Exploring an existing code base: measurements and instrumentation

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Abstract

Many architects struggle with a given large code-base, where a lot of knowledge about the code is in the head of people or worse where the knowledge has disappeared. One of the means to recover insight from a code base is by measuring and instrumenting the code-base. This presentation addresses measurements of the static aspects of the code, as well as instrumentation to obtain insight in the dynamic aspects of the code.

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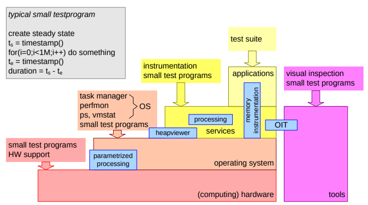


Problem Statement

wanted:
new functions and interfaces, higher performance levels, improvements, et cetera

given:

document repository

> 100 klines
> 1k docs

code repository

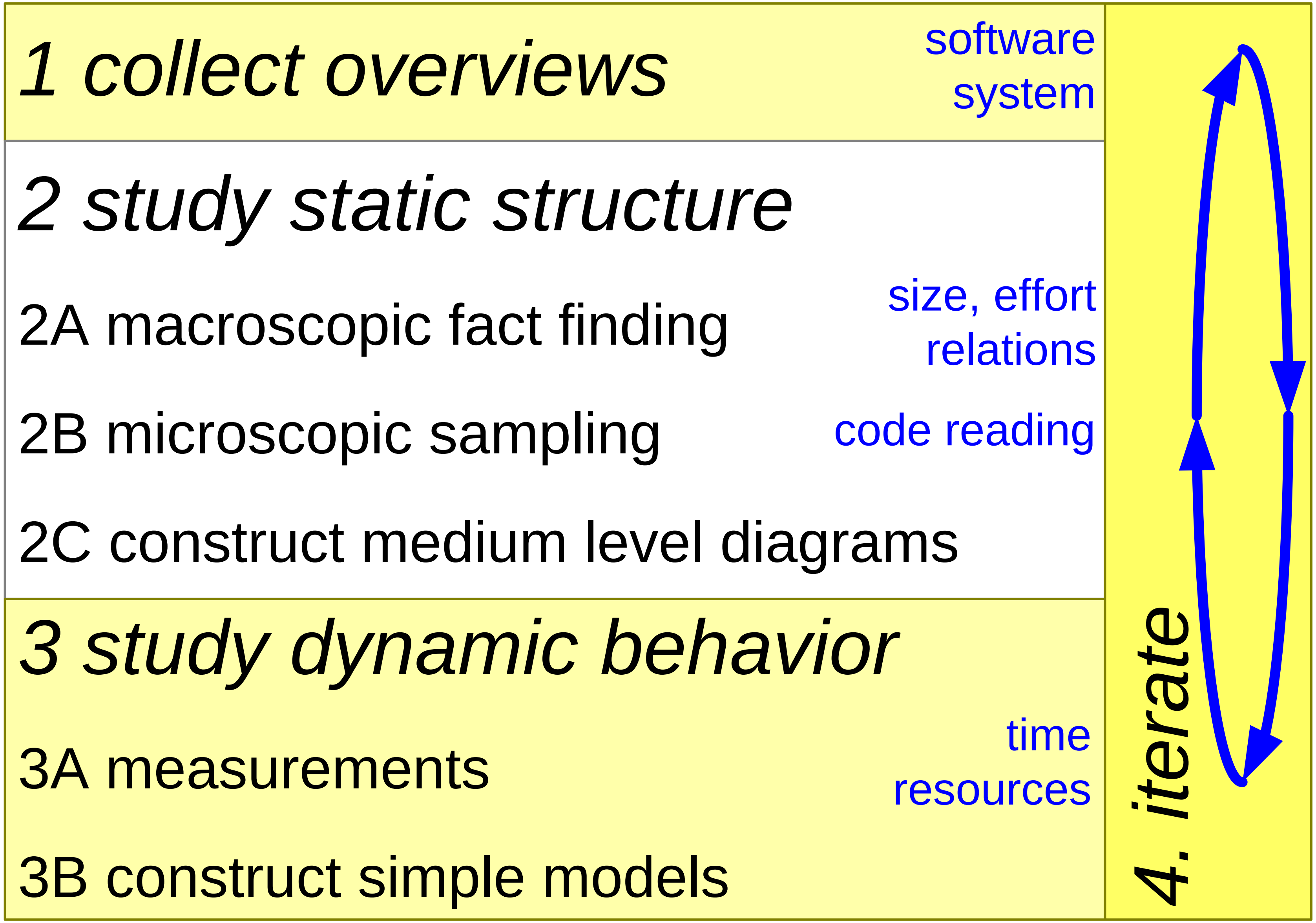
> 1Mloc
> 1k files

complex system

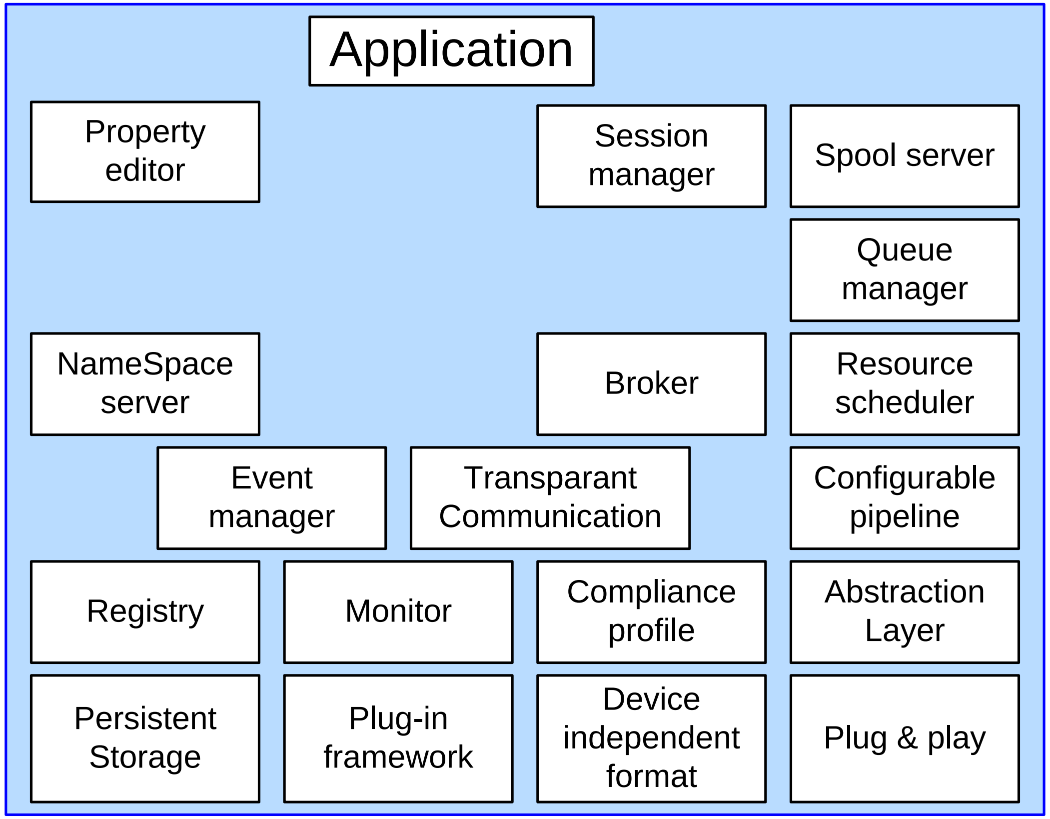
created by >100 people

>100 people left

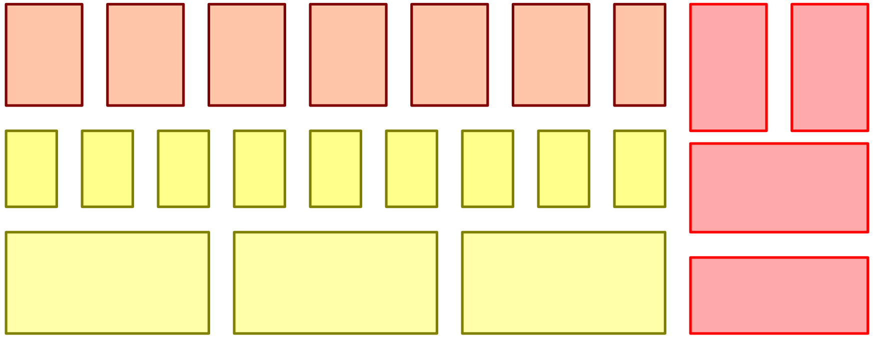
Overview of Approach and Presentation Agenda



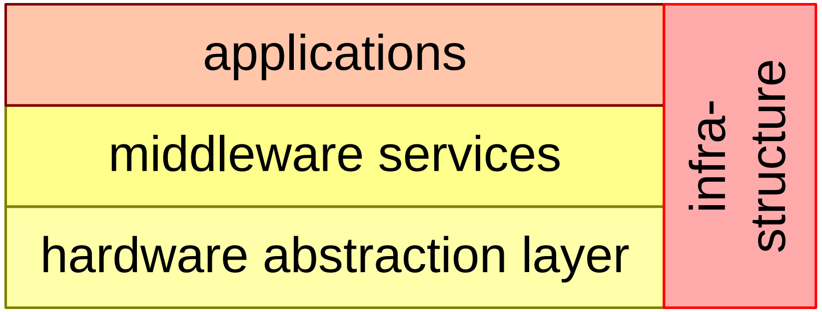
SW Overview(s)



mechanism centric



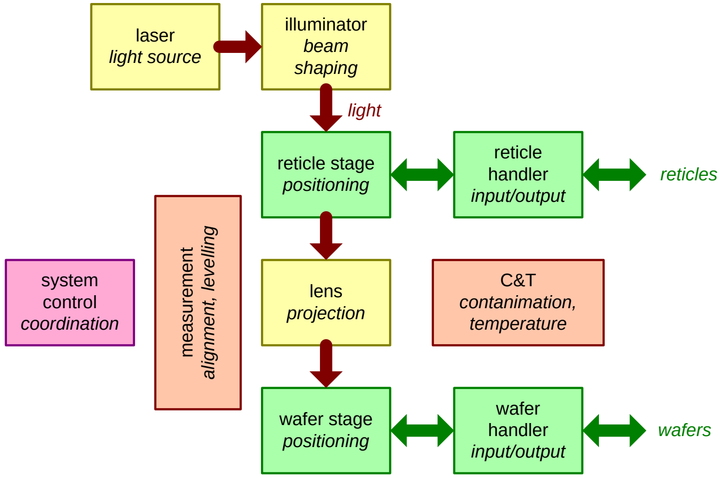
delivery centric



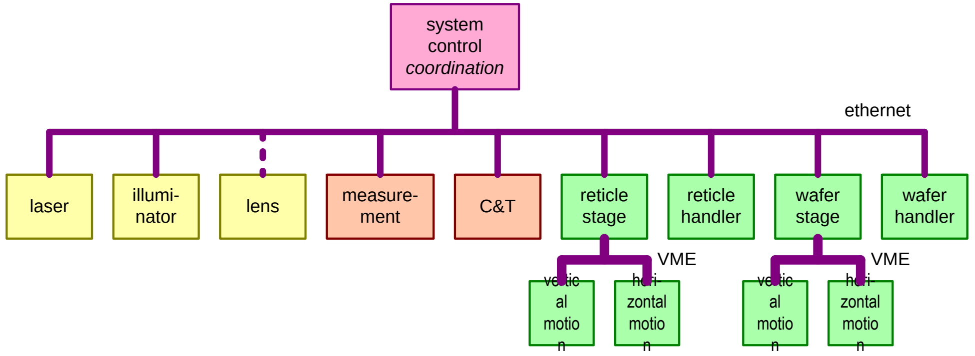
(over)simplistic

System Overviews

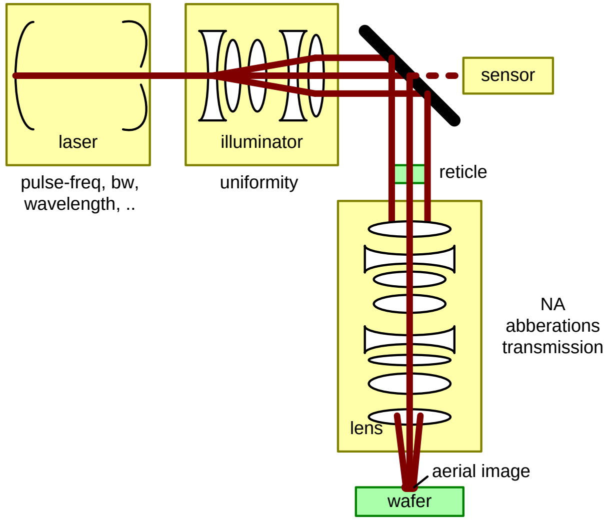
subsystems



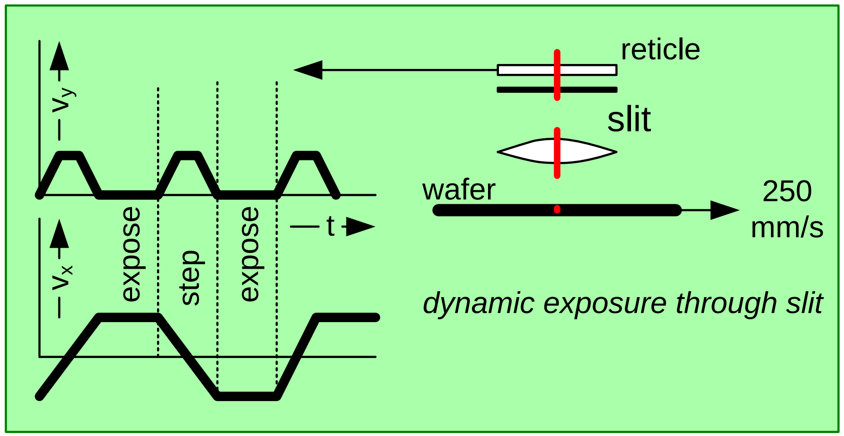
control hierarchy



physics/optics



kinematic



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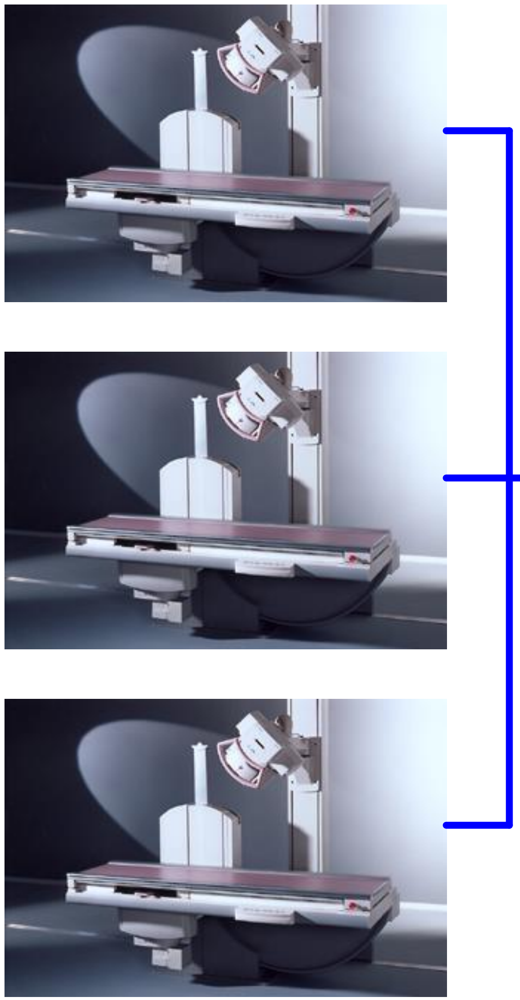
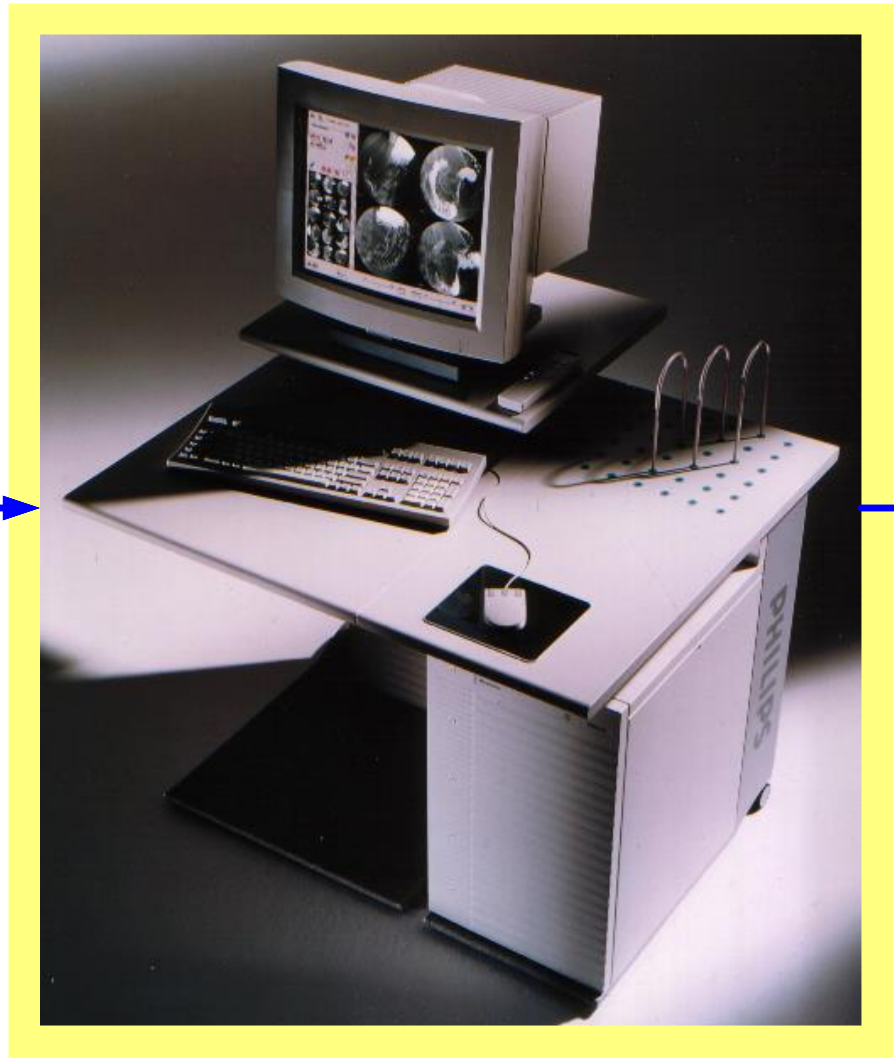
EBMIsystemDiagrams

Case 1: EasyVision (1992)



URF-systems



EasyVision: Medical Imaging Workstation

typical clinical image (intestines)

Examples of Macroscopic Fact Finding

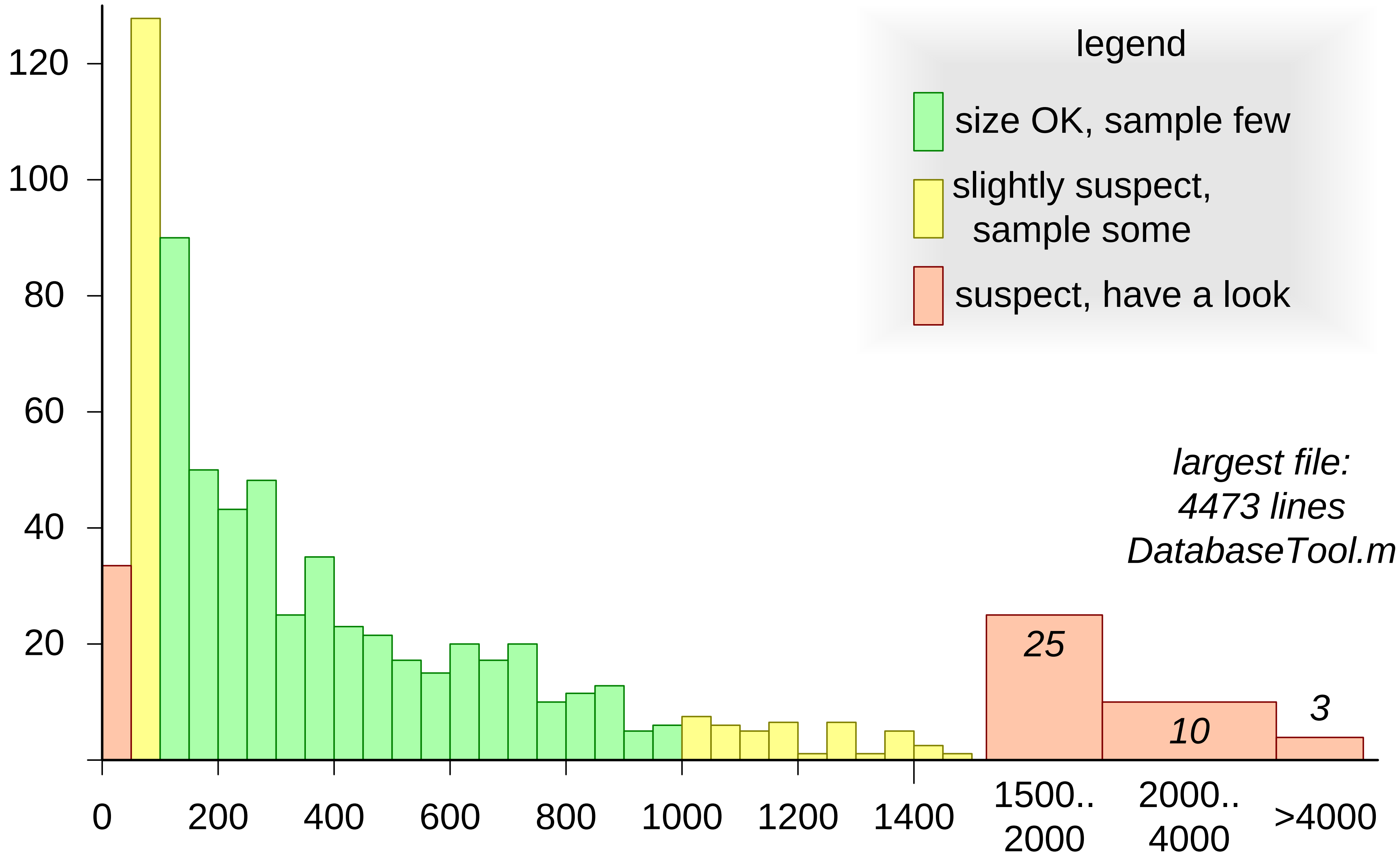
```
> wc -l  *.m
72 Acquisition.m
13 AcquisitionFacility.m
330 ActiveDataCollection.m
132 ActiveDataObject.m
304 Activity.m
281 ActivityList.m
551 AnnotateParser.m
1106 AnnotateTool.m
624 AnyOfList.m
466 AsyncBulkDataIO.m
264 AsyncDeviceIO.m
261 AsyncLocalDbIO.m
334 AsyncRemoteDbIO.m
205 AsyncSocketIO.m
```

version control information:
#new files
#deleted files
#changes per file since ...

package information:
files

metrics:
QAC type information
methods
globals

Histogram of File Sizes EV R1.0



Microscopic Sampling (Code Reading)

Example of small classes due to database design;
These classes are only supporting constructs

13 IndexBtree.m
12 IndexInteriorNode.m
13 IndexLeafNode.m
13 ObjectStoreBtree.m
12 ObjectStoreInteriorNode.m
13 ObjectStoreLeafNode.m

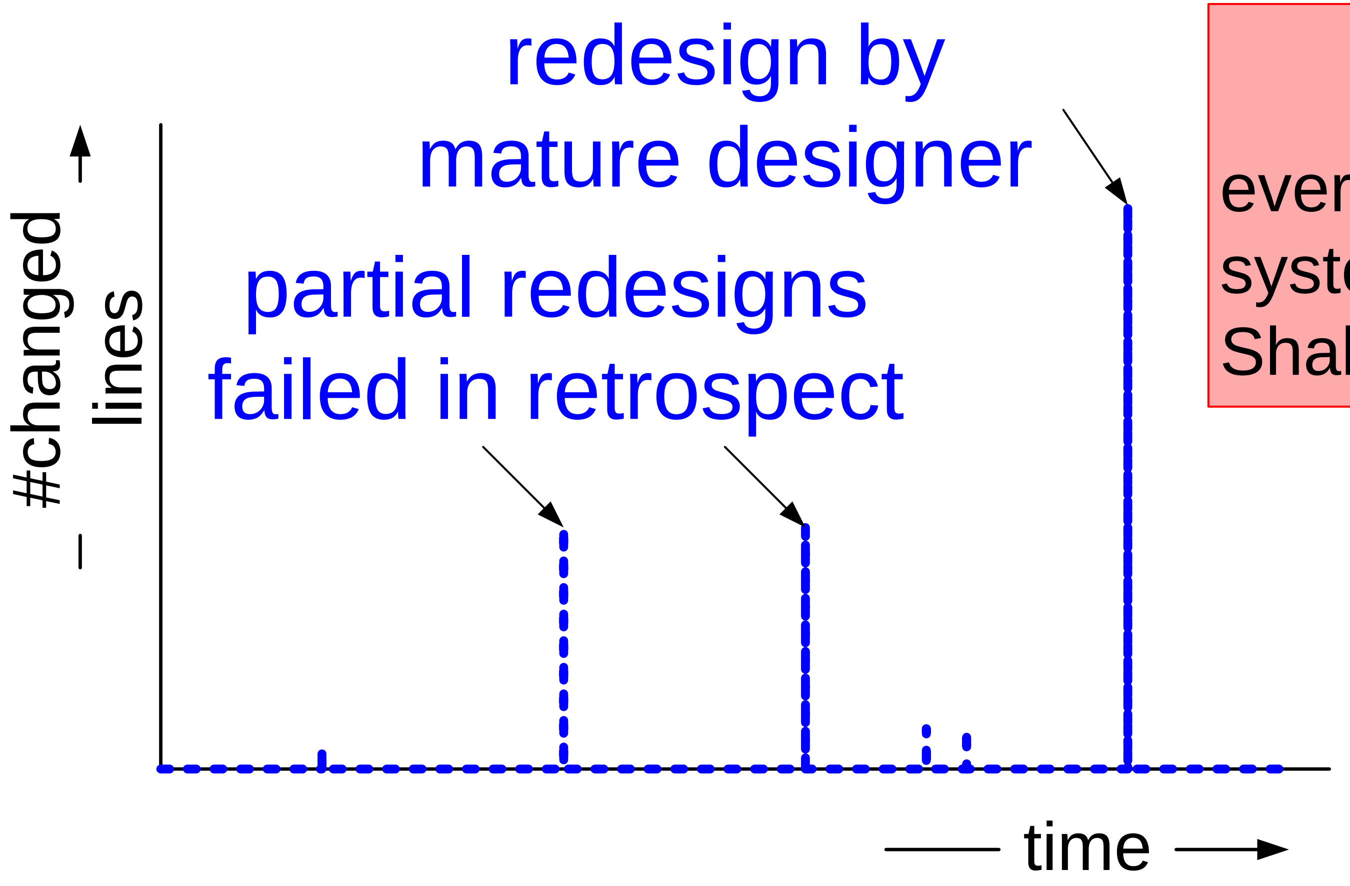
Example of large classes due to large amount of UI details

4473 DatabaseTool.m
1291 EnhancementTool.m
1106 AnnotateTool.m
1291 EnhancementTool.m
3471 GreyLevelTool.m
1639 HCConfigurationTool.m
1007 HCQueueViewingTool.m
1590 HardcopyTool.m

Example of large classes due to inherent complexity;
some of these classes are really suspect

1541 GenericRegion.m
1415 GfxArea.m
1697 GfxFreeContour.m
4095 GfxObject.m
1714 GfxText.m
1374 CVObject.m
1080 ChartStack.m
1127 Collection.m
1651 Composite.m
1725 CompositeProjectionImage.m
1373 Connection1.m
1181 Database1.m
3707 DatabaseClient.m
3240 Image.m
1861 ImageSet.m

Changes Over Time

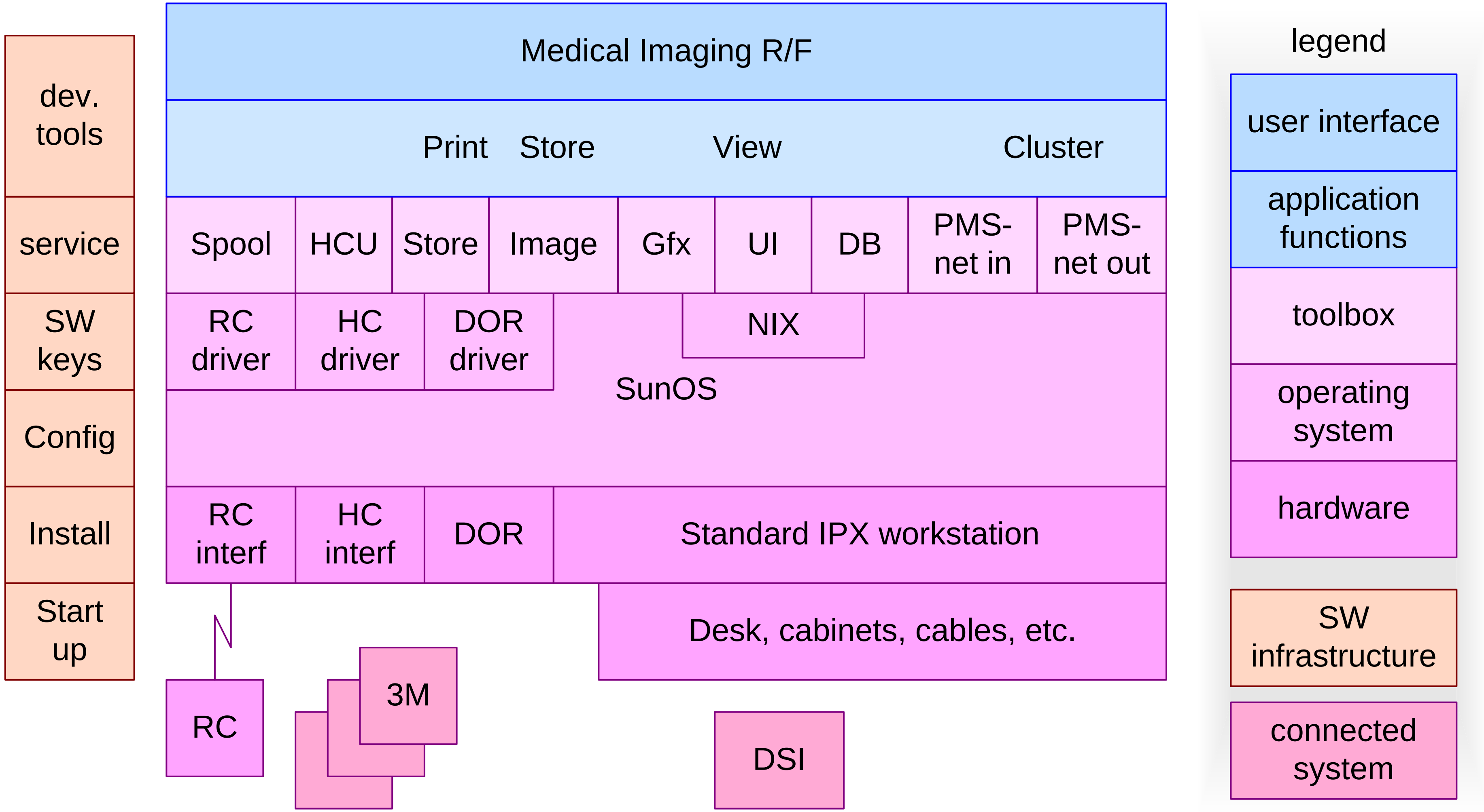


hot spots

ever changing files e.g.:
systemConstants.h
ShakyImplementation.m

Simplified Medium Level Diagram

The real layering diagram did have >15 layers



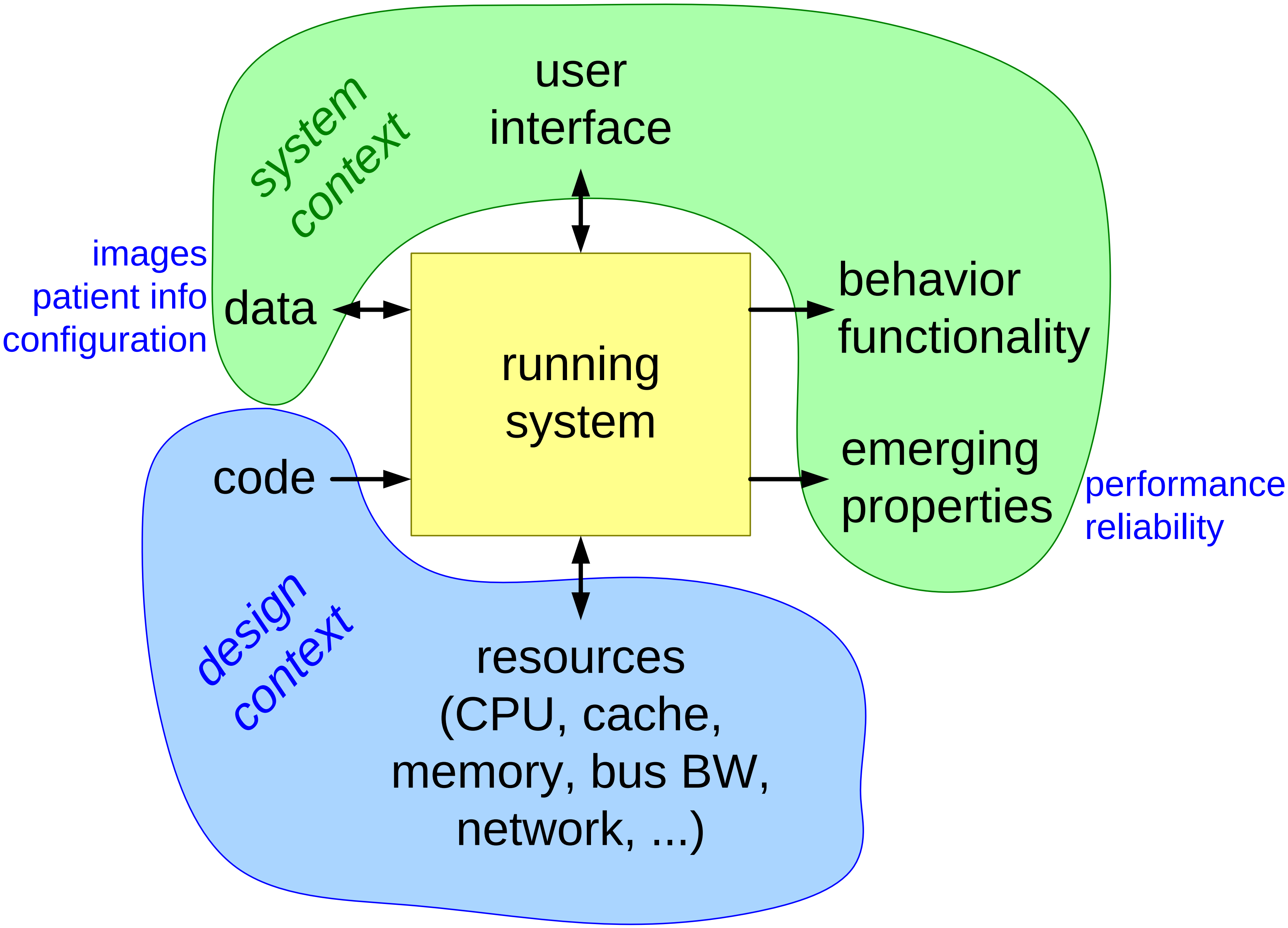
Conclusions Static Exploration

Quantification helps to *calibrate* the *intuition* of the architect

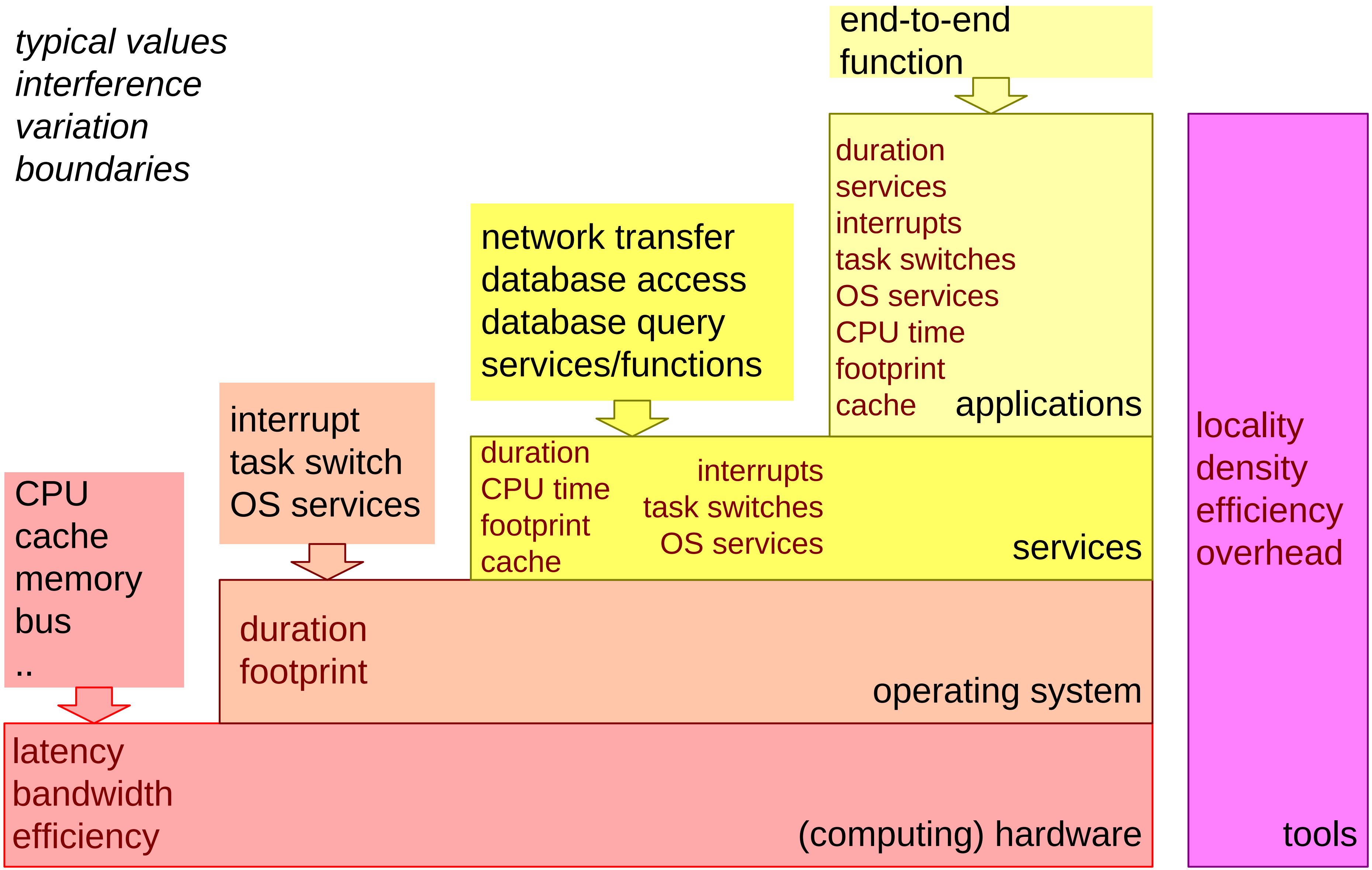
Macroscopic numbers related to *code level* understanding provides insight

+ relative complexity
+ relative effort
+ hot spots
+ (static) dependencies and relations

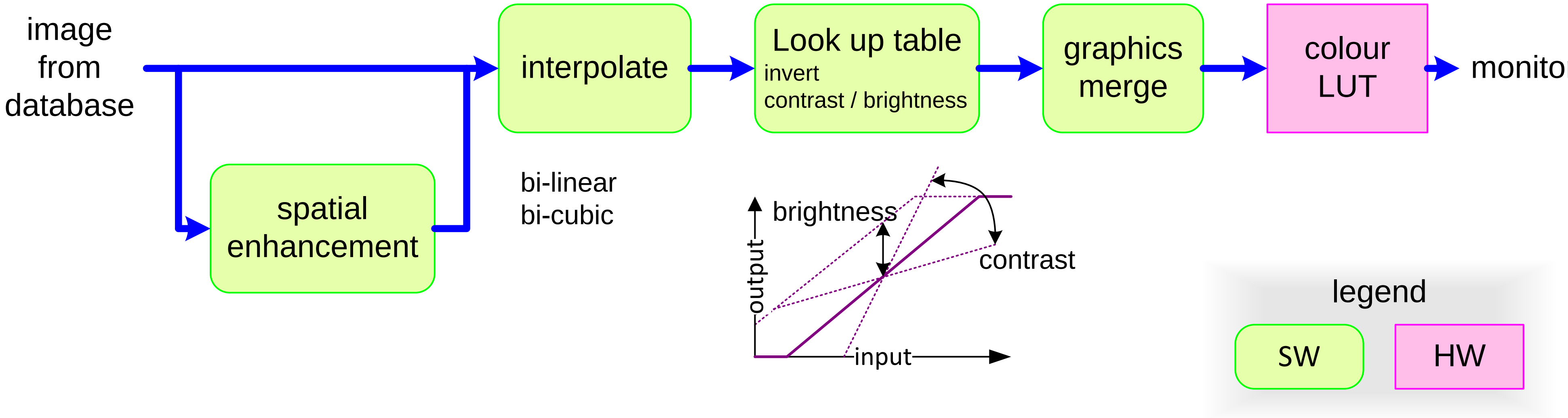
Dynamics $\gg$ Static



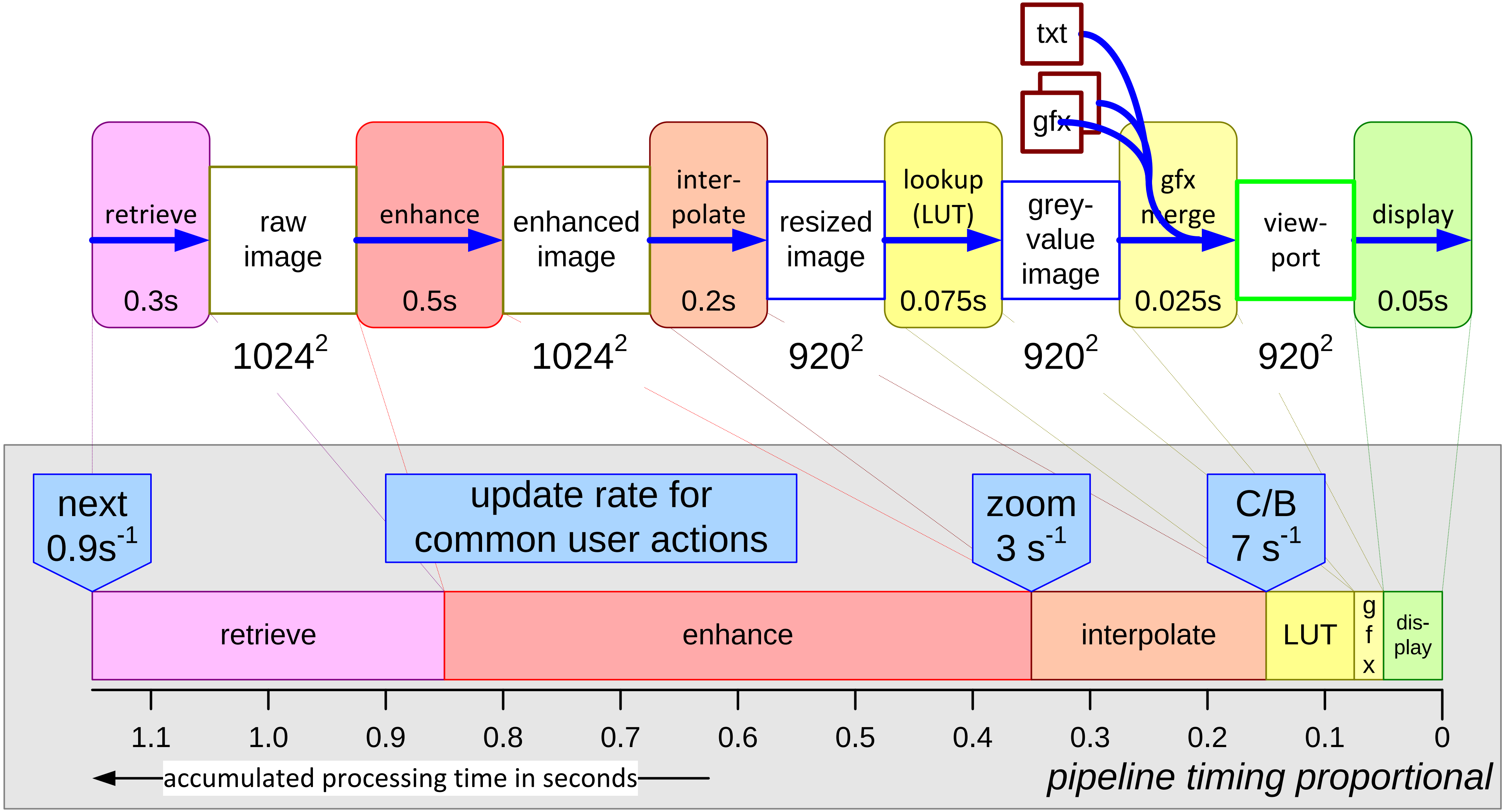
Layered Benchmarking



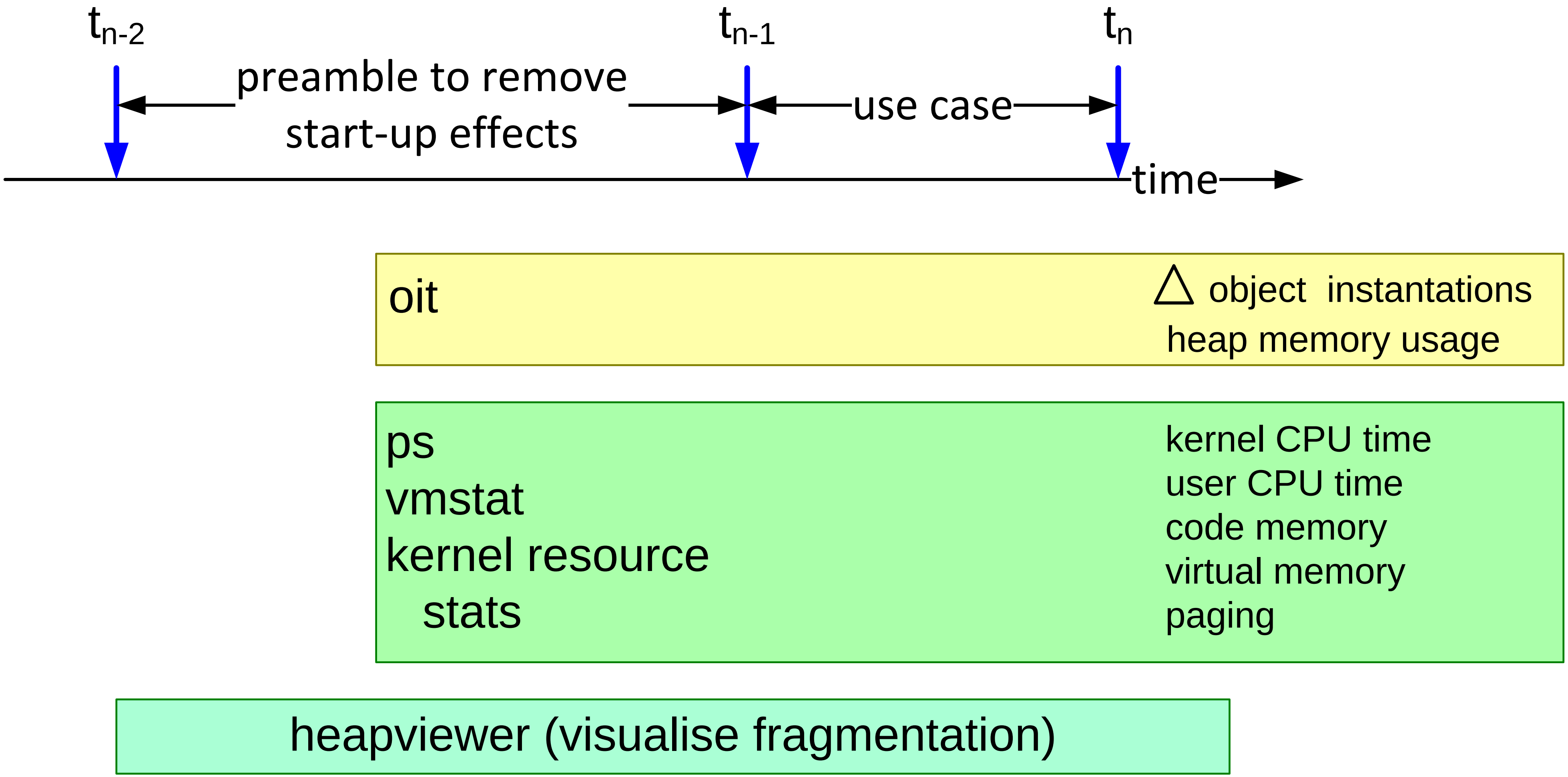
Example: Processing HW and Service Performance



Processing Performance



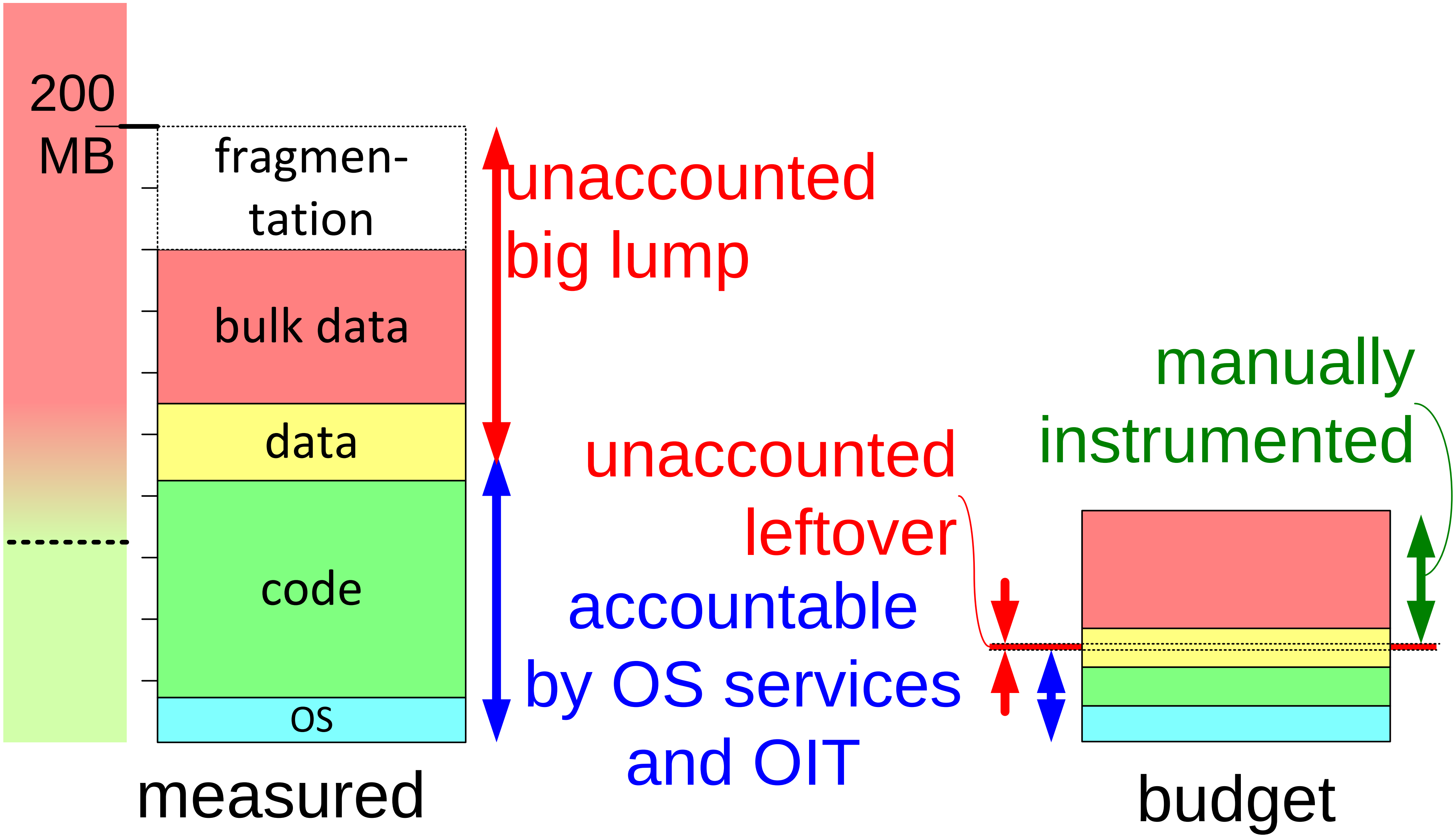
Resource Measurement Tools



Object Instantiation Tracing

class name	current nr of objects	deleted since t_{n-1}	created since t_{n-1}	heap memory usage
AsynchronousIO	0	-3	+3	
AttributeEntry	237	-1	+5	
BitMap	21	-4	+8	
BoundedFloatingPoint	1034	-3	+22	
BoundedInteger	684	-1	+9	
BtreeNode1	200	-3	+3	[819200]
BulkData	25	0	1	[8388608]
ButtonGadget	34	0	2	
ButtonStack	12	0	1	
ByteArray	156	-4	+12	[13252]

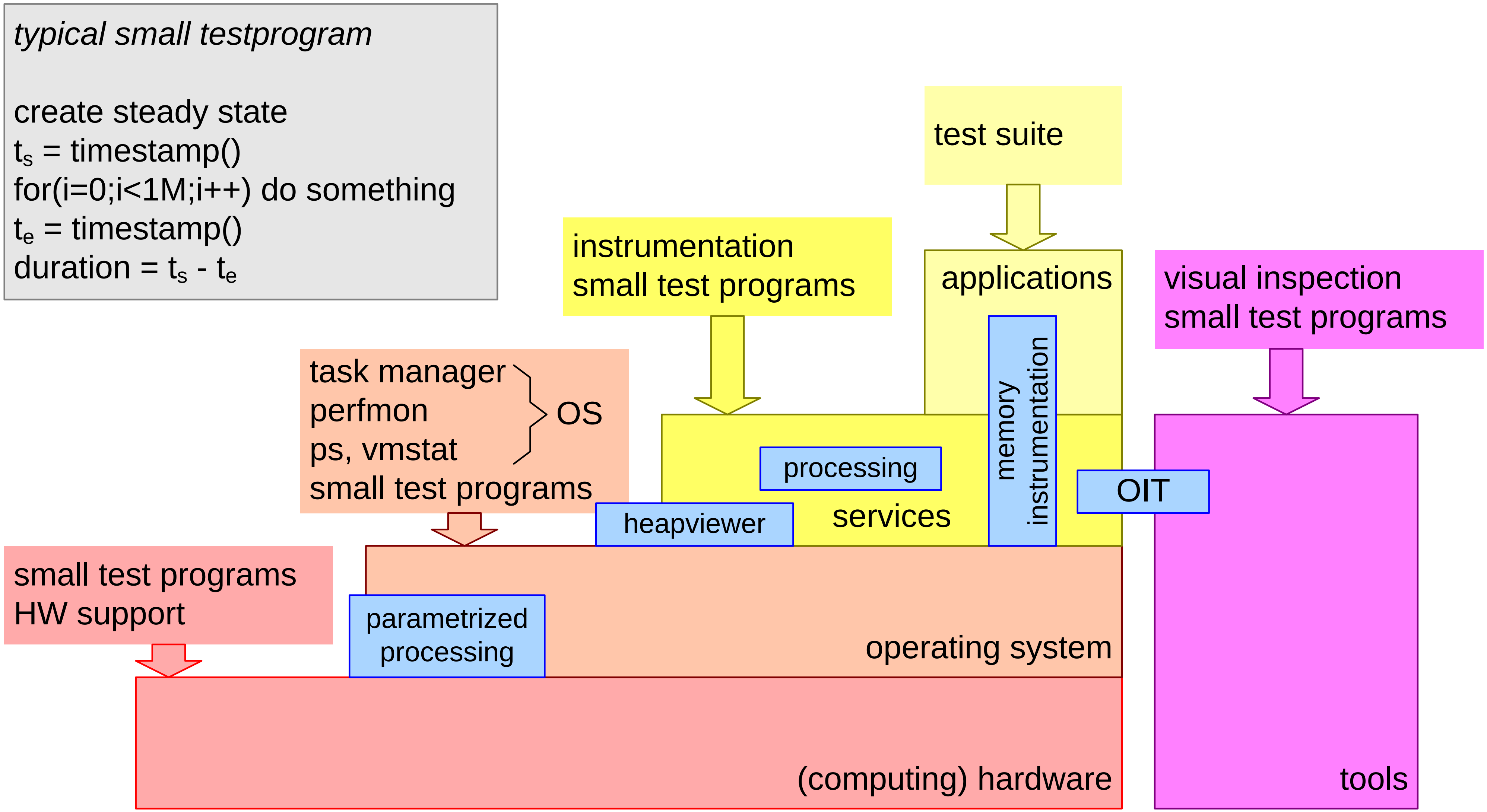
Memory Instrumentation



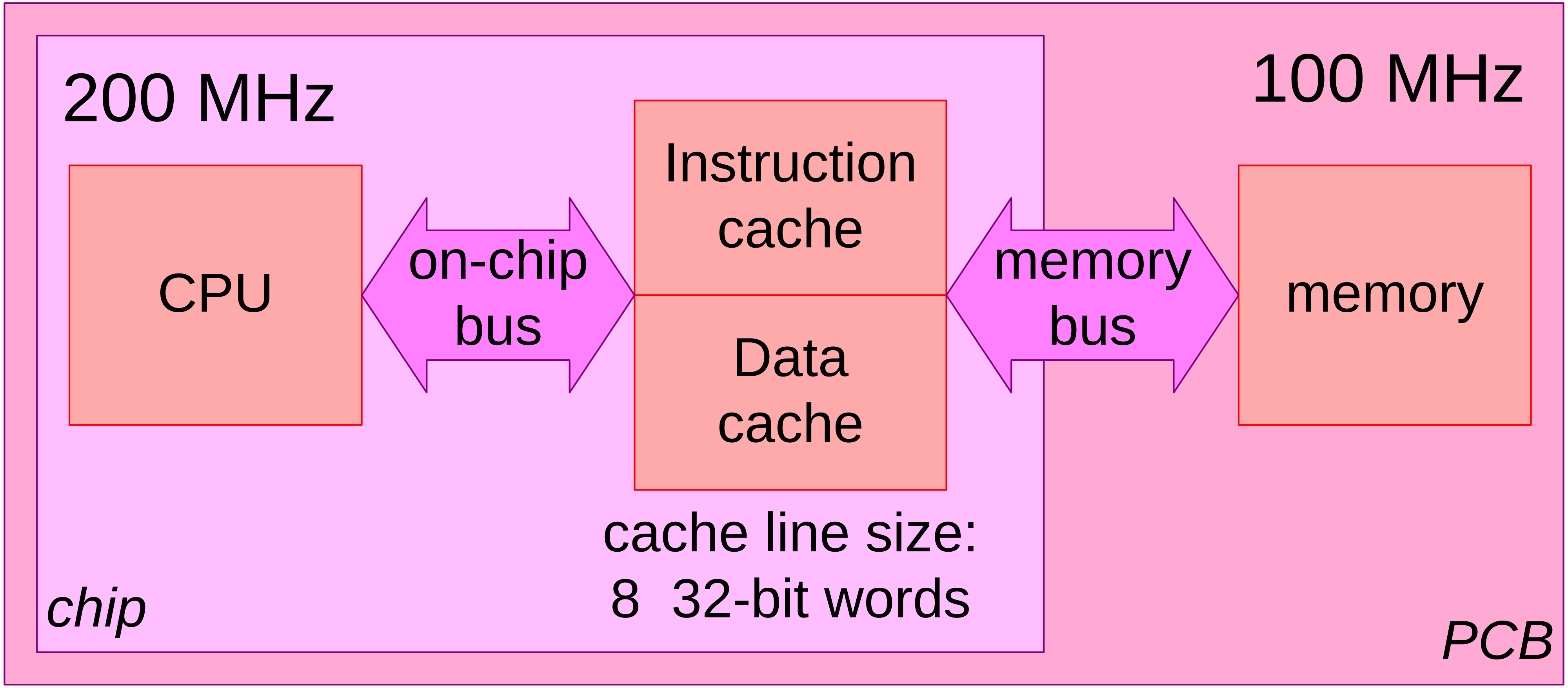
Overview of Benchmarks and Other Measurement Tools

	test / benchmark	what, why	accuracy	when
public	SpecInt (by suppliers)	CPU integer	coarse	new hardware
	Byte benchmark	computer platform performance OS, shell, file I/O	coarse	new hardware new OS release
self made	file I/O	file I/O throughput	medium	new hardware
	image processing	CPU, cache, memory as function of image, pixel size	accurate	new hardware
	Objective-C overhead	method call overhead memory overhead	accurate	initial
	socket, network	throughput CPU overhead	accurate	ad hoc
	data base	transaction overhead query behaviour	accurate	ad hoc
	load test	throughput, CPU, memory	accurate	regression

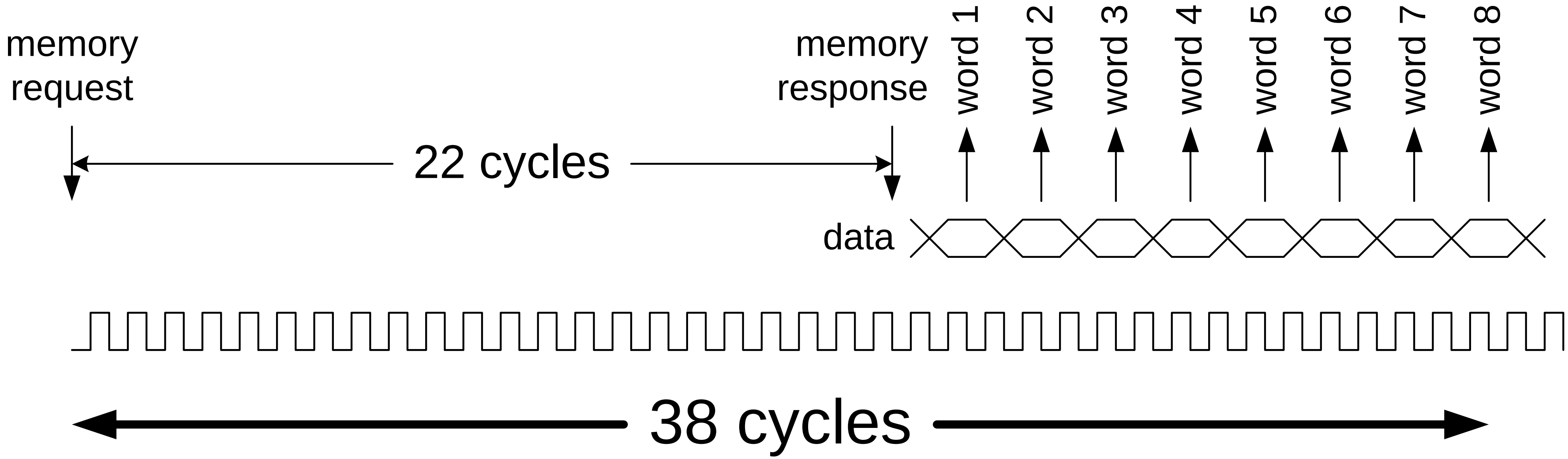
Tools and Instruments Positioned in the Stack



Case 2: 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 $t_{context\ switch}$
as function of cache use

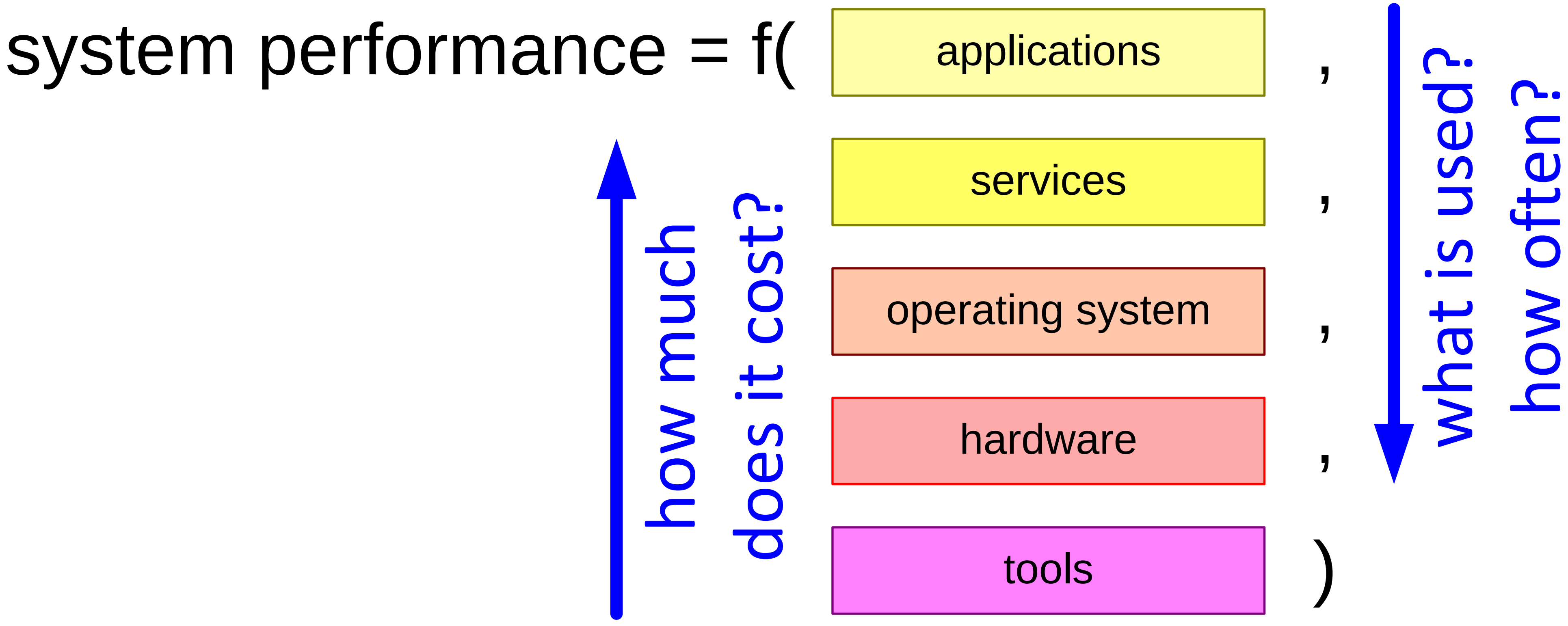
cache setting	$t_{context\ switch}$
From cache	2 µs
After cache flush	10 µs
Cache disabled	50 µs

Context Switch Overhead

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

$n_{context\ switch}$ (s^{-1})	$t_{context\ switch} = 10\mu s$		$t_{context\ switch} = 2\mu s$	
	$t_{overhead}$	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



Annotated Performance Formule

system performance = f(

applications	hit-rate, miss-rate, #transactions interrupt-rate, task switch rate CPU-load

,

services	transaction overhead: 25 ms

,

operating system	interrupt latency: 10 us task-switch: 10 us (with cache flush)

,

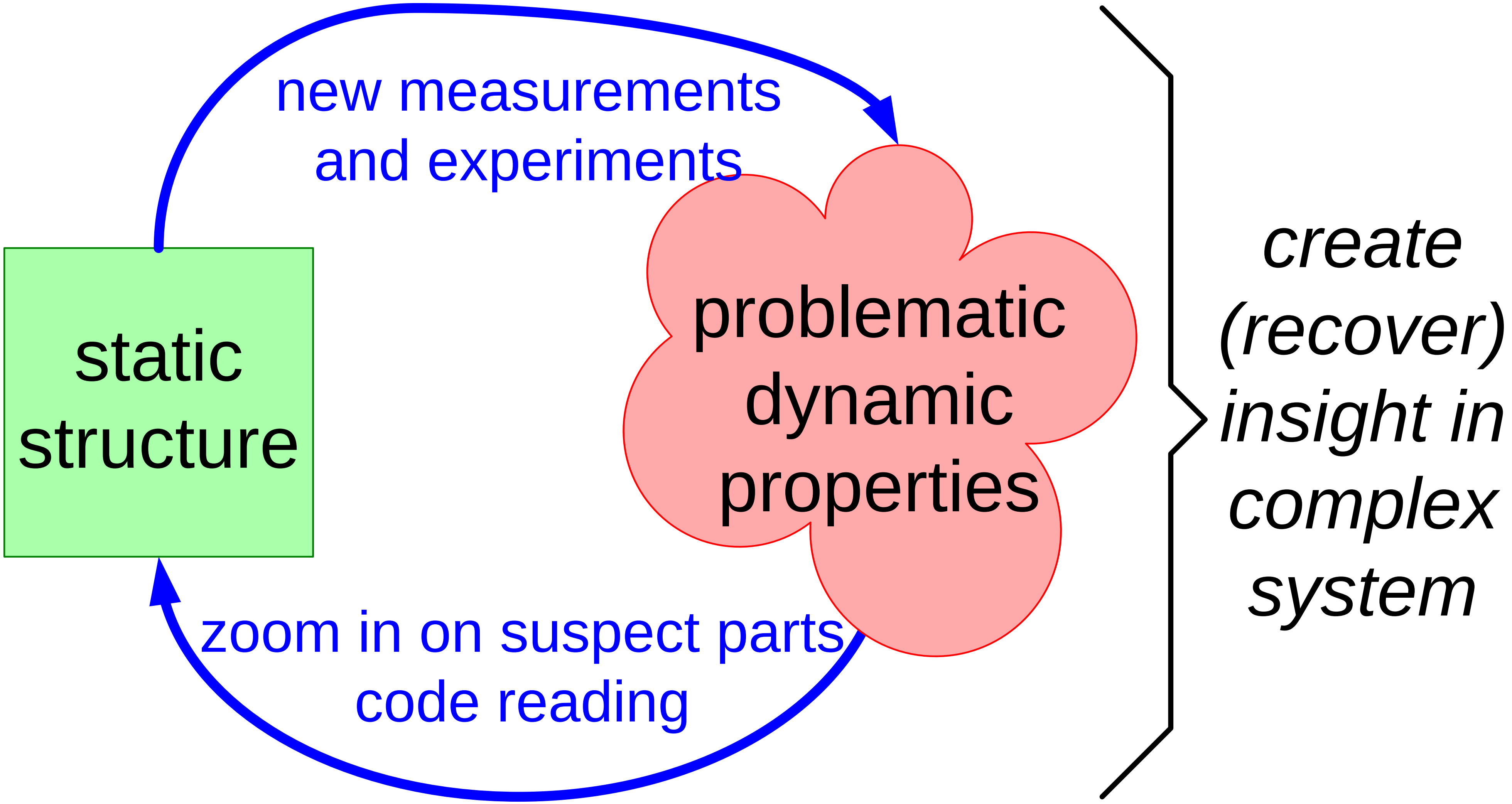
hardware	cache miss: 190ns

,

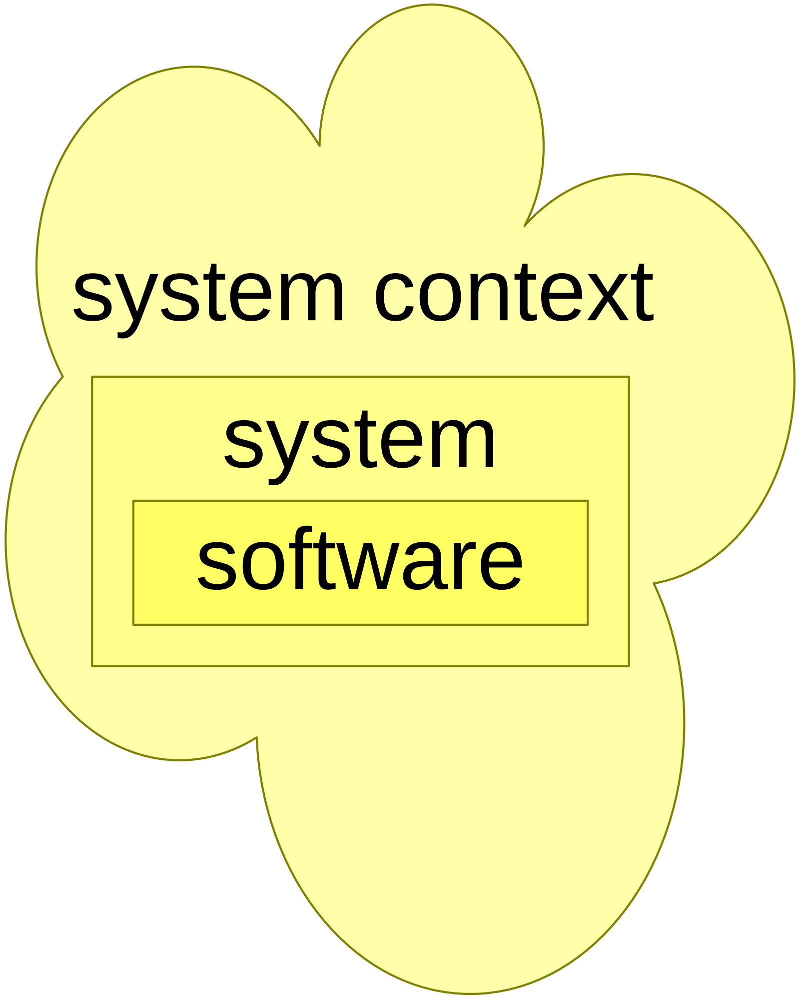
tools	

)

Keep iterating!



Discussion propositions



0. many design teams have lost the overview of the system

1. a good (sw) architect has a quantified understanding of system context, system and software

2. a good design facilitates measurements of critical aspects for a small realization effort