Medical Imaging Workstation: CR Views

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Abstract

The concepts and realization of the medical imaging workstation are described. The following concepts are described: presentation and processing pipeline, resource management (CPU and memory), including caching and anti-fragmentation strategy, software process decomposition and decomposition rules. The actual realization figures serve as illustration for the justification of some of the concepts.

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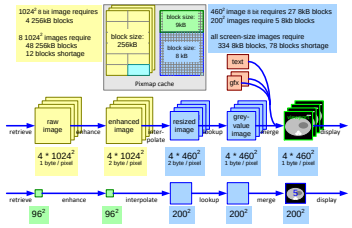
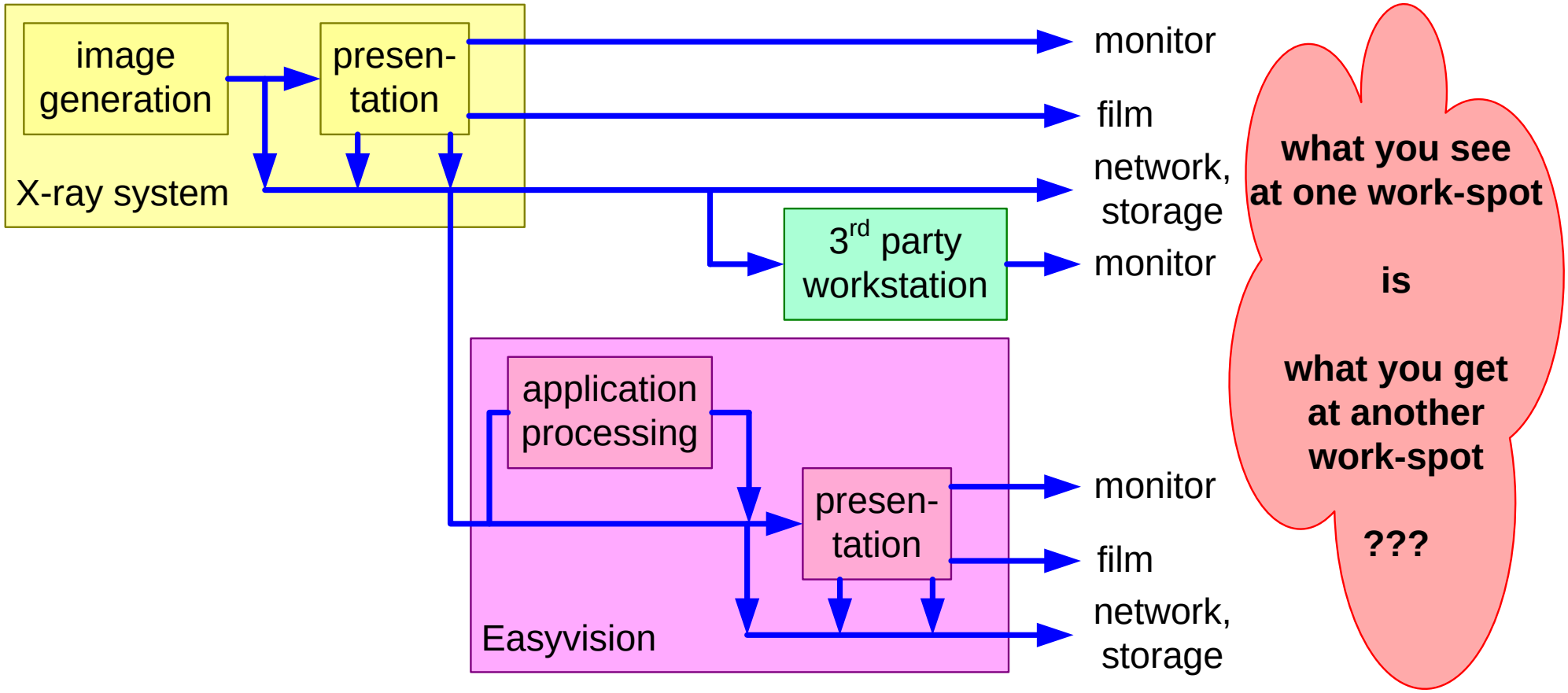
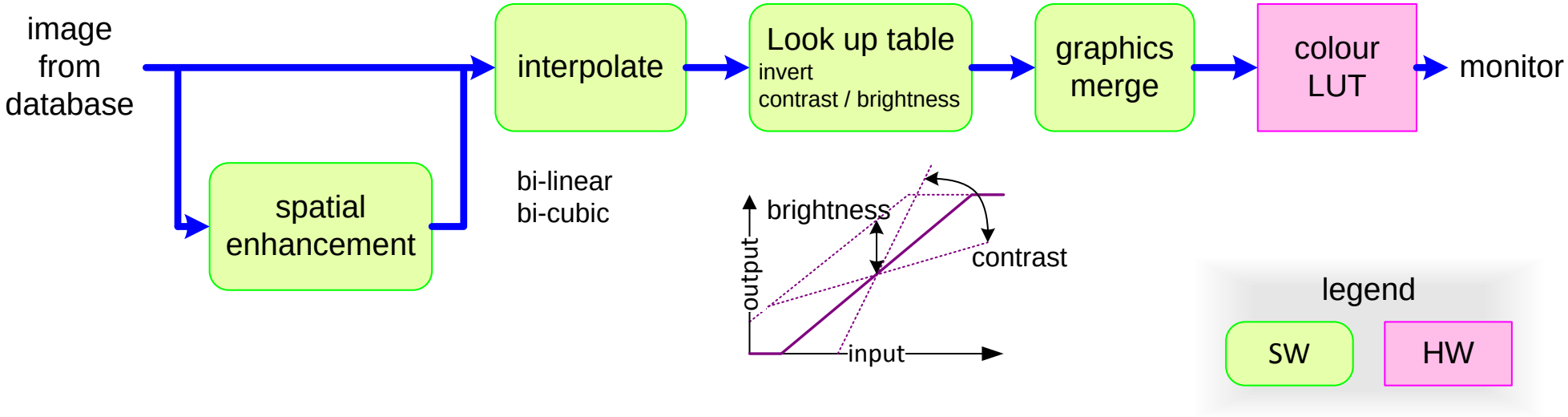


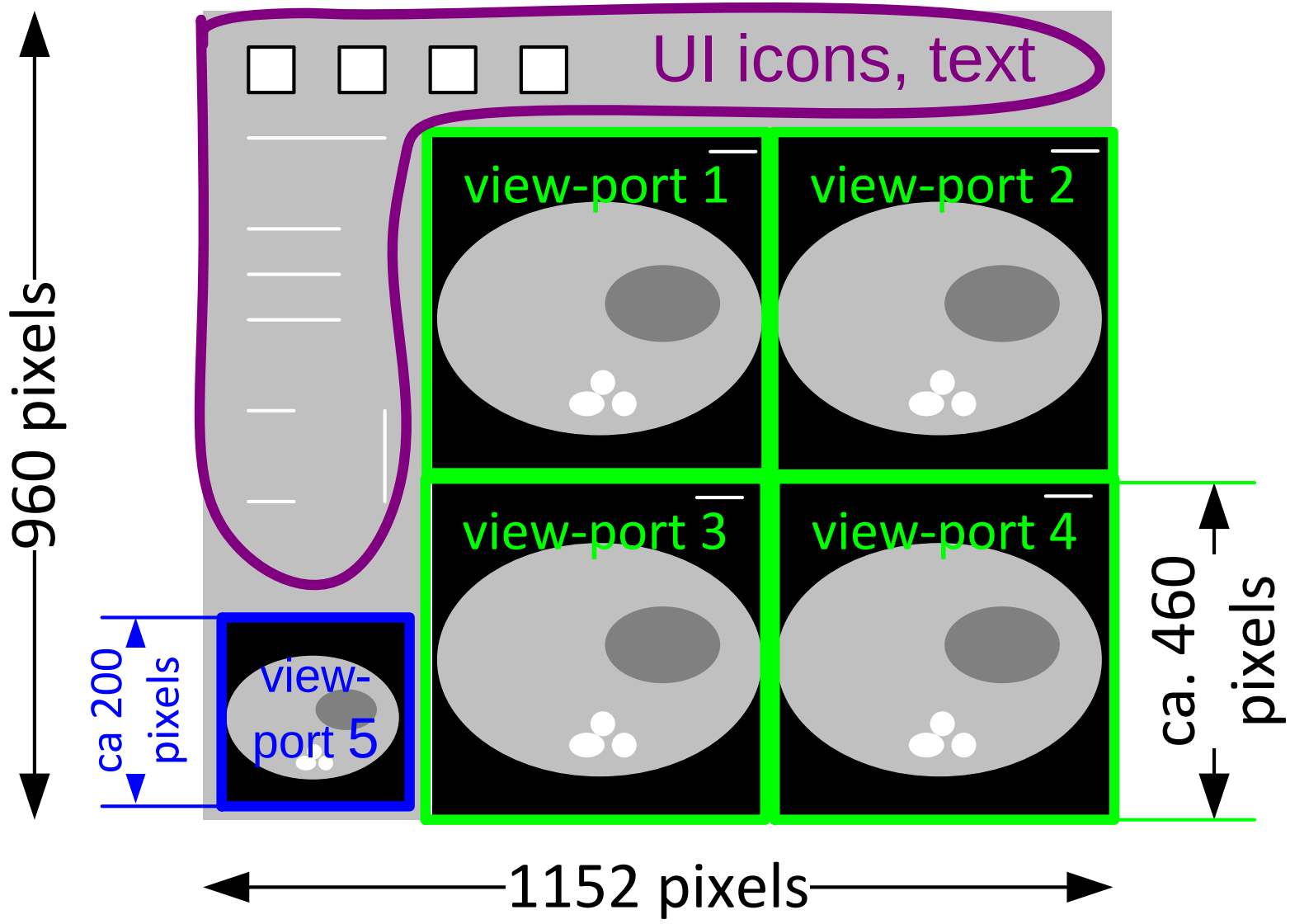
Image Quality expectation WYSIWYG



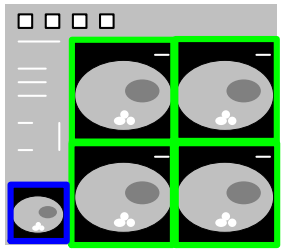
Presentation pipeline for X-ray images



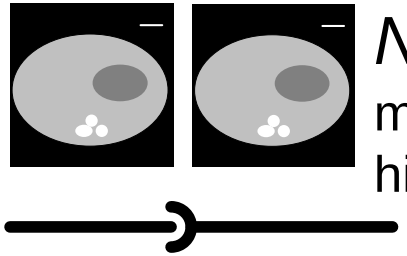
Quadruple view-port screen layout



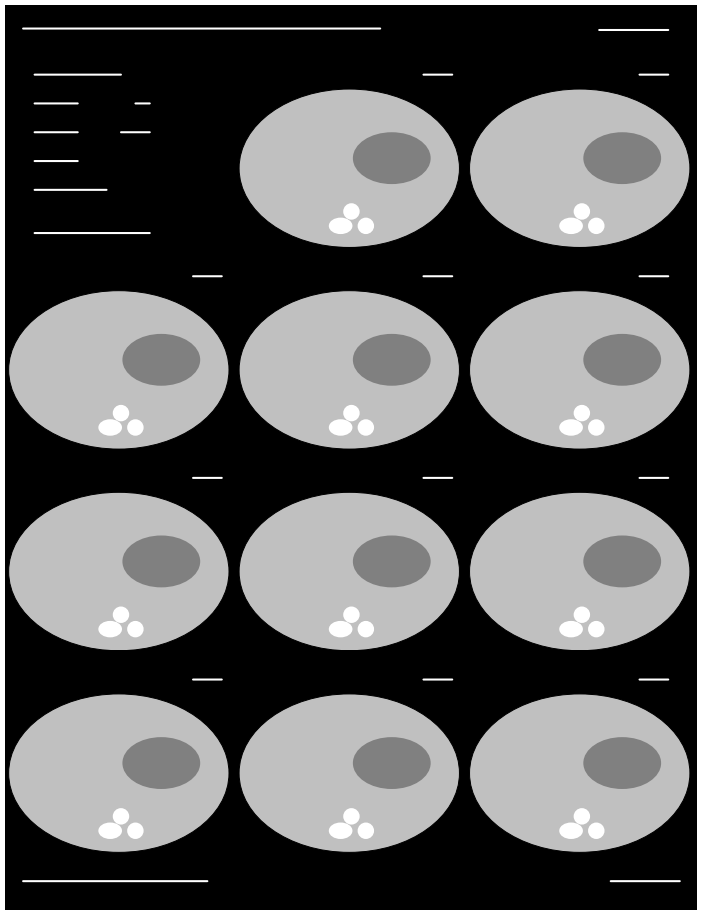
Rendered images at different destinations



Screen:
low resolution
fast response

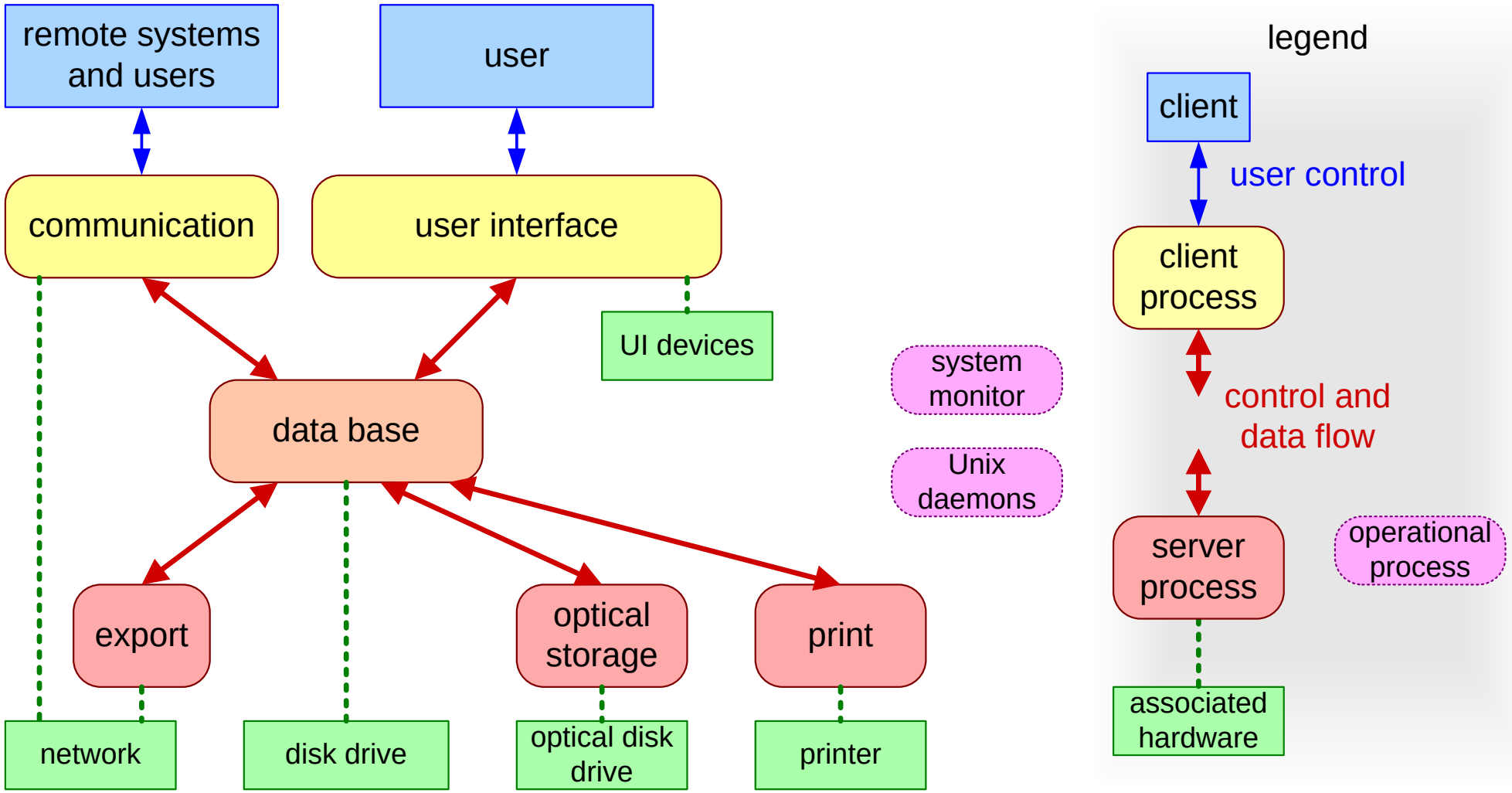


Network:
medium resolution
high throughput



Film:
high resolution
high throughput

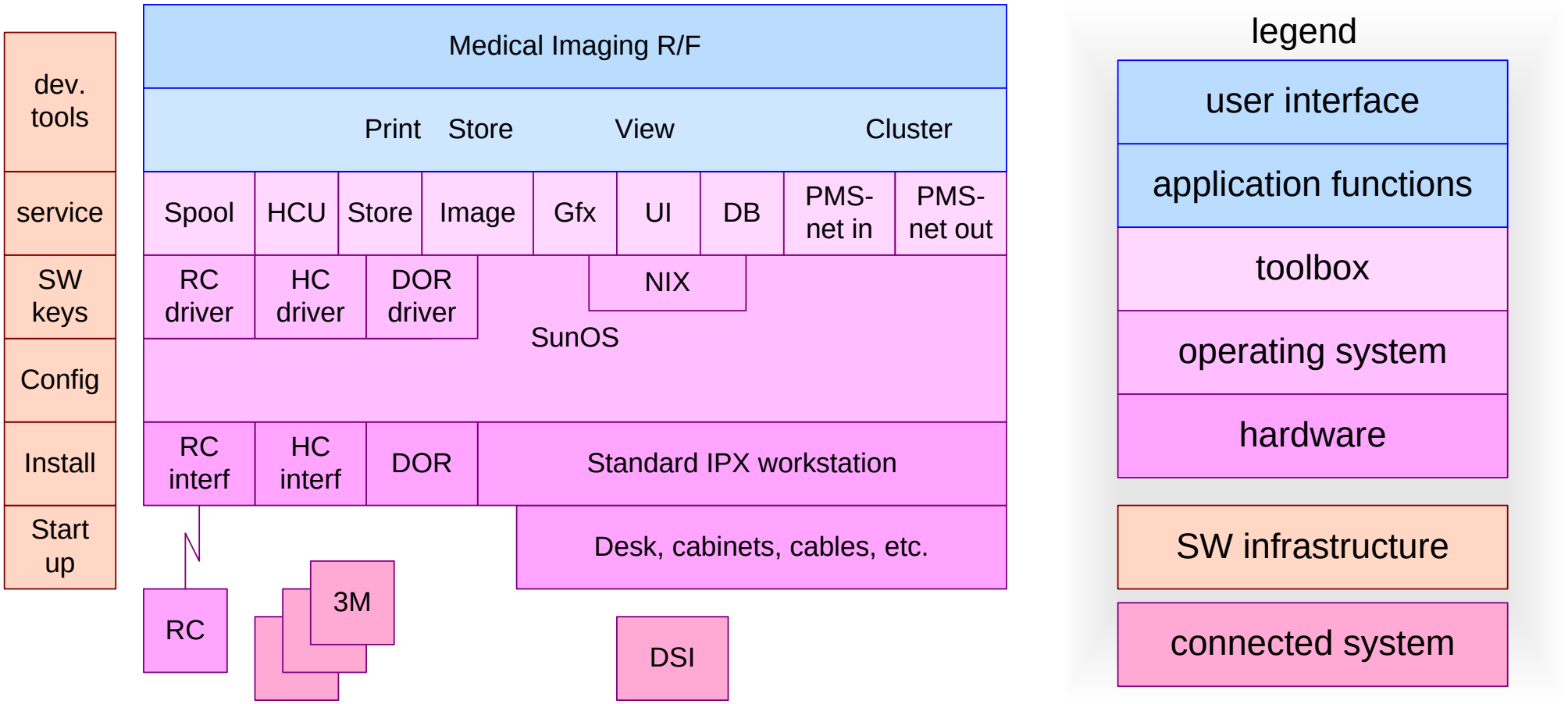
Concurrency via software processes



Criterions for process decomposition

- management of concurrency
- management of shared devices
- unit of memory budget (easy measurement)
- enables distribution over multiple processors
- unit of exception handling: fault containment and watchdog monitor

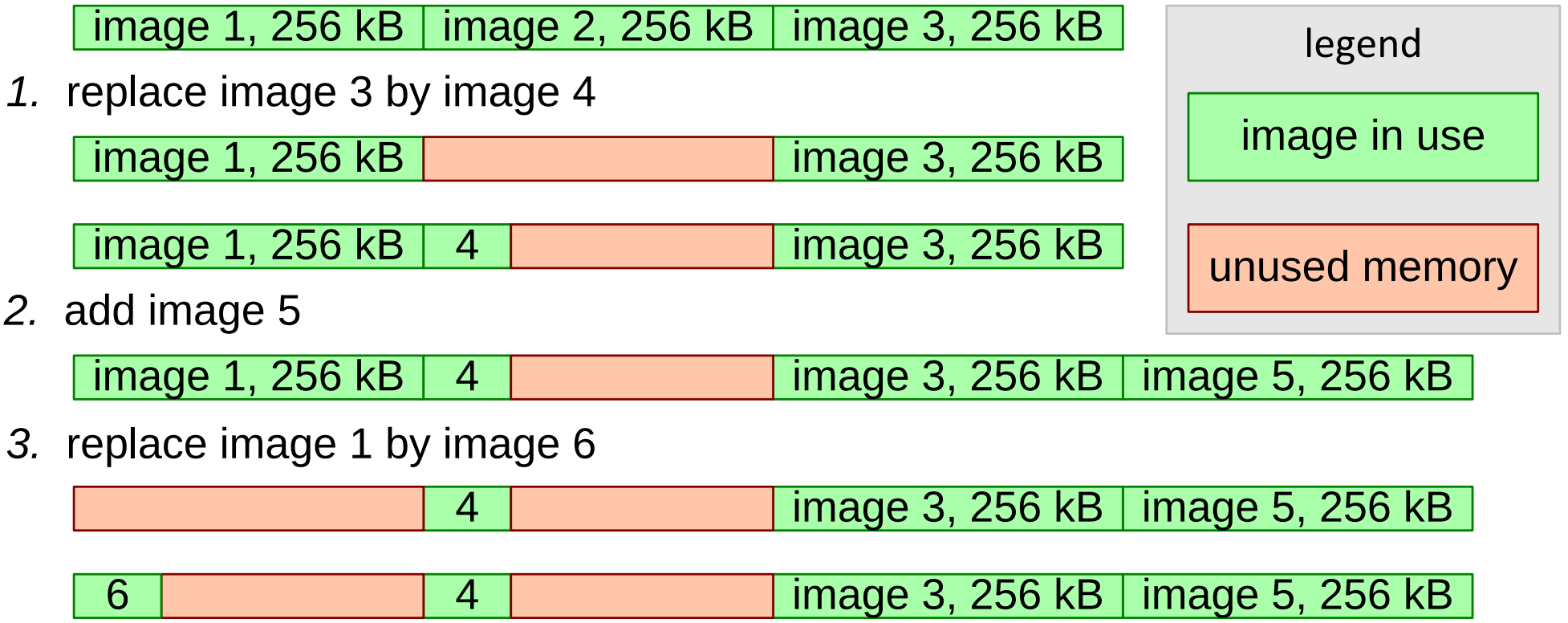
Simplified layering of the software



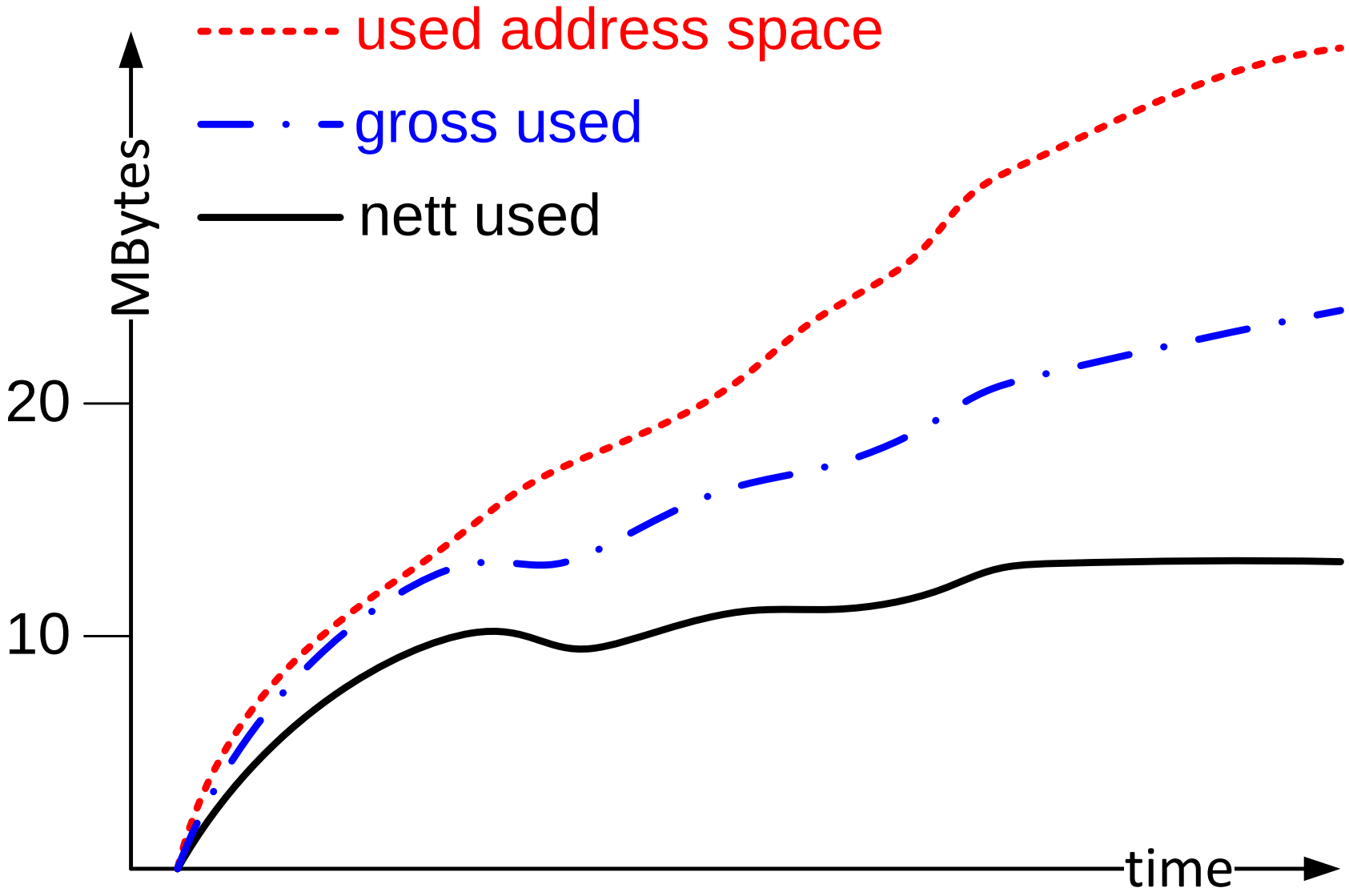
Memory budget of Easyvision RF R1 and R2

	code		object data		bulk data		total	
memory budget in Mbytes	R1	R2	R1	R2	R1	R2	R1	R2
shared code	6.0	11.0					6.0	11.0
UI process	0.2	0.3	2.0	3.0	12.0	12.0	14.2	15.3
database server	0.2	0.3	4.2	3.2		3.0	4.4	6.5
print server	0.4	0.3	2.2	1.2	7.0	9.0	9.6	10.5
DOR server	0.4	0.3	4.2	2.0	2.0	1.0	6.6	3.3
communication server	1.2	0.3	15.4	2.0	10.0	4.0	26.6	6.3
UNIX commands	0.2	0.3	0.5	0.2			0.7	0.5
compute server		0.3		0.5		6.0		6.8
system monitor		0.3		0.5				0.8
application total	8.6	13.4	28.5	12.6	31.0	35.0	66.1	61.0
UNIX							7.0	10.0
file cache							3.0	3.0
total							76.1	74.0

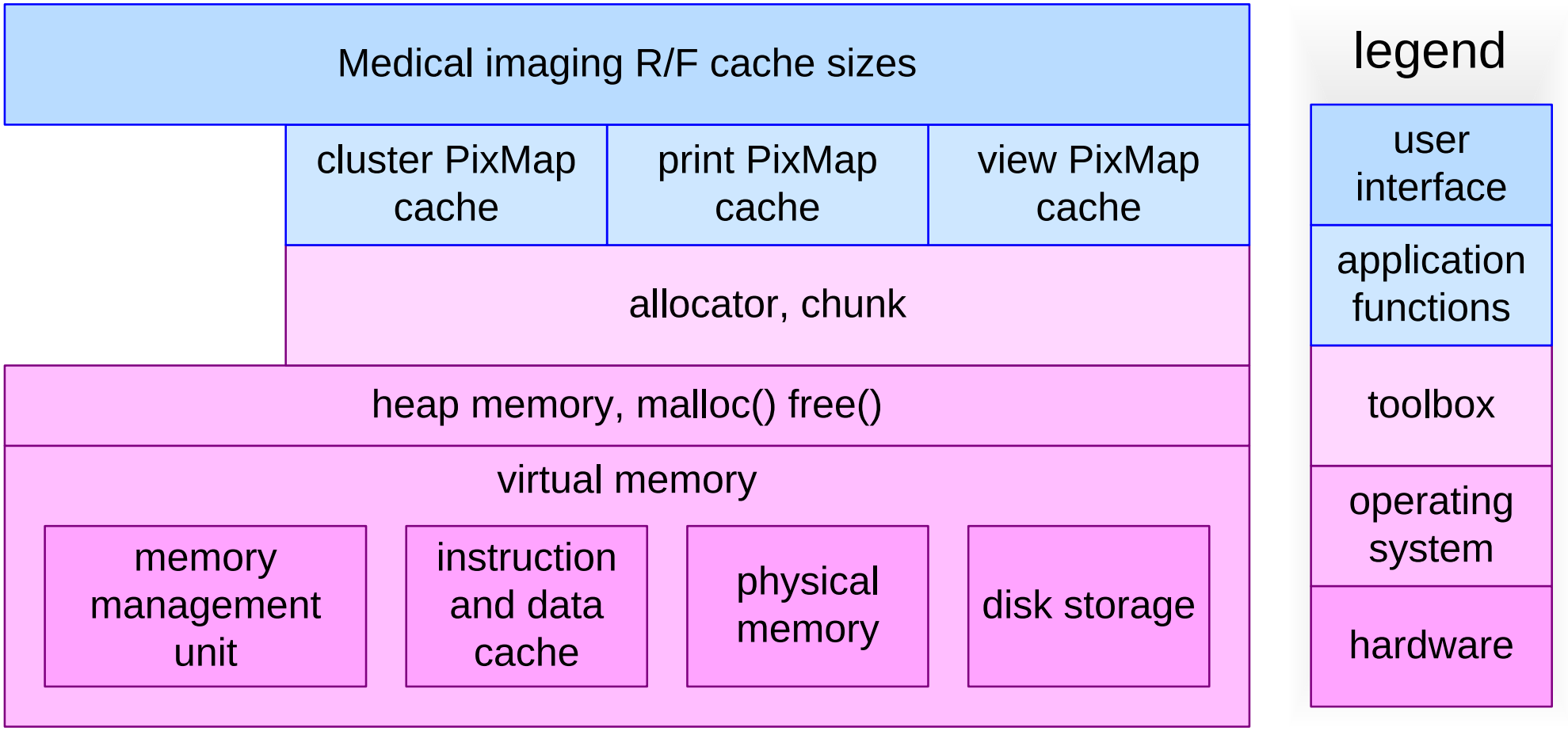
Memory fragmentation



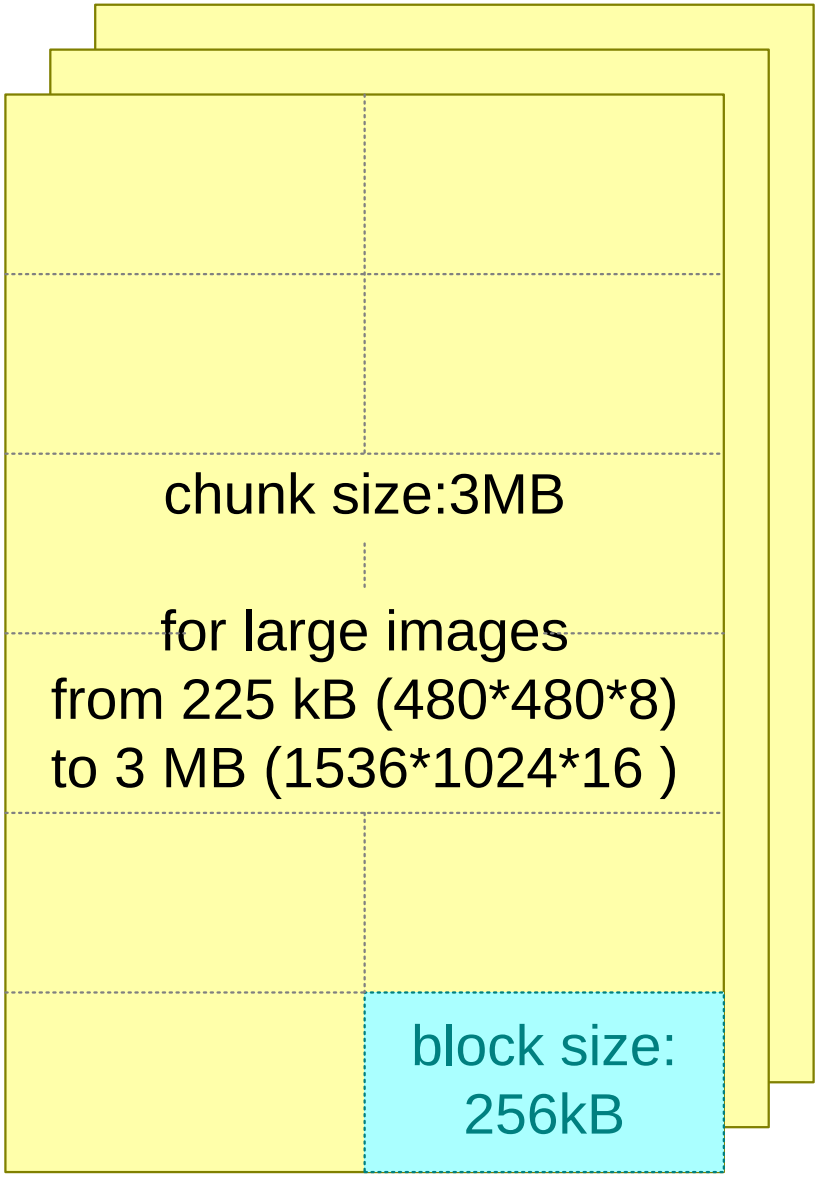
Memory fragmentation increase

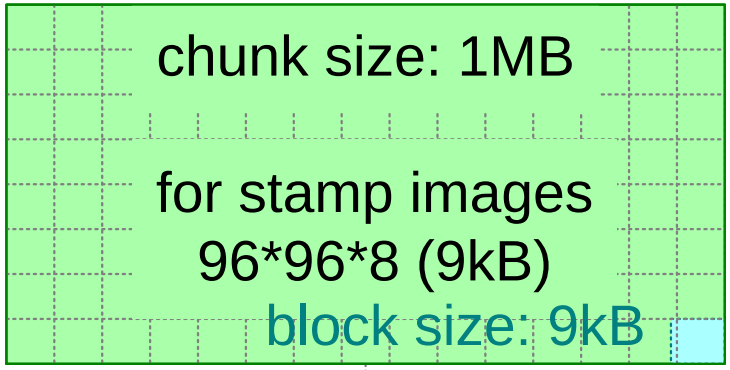


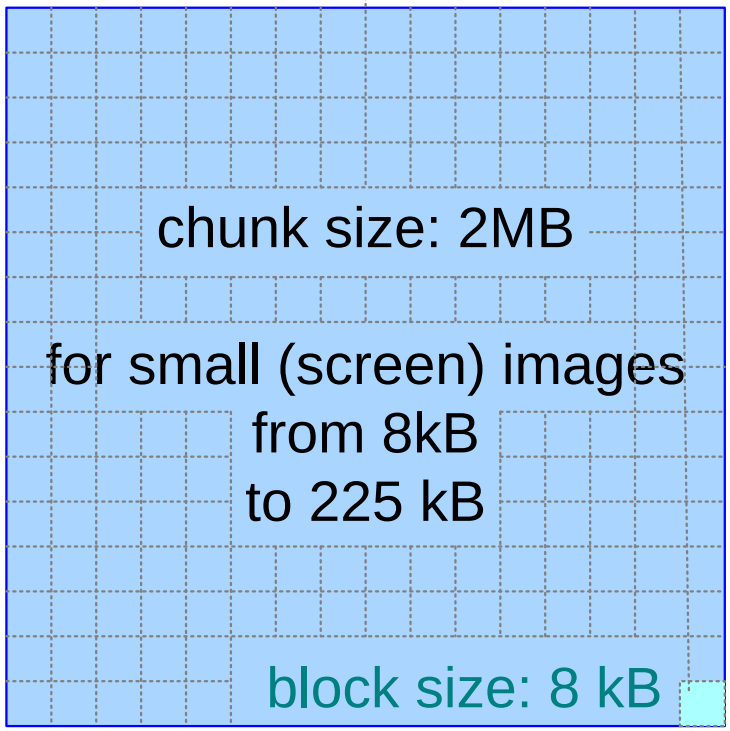
Cache layers



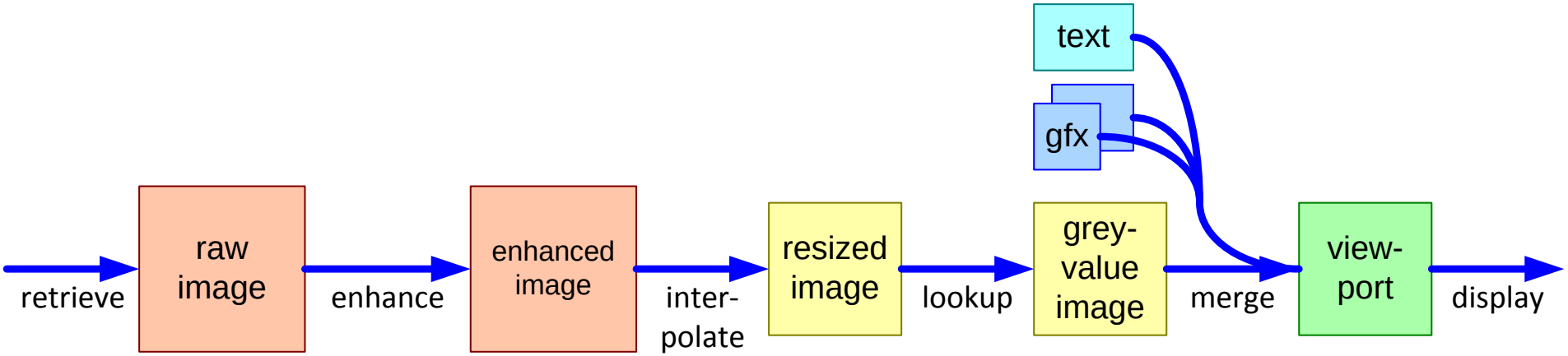
Bulk data memory management memory allocators



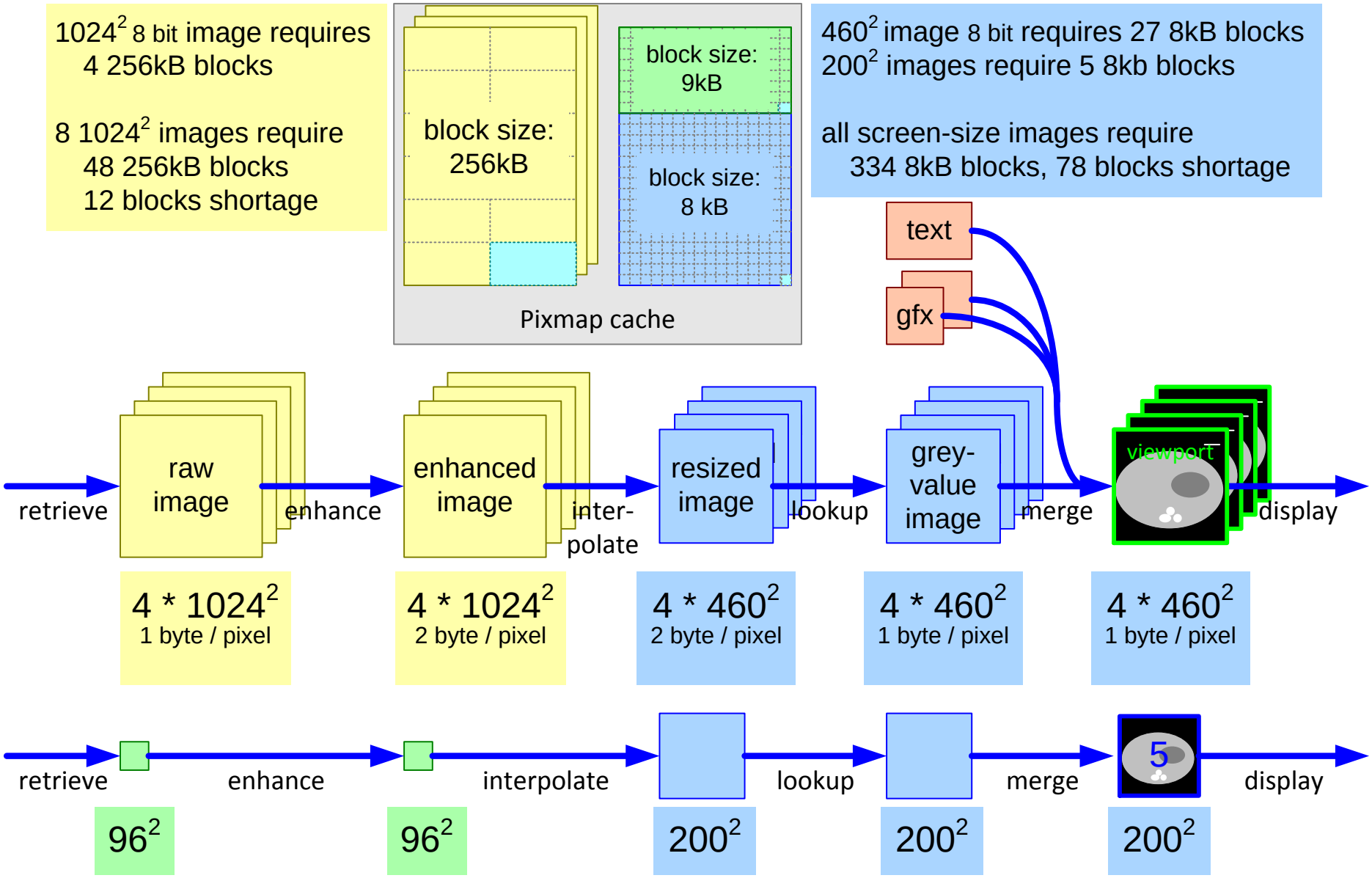




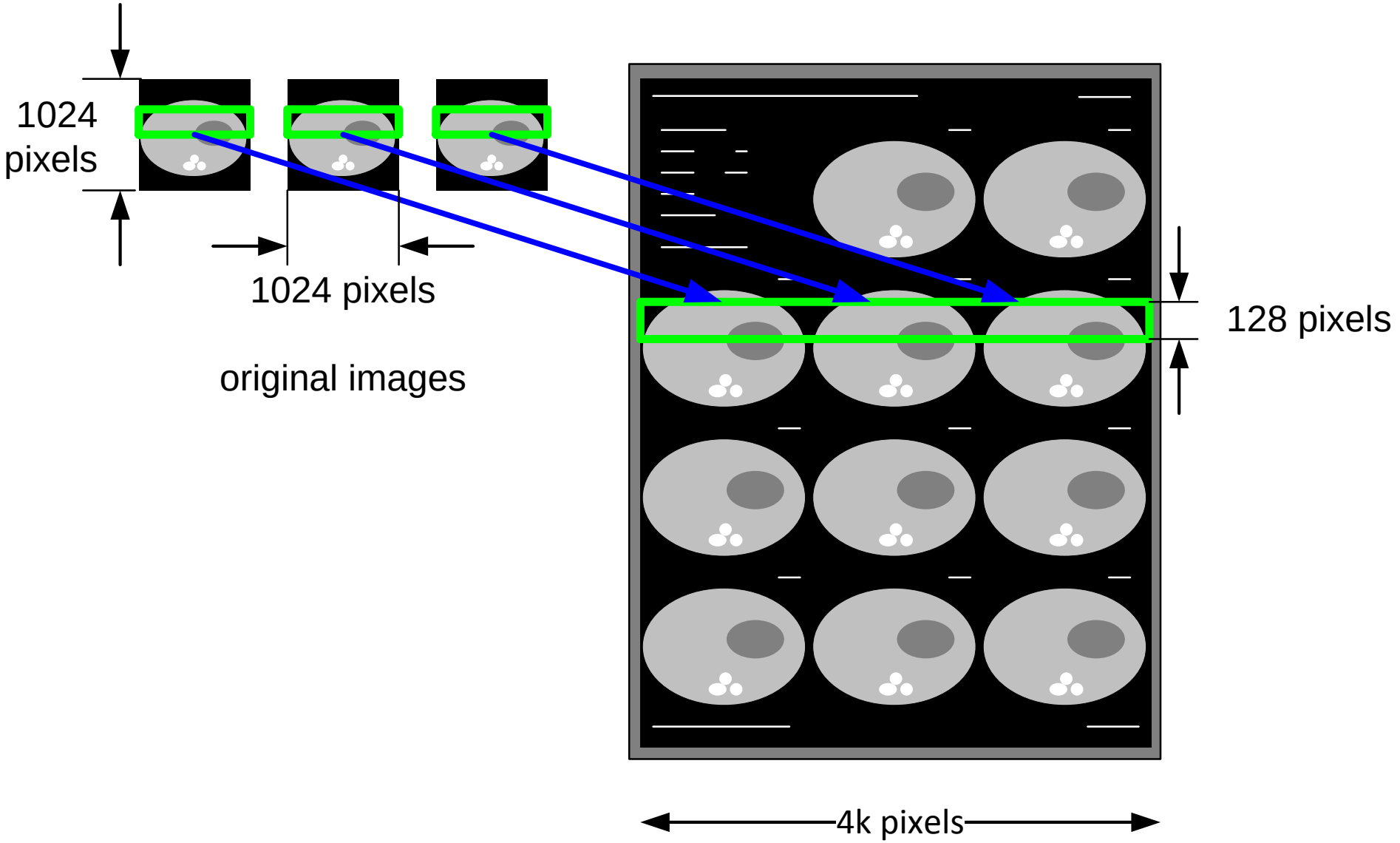
Cached intermediate processing results



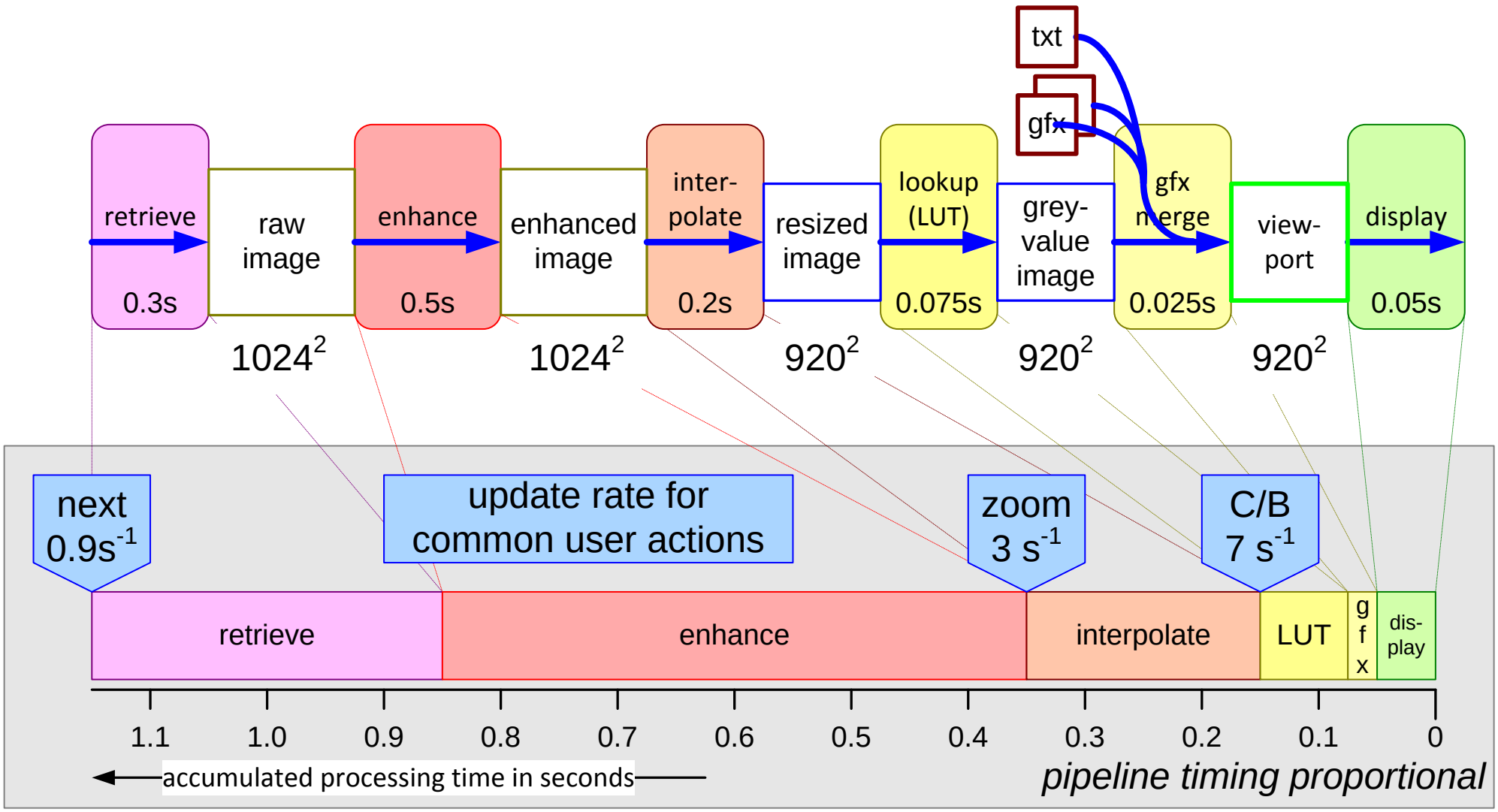
Example of allocator and cache use



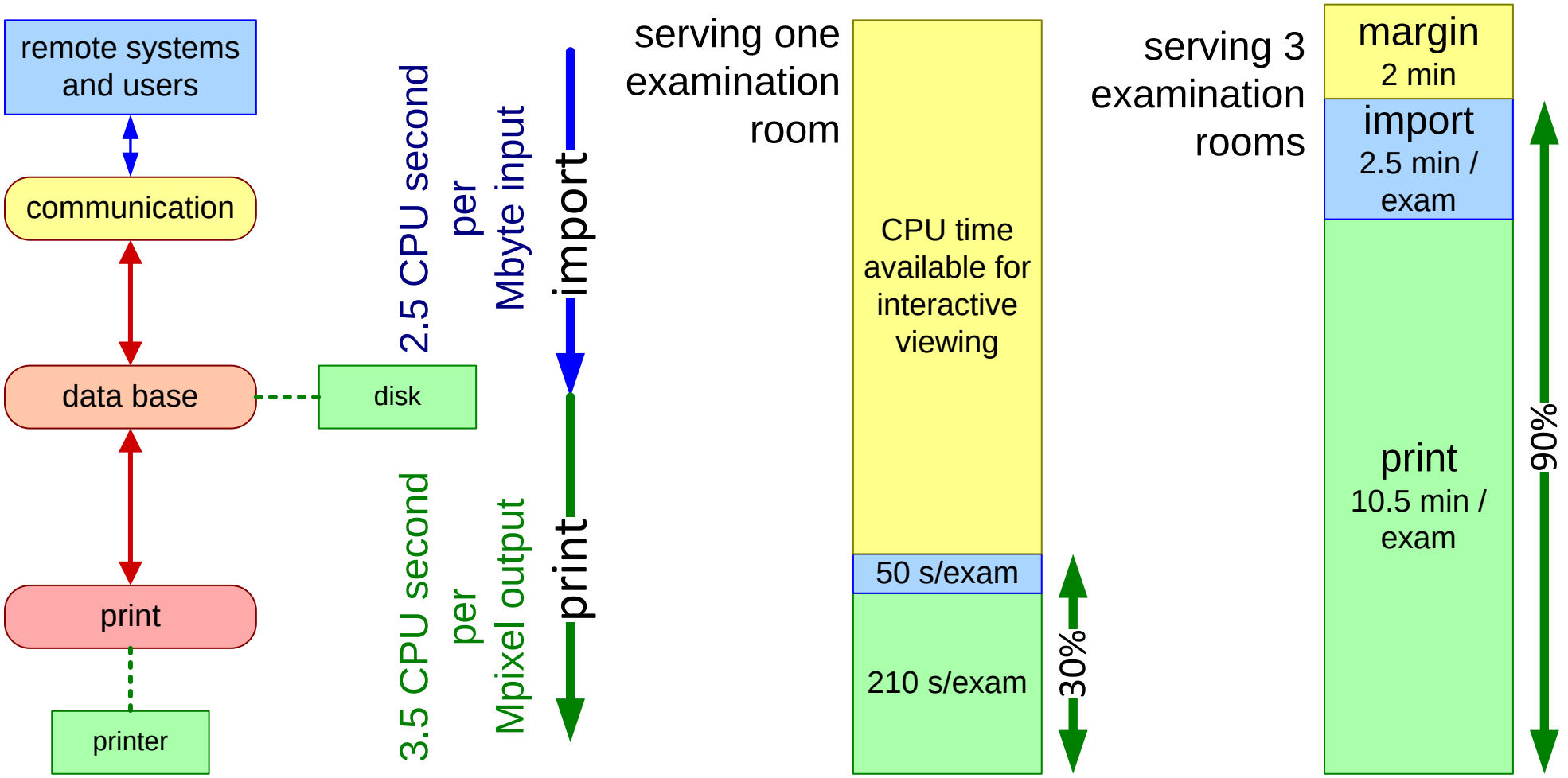
Print server is based on banding



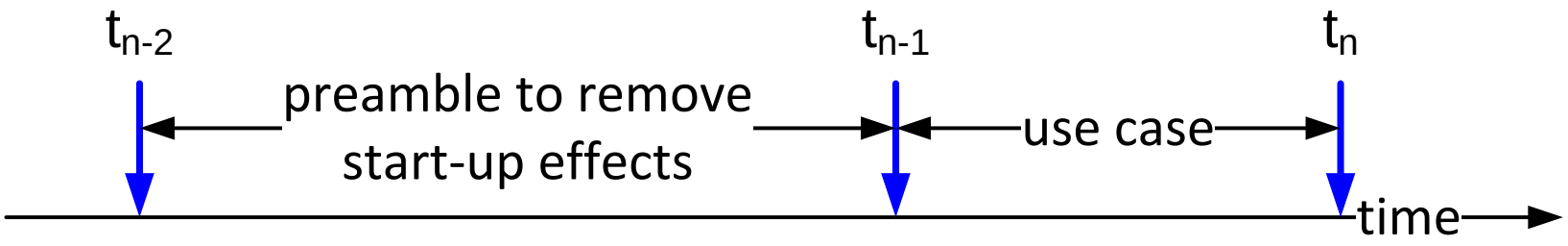
CPU processing times and viewing responsiveness



Server CPU load



Resource measurement tools



oit

△ object instantations
heap memory usage

ps
vmstat
kernel resource
stats

kernel CPU time
user CPU time
code memory
virtual memory
paging

heapviewer (visualise fragmentation)

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]

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

Coverage of submethods of the CR views

Conceptual	Realization
construction decomposition	*budget*
functional decomposition	*benchmarking*
designing with multiple decompositions	*performance analysis*
execution architecture	*granularity determination*
internal interfaces	
performance	
start up	
shutdown	
integration plan	
work breakdown	**value and cost**
safety	
reliability	safety analysis
security	reliability analysis
	security analysis

legend *explicitly addressed* **addressed only implicitly** not addressed

coverage based on documentation status of first product release

Nota Bene

disclaimer

The case material is based on actual data, from a complex context with large commercial interests. The material is ***simplified*** to increase the accessibility, while at the same time ***small changes*** have been made to remove commercial sensitivity. Commercial sensitivity is further reduced by using relatively ***old*** data (between 5 and 10 years in the past). Care has been taken that the illustrative value is maintained