Why Quantified Insight in System Design is Required.

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Abstract

Software education is mostly function-oriented. Techniques and formalisms are focused on system *behavior*. Software architects often don't have a quantified insight in problem domain or choosen solutions, although computers work internally with bits and bytes. This is a problem for IT systems in general, but is more so for embedded systems. Embedded systems interact with the physical world, which can be modeled quantitatively: energy consumption, speed, force, et cetera. This presentation addresses quantification of system and software design, illustrated by case examples.

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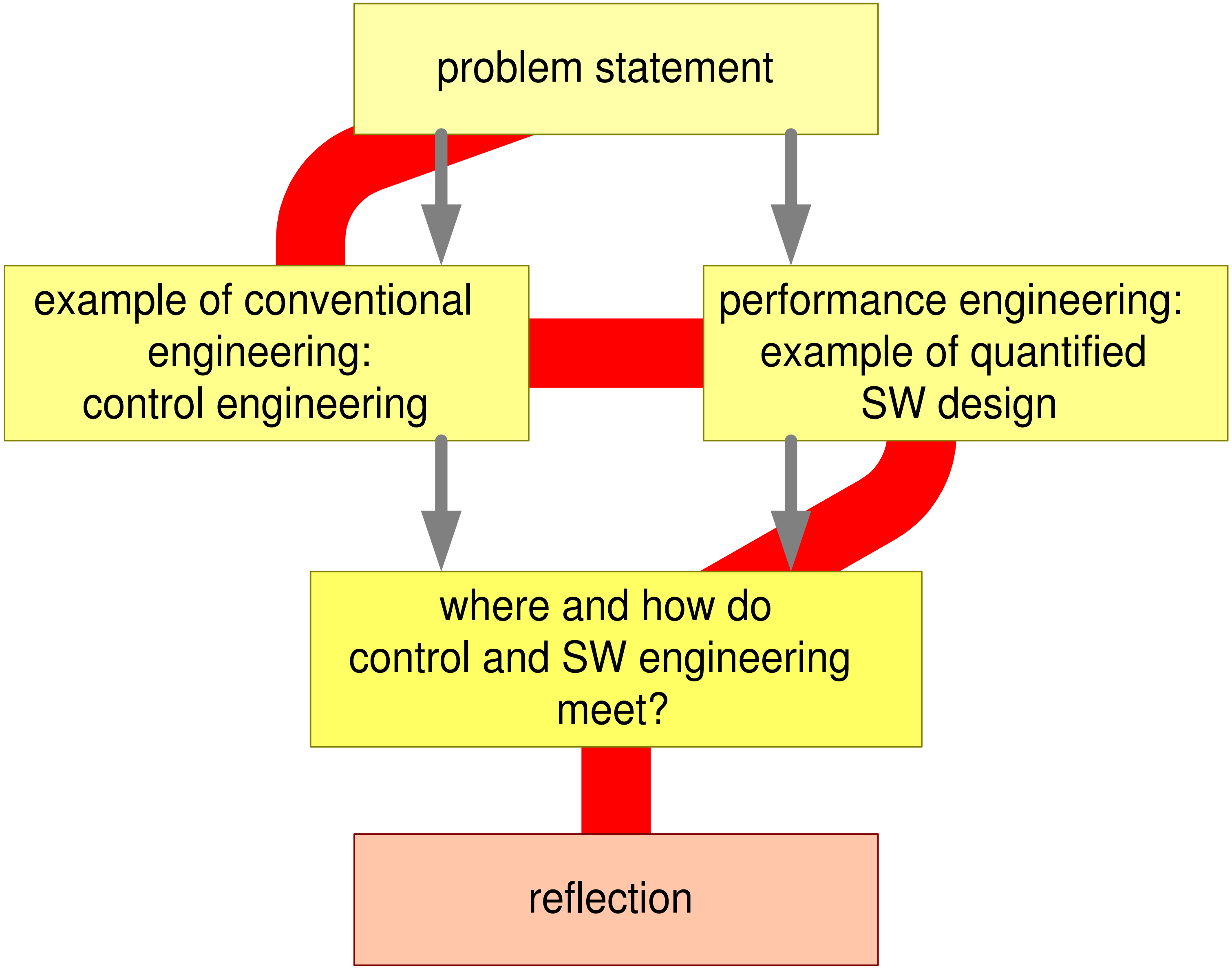
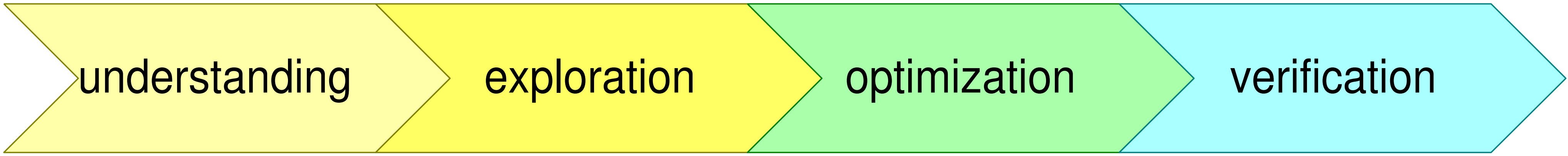
LANDELIJK architectuur congres ARCHITECTUUR VOOR DE WENDBARE ORGANISATIE

Figure Of Contents™



Purpose of Quantification



Challenge

Ask a SW-architect to *quantify* the product under construction.

What happens?

?

Challenge; Answer to the Question

Ask a SW-architect to *quantify*
the product under construction.

What happens?

The *project* is quantified, rather than
the *system* of interest

man-years *code-complexity*
lines-of-code *fault density*
problem reports *release schedule*

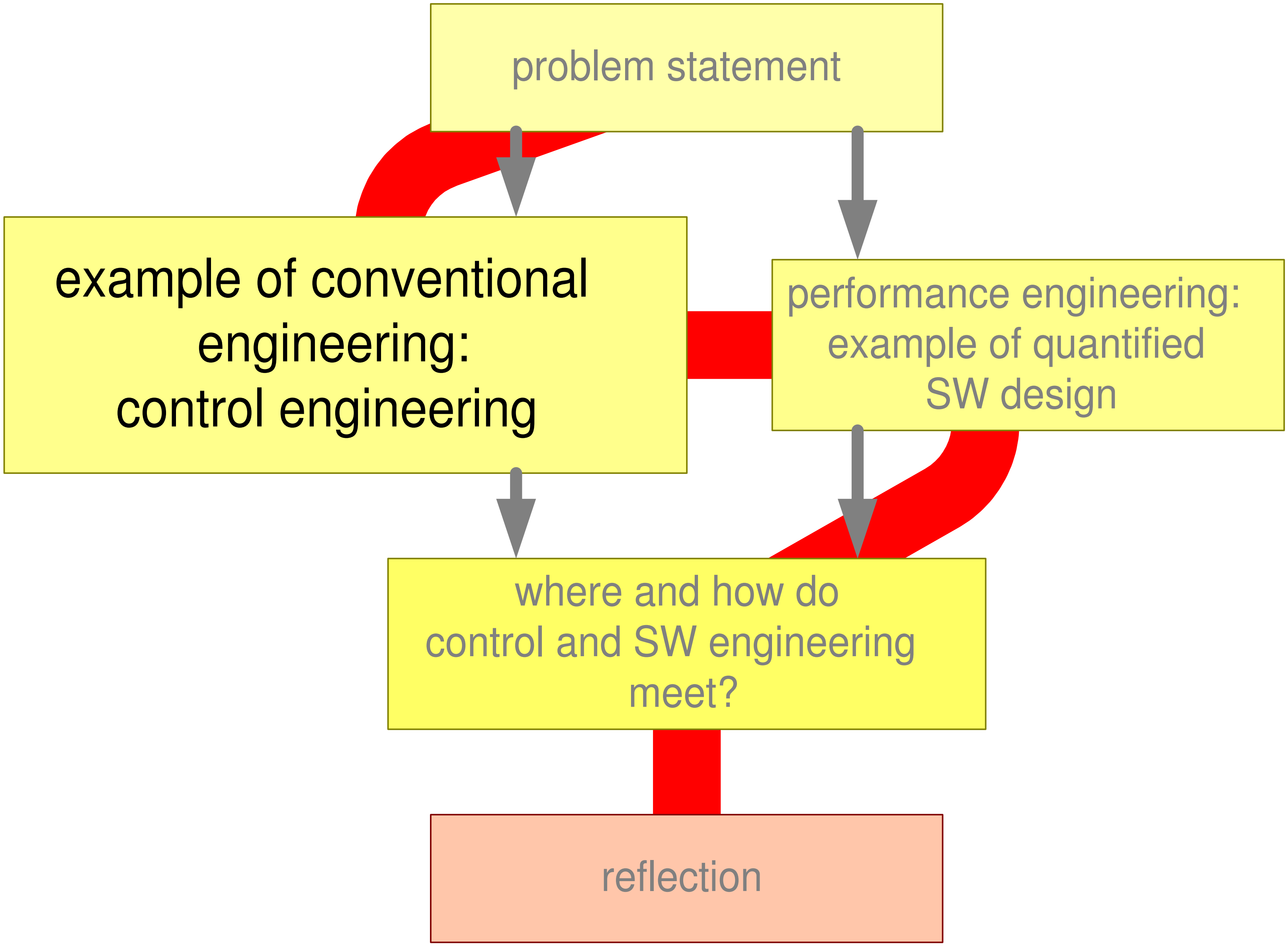
Problem Statement

The SW engineering discipline today is *process* oriented, quantities are process metrics.

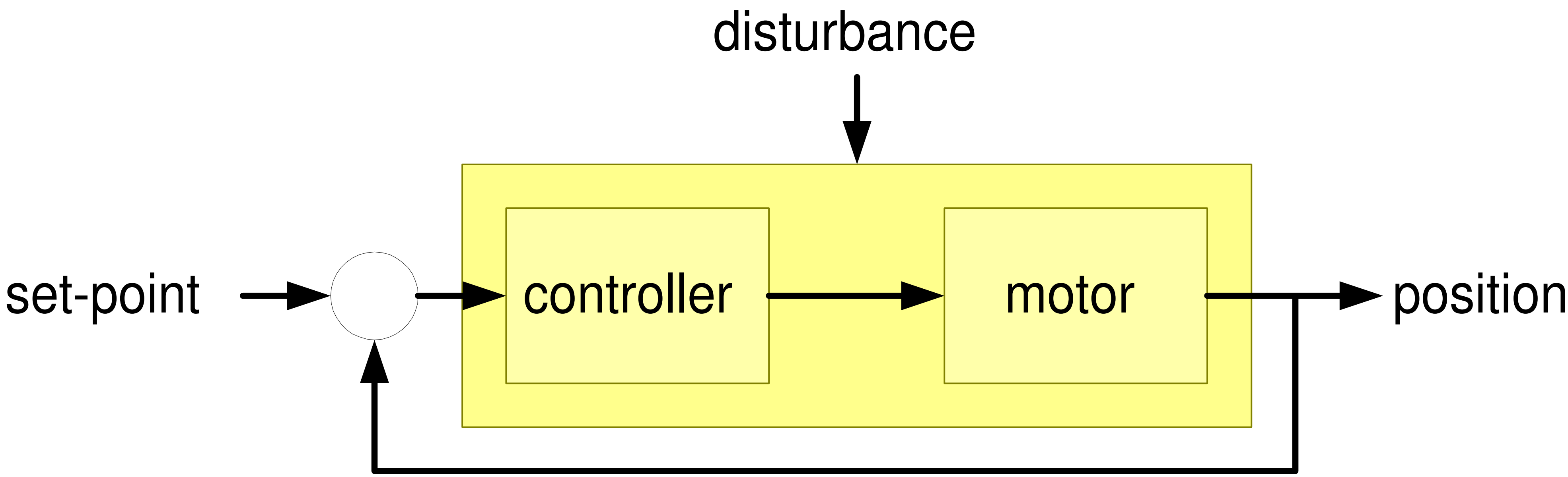
The System Of Interest (SOI) is designed from *behavioral* point of view.

Conventional Engineering disciplines design the SOI with *quantitative* techniques.

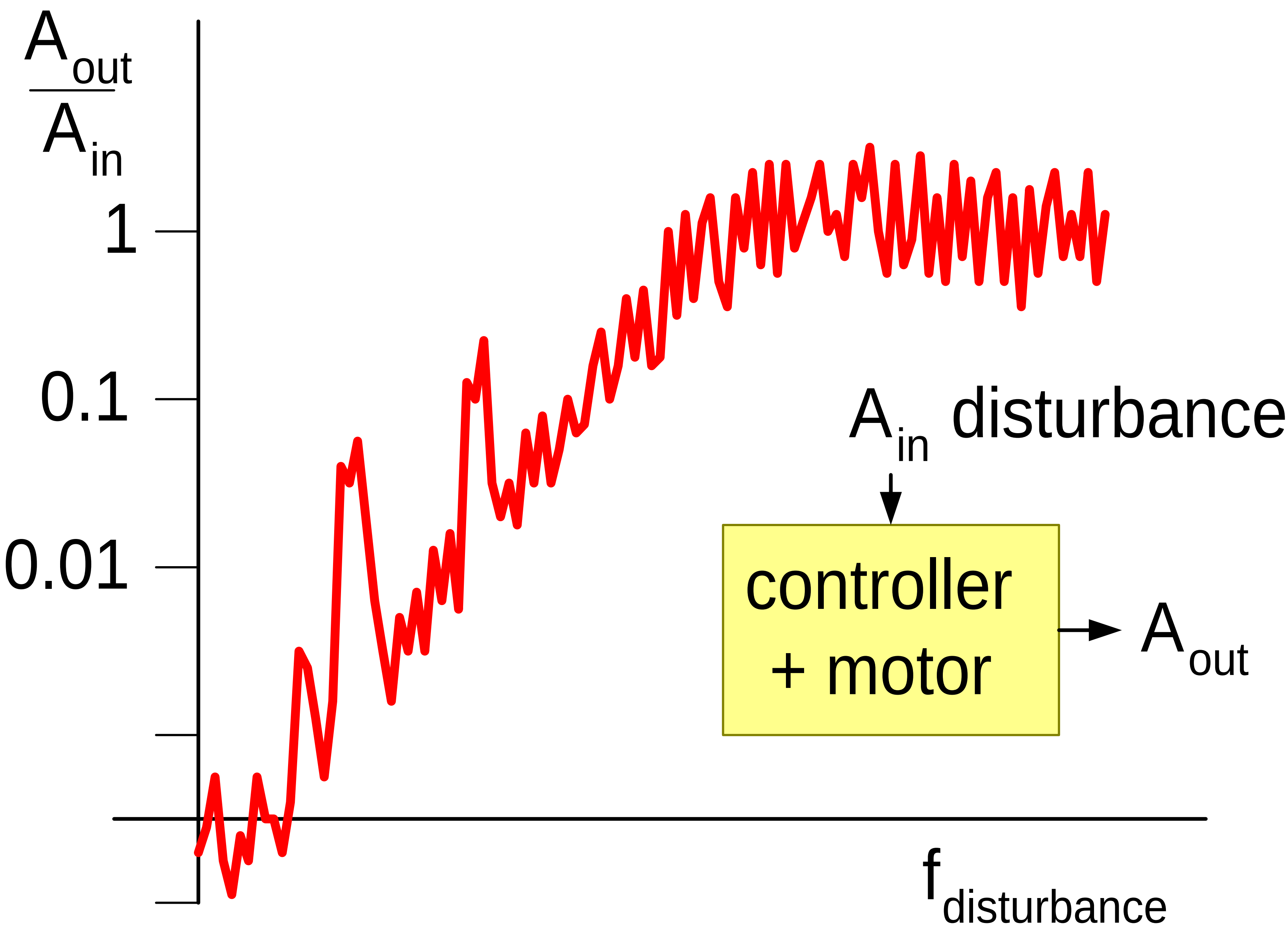
Qualities of SW intensive systems, such as performance, are *emerging* i.s.o. *predictable* properties


problem statement
example of conventional engineering: control engineering
performance engineering: example of quantified SW design
where and how do control and SW engineering meet?
reflection

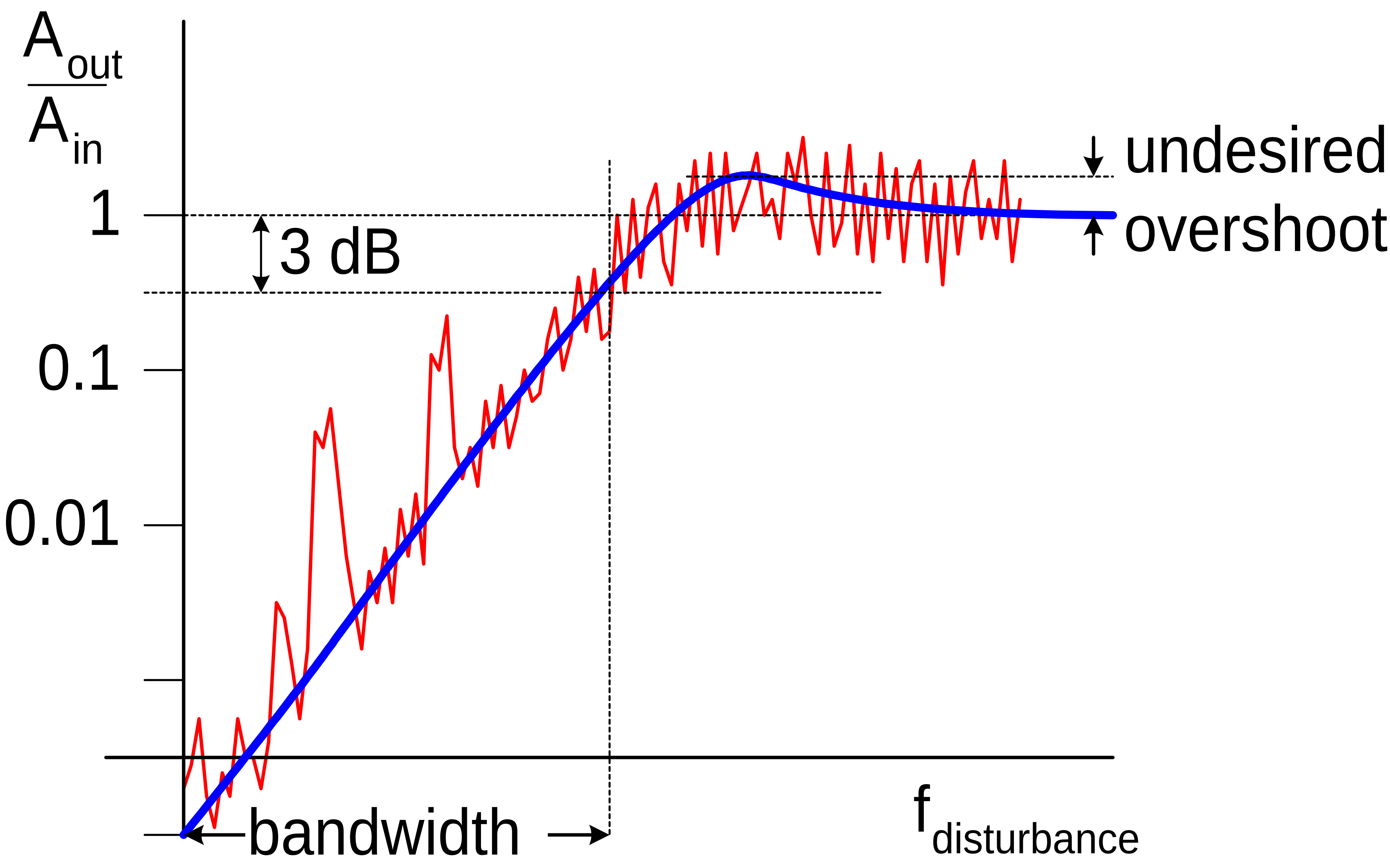
Block Diagram Control Measurement



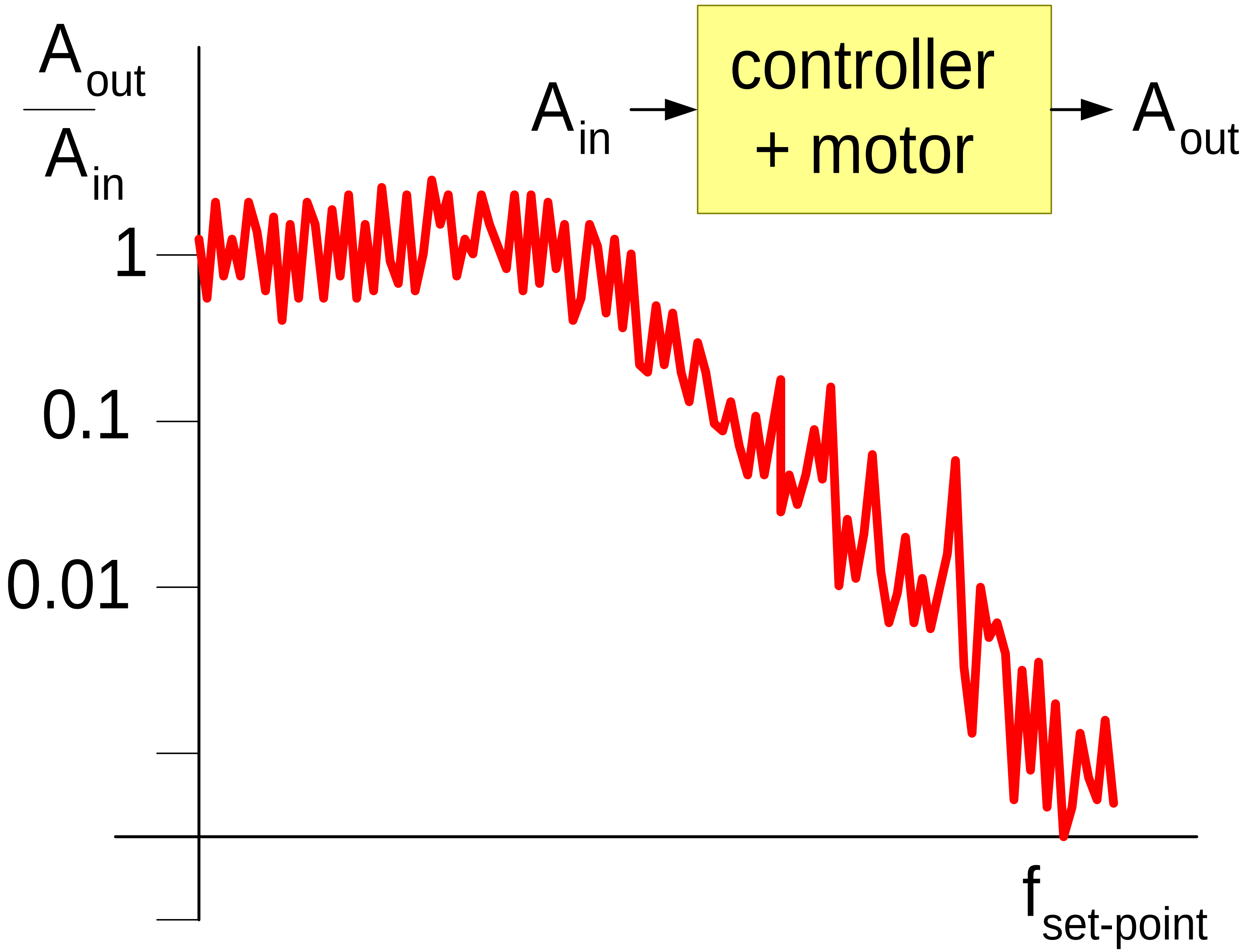
Measuring Disturbance Transfer



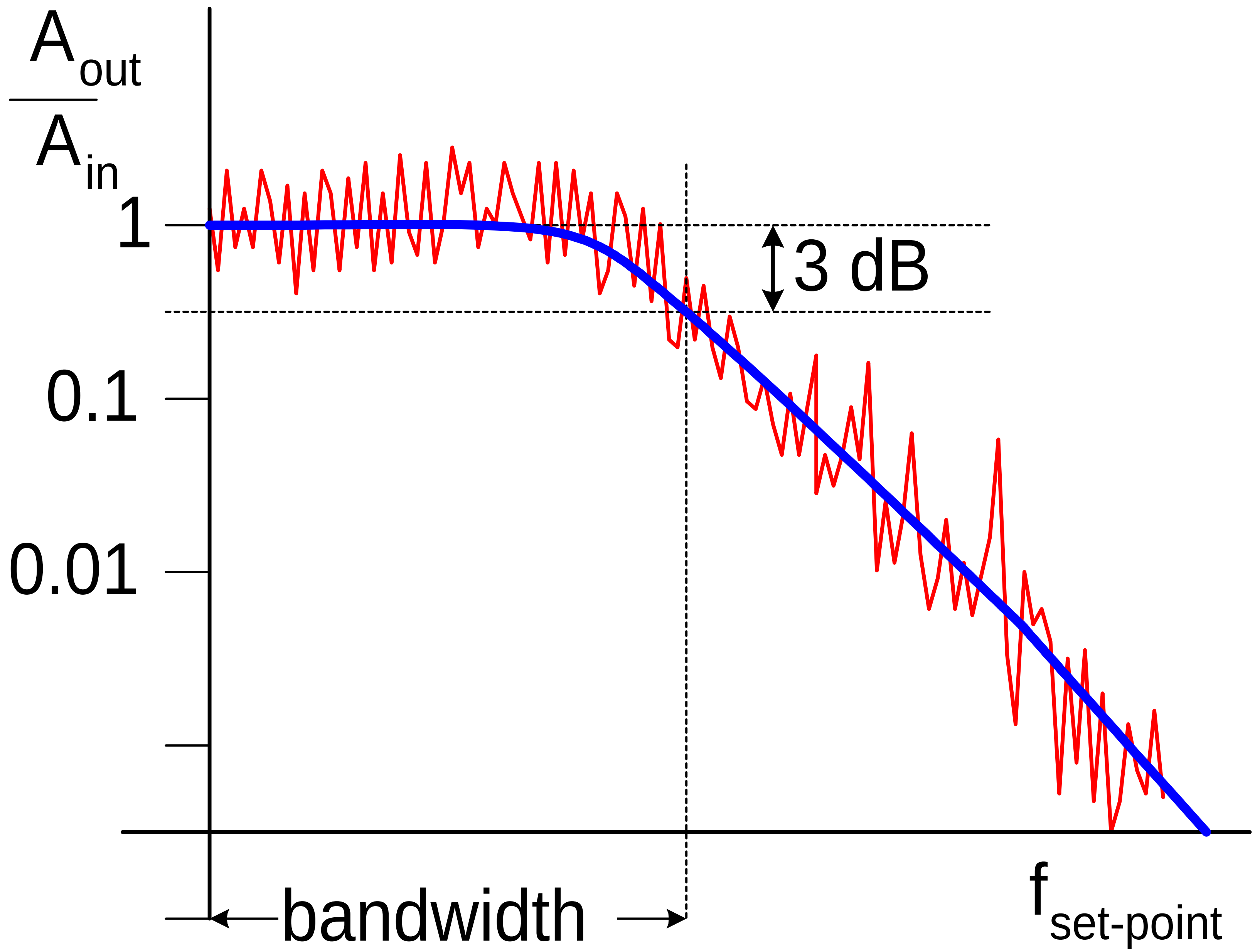
Idealized Disturbance Transfer



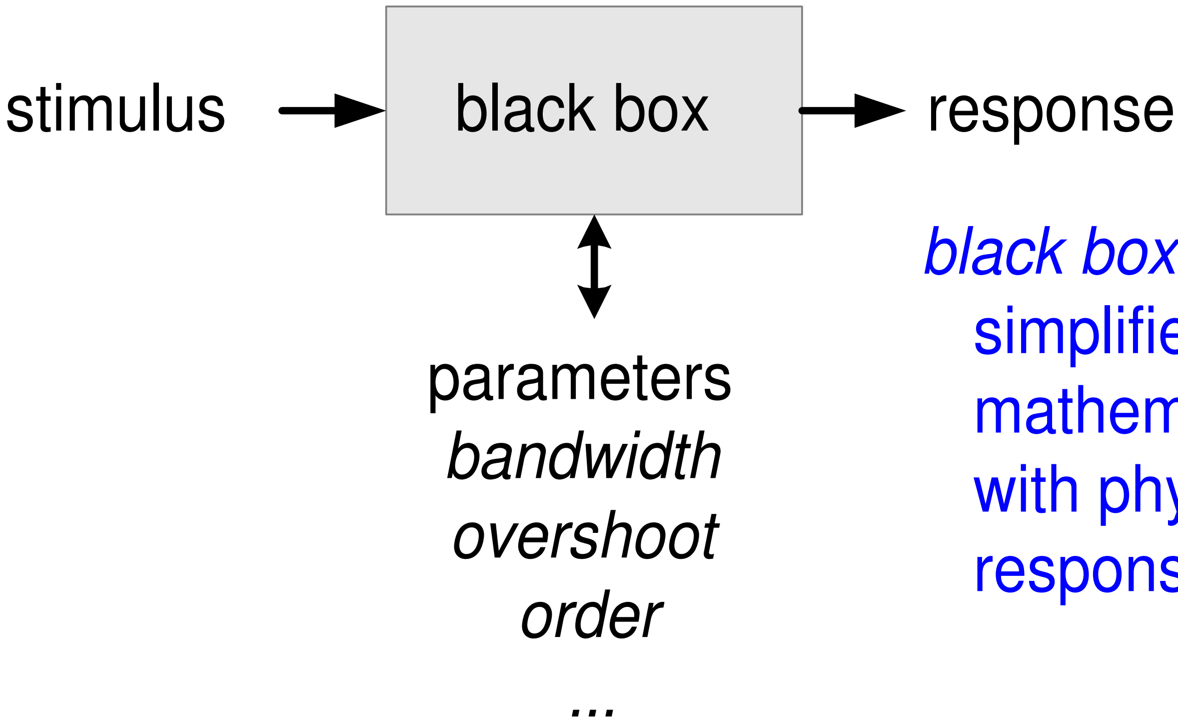
Measuring Tracking Response



Idealized Tracking Responce



Black Box Model



black box :

simplified model

mathematical formula

with physical interpretation:

response = f(stimulus, parameters)

White Box Model

stimulus → *white box* → response

friction
hysteresis
interference
...

↕

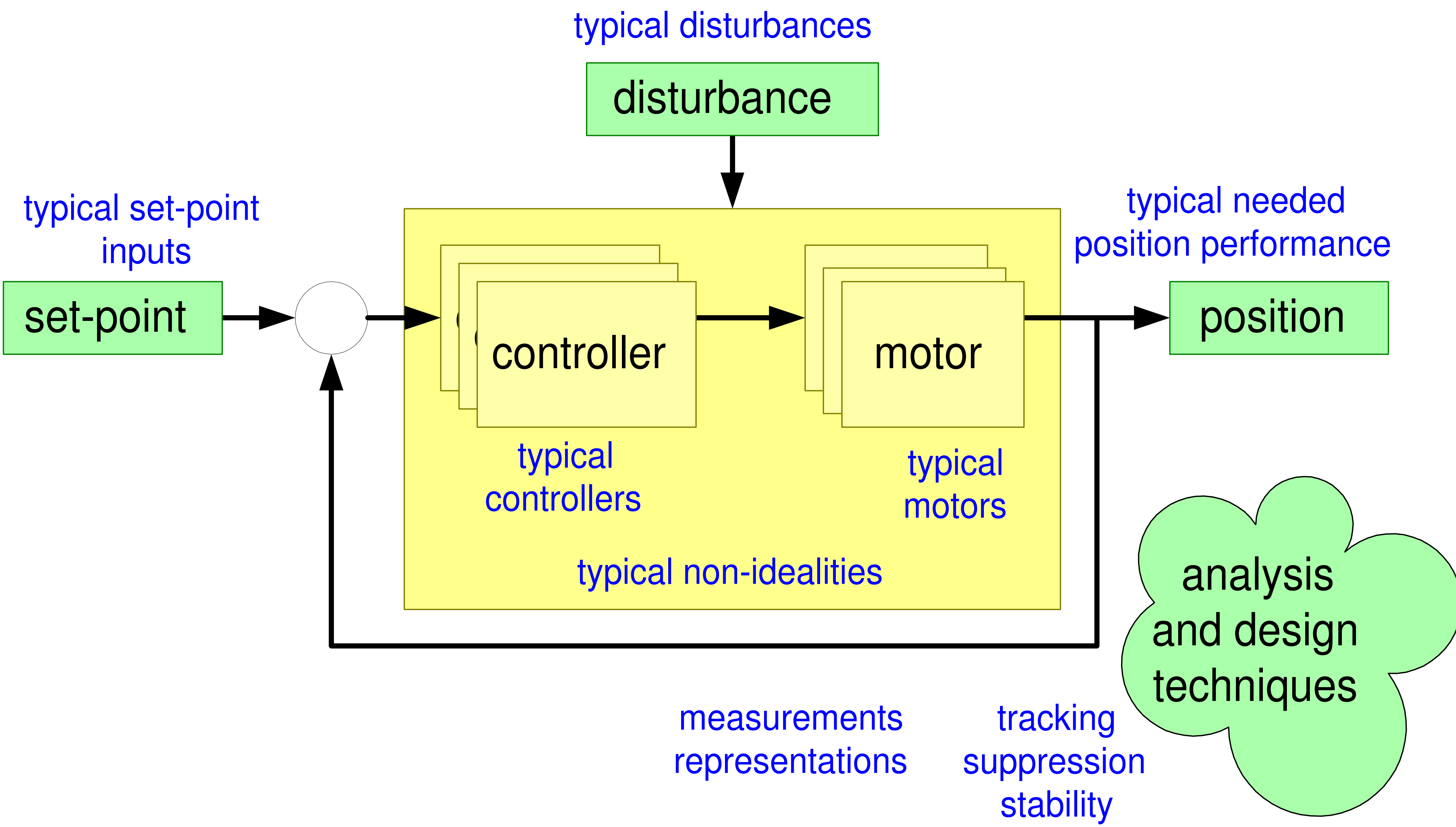
parameters
bandwidth
overshoot
order
...

white box :

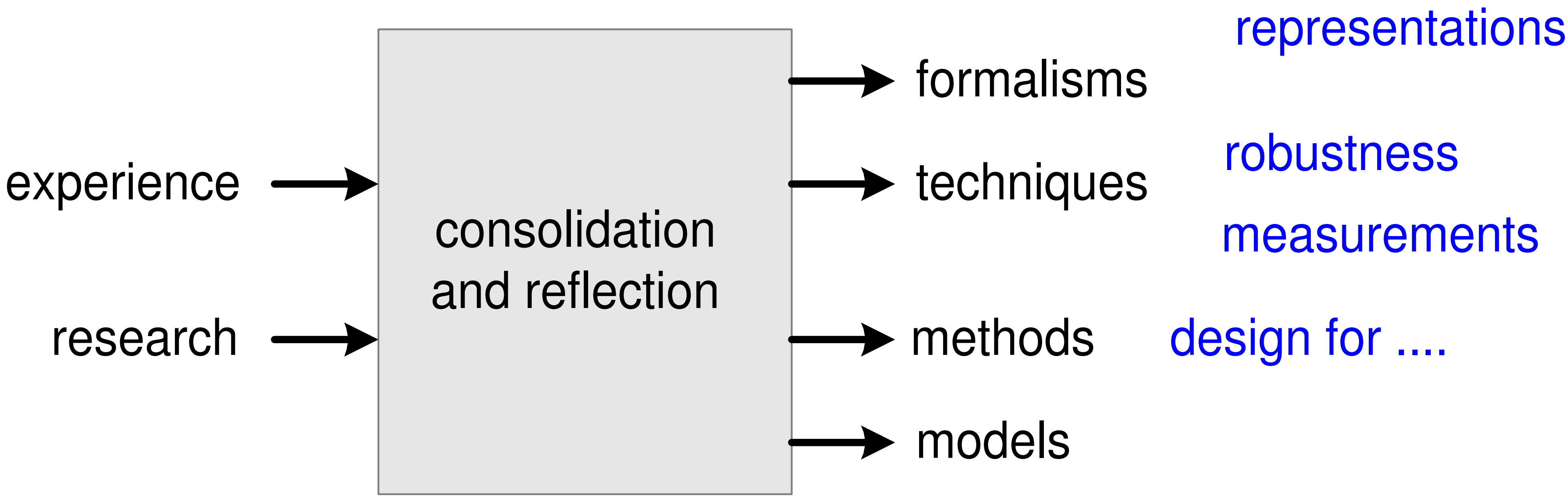
black box model plus
experience based reasoning
over non-idealities
response = f(stimulus, parameters,
some parametrized non-idealities)

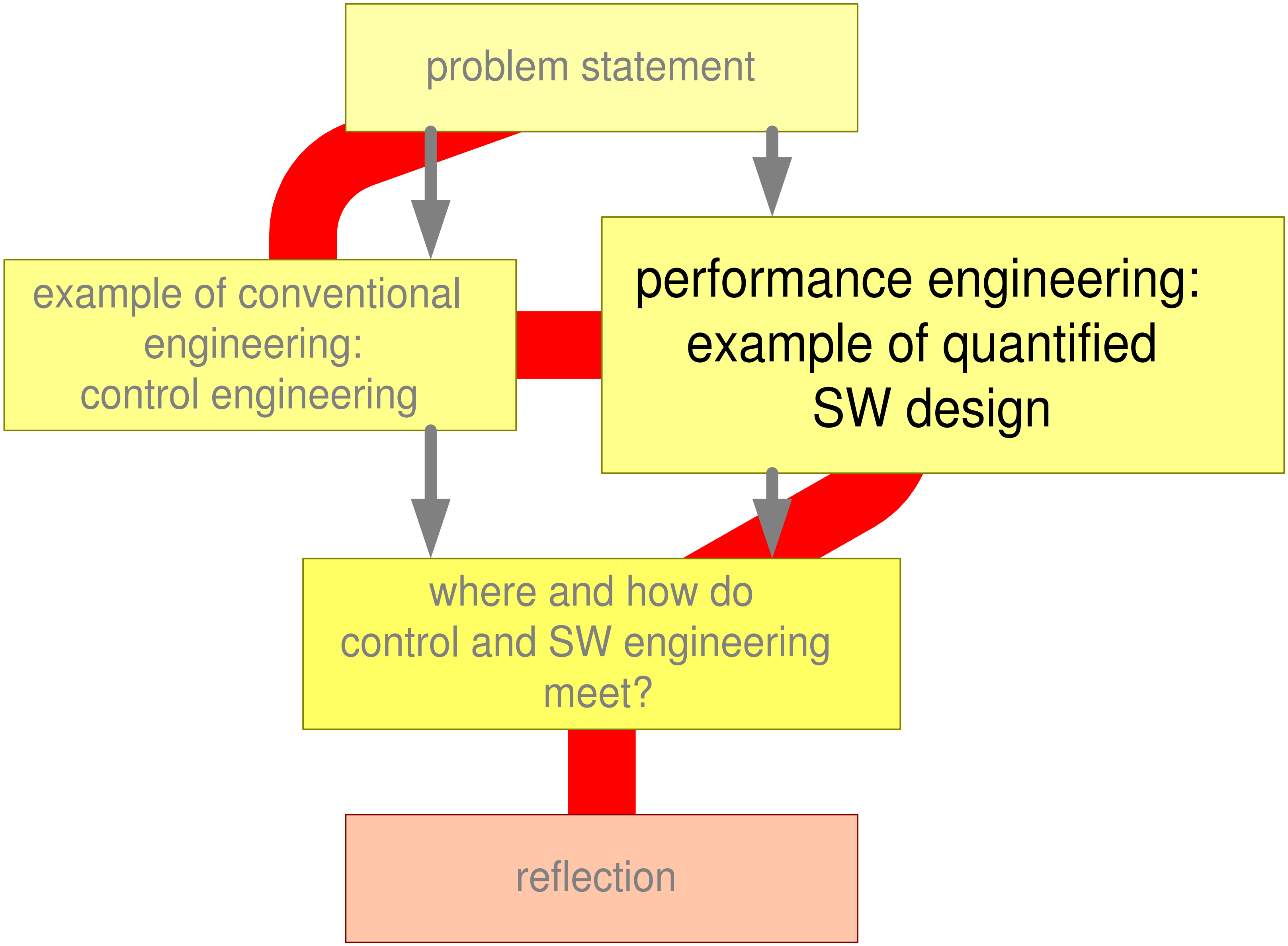
challenge: to know what non-idealities to ignore
and to ignore as much as possible

Control Engineering Knowledge



Summary of Control Engineering

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What is the Performance of this Code?

application need:

at event 3*3 show 3*3 images instanteneous

design

design

Sample application code:

```
for x = 1 to 3 {
   for y = 1 to 3 {
        retrieve_image(x,y)
   }
}
```

or

alternative application code:

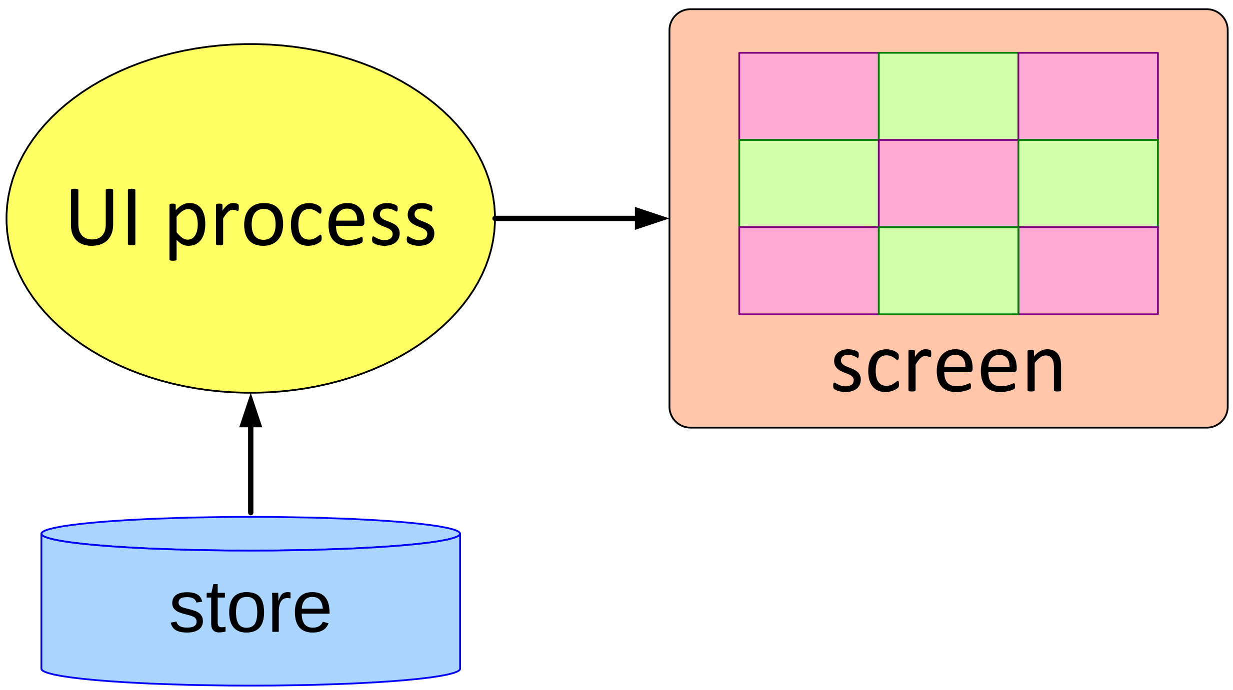
event 3*3 -> show screen 3*3

```
<screen 3*3>
    <row 1>
    <col 1><image 1,1></col 1>
    <col 2><image 1,2></col 2>
    <col 3><image 1,3></col 3>
  </row 1>
  <row 2>
    <col 1><image 1,1></col 1>
    <col 2><image 1,2></col 2>
    <col 3><image 1,3></col 3>
  </row 1>
  <row 2>
    <col 1><image 1,1></col 1>
    <col 2><image 1,2></col 2>
    <col 3><image 1,3></col 3>
  </row 3>
</screen 3*3>
```

What If....

Sample application code:

```
for x = 1 to 3 {
  for y = 1 to 3 {
        retrieve_image(x,y)
  }
}
```



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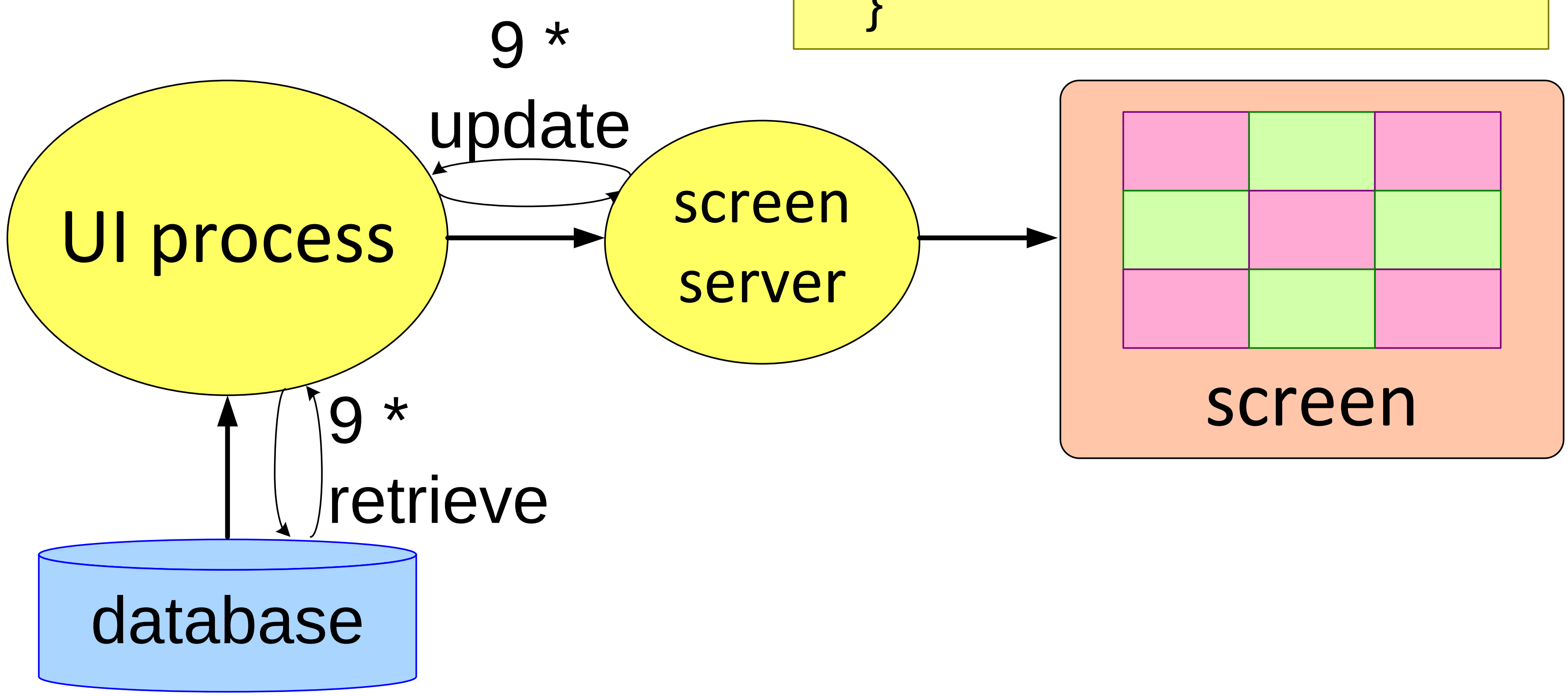
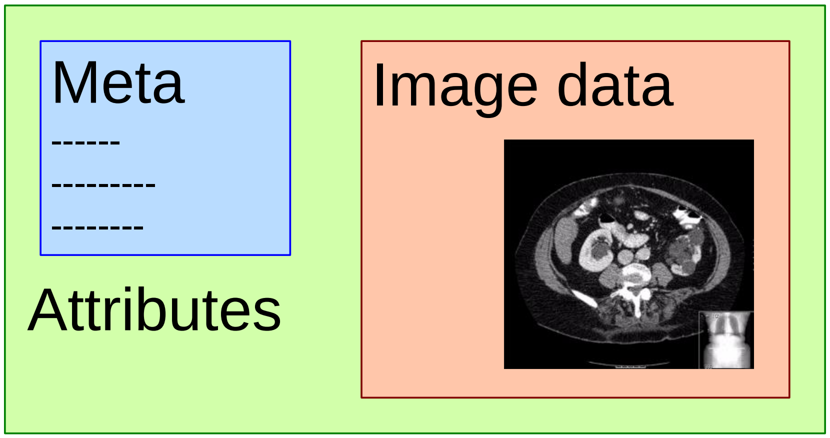


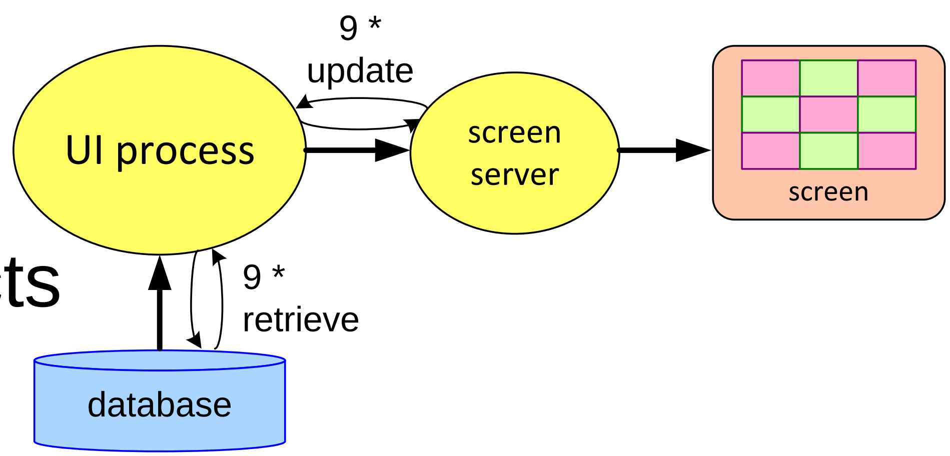
What If....



Sample application code:

```
for x = 1 to 3 {
  for y = 1 to 3 {
        retrieve_image(x,y)
  }
}
```

Attribute = 1 COM object
100 attributes / image
9 images = 900 COM objects
1 COM object = 80µs
9 images = 72 ms



What If....

Sample application code:

```
for x = 1 to 3 {
  for y = 1 to 3 {
        retrieve_image(x,y)
  }
}
```

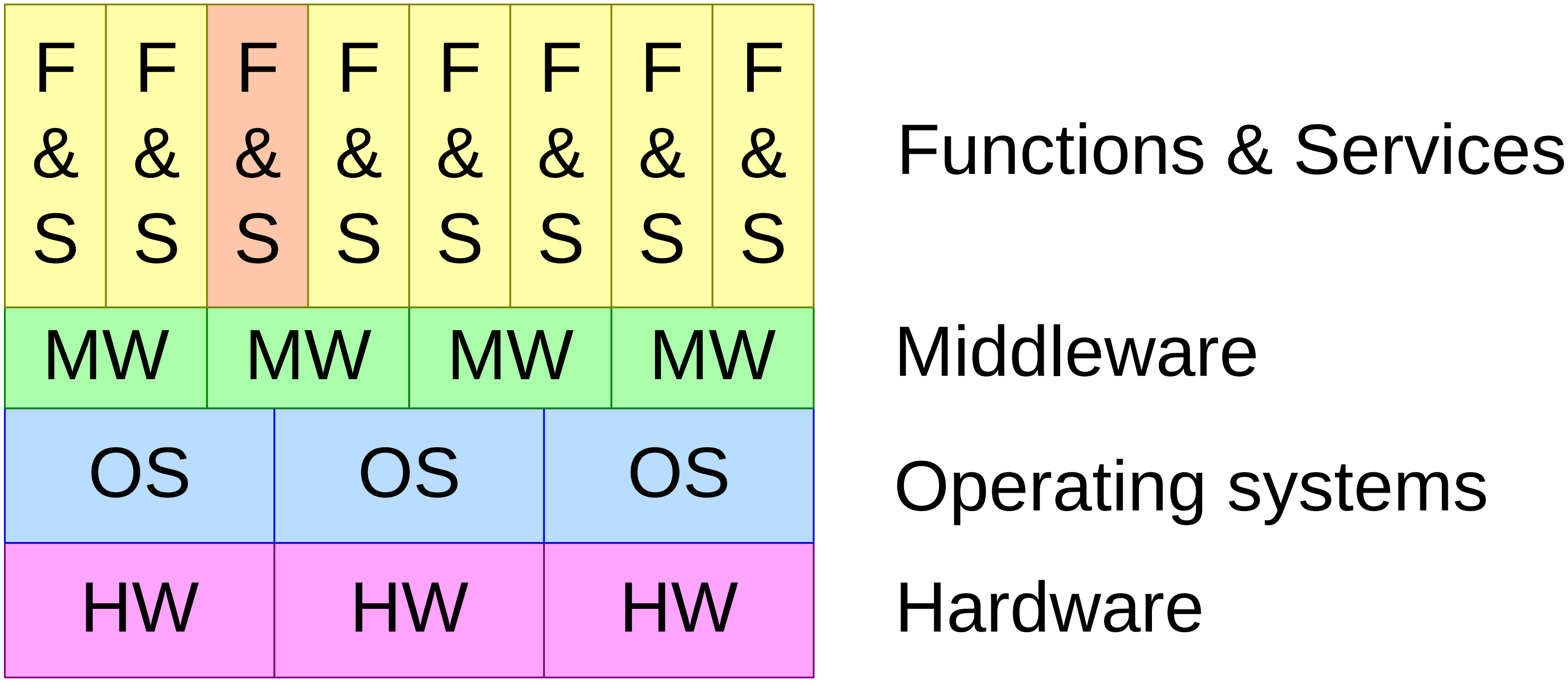
- I/O on line basis (512^2 image)

$9 * 512 * t_{I/O}$

$t_{I/O}$ ~= 1ms

- . . .

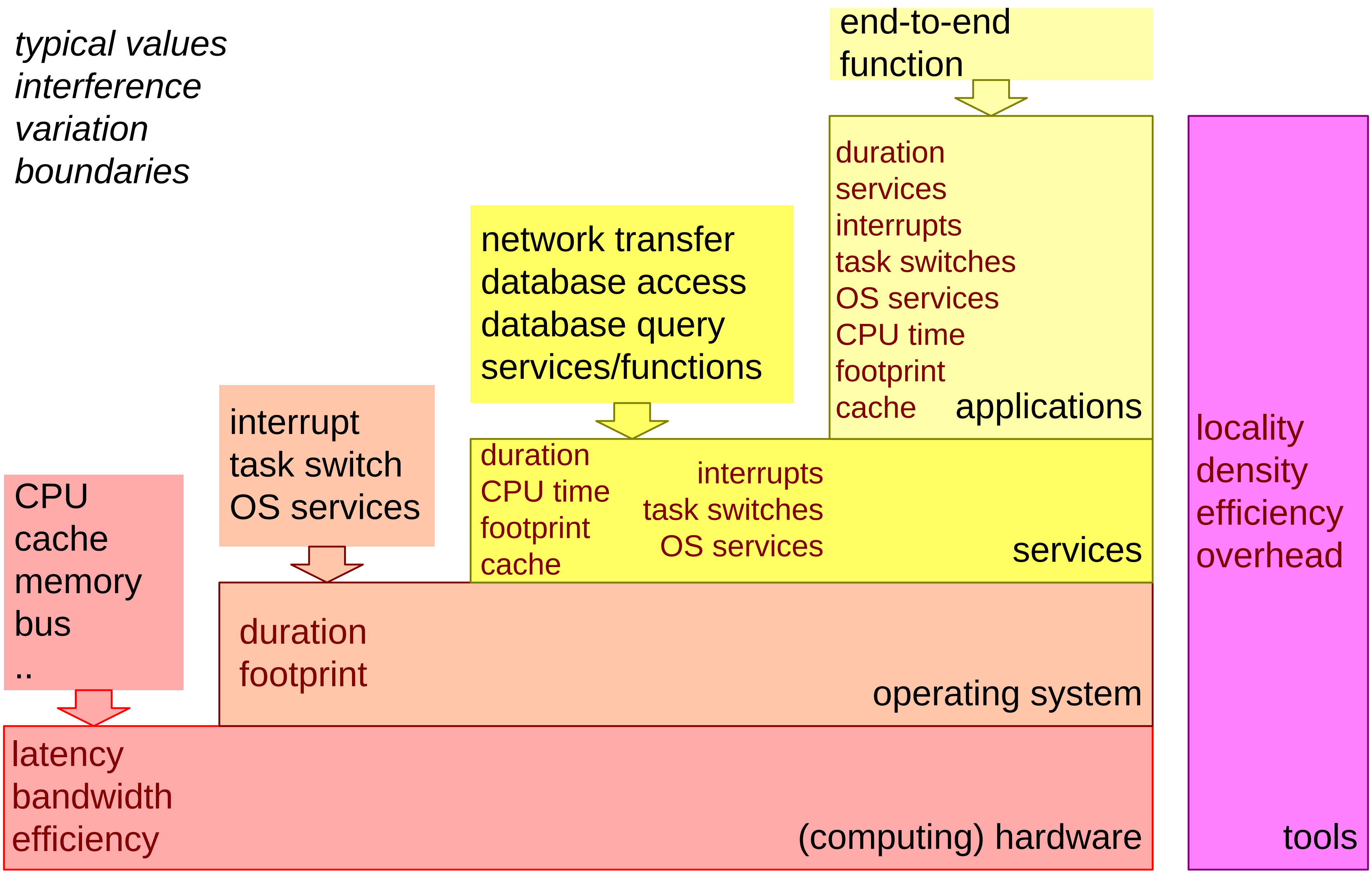
Challenge SW Performance Design



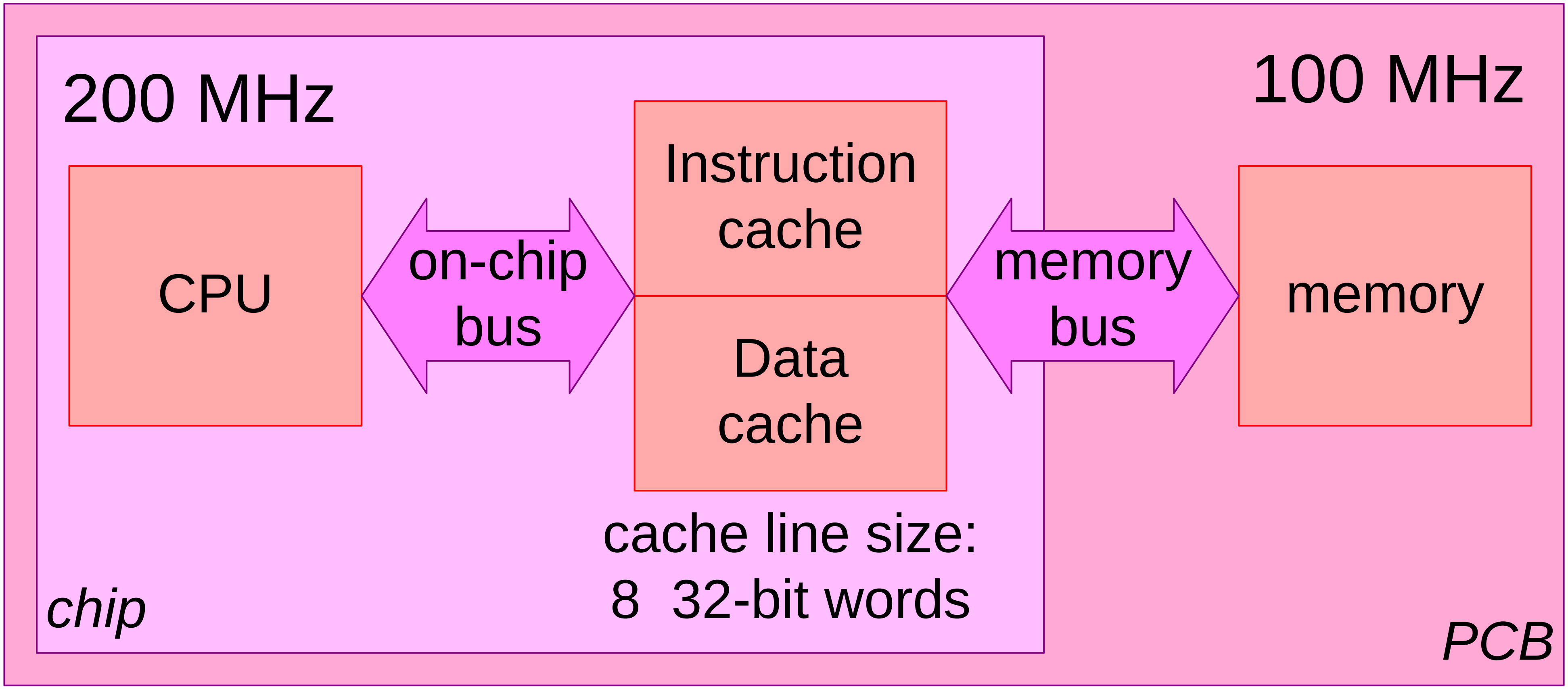
Performance = Function (F&S, other F&S, MW, OS, HW)
MW, OS, HW >> 100 Manyear : very complex

Challenge: How to understand MW, OS, HW
with only a few parameters

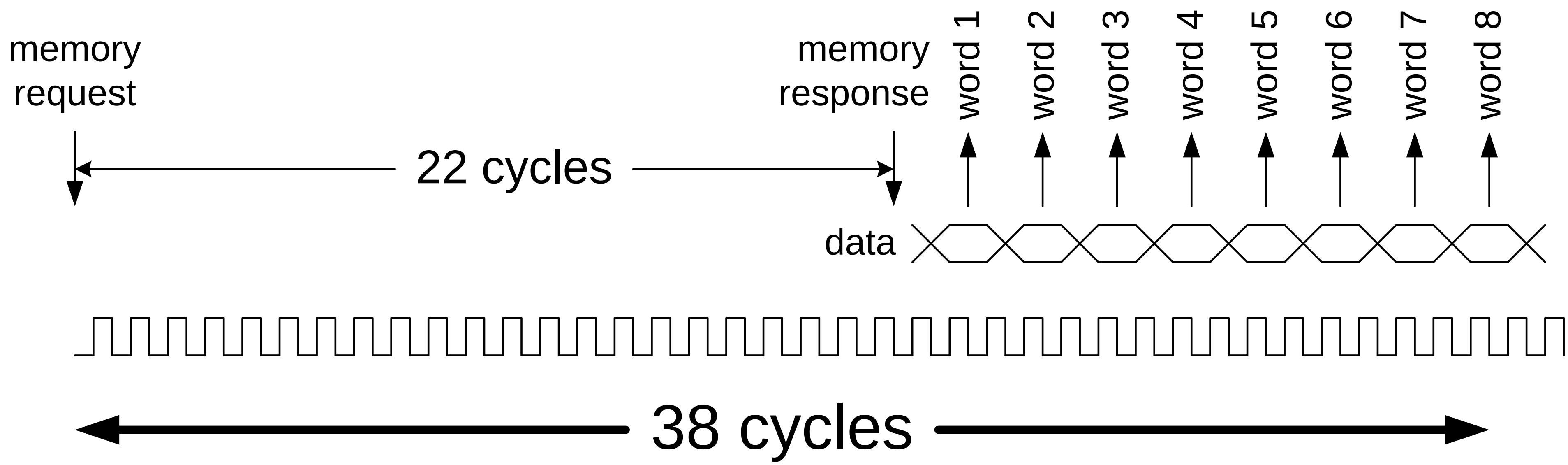
Layered Benchmarking



Case: ARM9 Cache Performance



Example Hardware Performance



memory access time in case of a cache miss
200 Mhz, 5 ns cycle: 190 ns

ARM9 200 MHz $t_{\text{context switch}}$ as function of cache use

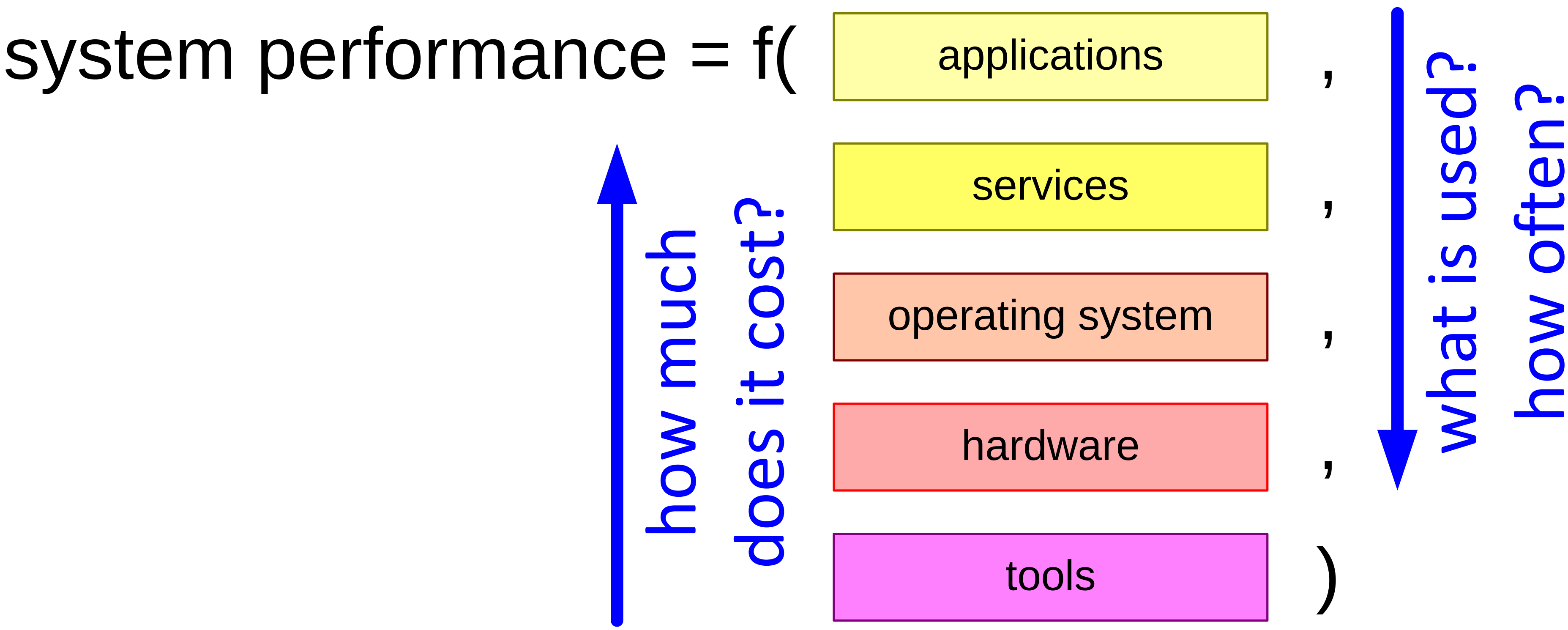
cache setting	$t_{\text{context switch}}$
From cache	2 µs
After cache flush	10 µs
Cache disabled	50 µs

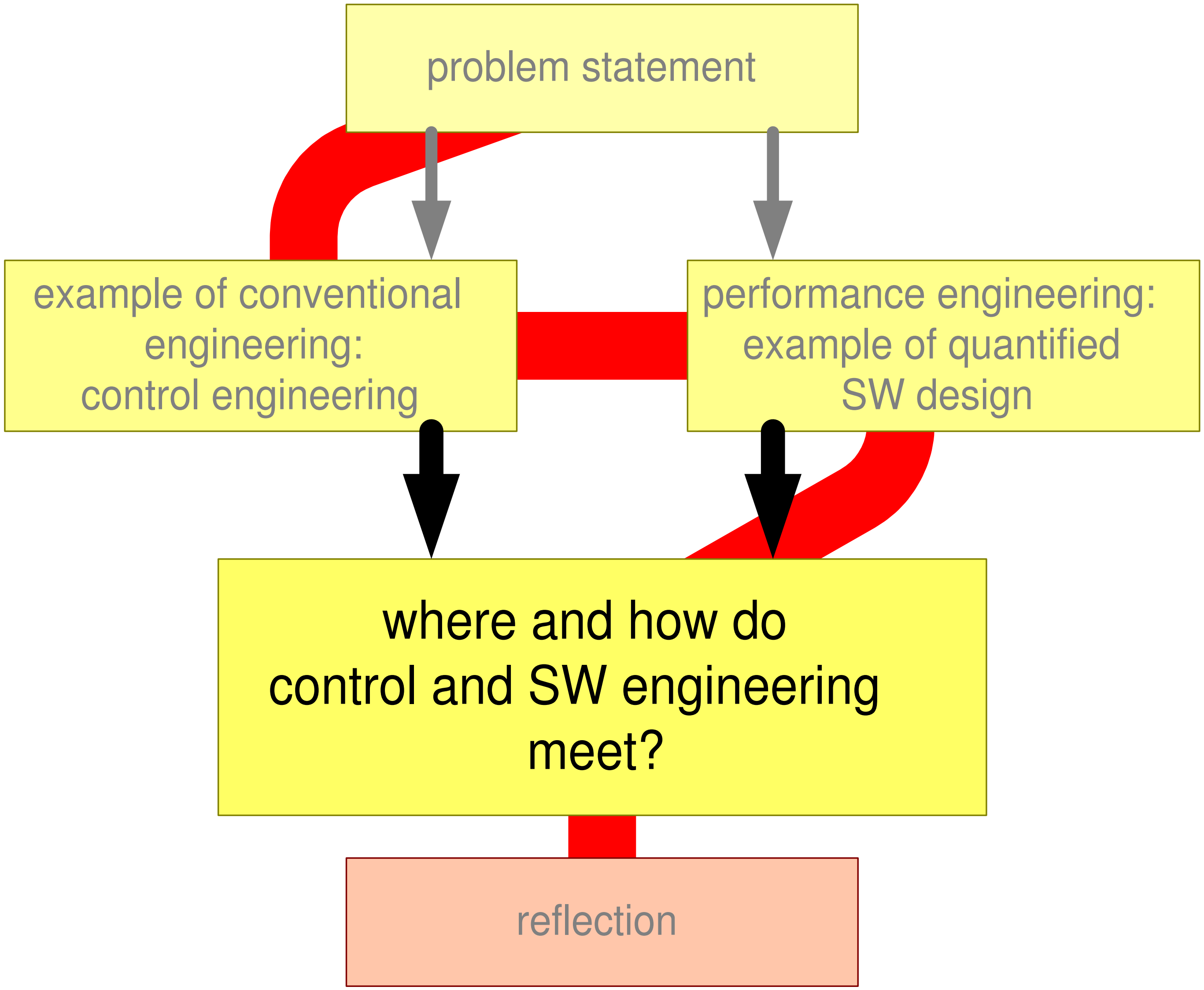
Context Switch Overhead

$$t_{overhead} = n_{context\ switch} * t_{context\ switch}$$

$n_{context\ switch}$ (s^{-1})	$t_{context\ switch}$ = 10µs		$t_{context\ switch}$ = 2µs	
	$t_{overhead}$	CPU load overhead	$t_{overhead}$	CPU load overhead
500	5ms	0.5%	1ms	0.1%
5000	50ms	5%	10ms	1%
50000	500ms	50%	100ms	10%

Performance as Function of all Layers

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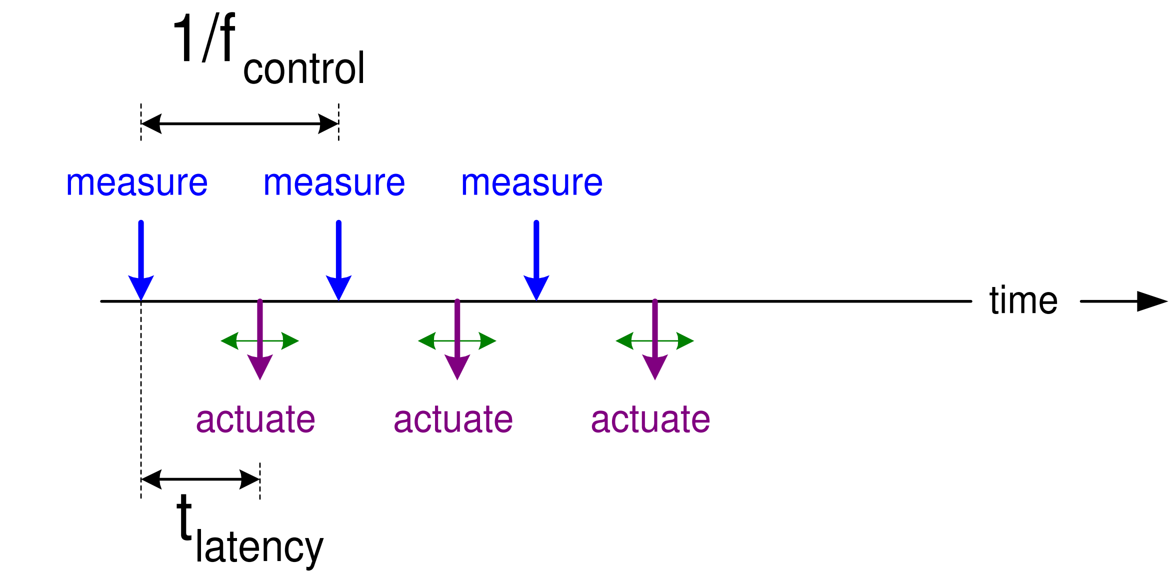
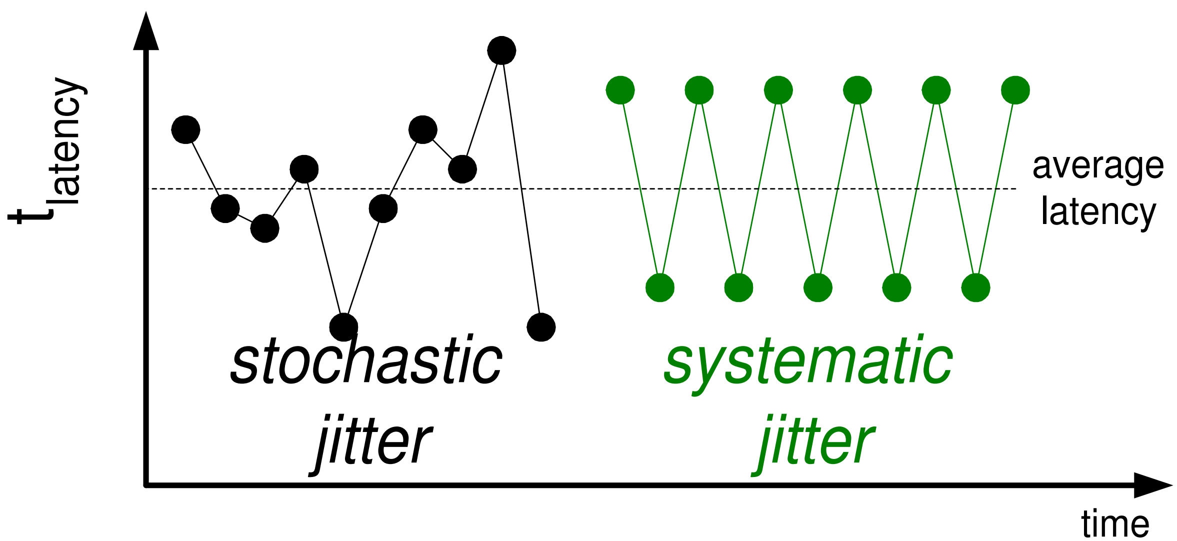
Impact of Timing on Control Performance



0^e order

$$Performance_{control} = f(\ f_{control}\ ,\ t_{latency}\ )$$

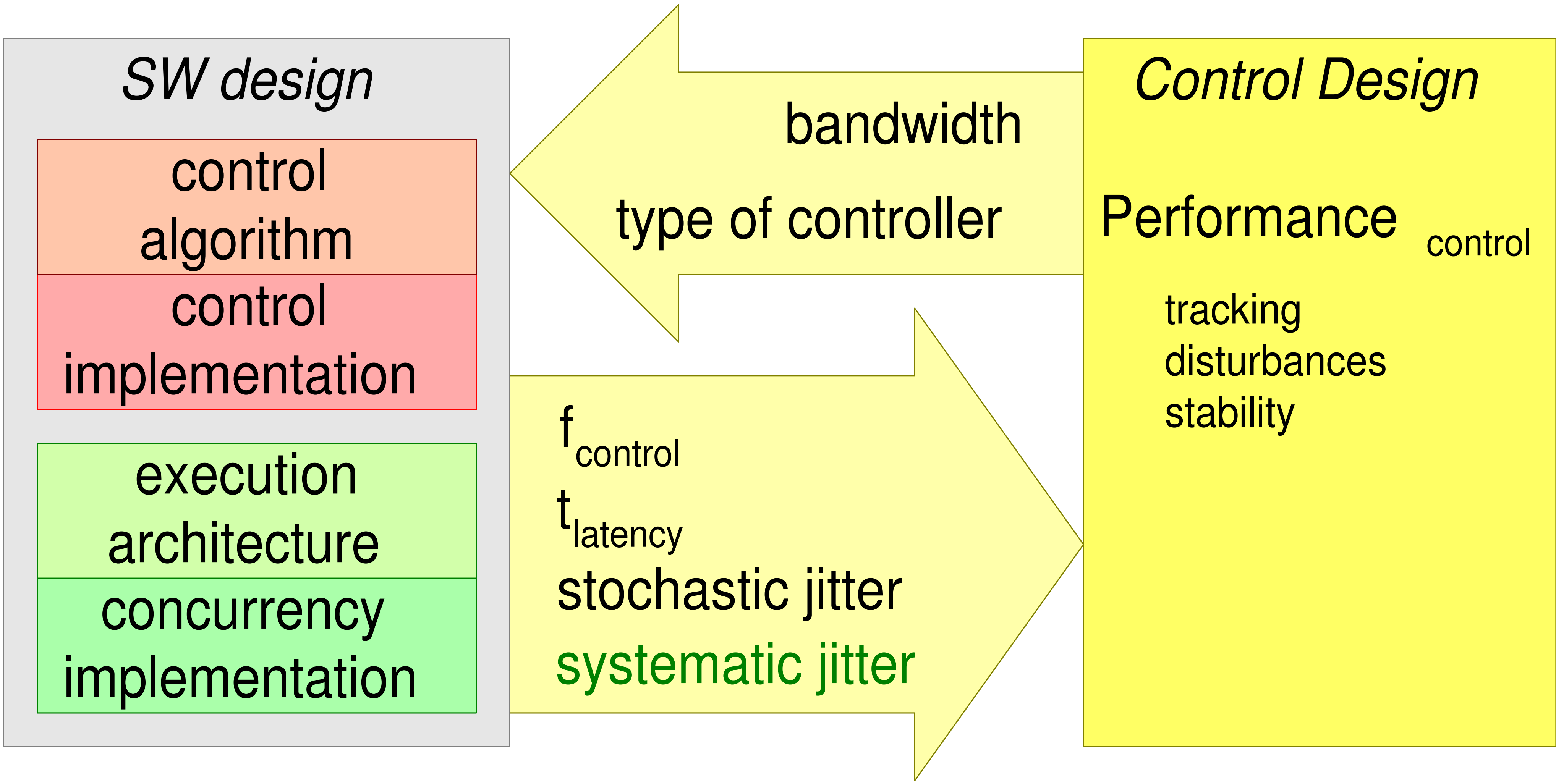


1e order

impact of jitter on

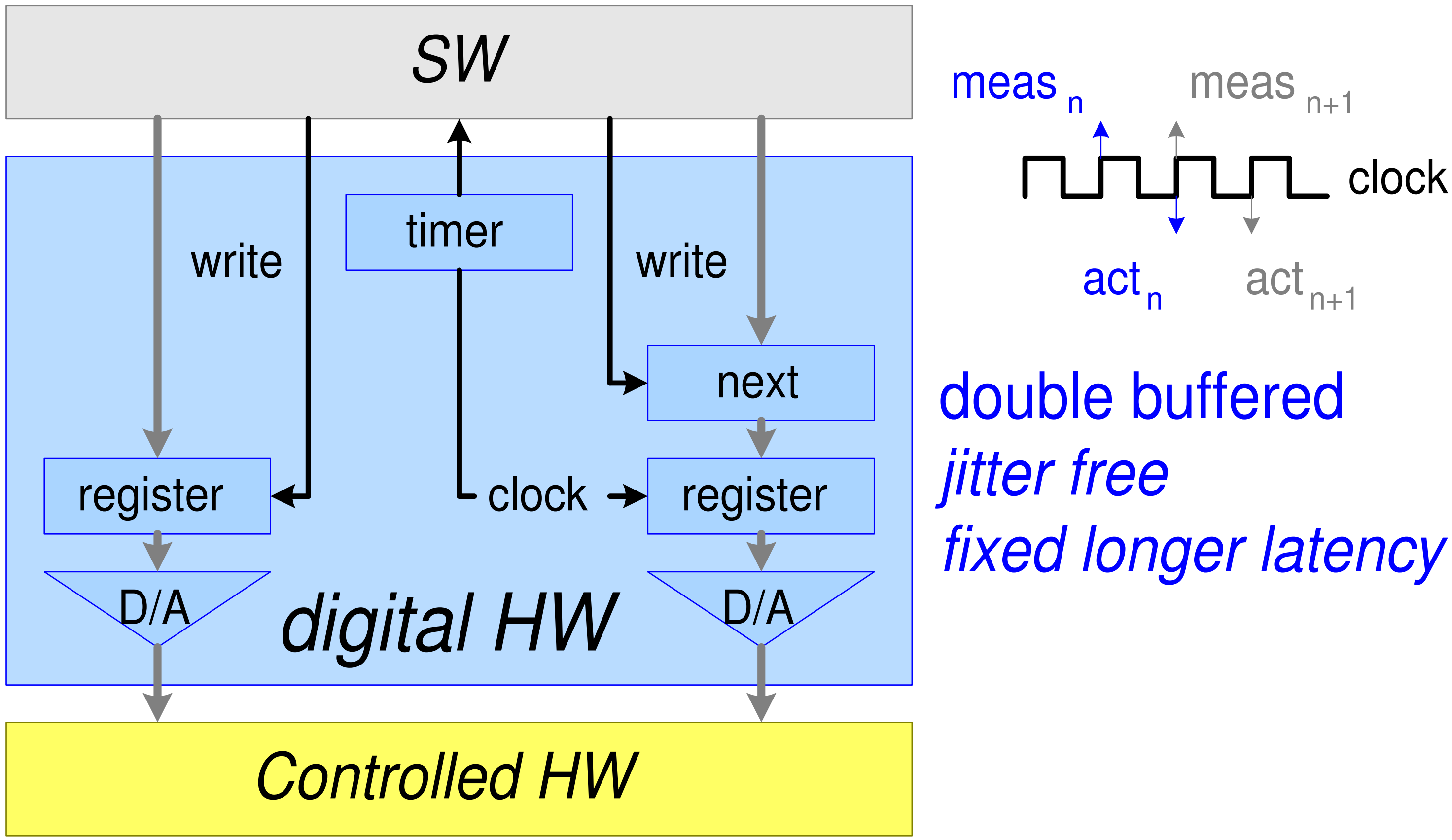
$Performance_{control}$

Mutual Impact of SW and Control Design

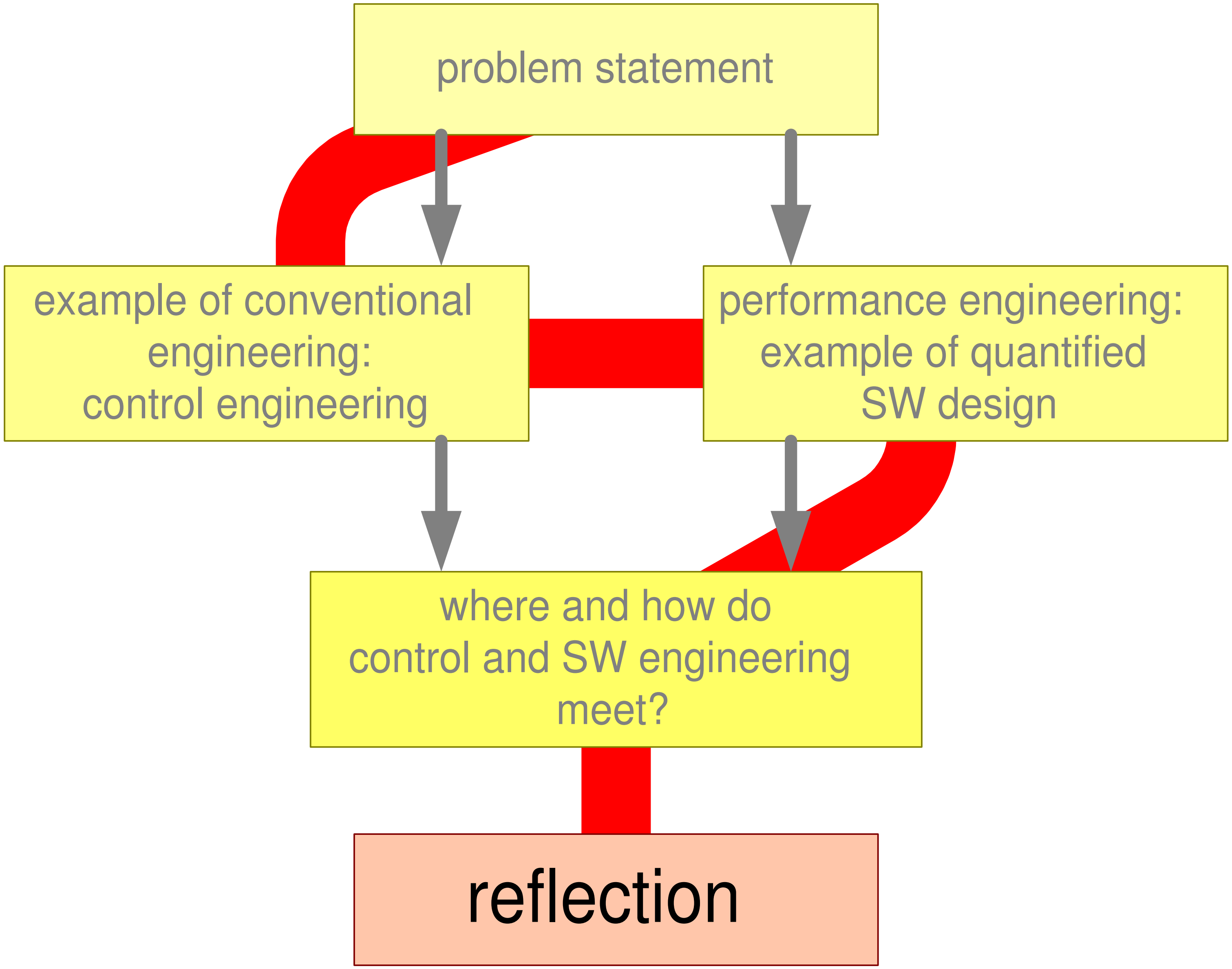


Impact of digital HW on SW and Control

single buffered
SW impl. jitter
variable latency



double buffered
jitter free
fixed longer latency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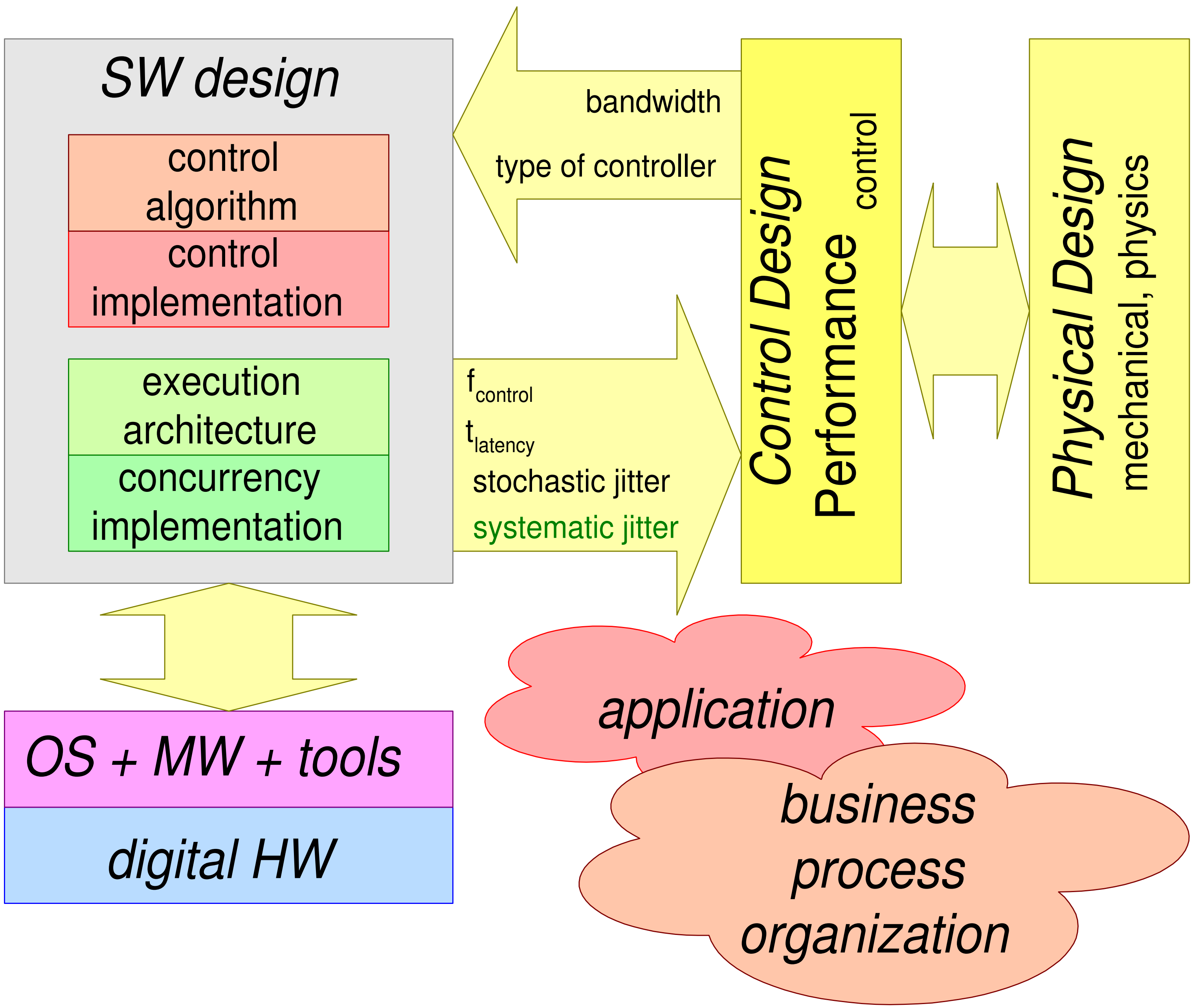
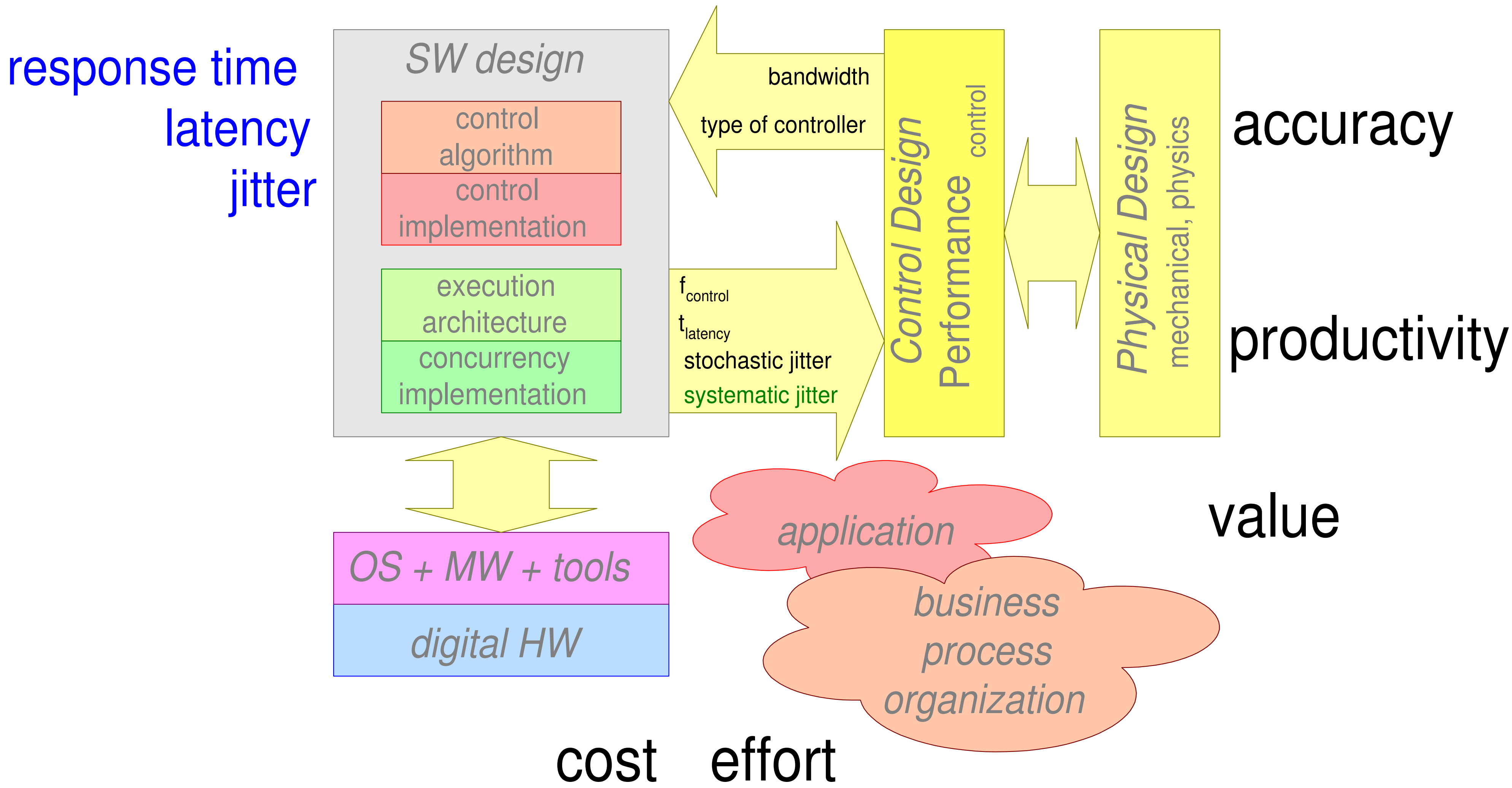
SW design = **Multi-** Multi- Disciplinary



Quantifications Connect Disciplines



Questions?

After this slide some more quantification examples and issues are shown

Examples of Quantification; Electronic Patient Record

Customer objectives
figures of merit

patients/physician
physician income
success rate
failure rate
integral cost

Application
typical quantities

patients
physicians
exams/day
exams/patient
information/ patient

Functional
critical specs

productivity
response time
capacity

Conceptual
working ranges

transactions
queries
peak&average

Realization
critical numbers

network speed
CPU speed
memory size
power consumption
query duration
transaction overhead

internal **O**perational view

market size
market share
growth rate

product life cycle
business model
market segments

maintenance effort
update frequency
service crew

suppliers
partners
competitors

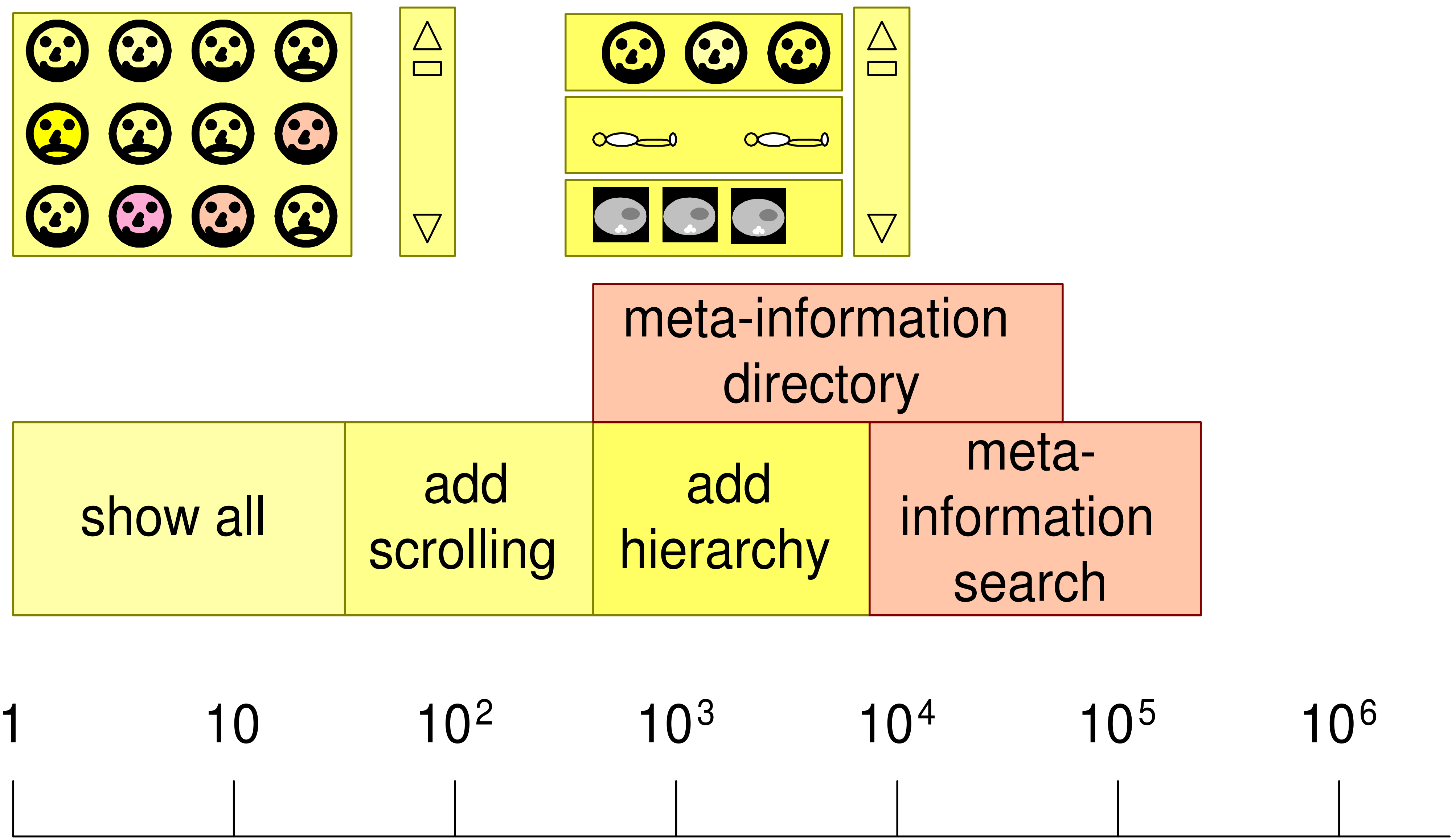
effort
cost
time

project size
engineers/discipline
teams

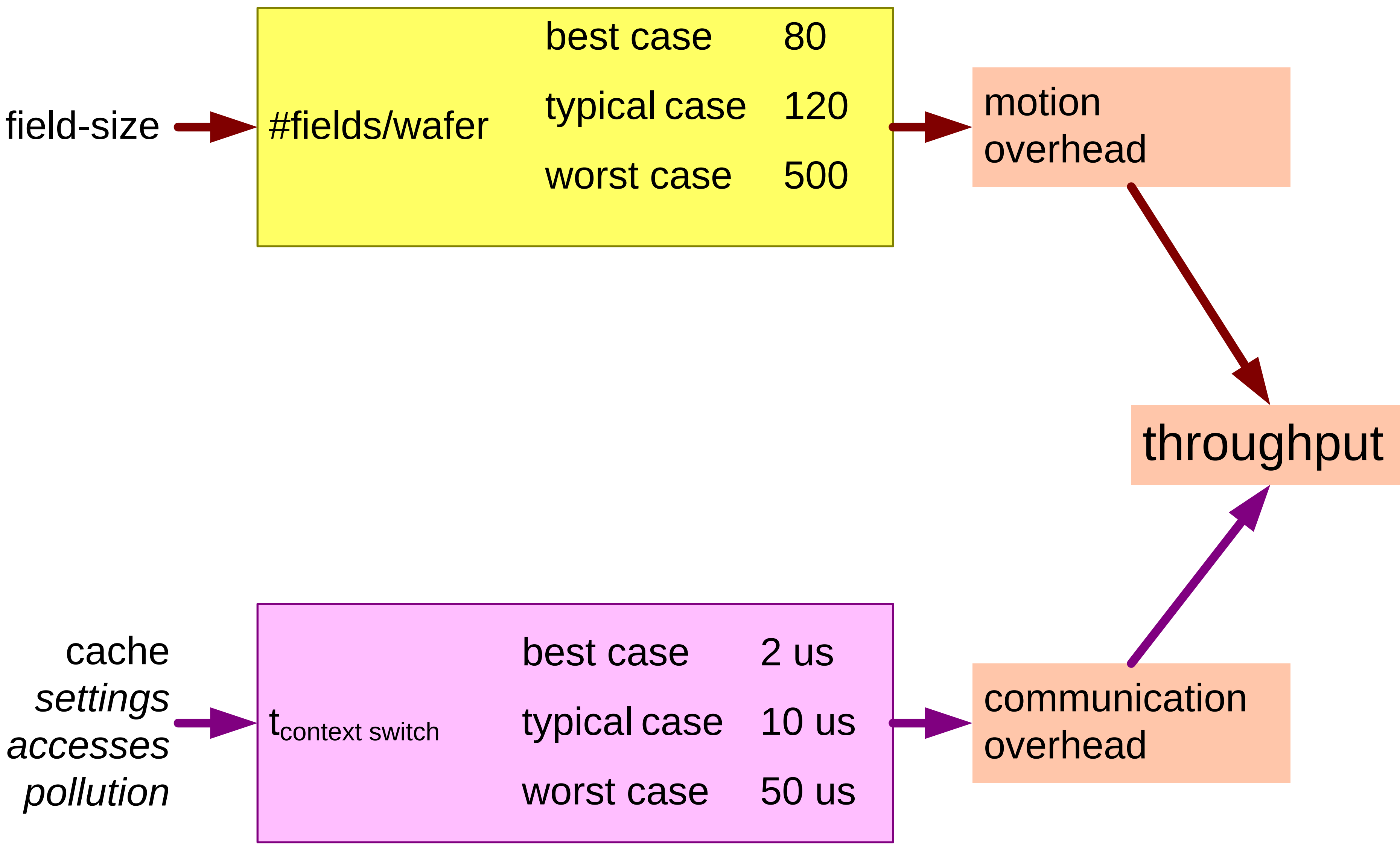
Where and When to Quantify

requirements analysis	paradigm boundaries application relevance design sensitivity
ranges and relations	typical, best, worst case dependencies
variation analysis	random vs systematic types of systematic variation time-base, rate of change
propagation analysis	amplification or dimming
evolution	application, business evolution technology evolution scaling, scaling boundaries

Example UI paradigms for Pictorial Index



Example of Combining Heterogeneous Quantifications



Example Computer Crime quantification

http://www.usatoday.com/tech/news/computersecurity/infotheft/2006-10-11-cybercrime-hacker-forums_x.htm

* $67.2 billion: FBI estimate of what U.S. businesses lose annually because of computer-related crimes.
* $8 billion: Consumer Reports estimate of what U.S. consumers lost the past two years because of viruses, spyware and Internet scams.
* 93.8 million: Privacy Rights Clearinghouse's count of personal records reported lost or stolen since February 2005.
* 26,150: The Anti-Phishing Working Group's count of unique variations of phishing scams reported in August 2006.

Typical costs of goods and services in forums:

* $1,000 to $5,000: Trojan program that can transfer funds between online accounts.
* $500: Credit card number with PIN.
* $80 to $300: Change of billing data, including account number, billing address, Social Security number, home address and birth date.
* $150: Driver's license.
* $150: Birth certificate.
* $100: Social Security card.
* $7 to $25: Credit card number with security code and expiration date.
* $7: PayPal account log-on and password.
* 4% to 8% of the deal price: Fee to have an escrow agent close a complex transaction.
* Free: Access to a service that gives details of the issuing bank for any credit card number.

1 -- Representative asking prices found recently on cybercrime forums

Source: USA TODAY research
referenced by http://groups.google.co.in/group/control-computer-crimes/