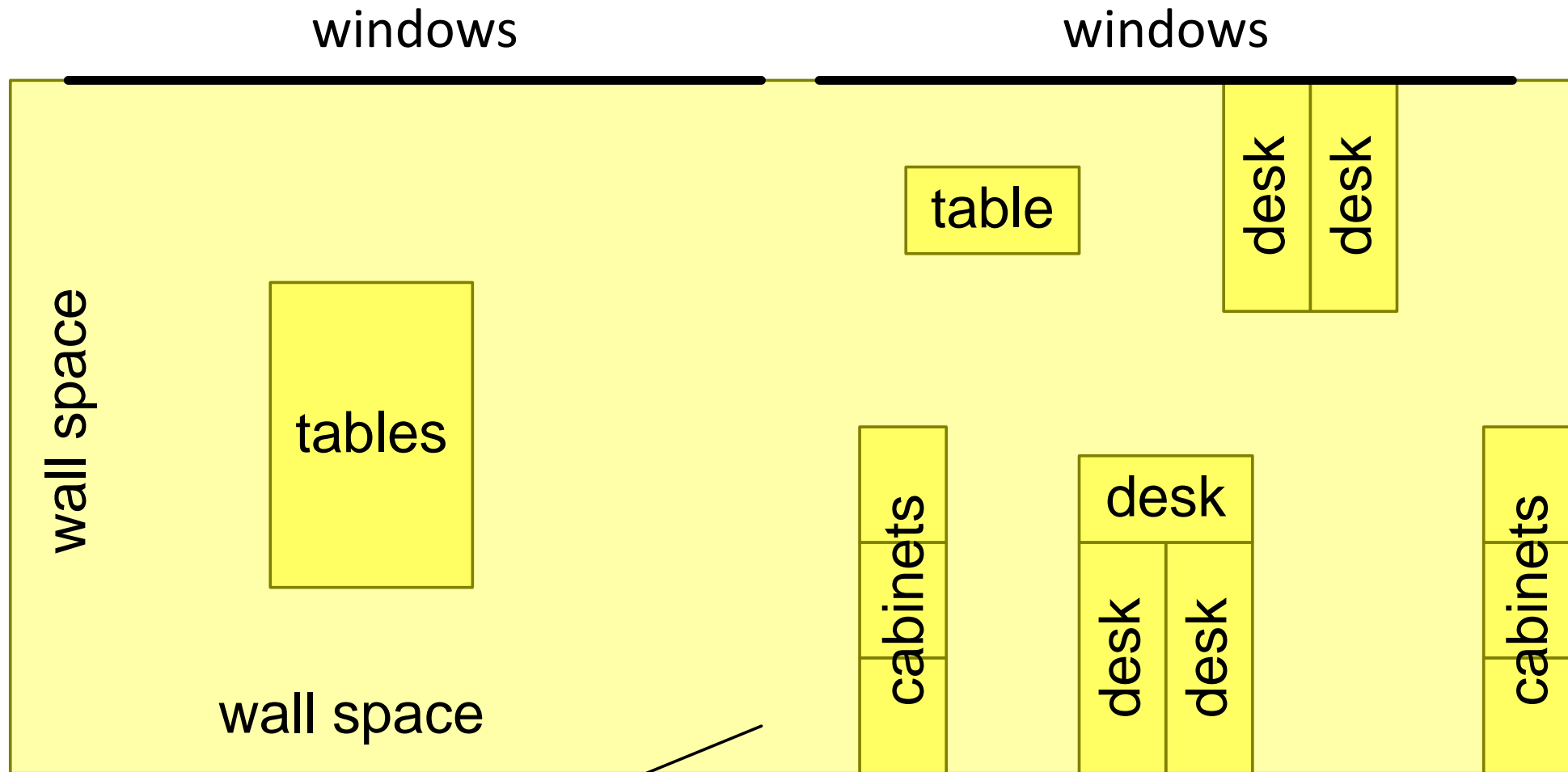
<i>plant</i> creative	<i>team worker</i> co-operative, averts friction	<i>implementer</i> disciplined, conservative, do-er
<i>resource investigator</i> enthusiatic communicator	<i>shaper</i> driver, dynamic	<i>completer finisher</i> conscientious, painstaking
<i>co-ordinator</i> mature, chairman	<i>monitor evaluator</i> sober, analytical	<i>specialist</i> single-minded, rare skills

Belbin's team roles

Process of creating and using a team

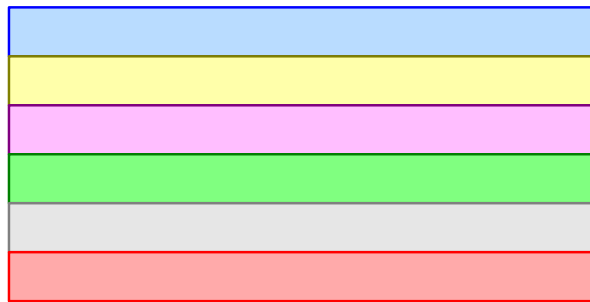
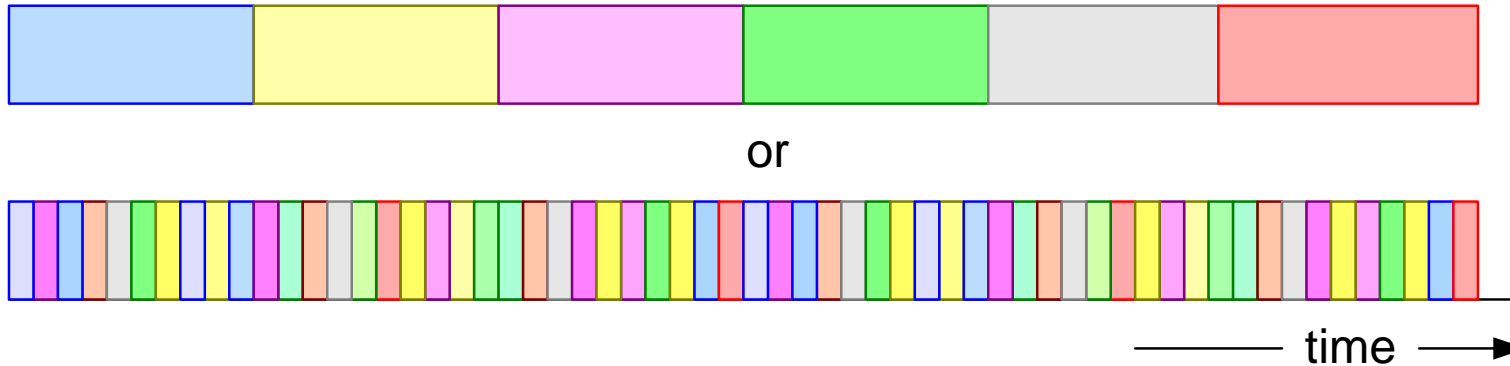


“War Room” is very effective

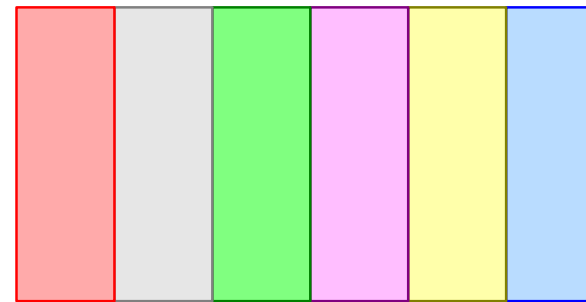


Concurrency and Fragmentation lower efficiency

How many (semi-)concurrent tasks can a person handle?
Working in burst-mode (concentrating on one task for one day, week or month) can increase efficiency.

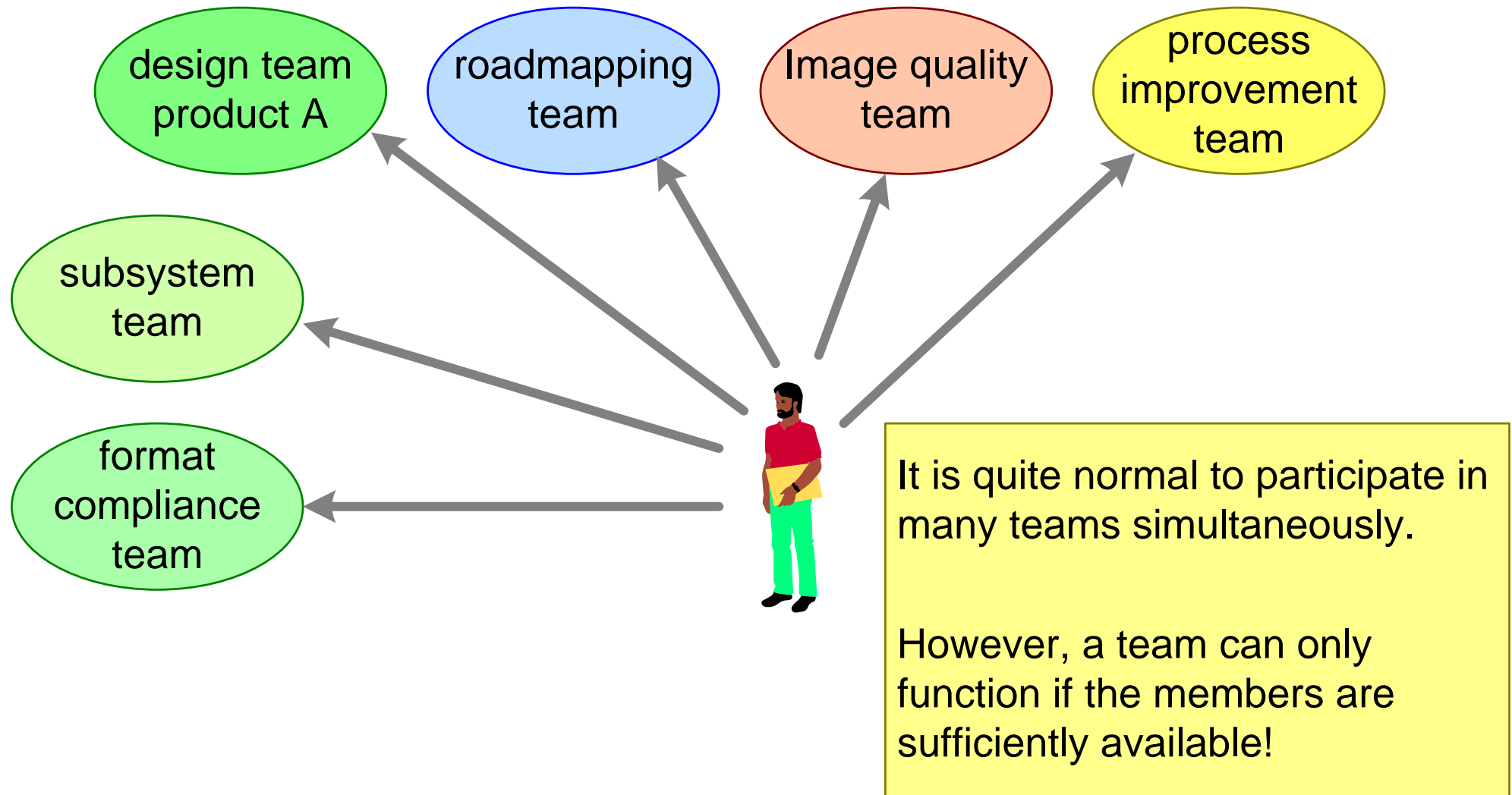


six tasks in parallel:
all results are late



six tasks sequential
first result in 1/6 of time!

One person will be member of multiple teams



Critical Success Factors for teams

well defined charter
clear owner of the result
respect for the output of the team
freedom of way-of-working
housing and location
availability of team members
complementary roles
diversity, pluriformity

Architecting Interaction Styles

by *Gerrit Muller* USN-SE

e-mail: gaudisite@gmail.com

www.gaudisite.nl

Abstract

A system architects needs skills to apply different interactions styles, depending on the circumstances. This document discusses the following interaction styles: provocation, facilitation, leading, empathic, interviewing, white board simulation, and judo tactics.

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version: 0.2

provocation	when in an impasse: provoke effective when used sparsely
facilitation	especially recommended when new in a field: contribute to the team, while absorbing new knowledge
leading	provide vision and direction, make choices risk: followers stop to give the needed feedback
empathic	take the viewpoint of the stakeholder acknowledge the stakeholder's feelings, needs, concerns
interviewing	investigate by asking questions
whiteboard simulation	invite a few engineers and walk through the system operation step by step
judo tactics	first listen to the stakeholder and then explain cost and alternative opportunities

Architecting Styles

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Function Profiles; The Sheep with Seven Legs

by *Gerrit Muller* USN-SE

e-mail: gaudisite@gmail.com

www.gaudisite.nl

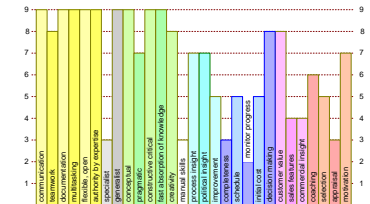
Abstract

The profile of a system architect is quantified for a large list of system architect related characteristics. For comparison the function profiles of related functions are given as well. This profile is based on personal observations and experience.

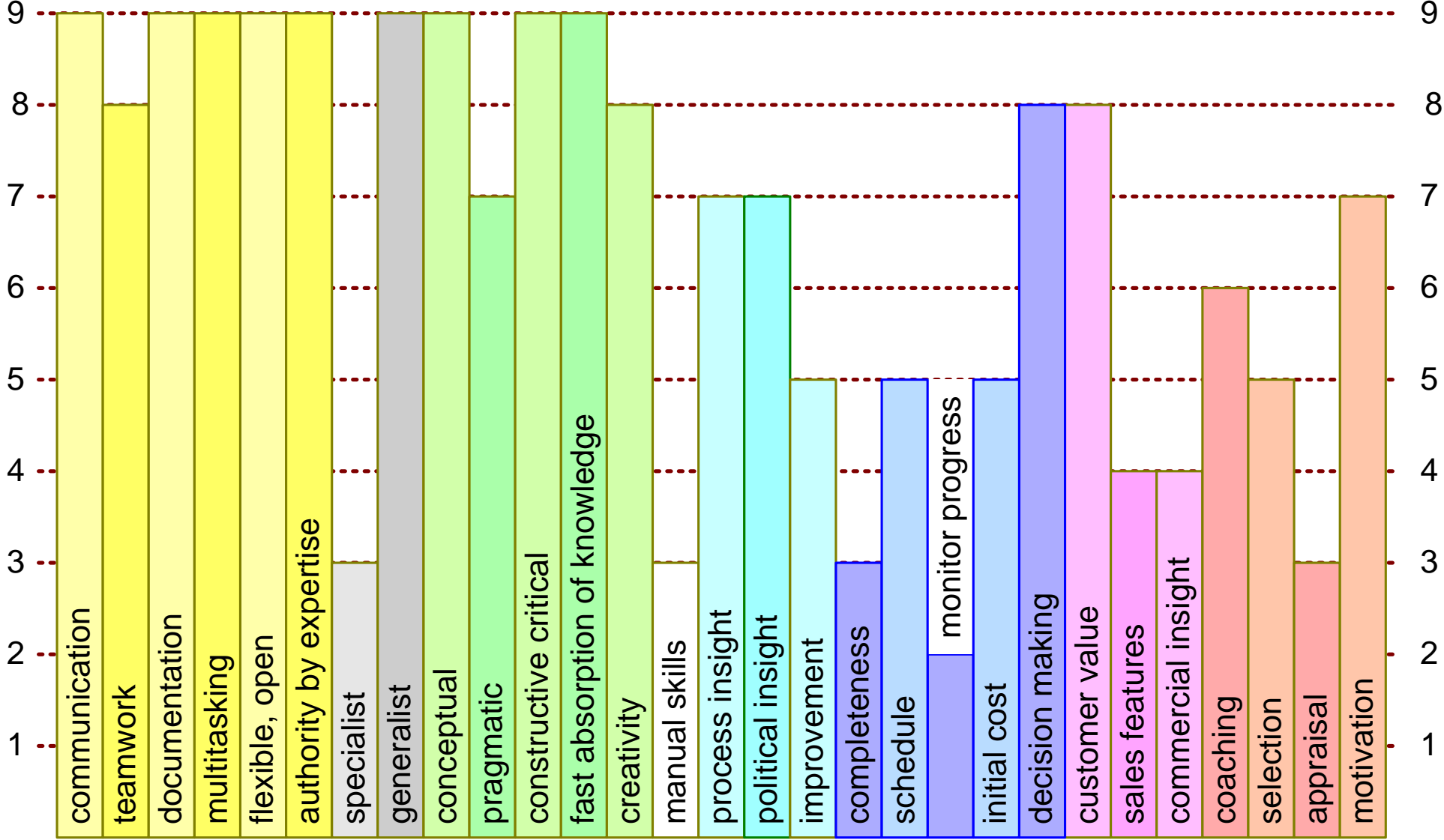
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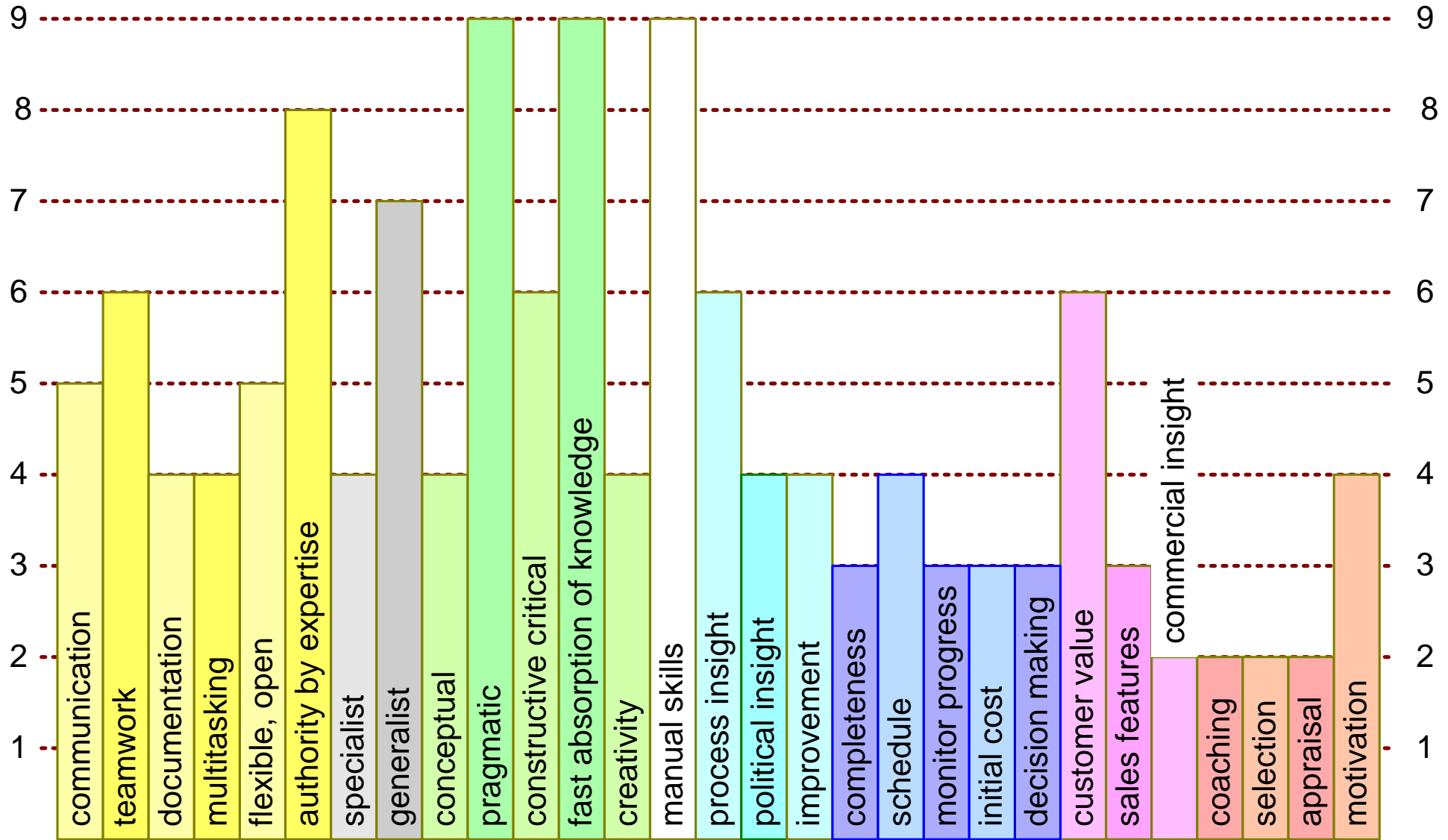
August 16, 2025
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version: 1.0



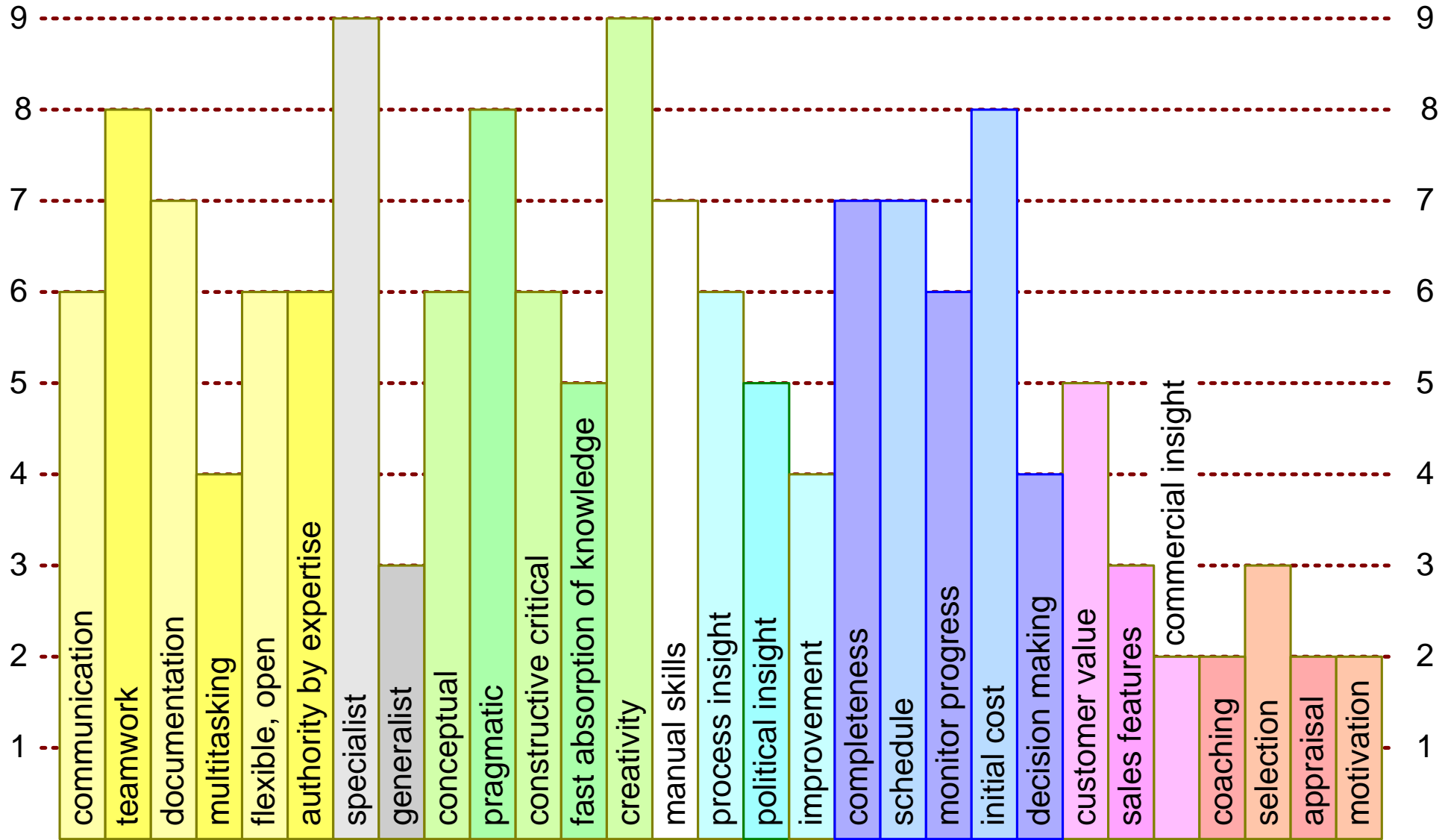
System Architect



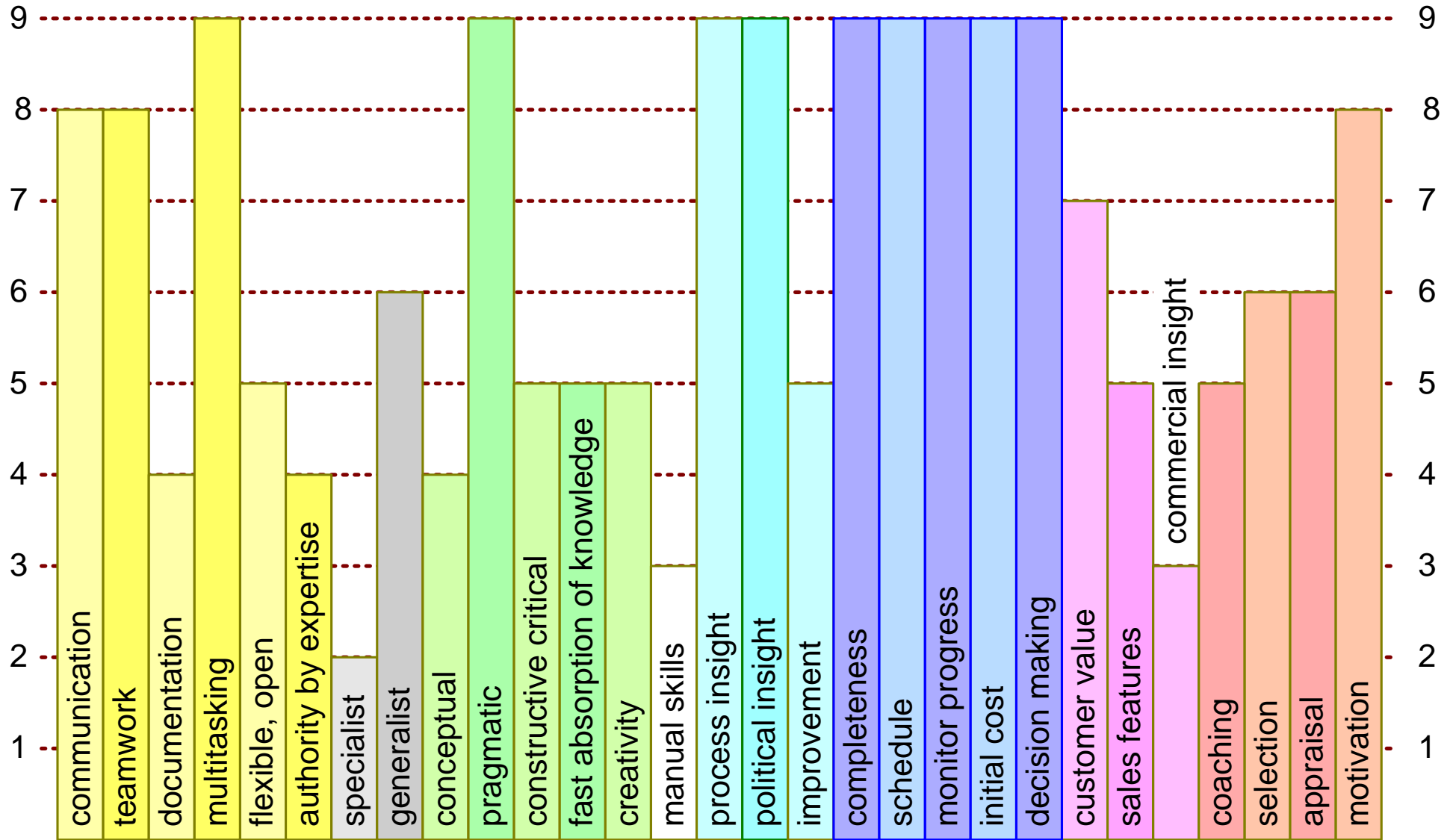
Test Engineer



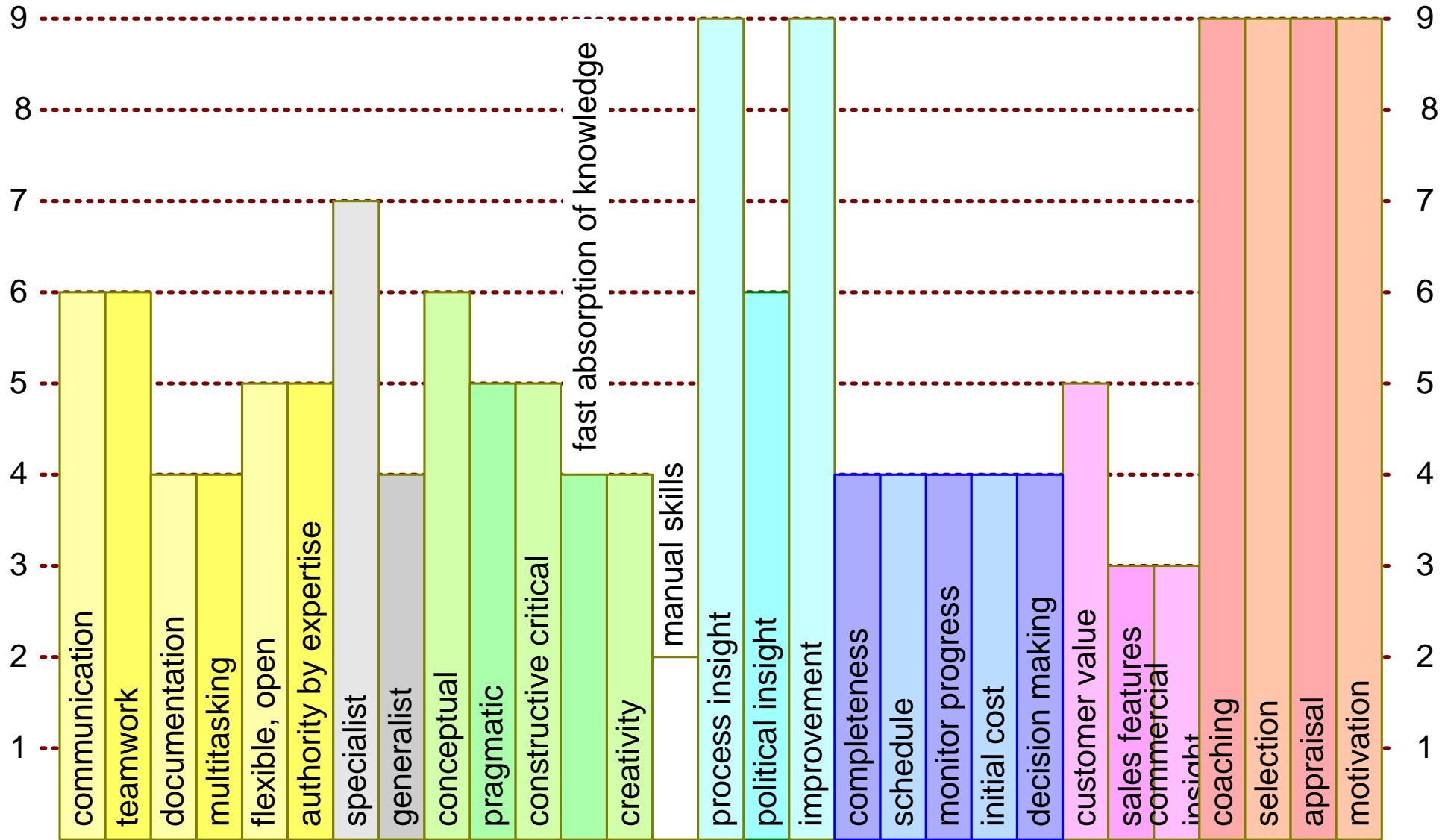
Developer



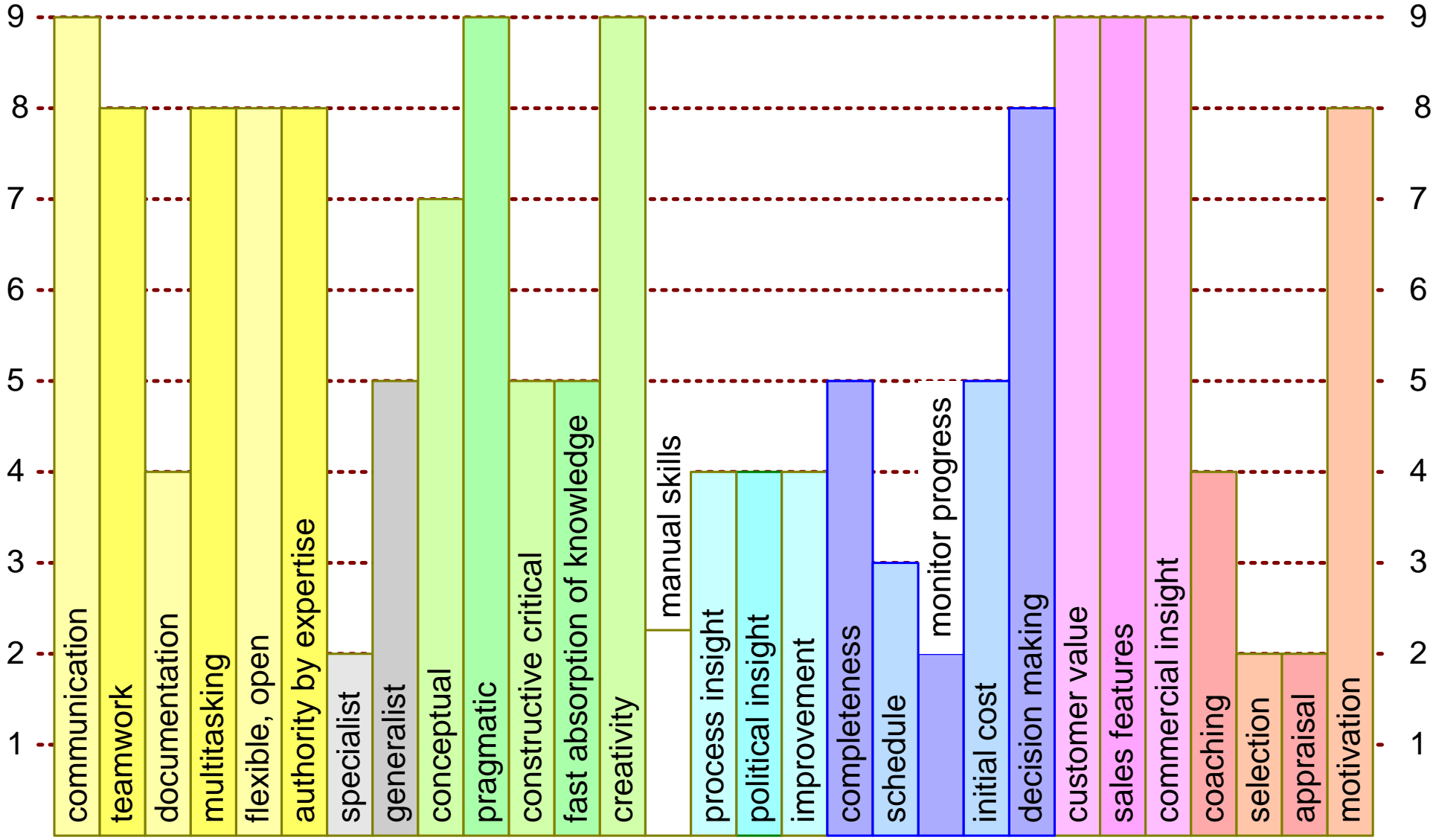
Operational Leader



Line Manager



Commercial Manager



The numbers behind the bars

	communication	teamwork	documentation	multitasking	flexible, open	authority by expertise	specialist	generalist	conceptual	pragmatic	constructive critical	fast absorption of knowledge	creativity	manual skills	process insight	political insight	improvement	completeness	schedule	monitor progress	initial cost	decision making	customer value	sales features	commercial insight	coaching	selection	appraisal	motivation
systems architect	9	8	9	9	9	9	3	9	9	7	9	9	8	3	7	7	5	3	5	2	5	8	8	4	4	6	5	3	7
test engineer	5	6	4	4	5	8	4	7	4	9	6	9	4	9	6	4	4	3	4	3	3	3	6	3	2	2	2	2	4
developer	6	8	7	4	6	6	9	3	6	8	6	5	9	7	6	5	4	7	7	6	8	4	5	3	2	2	3	2	2
operational leader	8	8	4	9	5	4	2	6	4	9	5	5	5	3	9	9	5	9	9	9	9	9	7	5	3	5	6	6	8
line manager	6	6	4	4	5	5	7	4	6	5	5	4	4	2	9	6	9	4	4	4	4	4	5	3	3	9	9	9	9
commercial manager	9	8	4	8	8	8	2	5	7	9	5	5	9	2	4	4	4	5	5	2	5	8	9	9	9	4	2	2	8

Short introduction to basic “CAFCR” model

by *Gerrit Muller* University of South-Eastern Norway-NISE

e-mail: `gaudisite@gmail.com`

`www.gaudisite.nl`

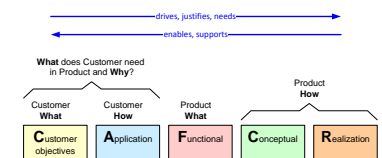
Abstract

The basic “CAFCR” reference model is described, which is used to describe a system in relation to its context. The main stakeholder in the context is the customer. The question “Who is the customer?” is addressed.

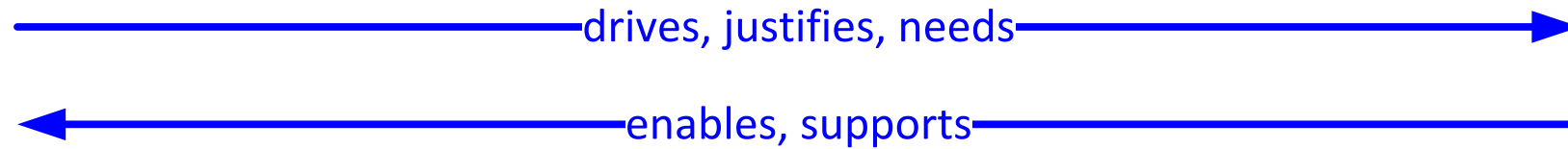
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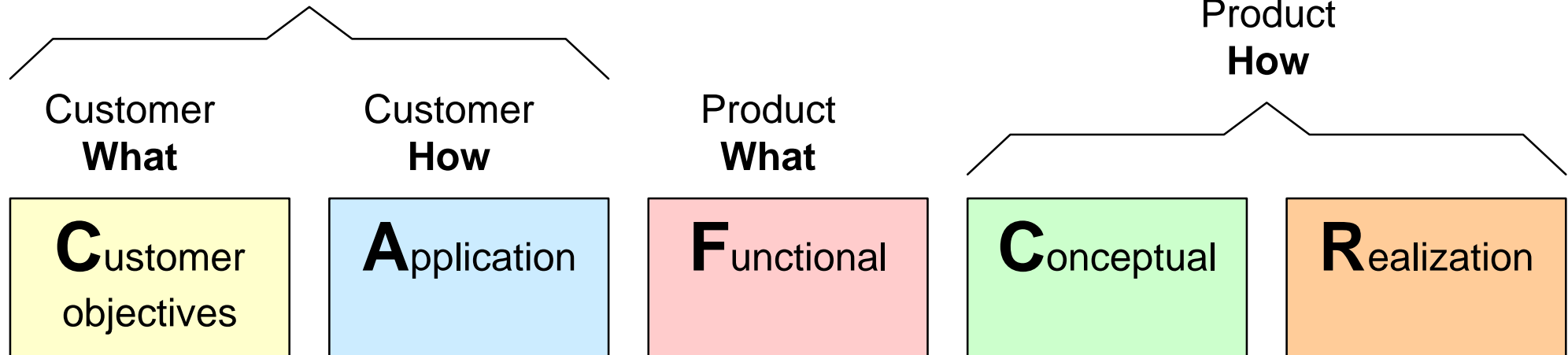
August 16, 2025
status: draft
version: 0.4



The “CAFCR” model

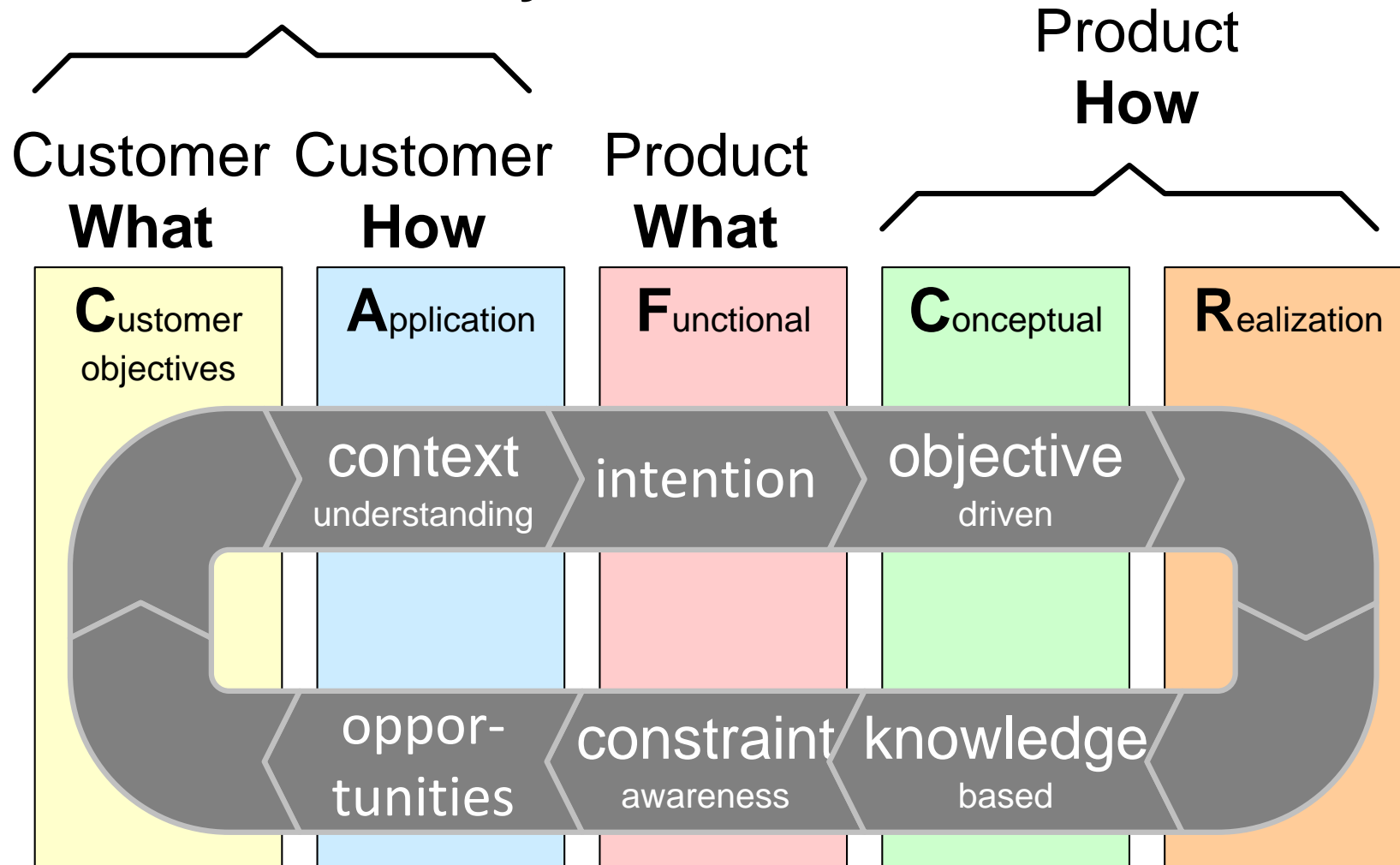


What does Customer need
in Product and **Why?**

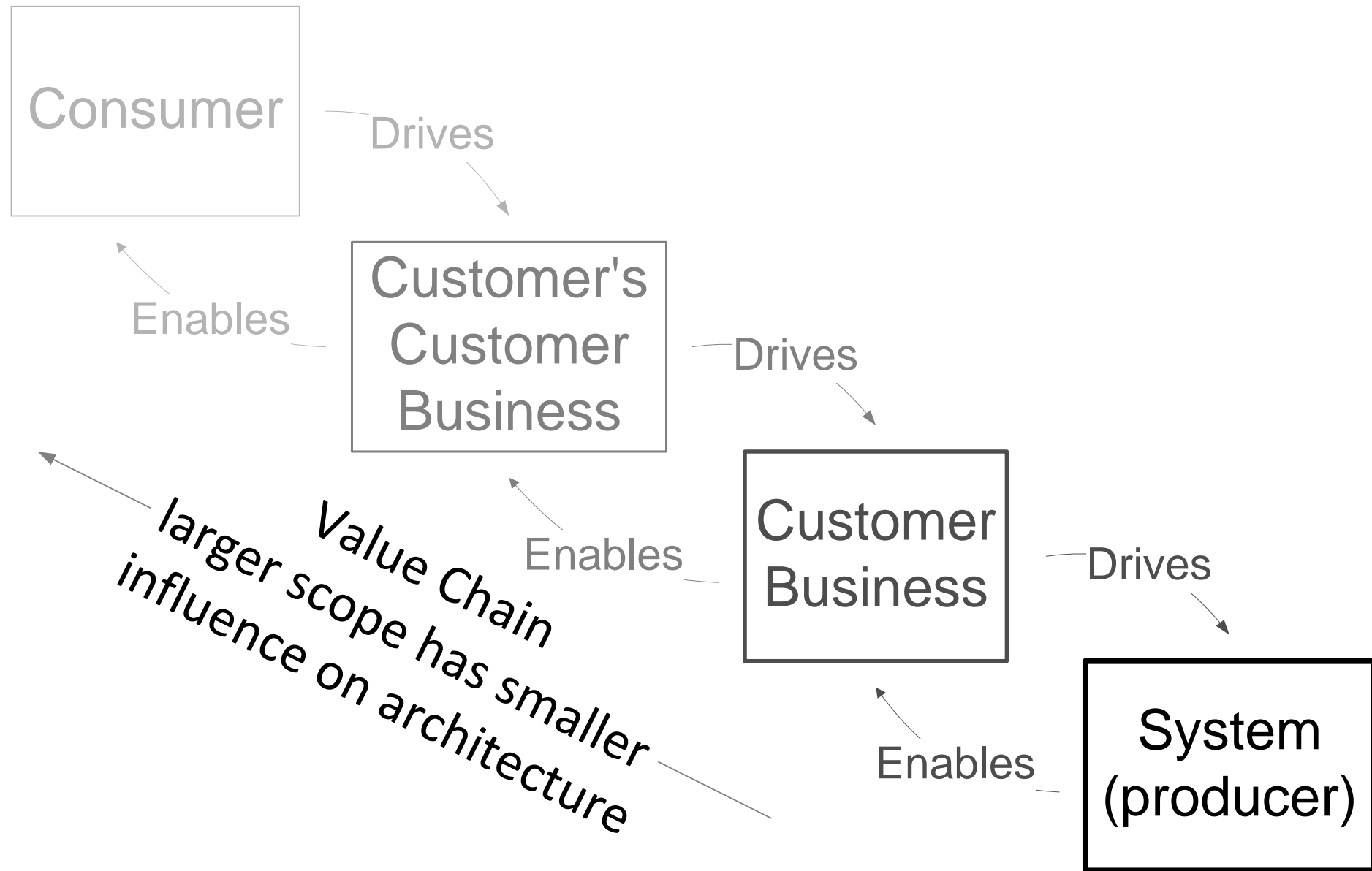


Integrating CAFCR

What does Customer need
in Product and **Why?**



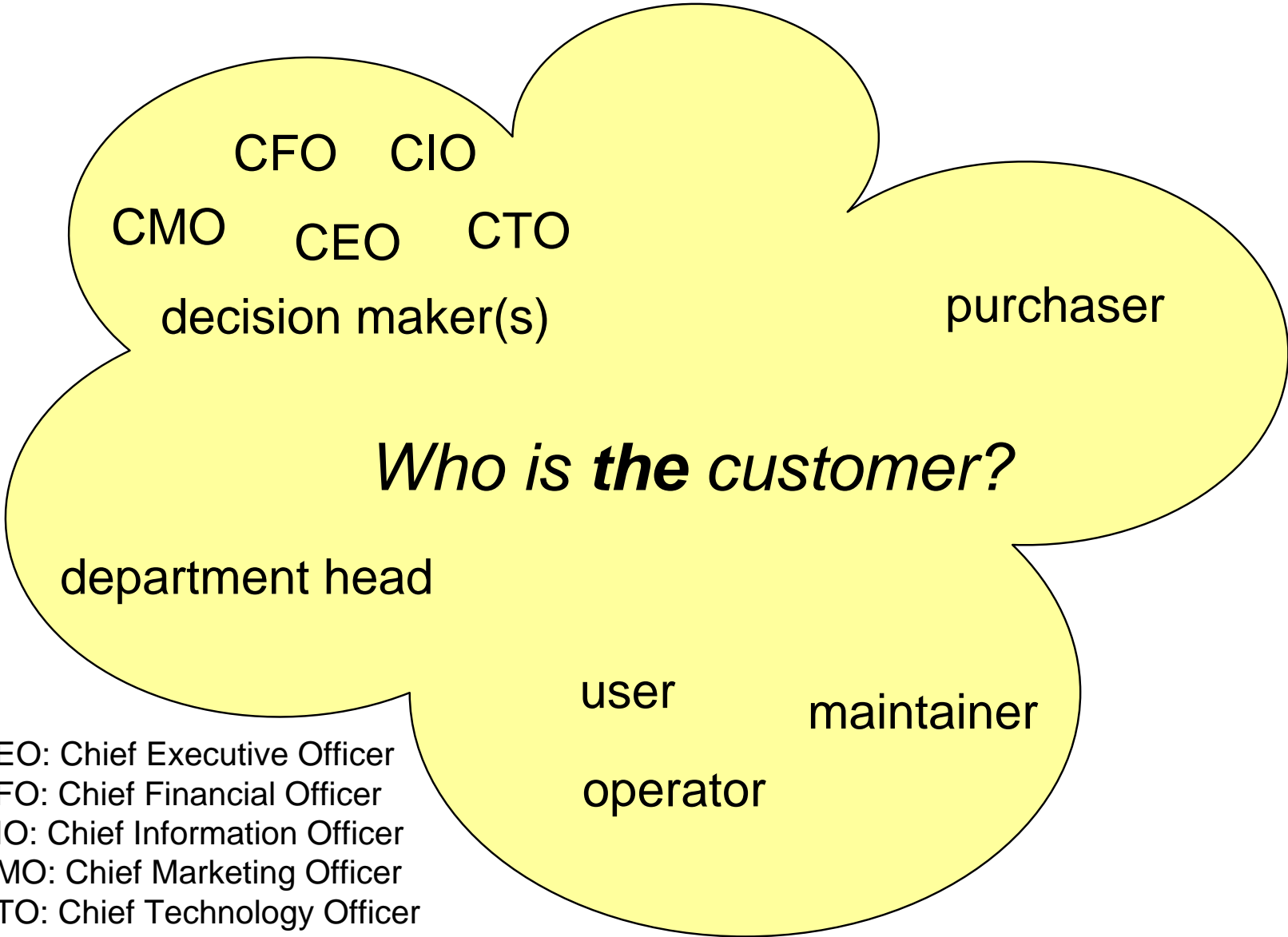
CAFCR can be applied recursively



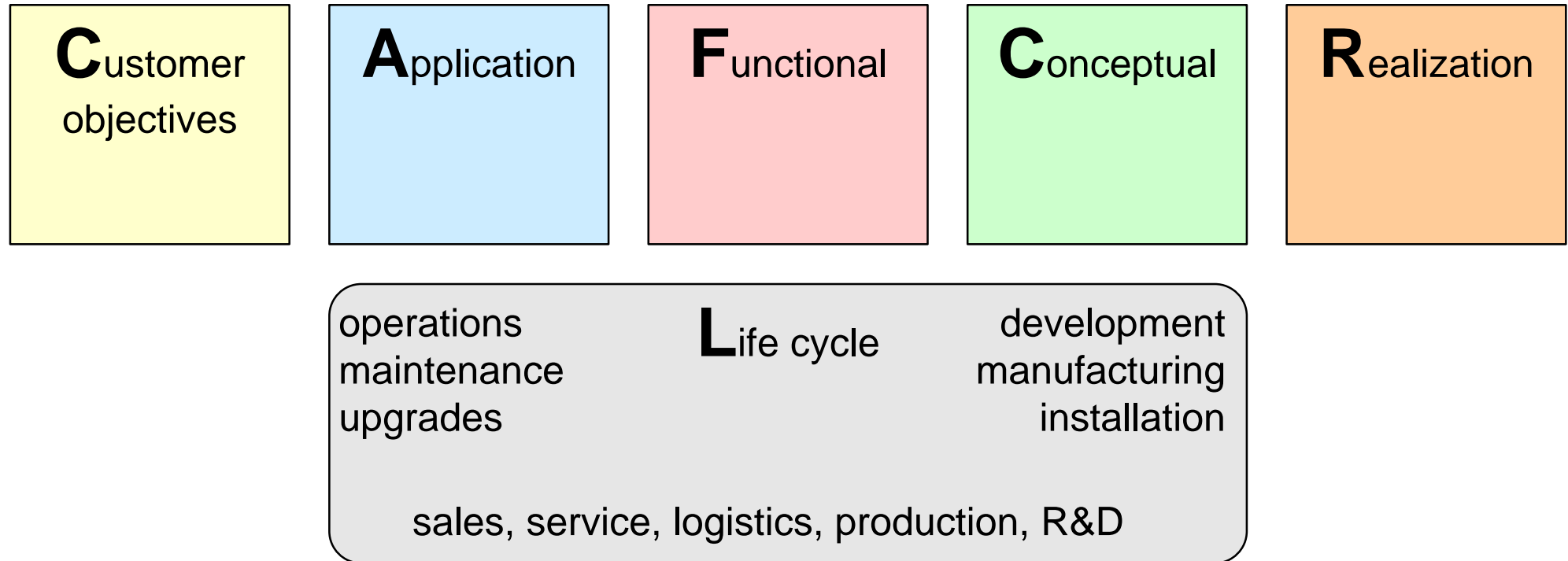
Market segmentation

segmentation axis	examples
geographical	USA, UK, Germany, Japan, China
business model	profit, non profit
economics	high end versus cost constrained
consumers	youth, elderly
outlet	retailer, provider, OEM, consumer direct

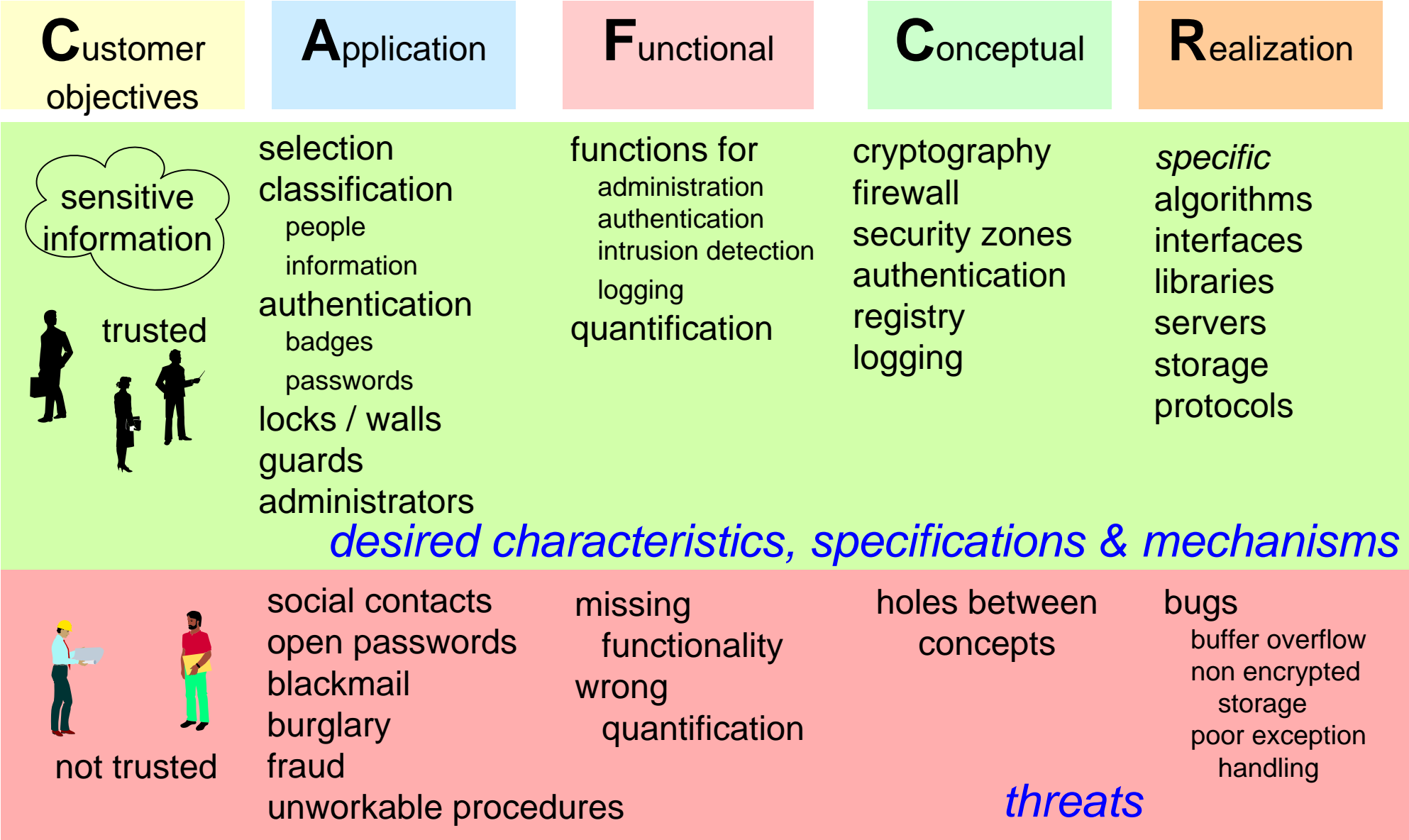
Example of a small buying organization



CAFCR+ model; Life Cycle View



Security as example through all views



Story How To

by *Gerrit Muller* University of South-Eastern Norway-NISE

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`www.gaudisite.nl`

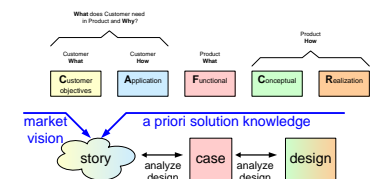
Abstract

A story is an easily accessible story or narrative to make an application live. A good story is highly specific and articulated entirely in the problem domain: the native world of the users. An important function of a story is to enable specific (*quantified, relevant, explicit*) discussions.

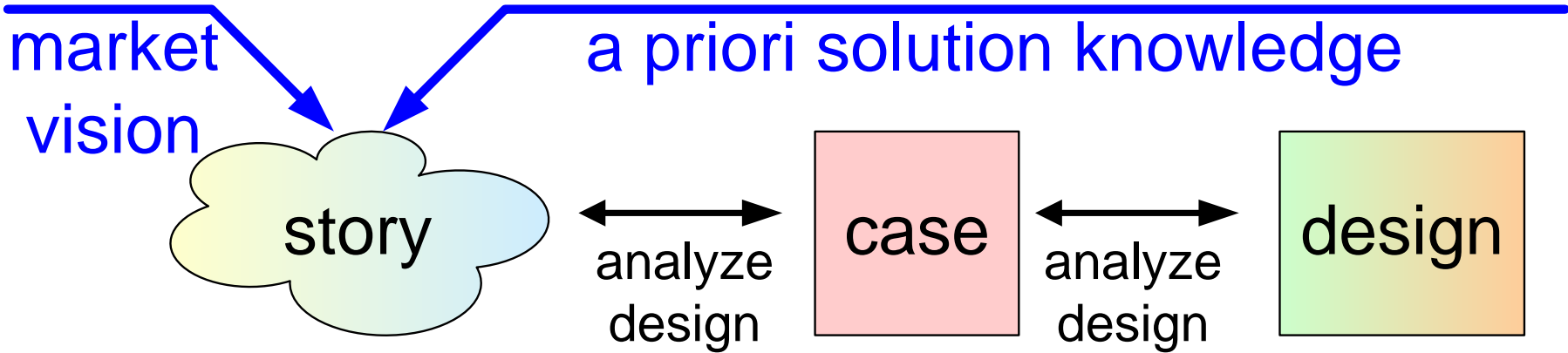
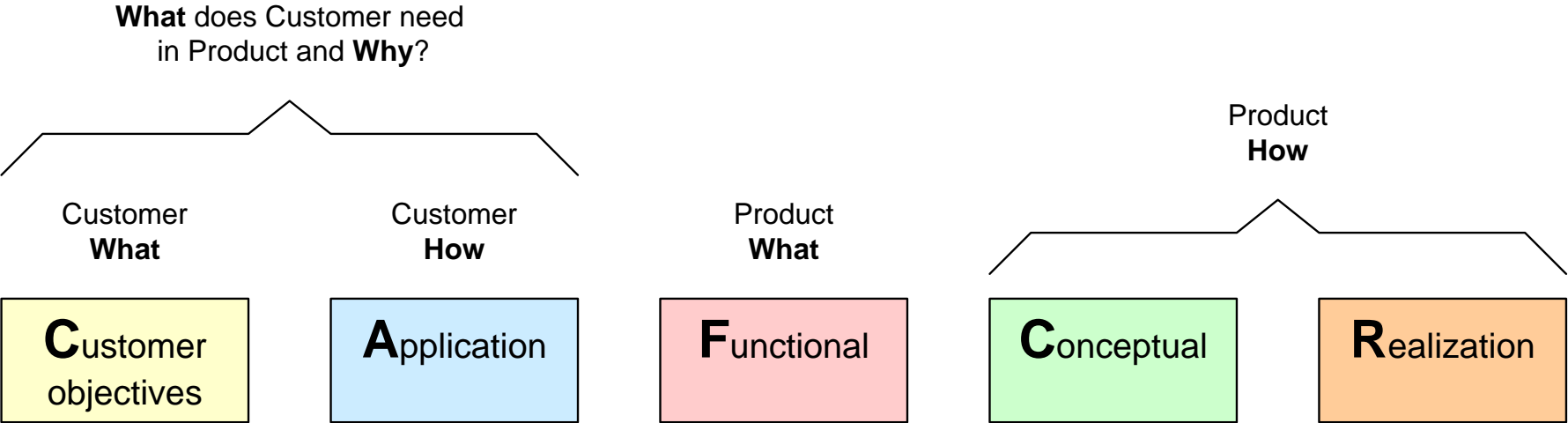
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version: 1.2



From story to design



Example story layout

ca. half a page of plain English text

A day in the life of Bob

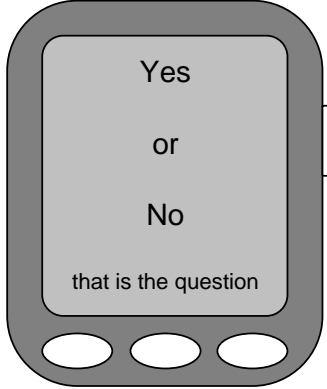
bla blah bla, rabarber music
bla bla composer bla bla
qwwwety30 zepts.

nja nja njet njippie est quo
vadis? Pjotr jaleski bla bla
bla brree fgfg gsg hgrg

mjmm bas engel heeft een
interessant excuus, lex stelt
voor om vanavond door te
werken.

In the middle of the night he
is awake and decides to
change the world forever.

The next hour the great
event takes place:



This brilliant invention will change the world foreverbecause it is so unique and
valuable that nobody beliefs the feasibility. It is great and WOW at the same time,
highly exciting.

Vtables are seen as the soltution for an indirection problem. The invention of Bob will
obsolete all of this in one incredibke move, which will make him famous forever.

He opens his PDA, logs in and enters his provate secure unquie non trivial password,
followed by a thorough authentication. The PDA asks for the fingerprint of this little left
toe and to pronounce the word shit. After passing this test Bob can continue.

draft or sketch of
some essential
appliance

Criteria for a good story

Customer objectives
Application

- accessible, understandable

"Do you see it in front of you?"

Customer objectives
Application

- valuable, appealing

attractive, important

"Are customers queuing up for this?"

Conceptual
Realization

- critical, challenging

"What is difficult in the realization?"

"What do you learn w.r.t. the design?"

Application

- frequent, no exceptional niche

"Does it add significantly to the bottom line?"

Application
Functional

- specific

names, ages, amounts, durations, titles, ...

Example of a story

Betty is a 70-year-old woman who lives in Eindhoven. Three years ago her husband passed away and since then she lives in a home for the elderly. Her 2 children, Angela and Robert, come and visit her every weekend, often with Betty's grandchildren Ashley and Christopher. As so many women of her age, Betty is reluctant to touch anything that has a technical appearance. She knows how to operate her television, but a VCR or even a DVD player is way to complex.

When Betty turned 60, she stopped working in a sewing studio. Her work in this noisy environment made her hard-of-hearing with a hearing-loss of 70dB around 2kHz. The rest of the frequency spectrum shows a loss of about 45dB. This is why she had problems understanding her grandchildren and why her children urged her to apply for hearing aids two years ago. Her technophobia (and her first hints of arthritis) inhibit her to change her hearing aids' batteries. Fortunately her children can do this every weekend.

This Wednesday Betty visits the weekly Bingo afternoon in the meetingplace of the old-folk's home. It's summer now and the tables are outside. With all those people there it's a lot of chatter and babble. Two years ago Betty would never go to the bingo: "I cannot hear a thing when everyone babbles and clatters with the coffee cups. How can I hear the winning numbers?!". Now that she has her new digital hearing instruments, even in the bingo cacophony, she can understand everyone she looks at. Her social life has improved a lot and she even won the bingo a few times.

That same night, together with her friend Janet, she attends Mozart's opera The Magic Flute. Two years earlier this would have been one big low rumbly mess, but now she even hears the sparkling high piccolos. Her other friend Carol never joins their visits to the theaters. Carol also has hearing aids, however hers only "work well" in normal conversations. "When I hear music it's as if a butcher's knife cuts through my head. It's way too sharp!". So Carol prefers to take her hearing aids out, missing most of the fun. Betty is so happy that her hearing instruments simply know where they are and adapt to their environment.



source: Roland Mathijssen
Embedded Systems Institute
Eindhoven

Value and Challenges in this story

Customer objectives

Application

Value proposition in this story:

quality of life:

active participation in different social settings

usability for nontechnical elderly people:

"intelligent" system is simple to use

loading of batteries

Conceptual

Realization

Challenges in this story:

Intelligent hearing instrument

Battery life — at least 1 week

No buttons or other fancy user interface on the hearing instrument, other than a robust On/Off method

The user does not want a technical device but a solution for a problem

Instrument can be adapted to the hearing loss of the user

Directional sensitivity (to prevent the so-called cocktail party effect)

Recognition of sound environments and automatic adaptation (adaptive filtering)

source: Roland Mathijssen, Embedded Systems Institute, Eindhoven