Medical Imaging; Evolution of Understanding

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Abstract

The medical imaging workstation is used as case to show the increased understanding during the creation of the product. We also show the later strategic vision based on the increased customer understanding.

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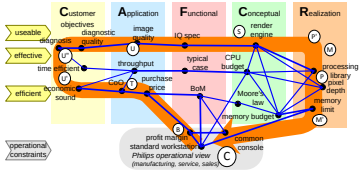
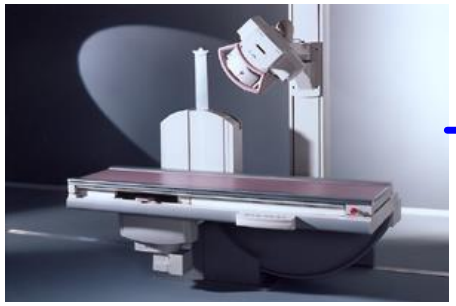
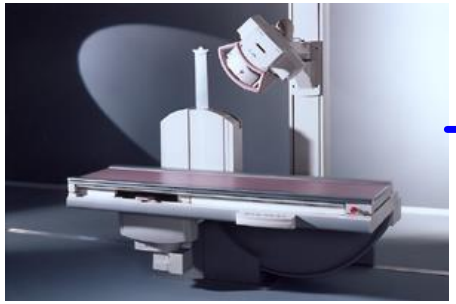
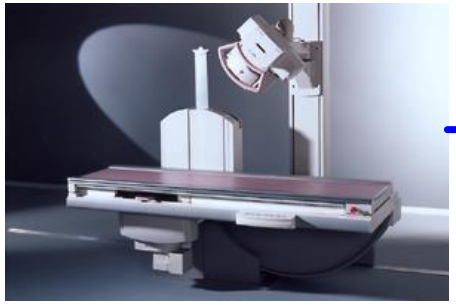


cost revisited in context of clinical needs and realization constraints; note: original threads are significantly simplified

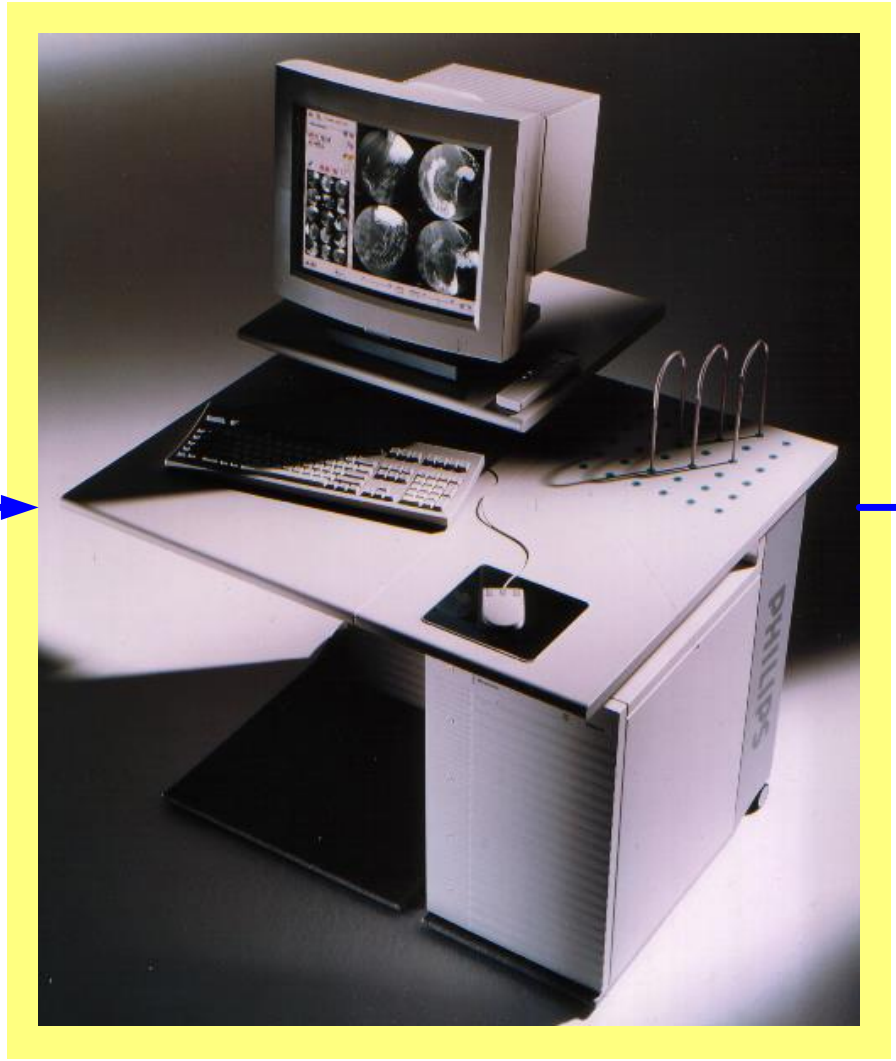
Easyvision serving three URF examination rooms







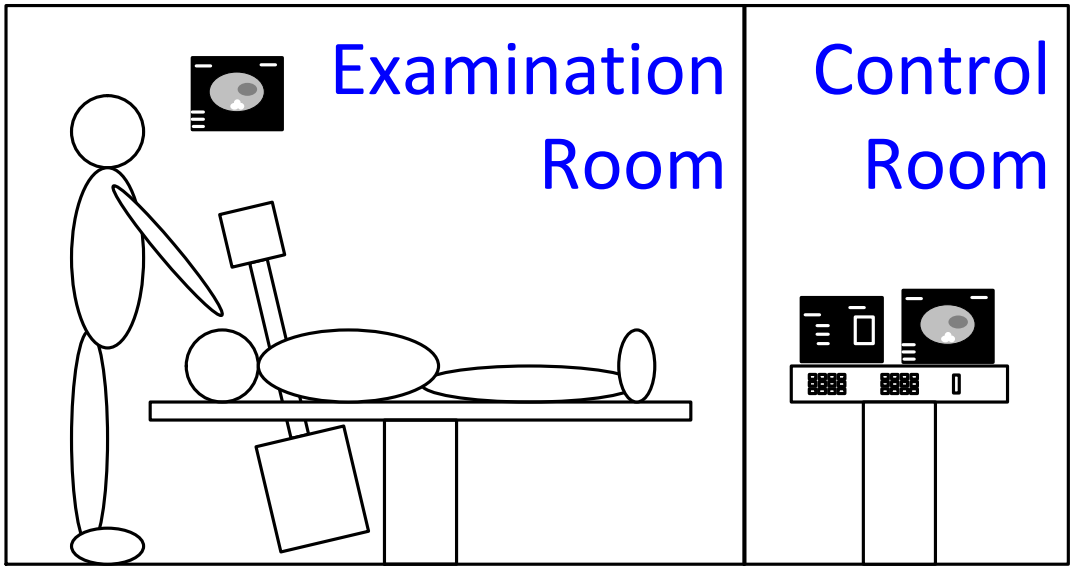
URF-systems

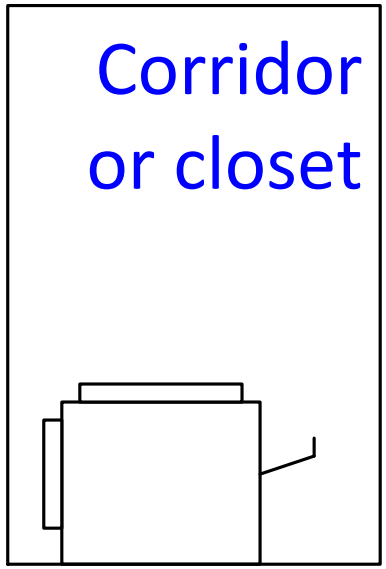


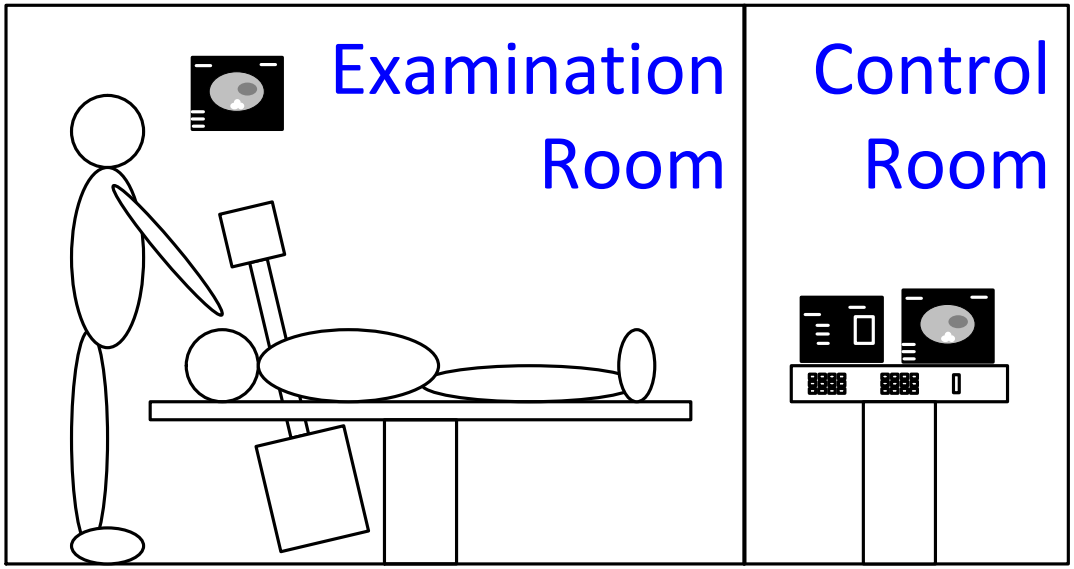
EasyVision: Medical Imaging Workstation

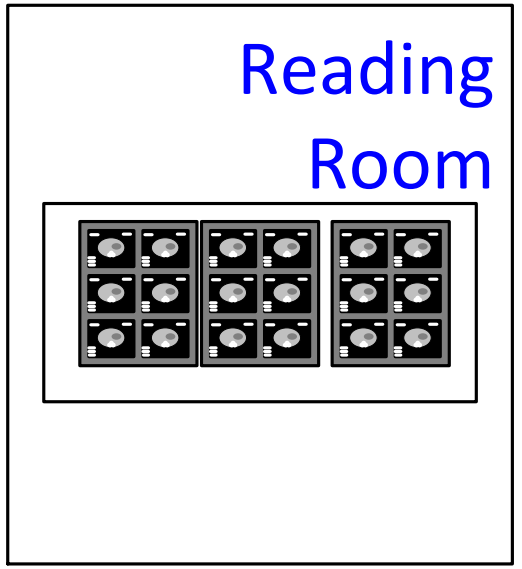
typical clinical image (intestines)

X-ray rooms from examination to reading around 1990

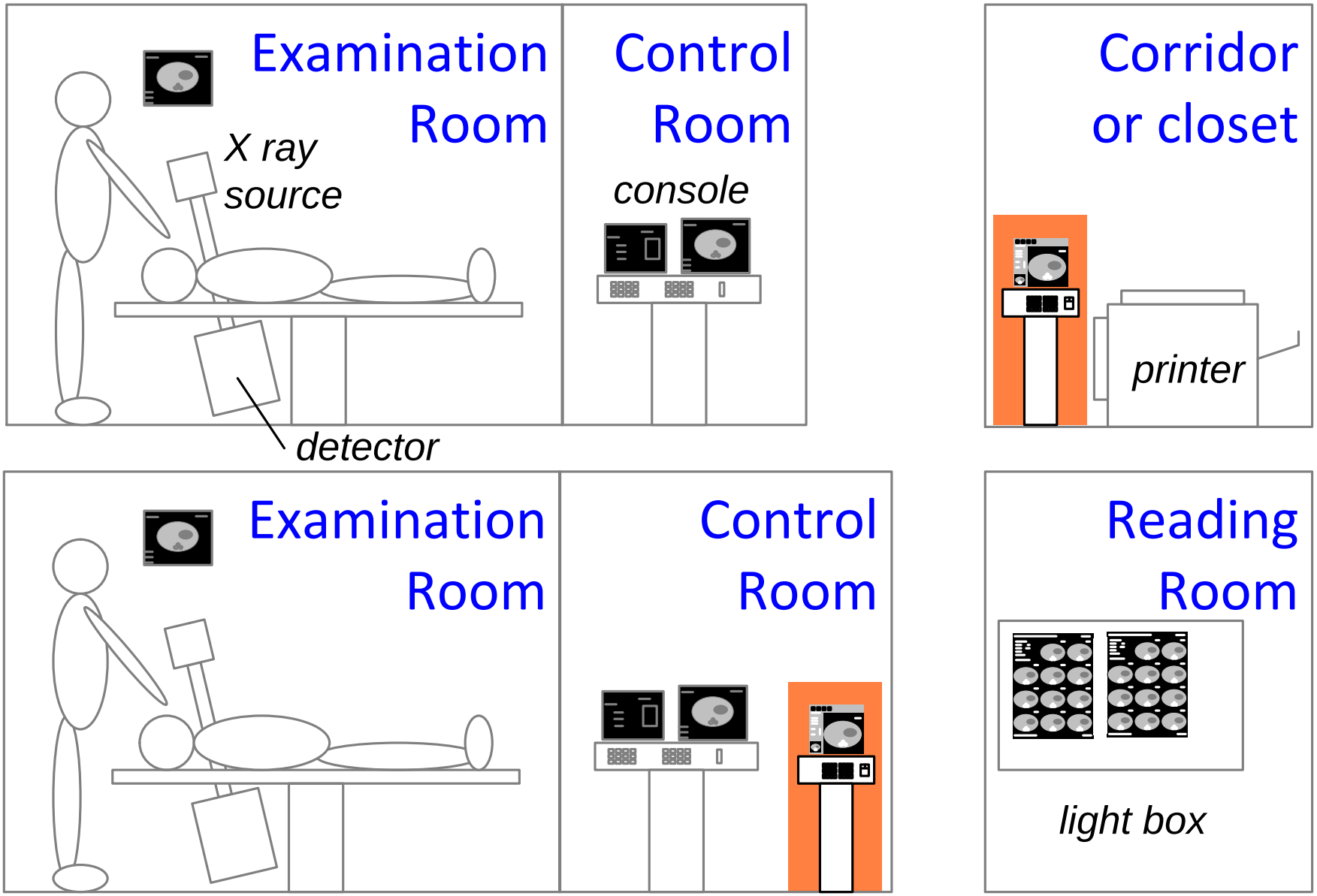




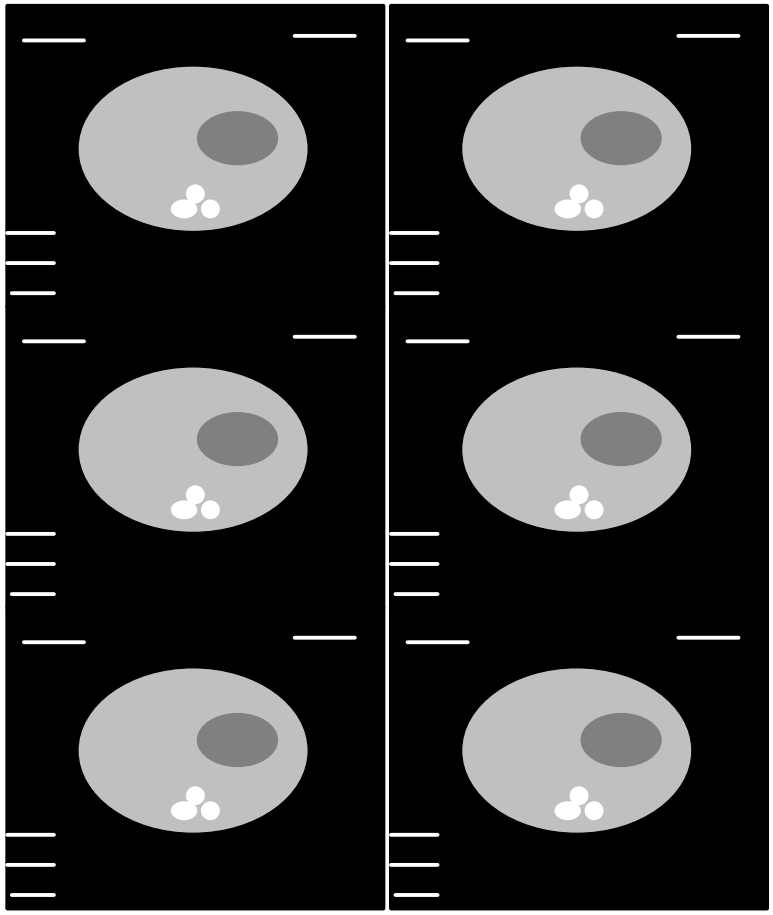




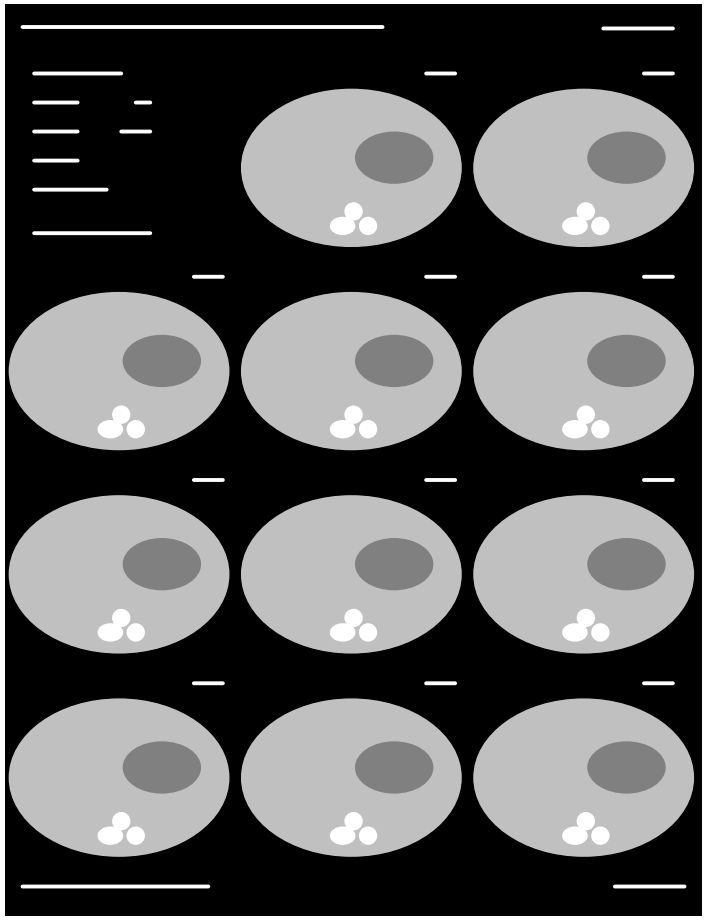
X-ray rooms with Easyvision applied as printserver



Comparison screen copy versus optimized film



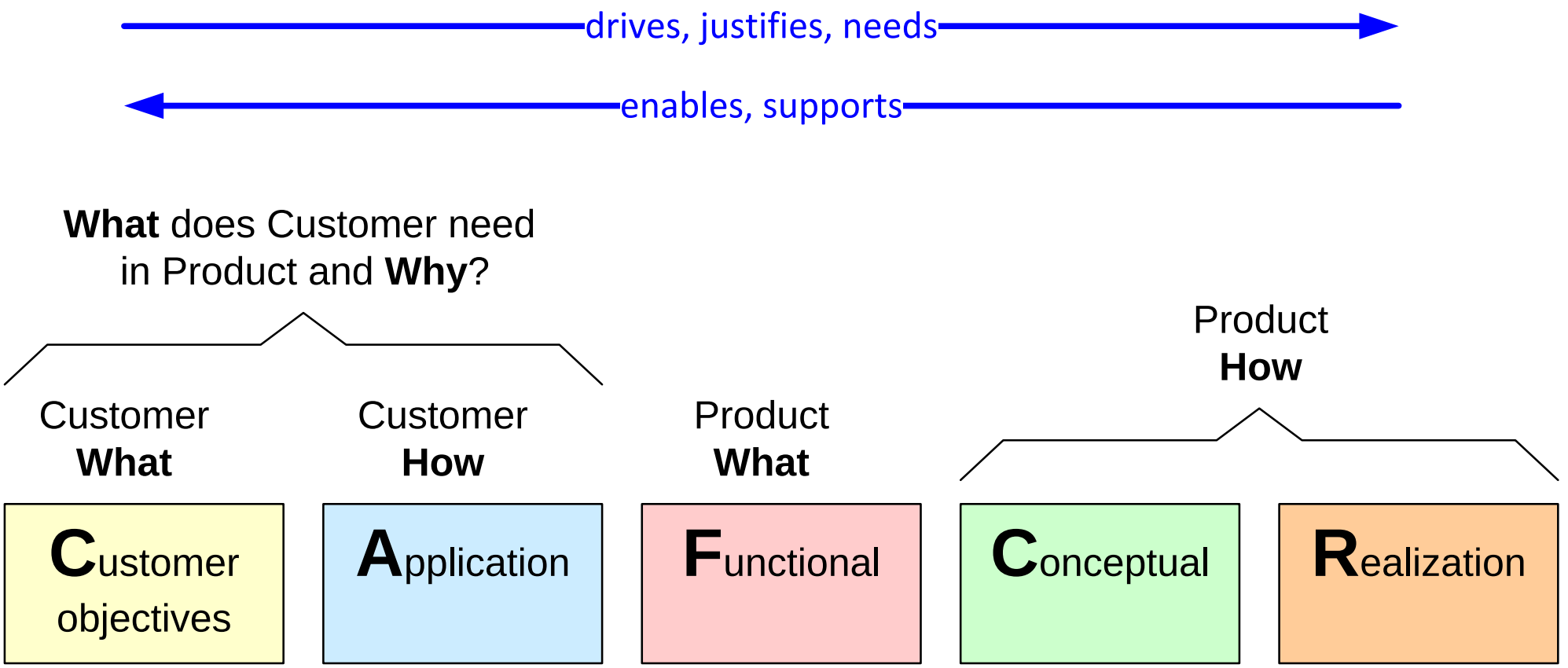
old: screen copy



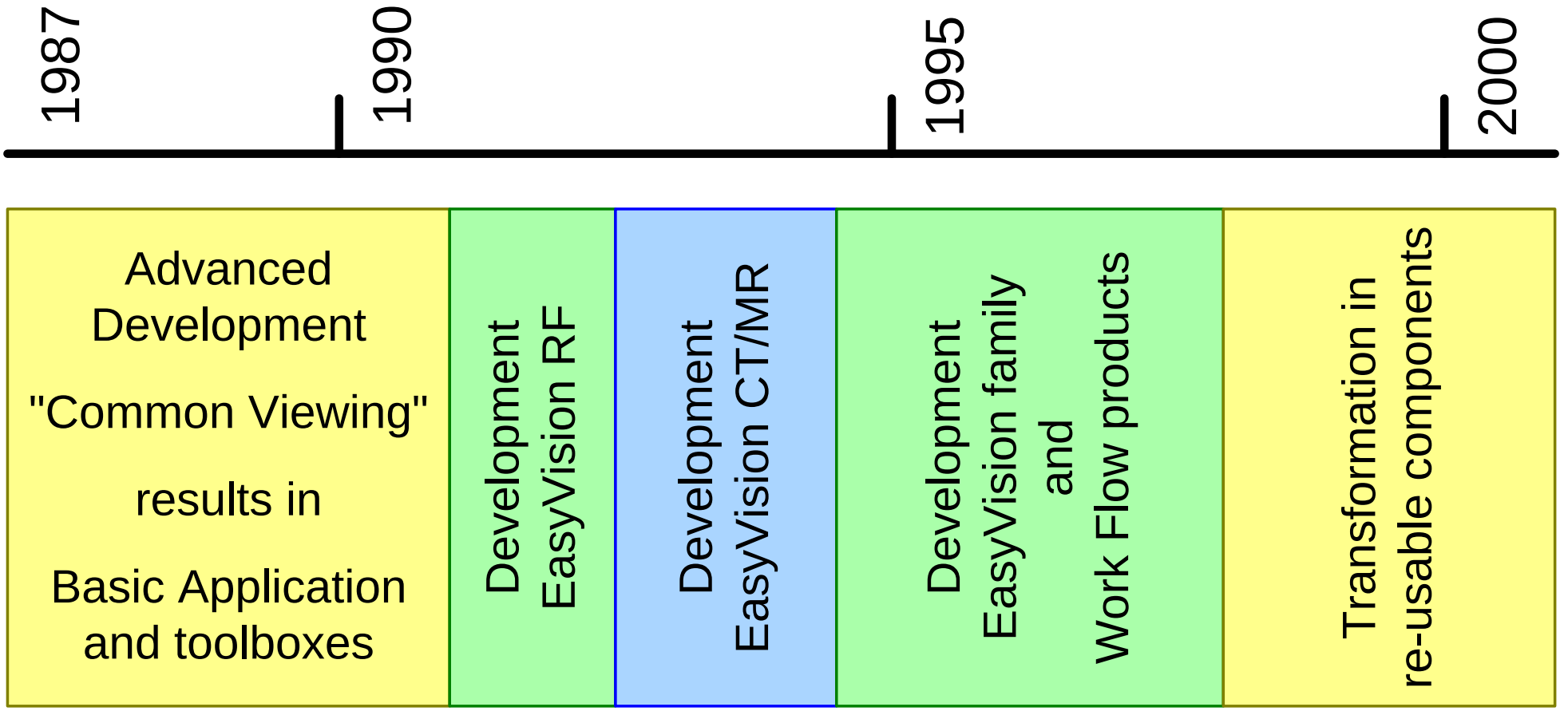
new: SW formatting

20 to 50% less film needed

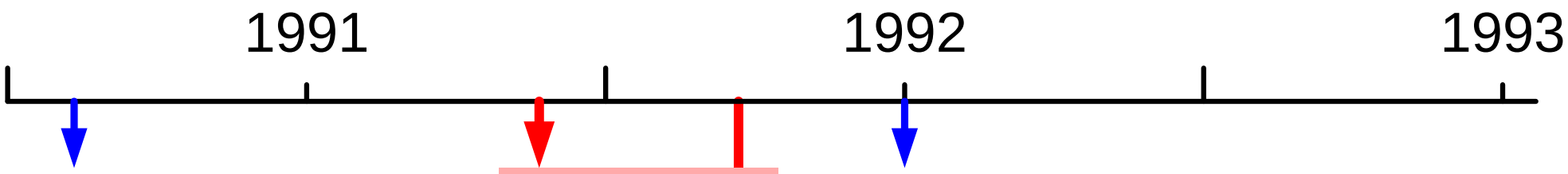
CAFCR viewpoints



Time line of Viewing Products



Chronology of Easyvision RF R1 development



basic application
toolboxes
100 kloc

interactive viewing

performance
problems

IQ
problems

Easyvision RF
integrated product
360 kloc

print server +
communication +
interactive viewing

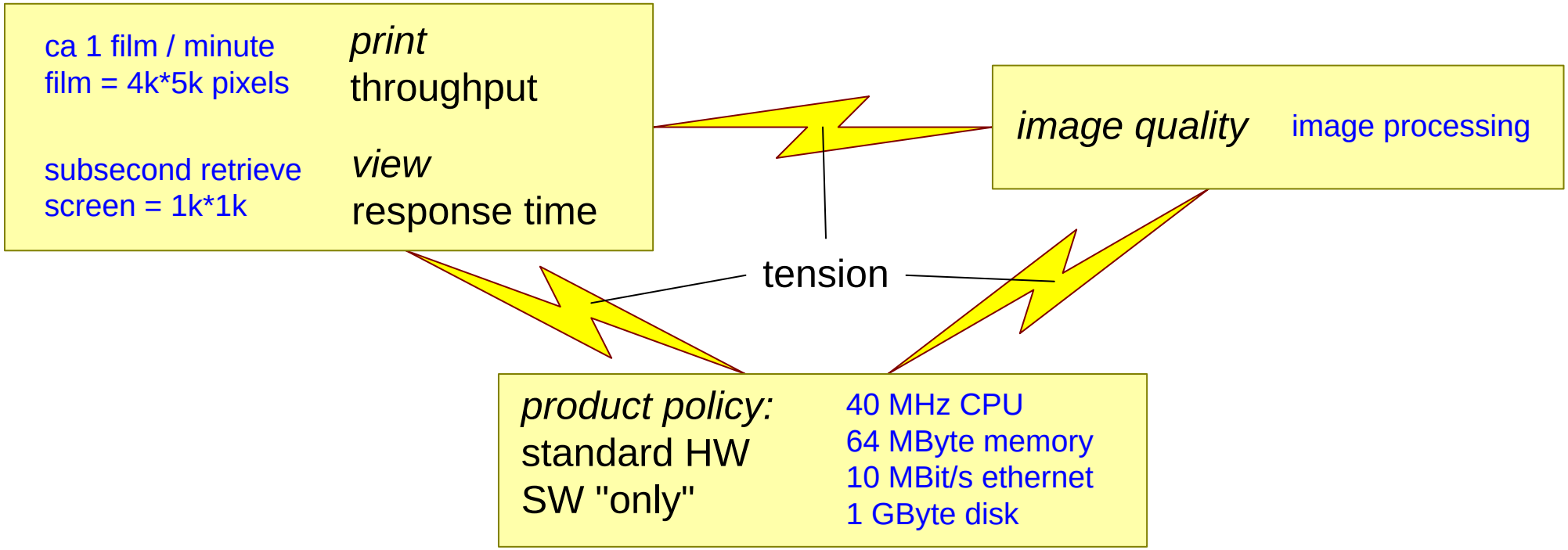
marketing opinion:
"All the functionality is available,
we only have to provide a clinical UI"

Technology Innovations initiated by AD

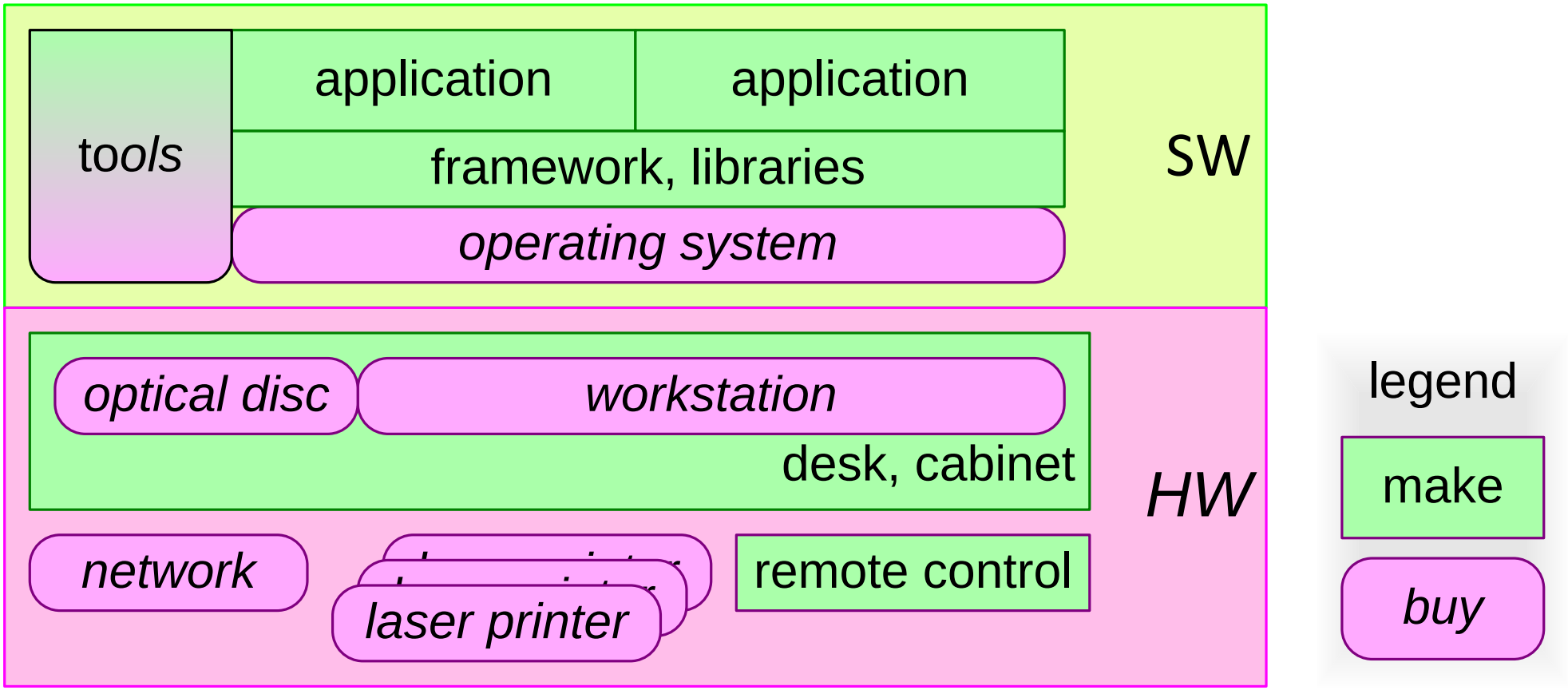
performance
cost

- standard UNIX based workstation
- full SW implementation, more flexible
- object oriented design and implementation (Objective-C)
- graphical User Interface, with windows, mouse etcetera
- call back scheduling, fine-grained notification
- data base engine, fast, reliable and robust
- extensive set of toolboxes
- property based configuration
- multiple coordinate spaces

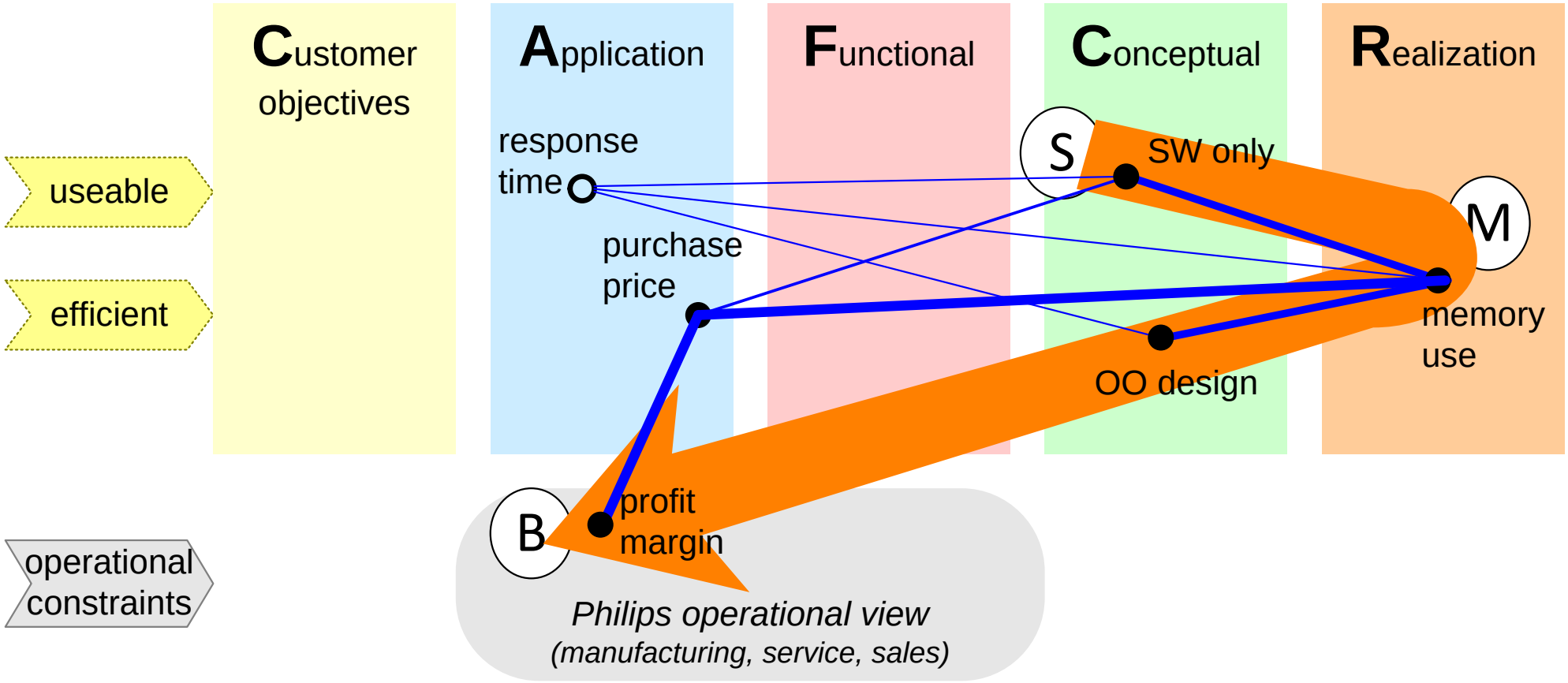
Challenges for product creation



Top level decomposition

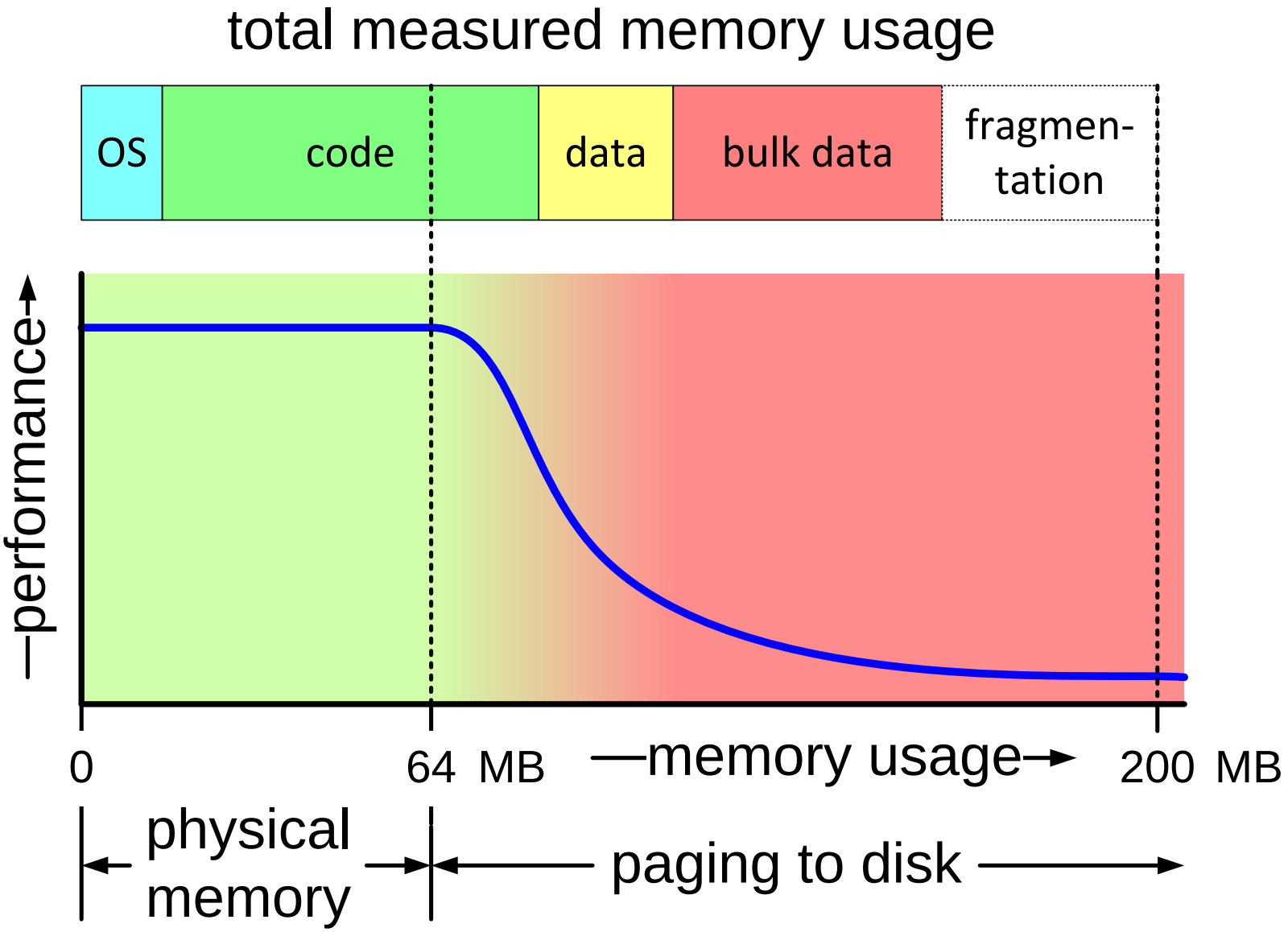


Thread of reasoning; introvert phase

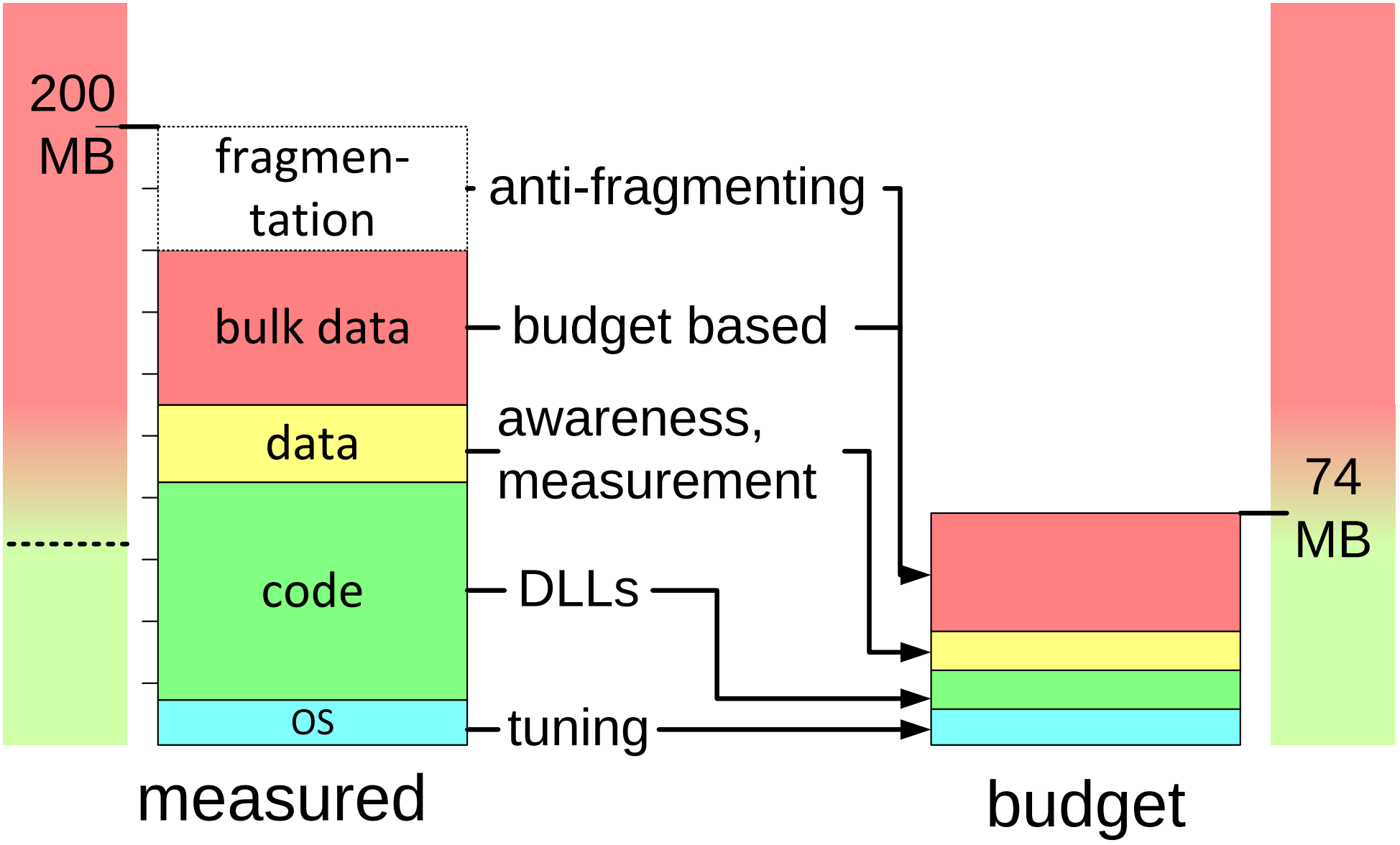


Introvert view: cost and impact of new technologies

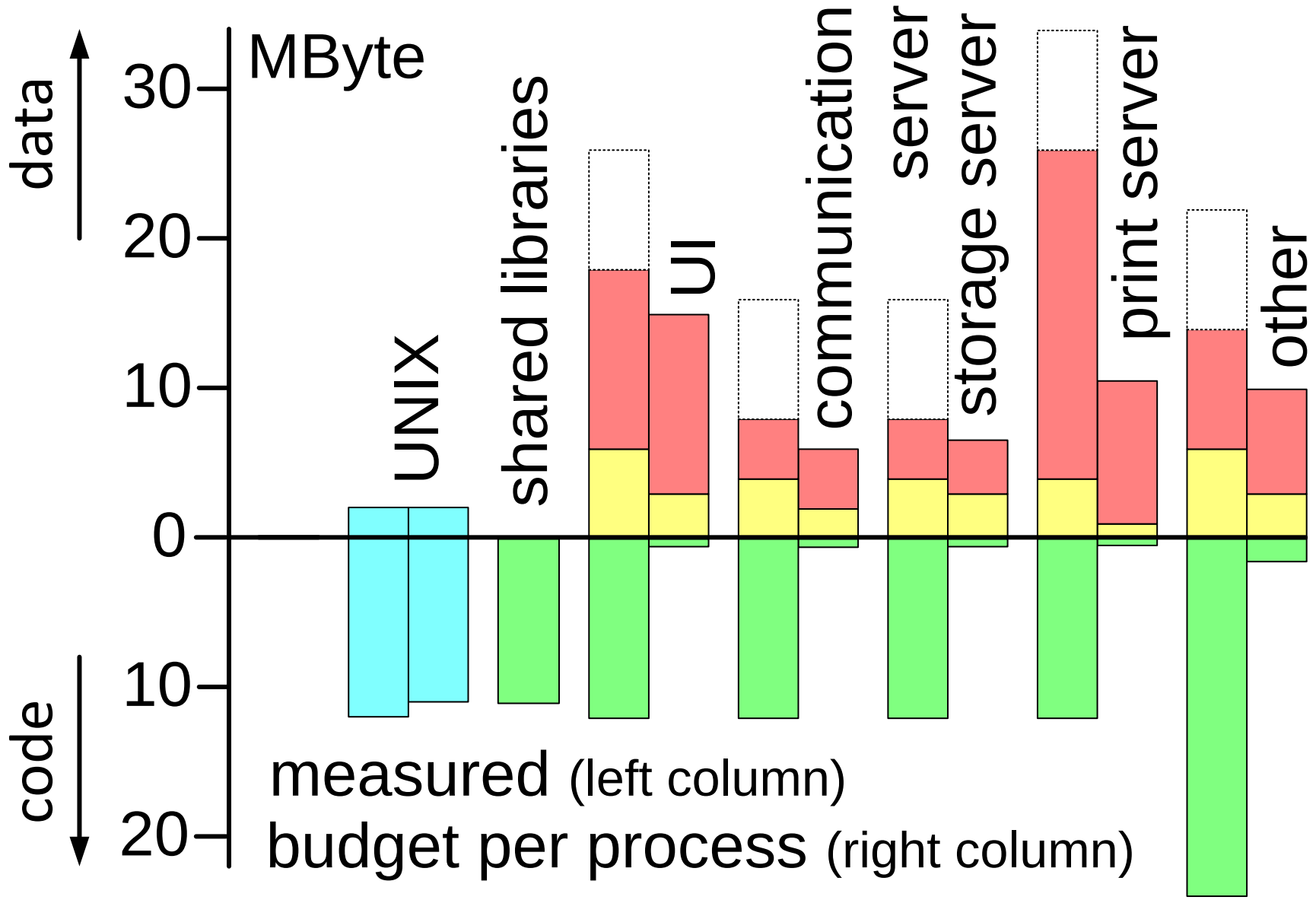
Memory usage half way R1



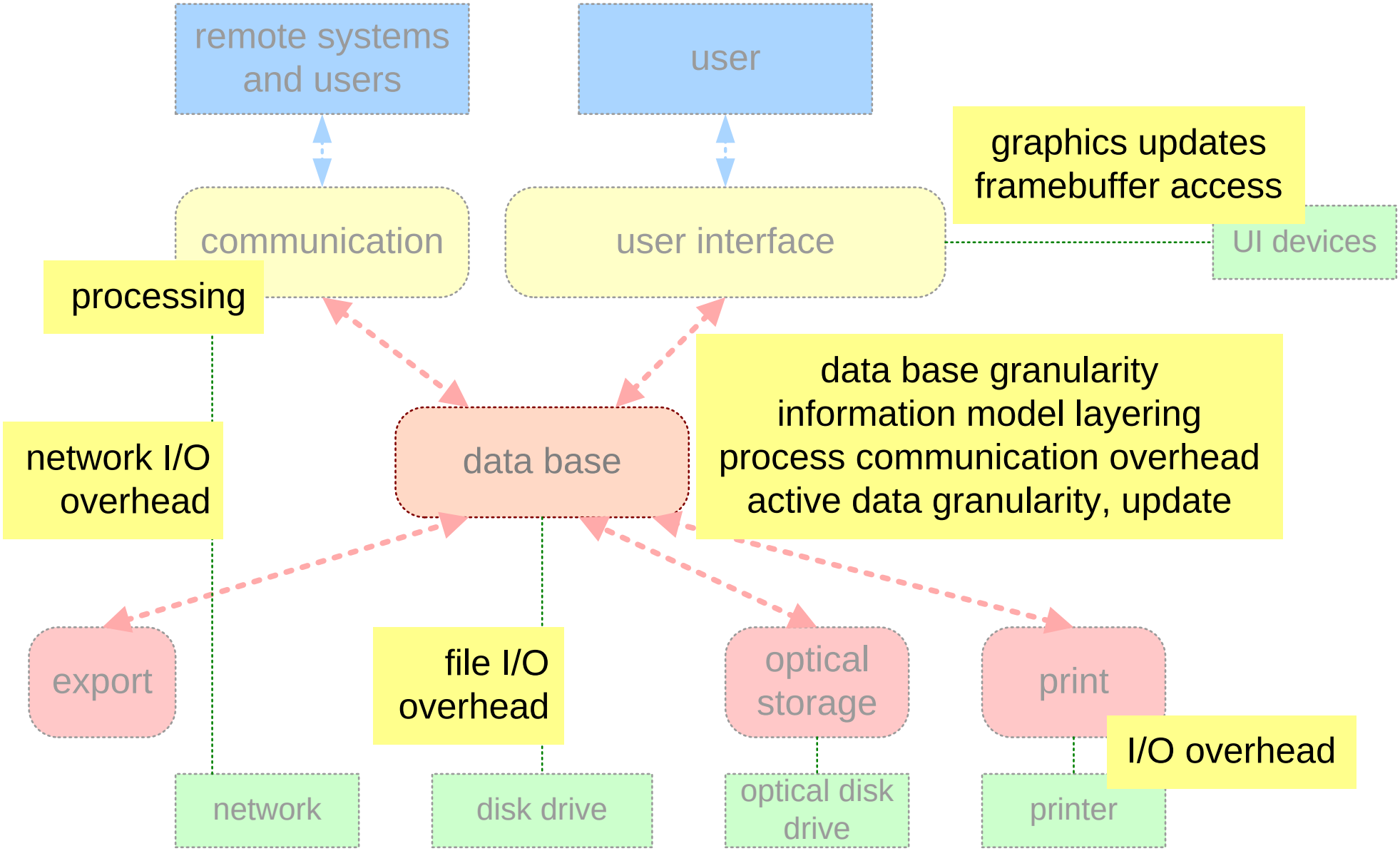
Solution of memory performance problem



Visualization memory use per process

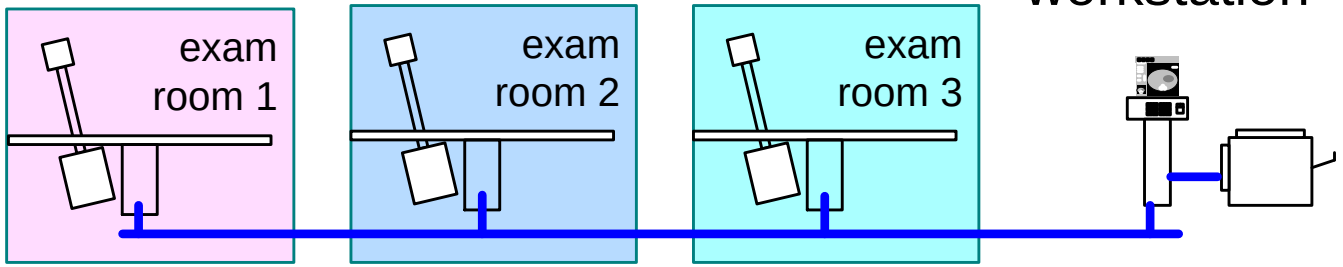


Causes of Performance Problems other than Memory Use



Typical case URF examination

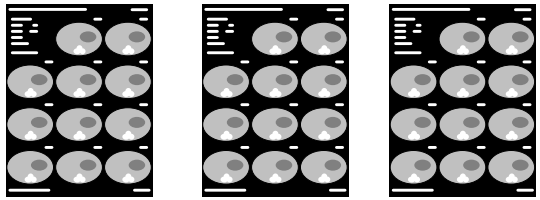
3 examination rooms connected to 1 medical imaging workstation + printer



examination room: average 4 interleaved examinations / hour

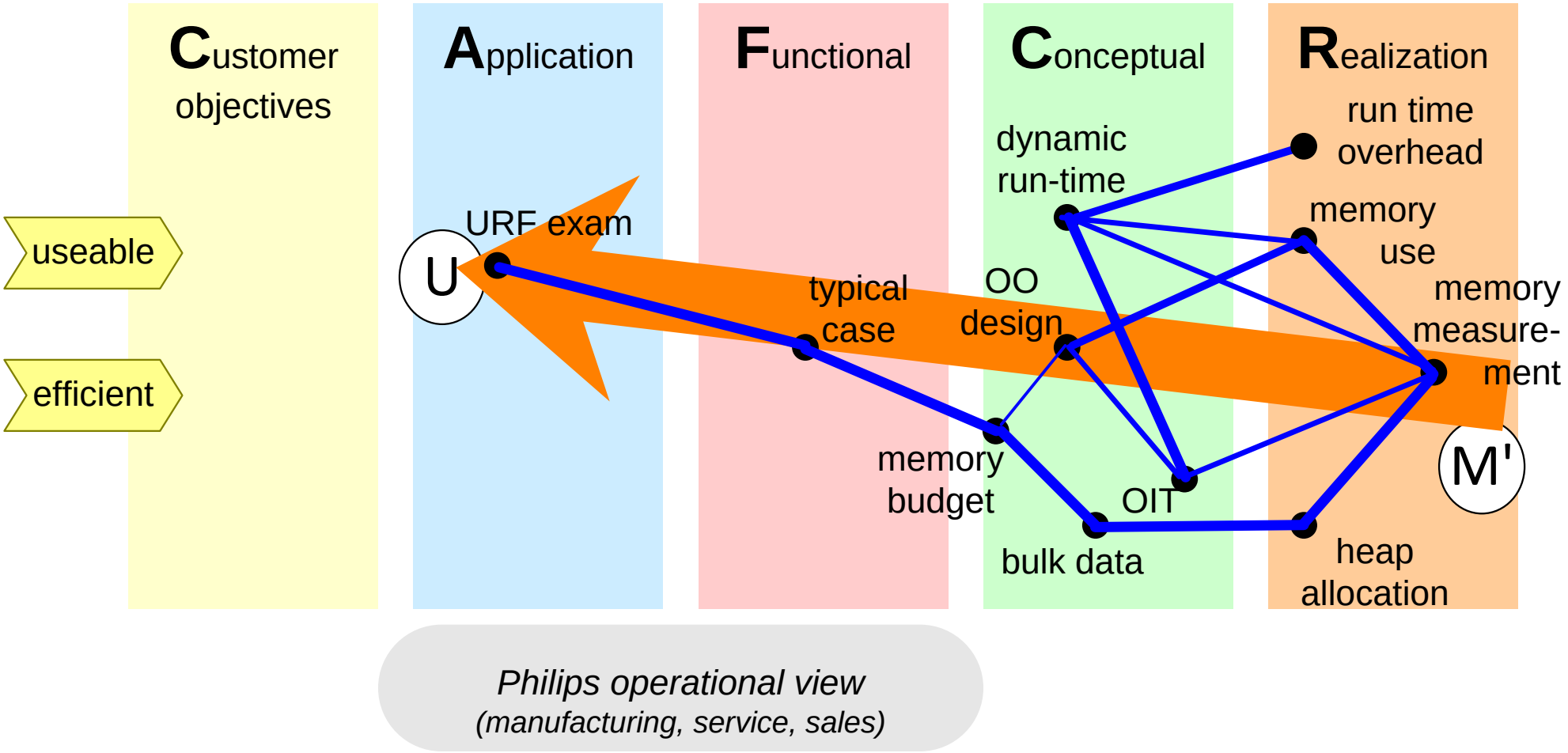
image production: 20 1024^2 8 bit images per examination

film production: 3 films of 4k*5k pixels each



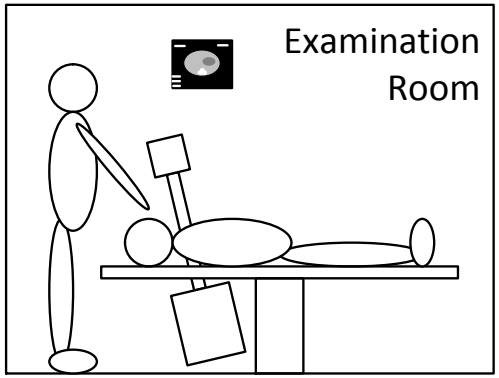
high quality output
(bi-cubic interpolation)

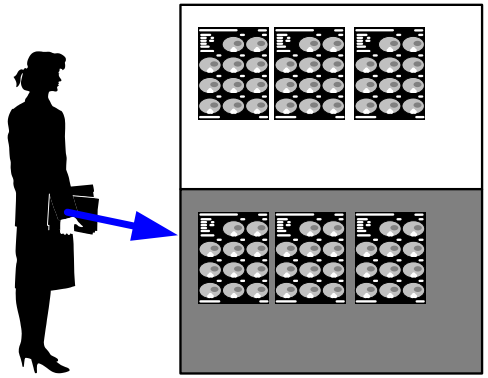
Thread of reasoning; phase 2



How to measure memory, how much is needed?
from introvert to extrovert

Radiologist workspots and activities





dictation
room

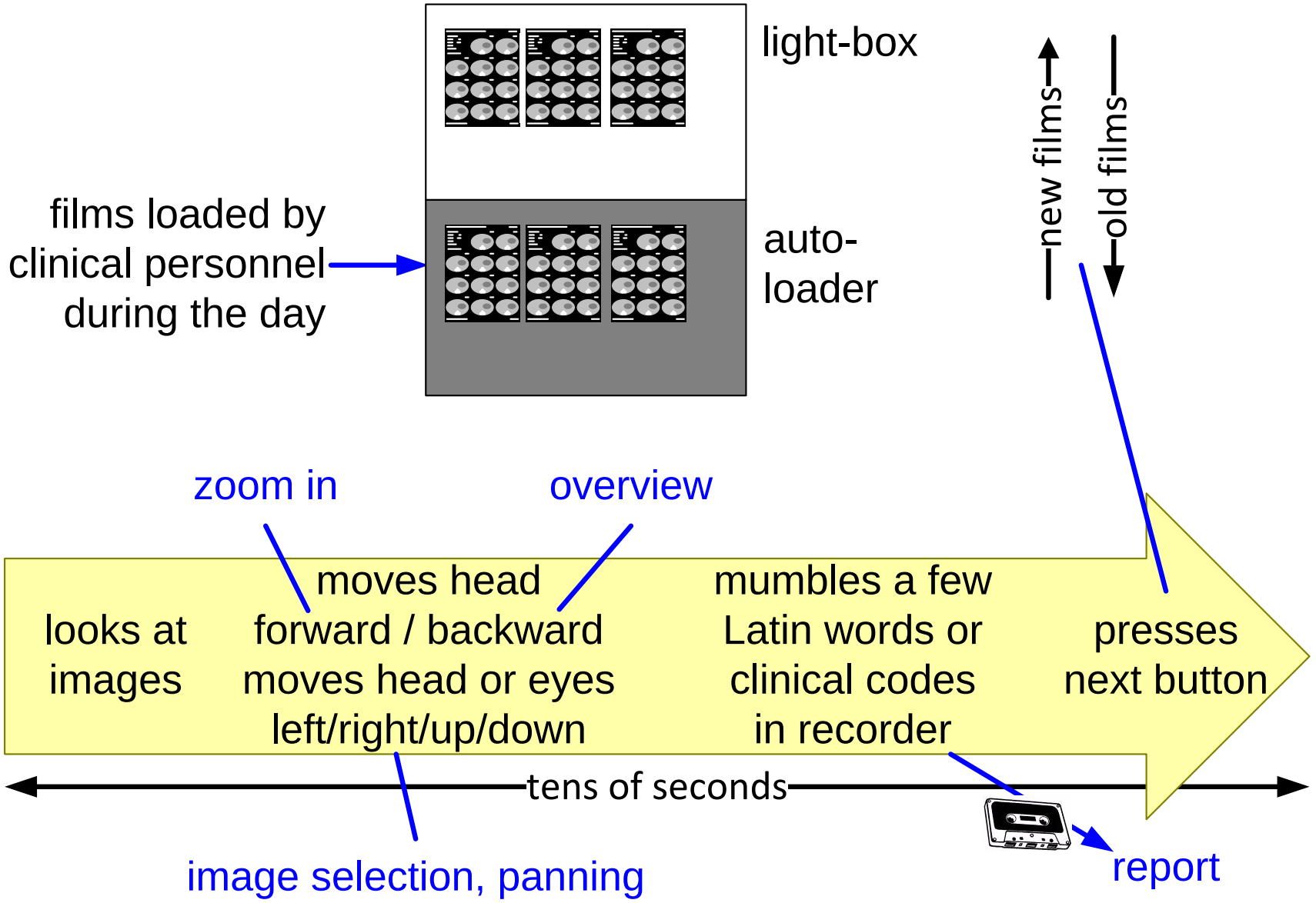
supervision
of the
examination

view and
diagnose,
dictate report

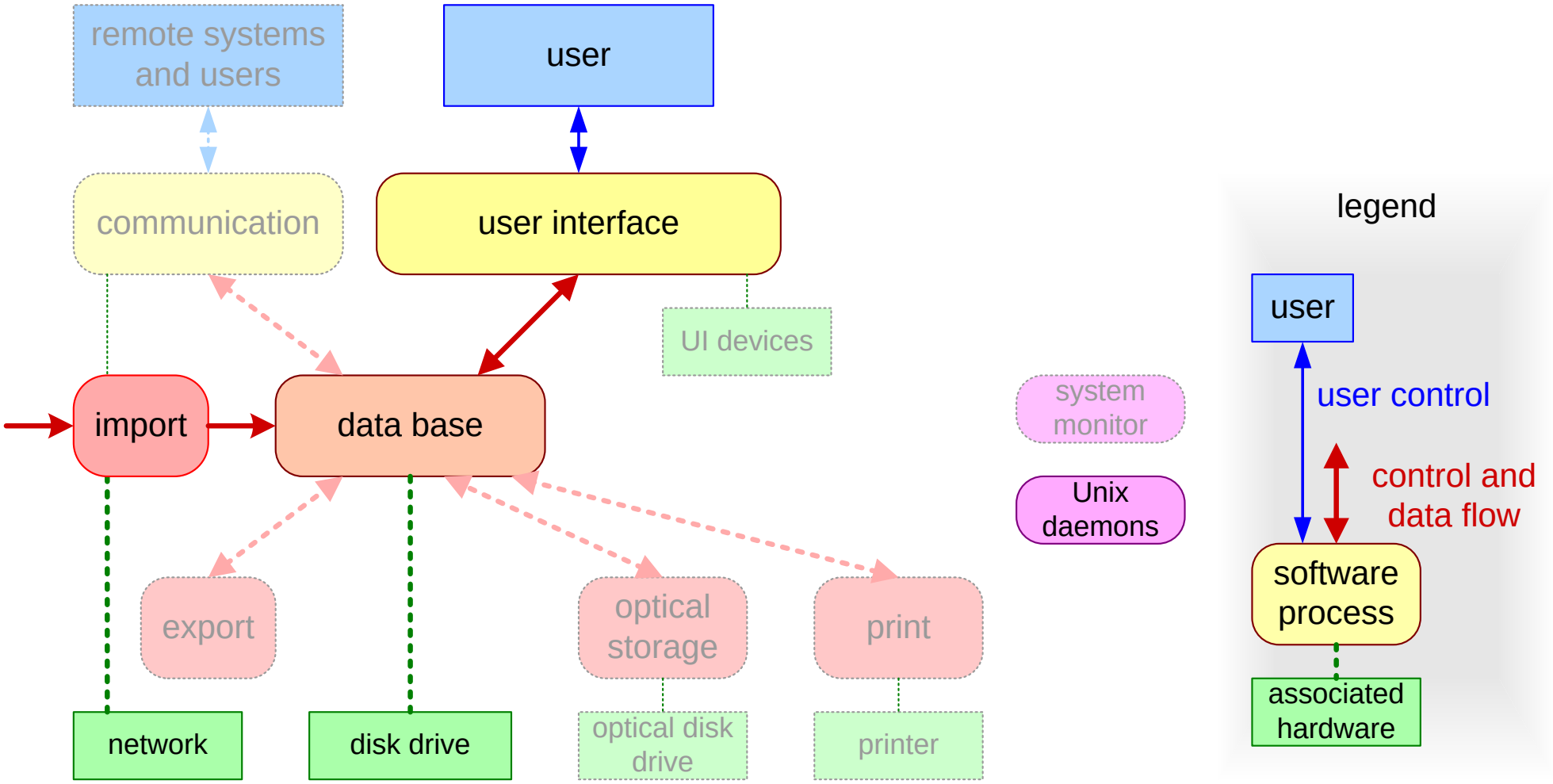
verify and
authorise
report

activities of the radiologist

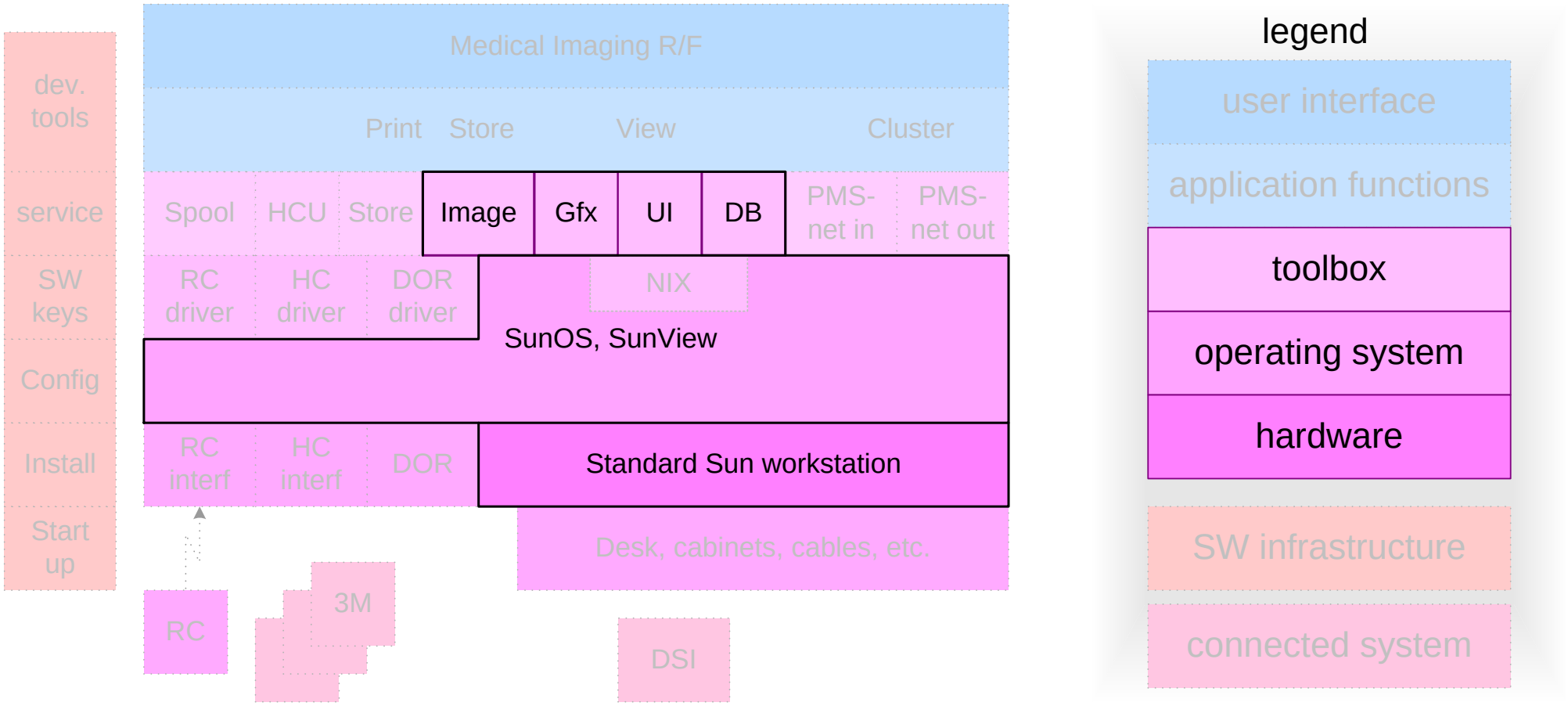
Diagnosis in tens of seconds



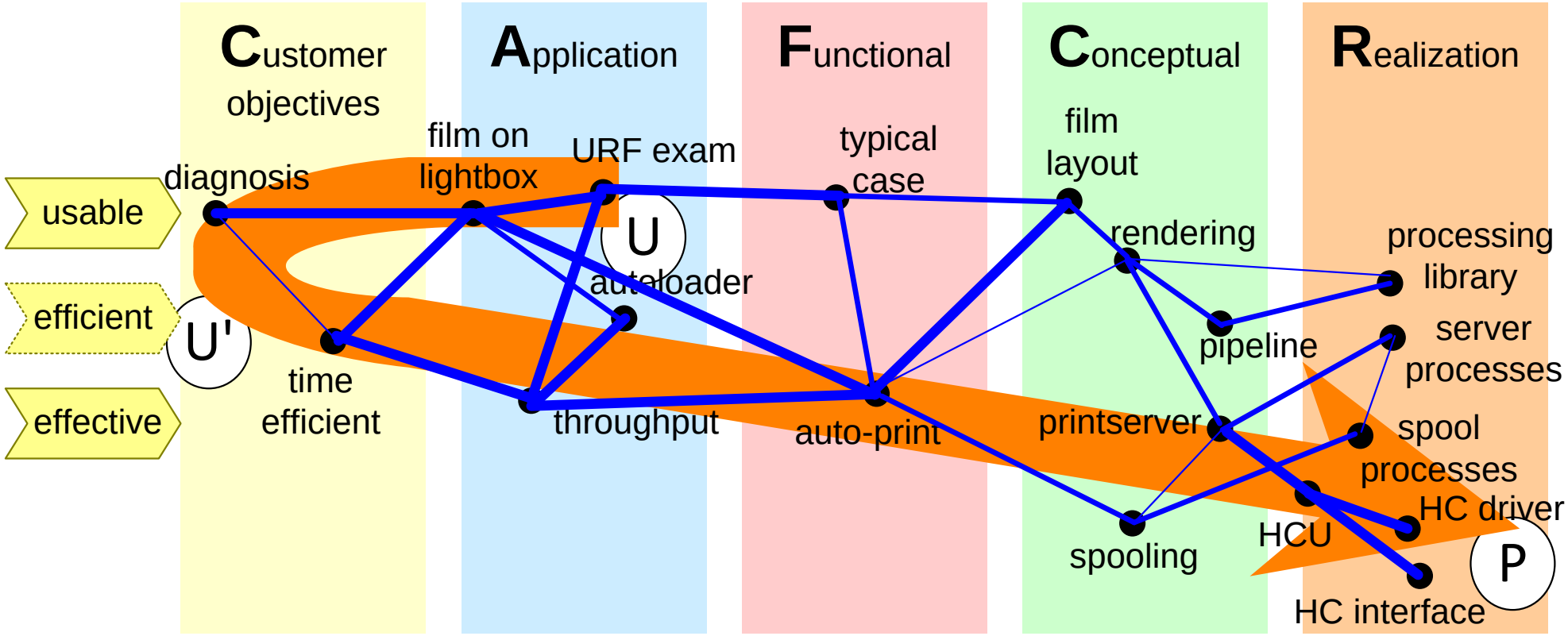
SW Process structure 1991



SW layers 1991



Thread of reasoning; phase 3



Philips operational view
(manufacturing, service, sales)

Radiologists diagnose from film, throughput is important
Extrovert view shows conceptual and realization gaps!

Image quality and safety problem

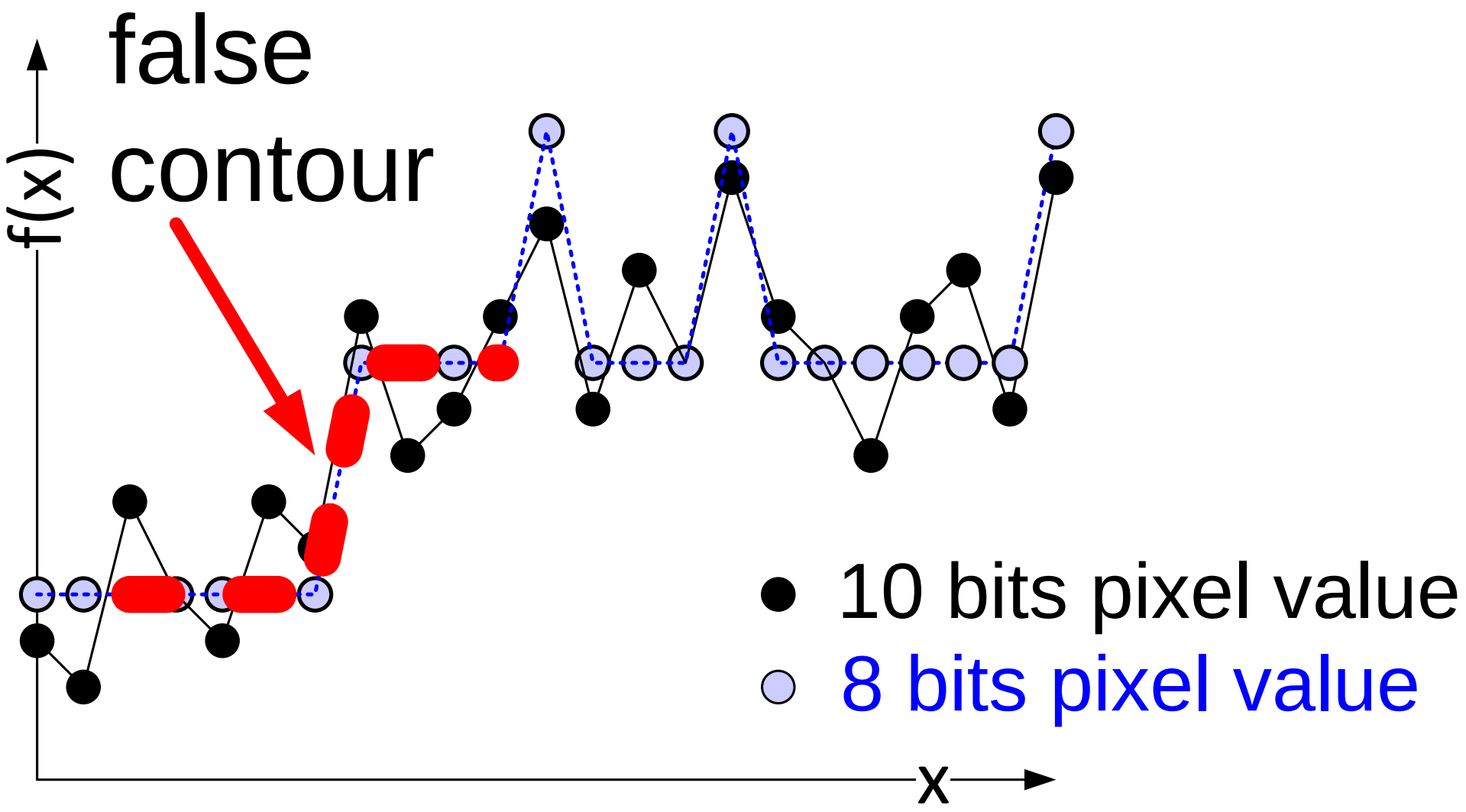
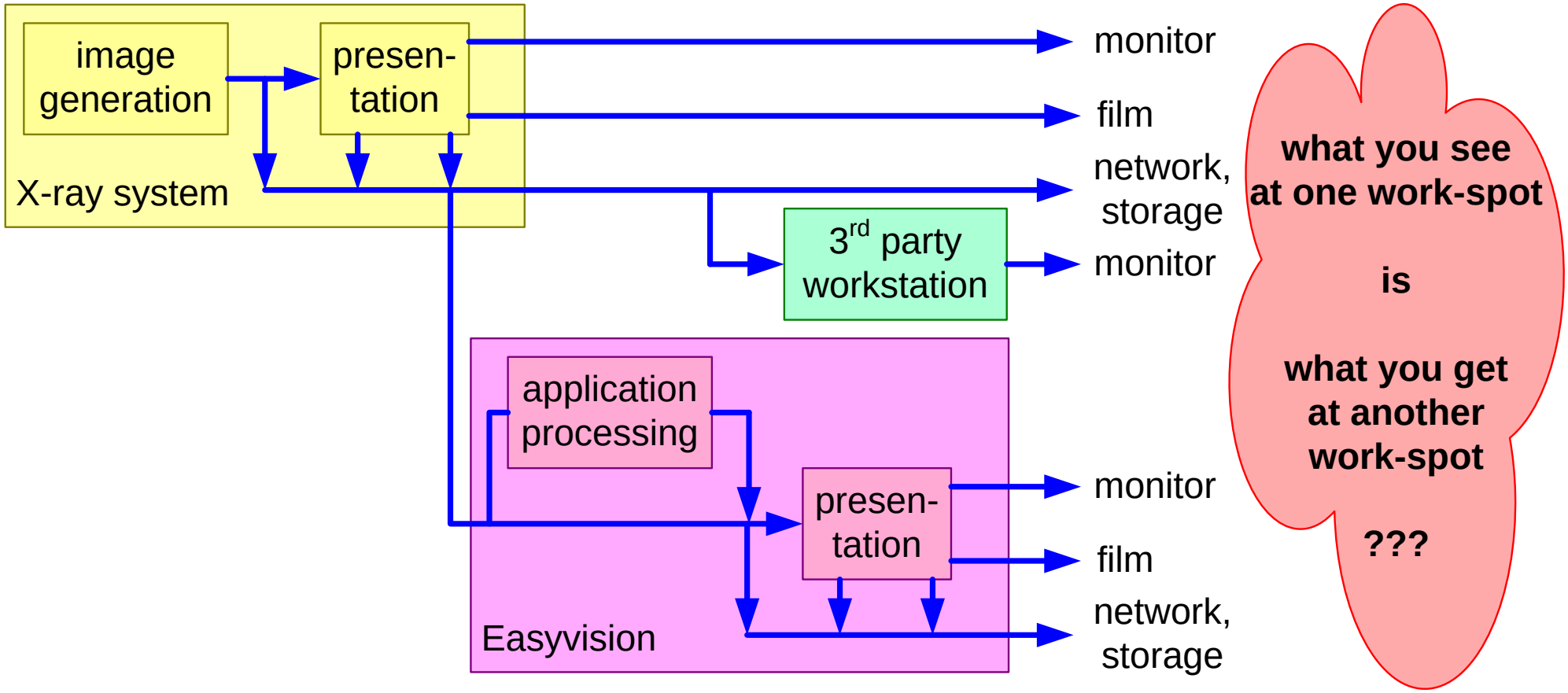
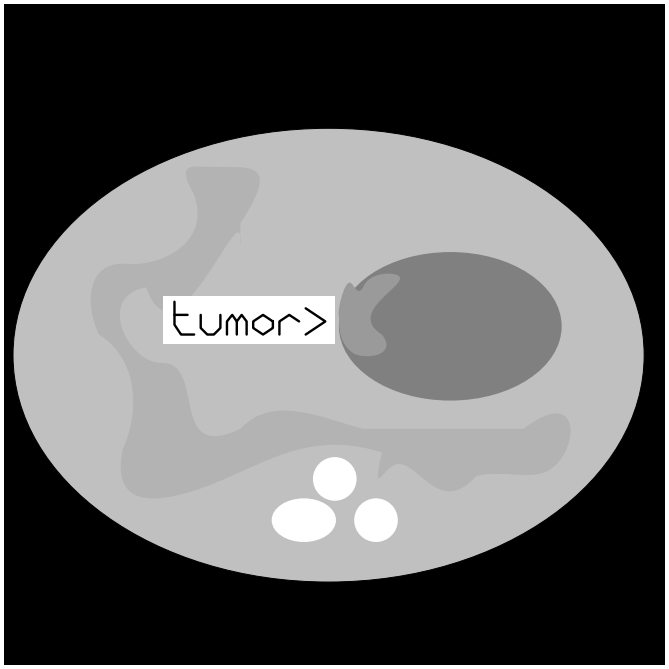


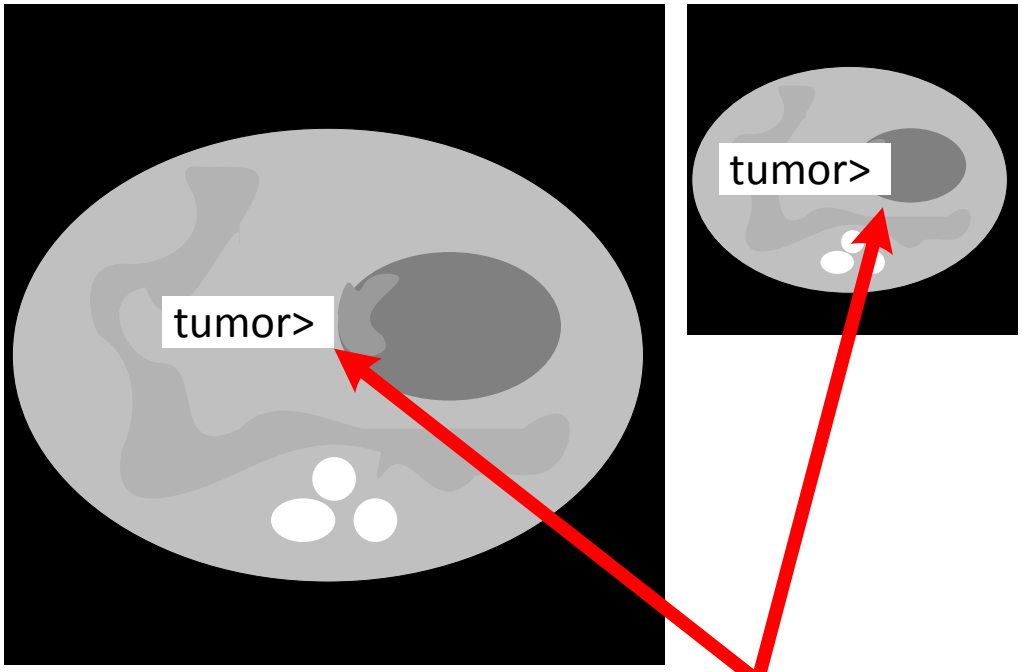
Image Quality expectation WYSIWYG



Safety problem



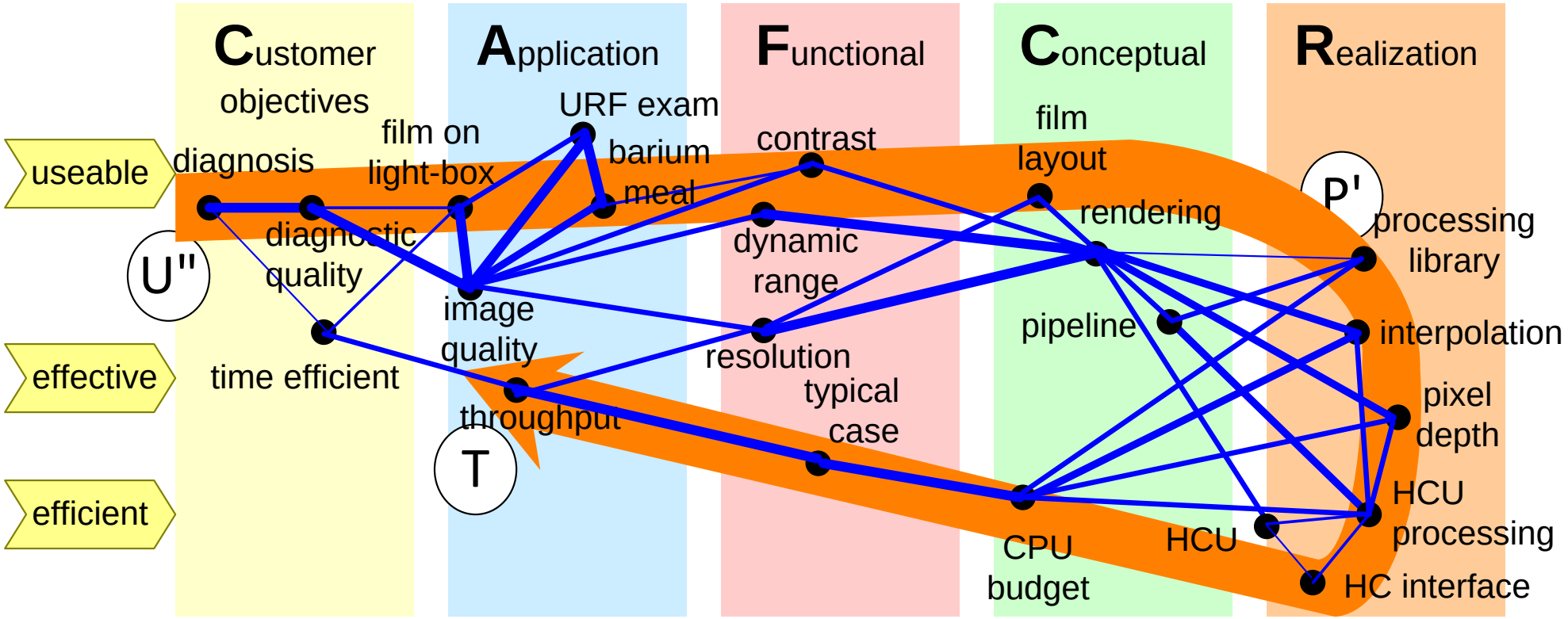
URF monitor output:
fixed size letters at fixed grid



for user readability the font-size was determined "intelligently"; causing a dangerous mismatch between text and image

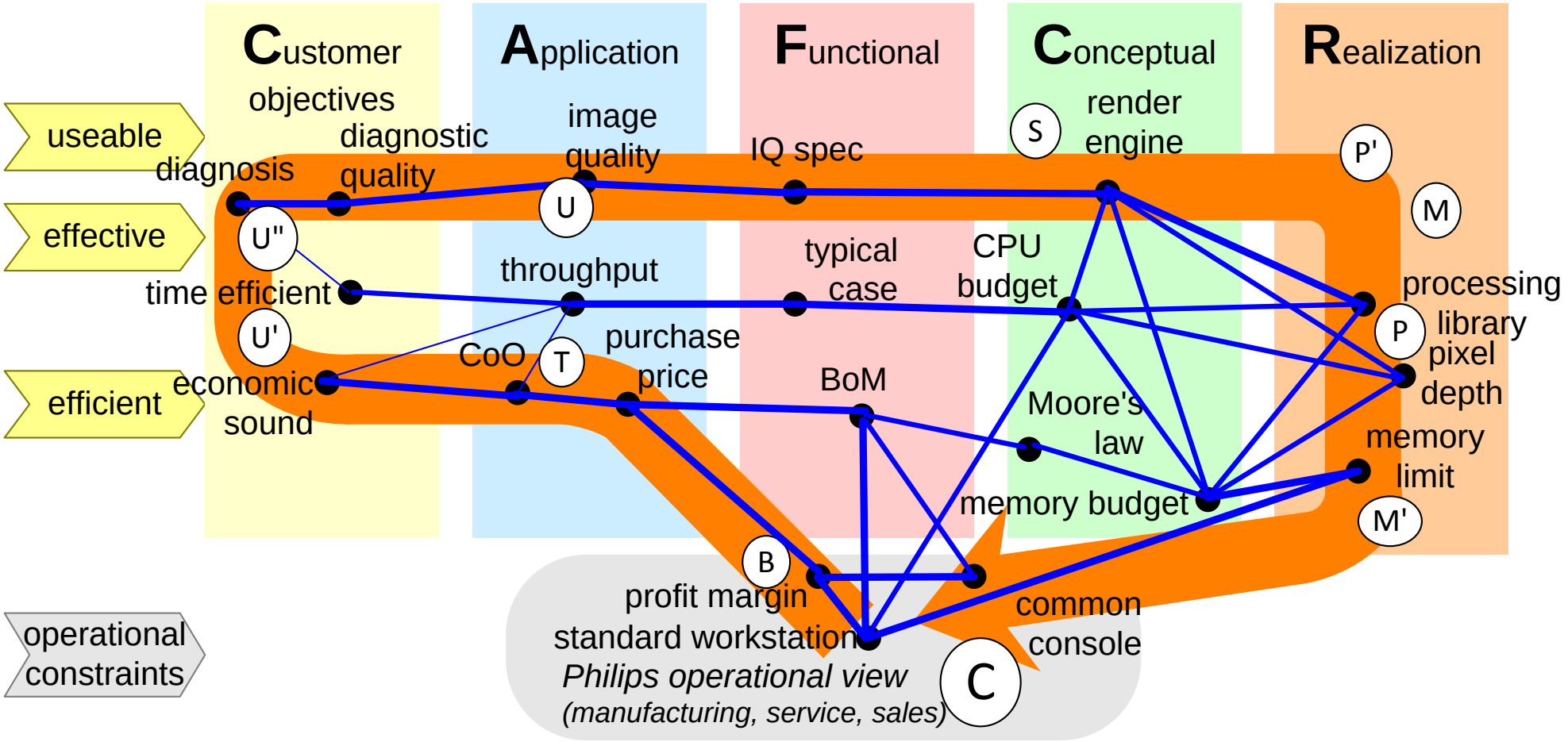
EV output: scaleable fonts in graphics overlay

Thread of reasoning; phase 4



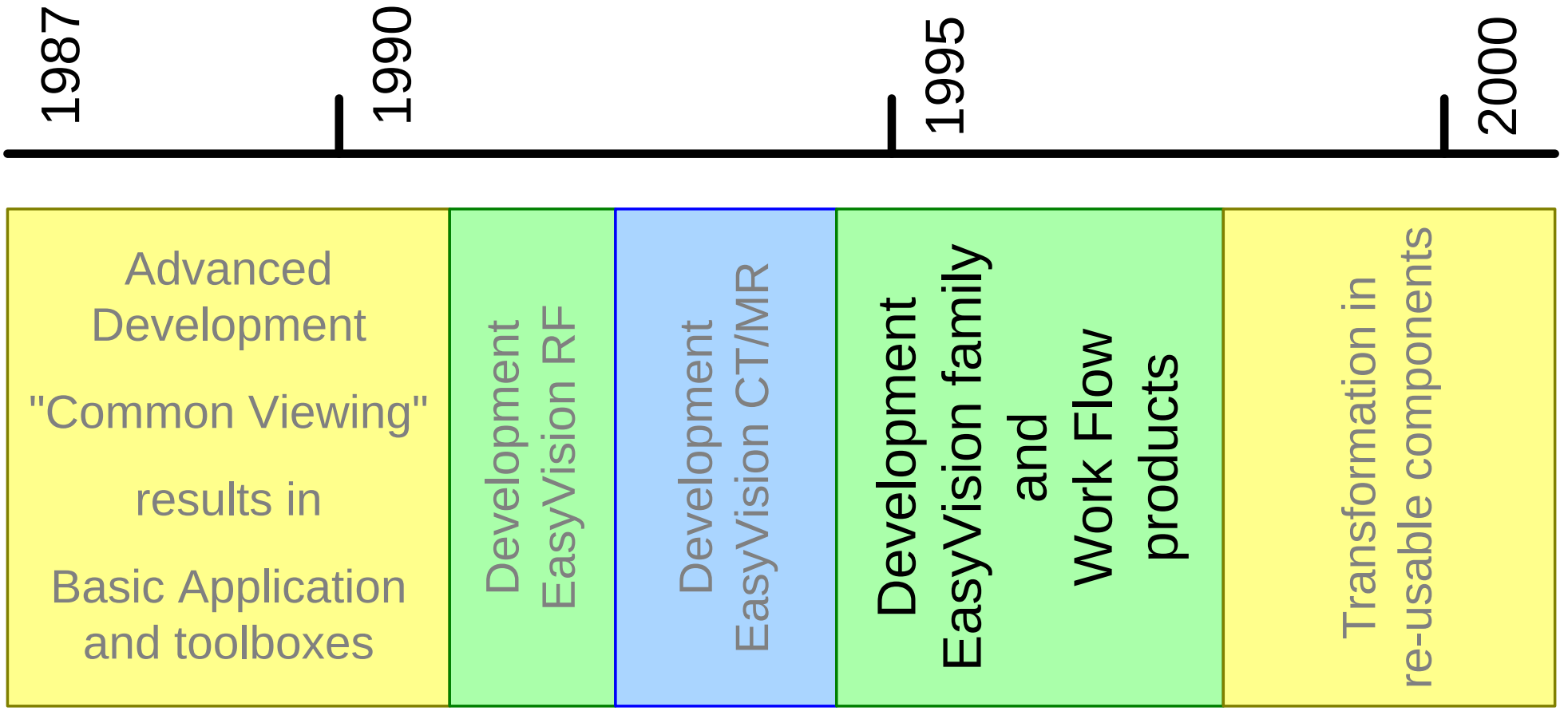
from extrovert diagnostic quality, via image quality, algorithms and load, to extrovert throughput

Thread of reasoning; phase 5

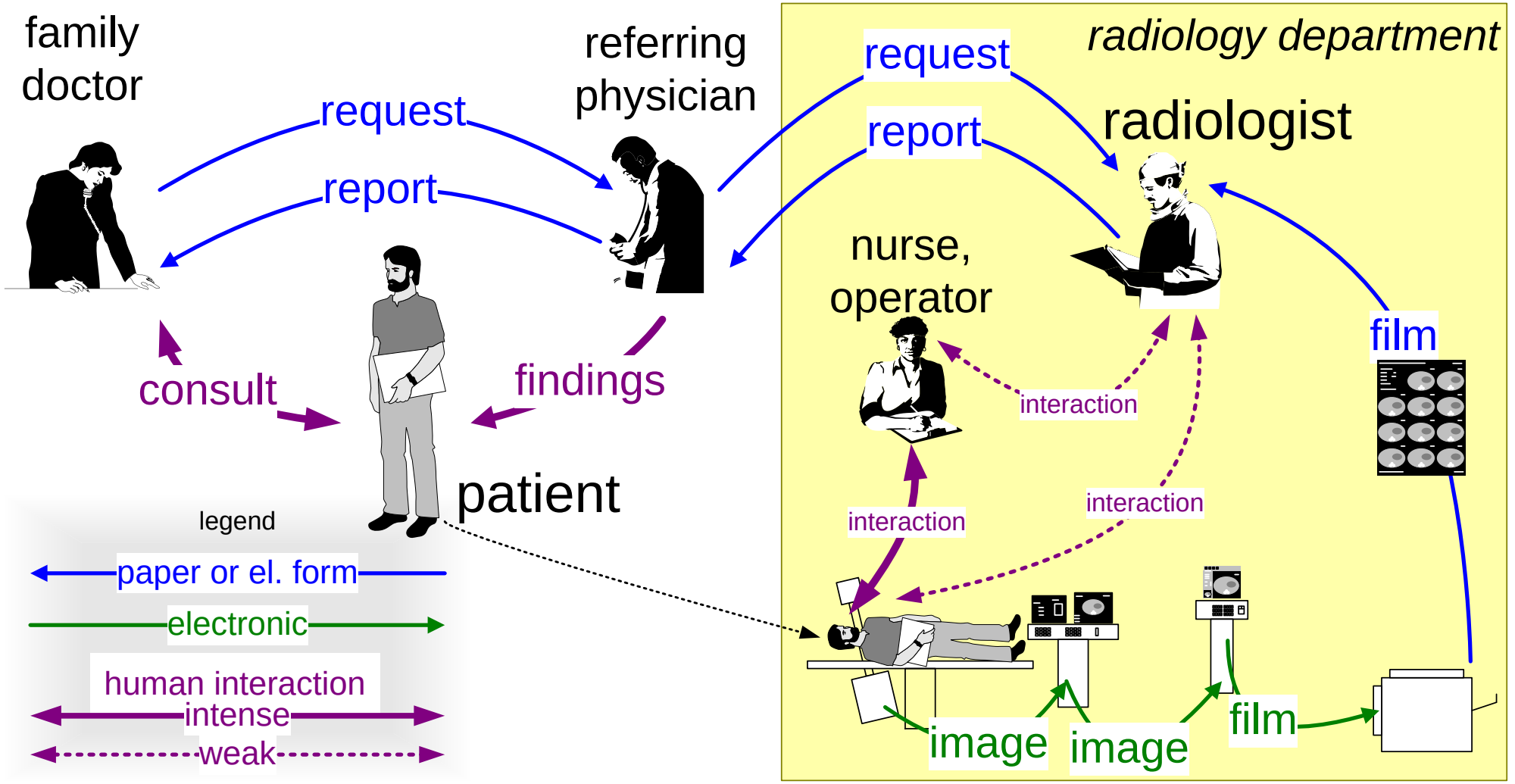


cost revisited in context of clinical needs and realization constraints; note: original threads are significantly simplified

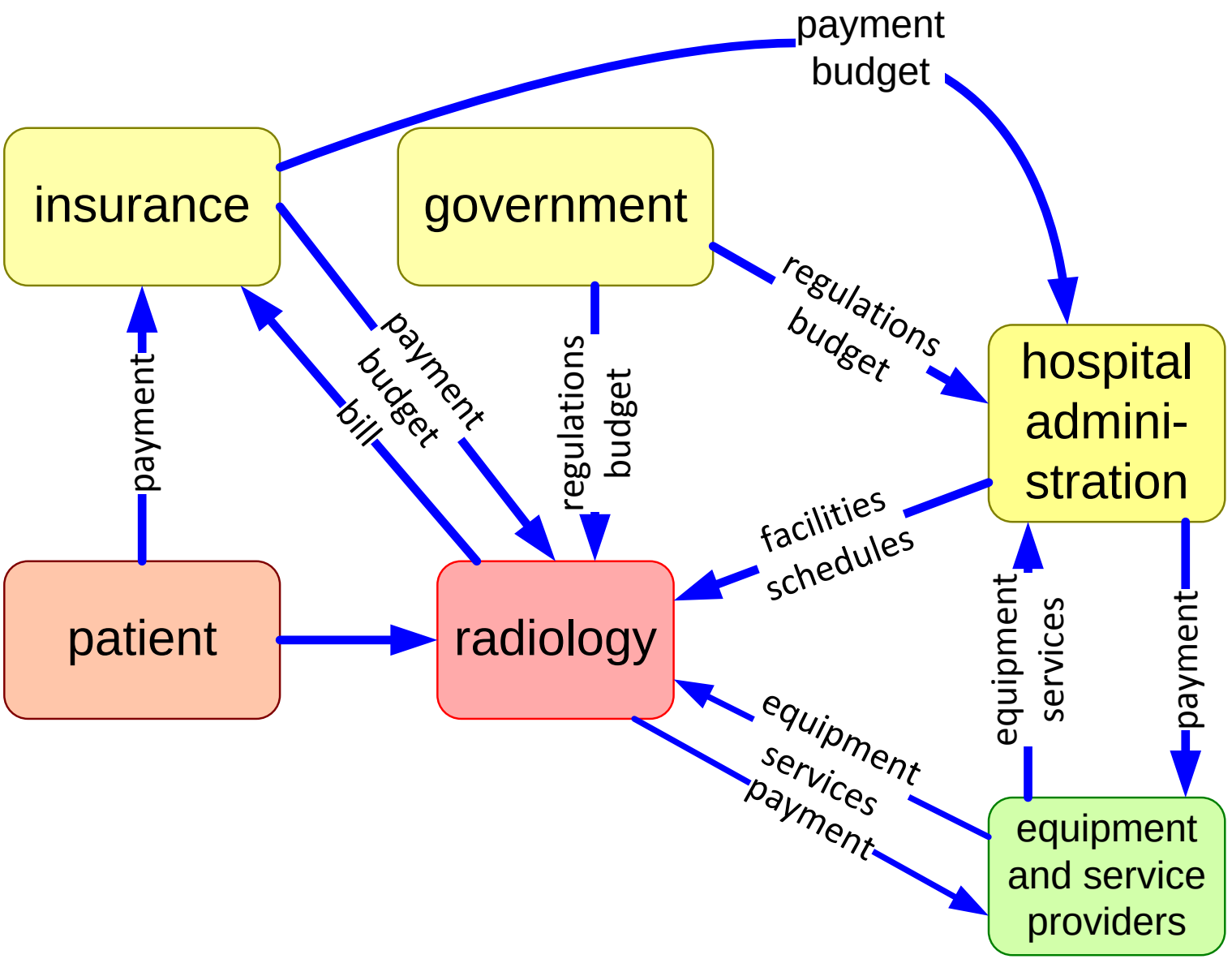
Strategy Development Work Flow Products



The clinical context of the radiology department



The financial context of the radiology department



Key drivers, application drivers and requirements

Customer key drivers	derived Application drivers
report quality	selection of relevant material use of standards
diagnostic quality	acquisition and viewing settings contrast, brightness and resolution of light-box
safety and liability	clear patient identification left right indicators follow procedures freeze diagnostic information
cost per diagnose	interoperability over systems and vendors multiple images per film minimise operator handling multiple applications per system
time per diagnose	diagnose at light-box with films all preparation in exam room

Requirements

- import
- auto-print
  - parameterized layout
  - spooling
- storage
  - navigation / selection
  - auto-delete
- viewing
  - contrast / brightness
  - zoom
  - annotate
- export

functionality

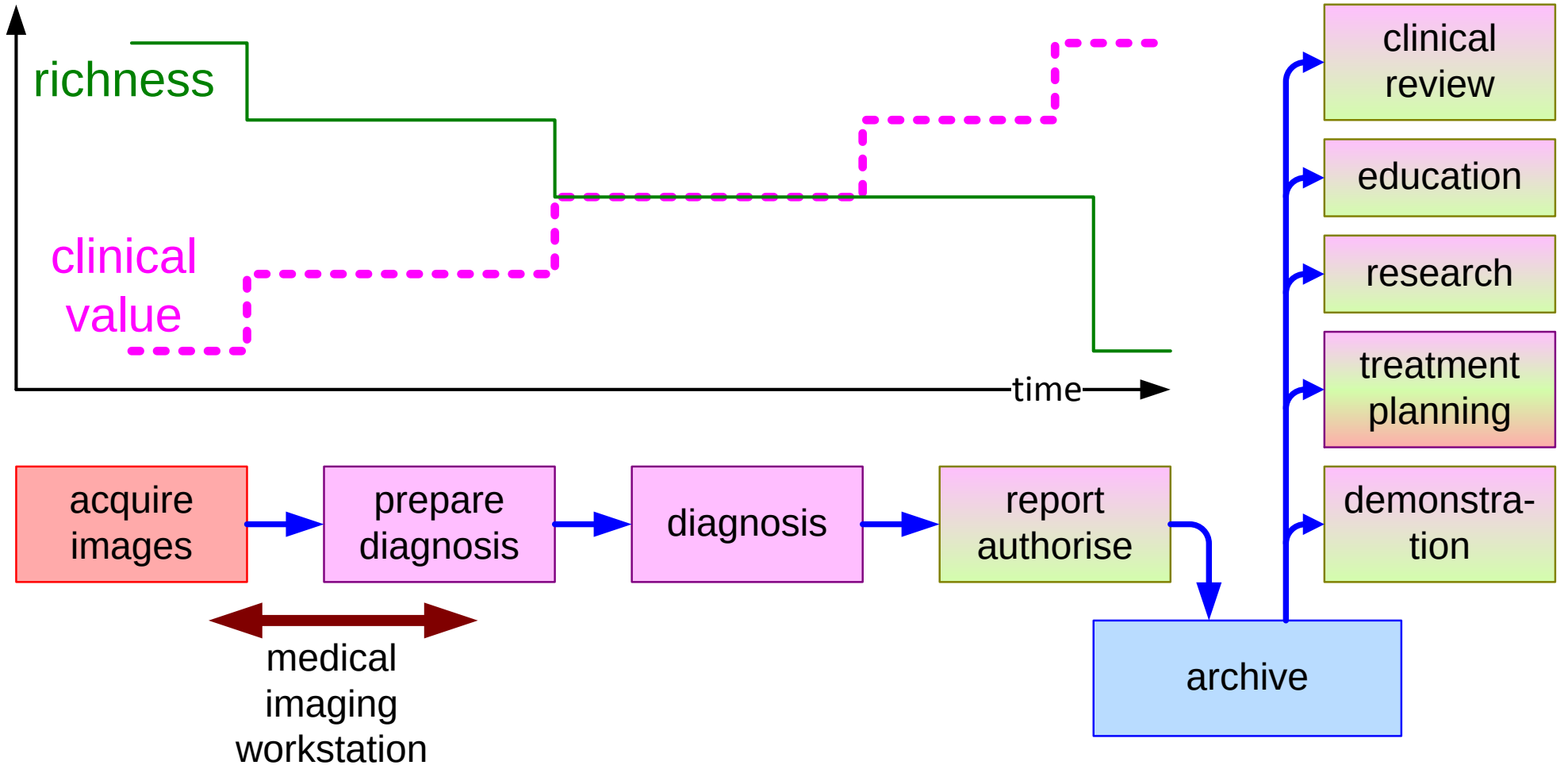
- system response
- system throughput
- image quality
  - annotation
- material cost
- operational cost

qualities

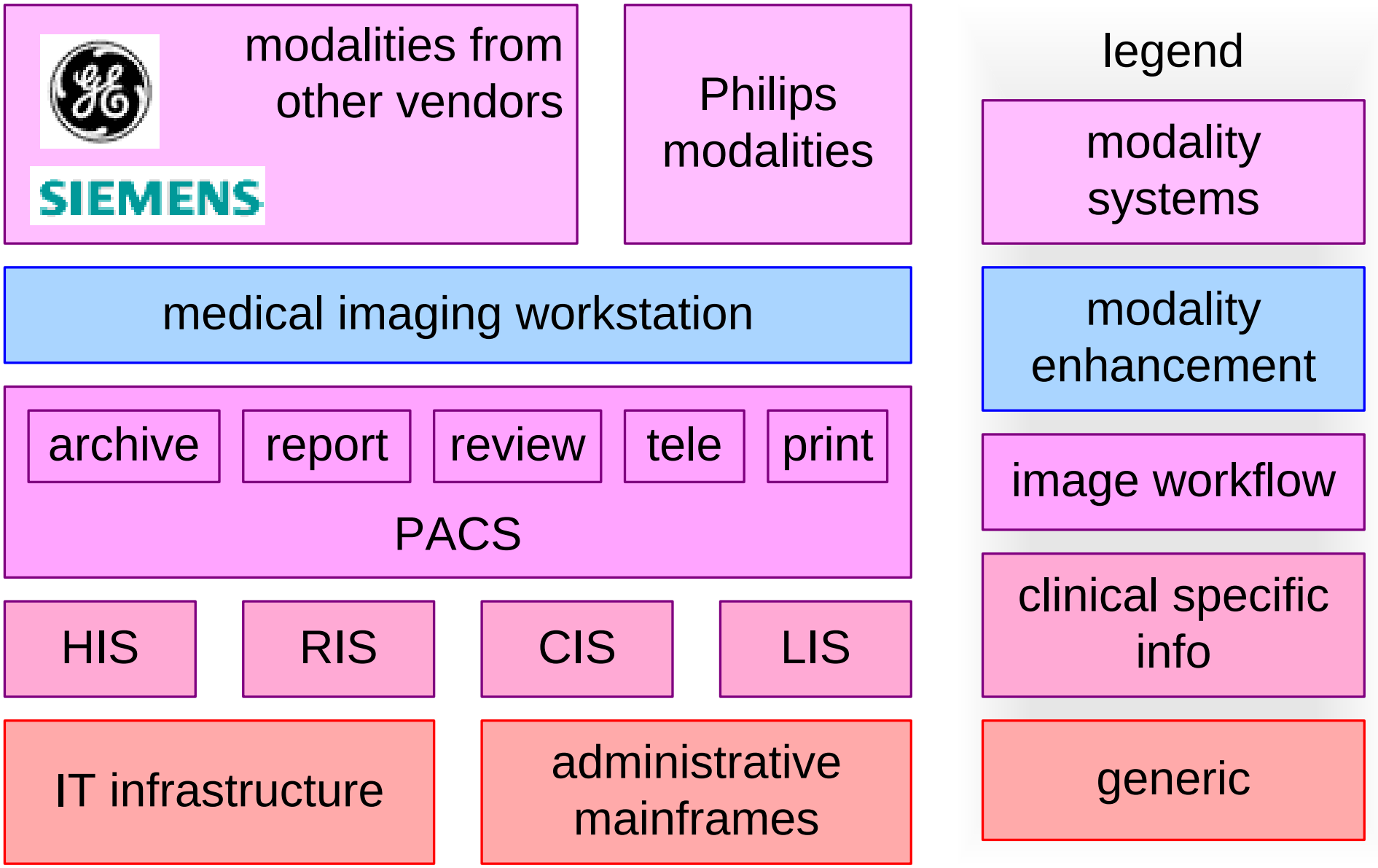
- shared information model
  - viewing settings
  - patient, exam info

interfaces

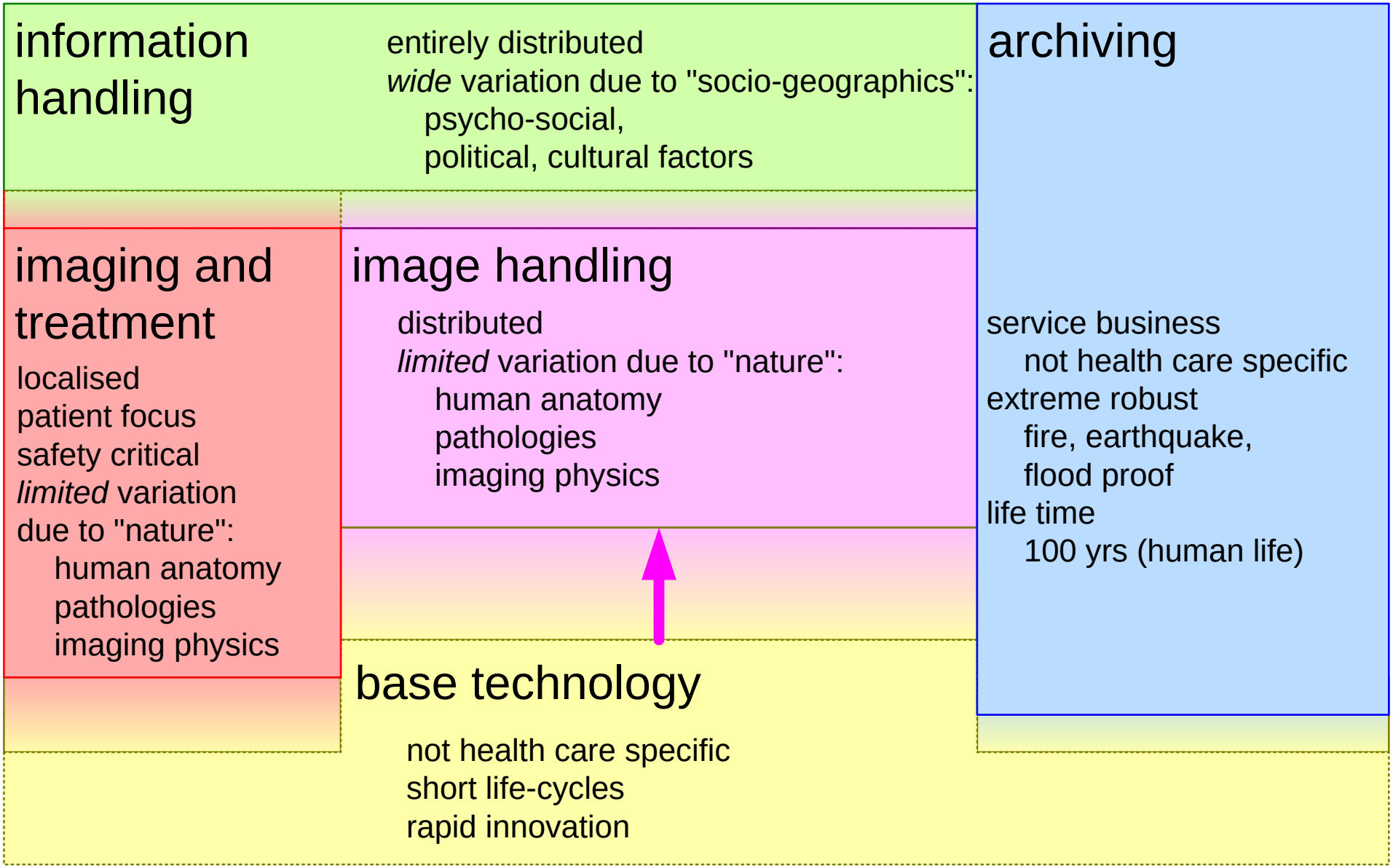
Clinical information flow



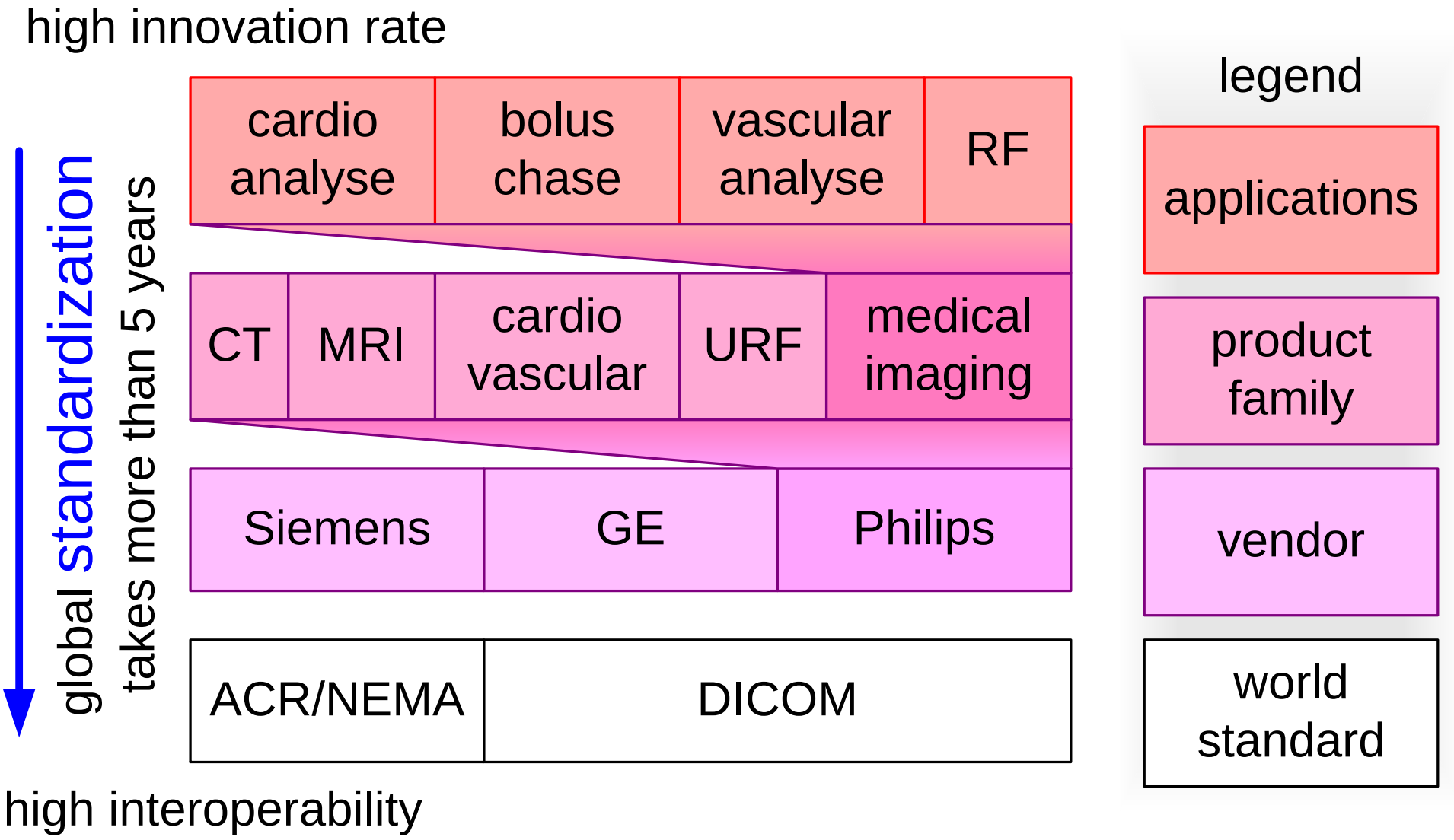
Application layering of IT systems



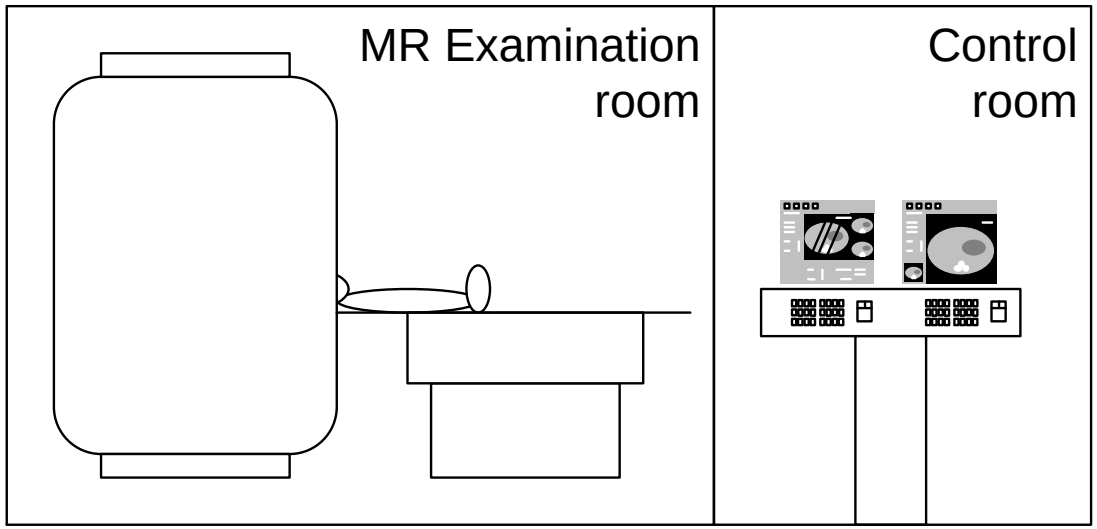
Reference model for healthcare automation

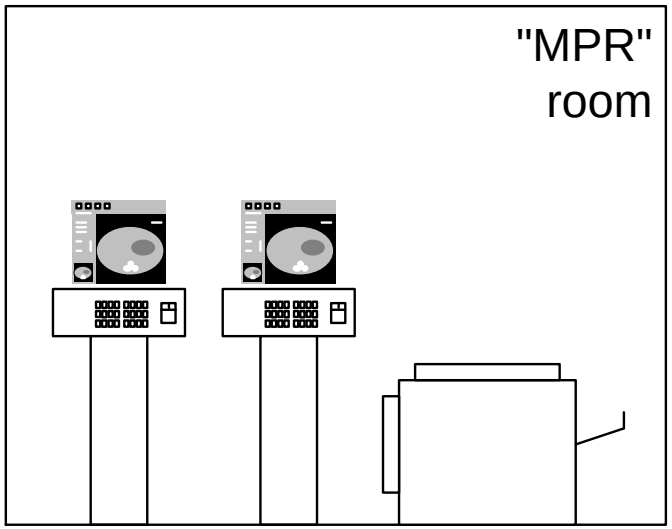


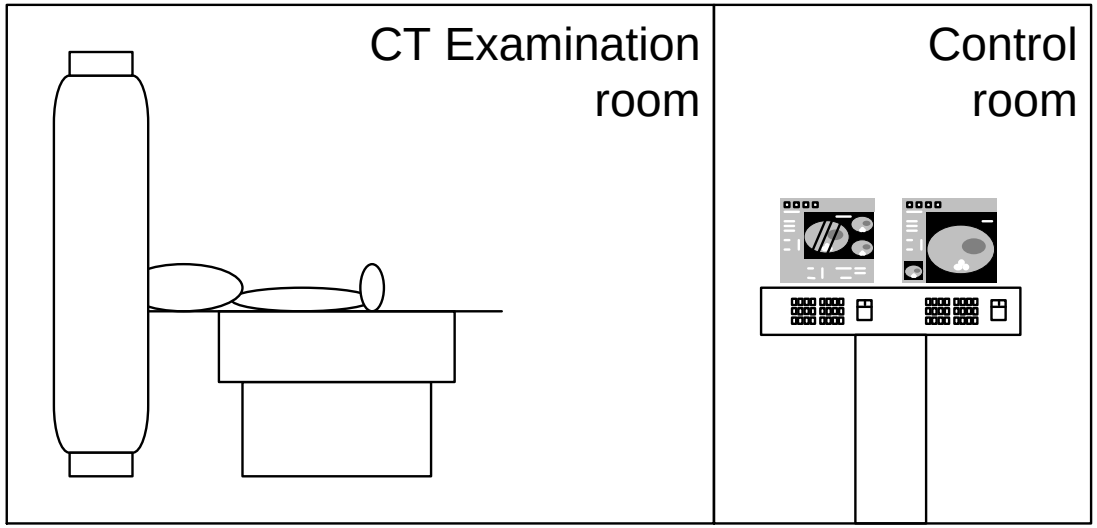
Information model, standardization for interoperability

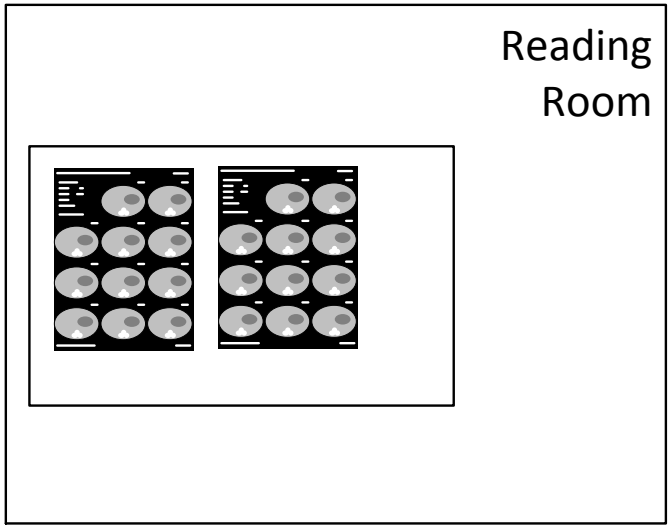


Example CT/MR department

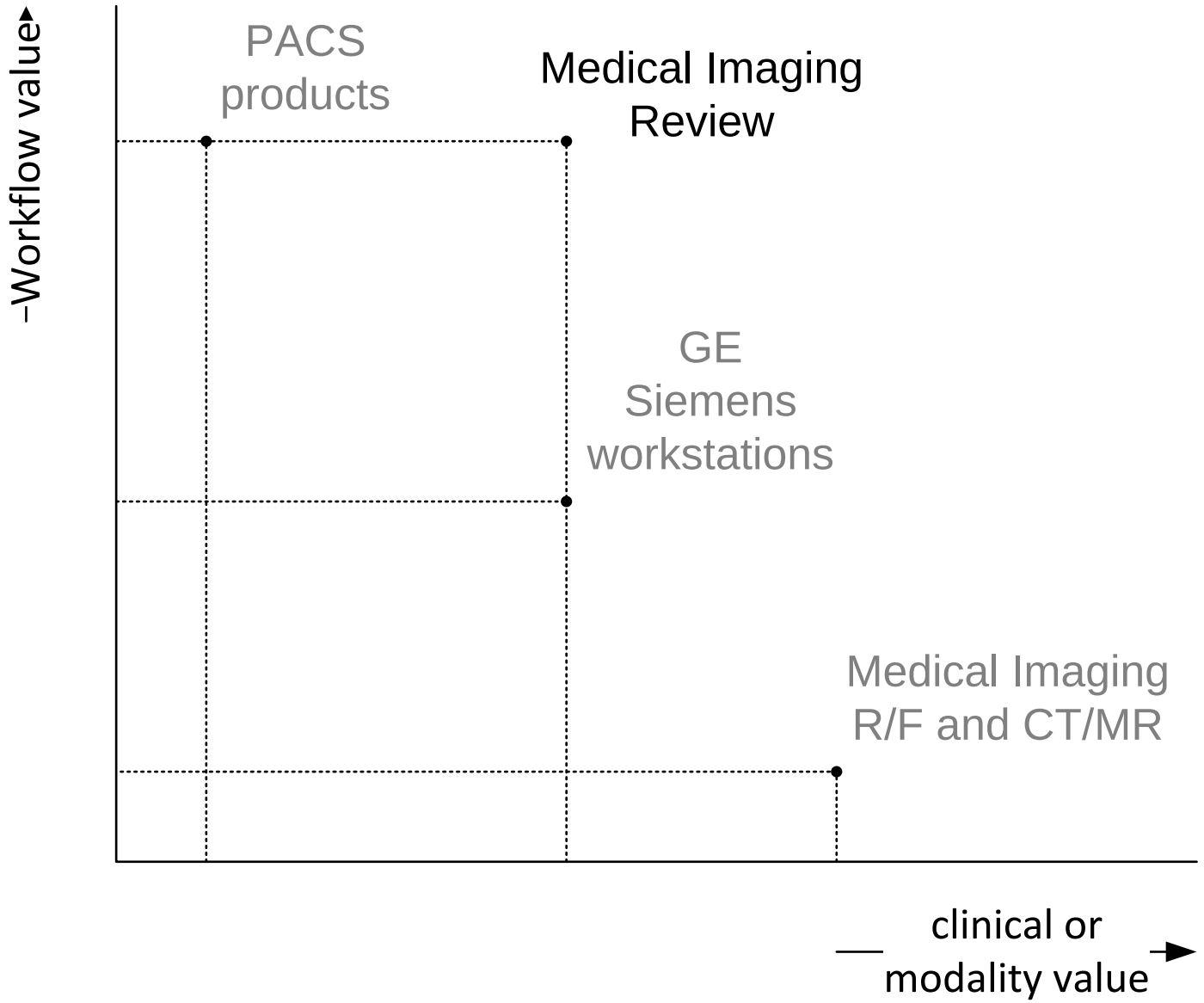




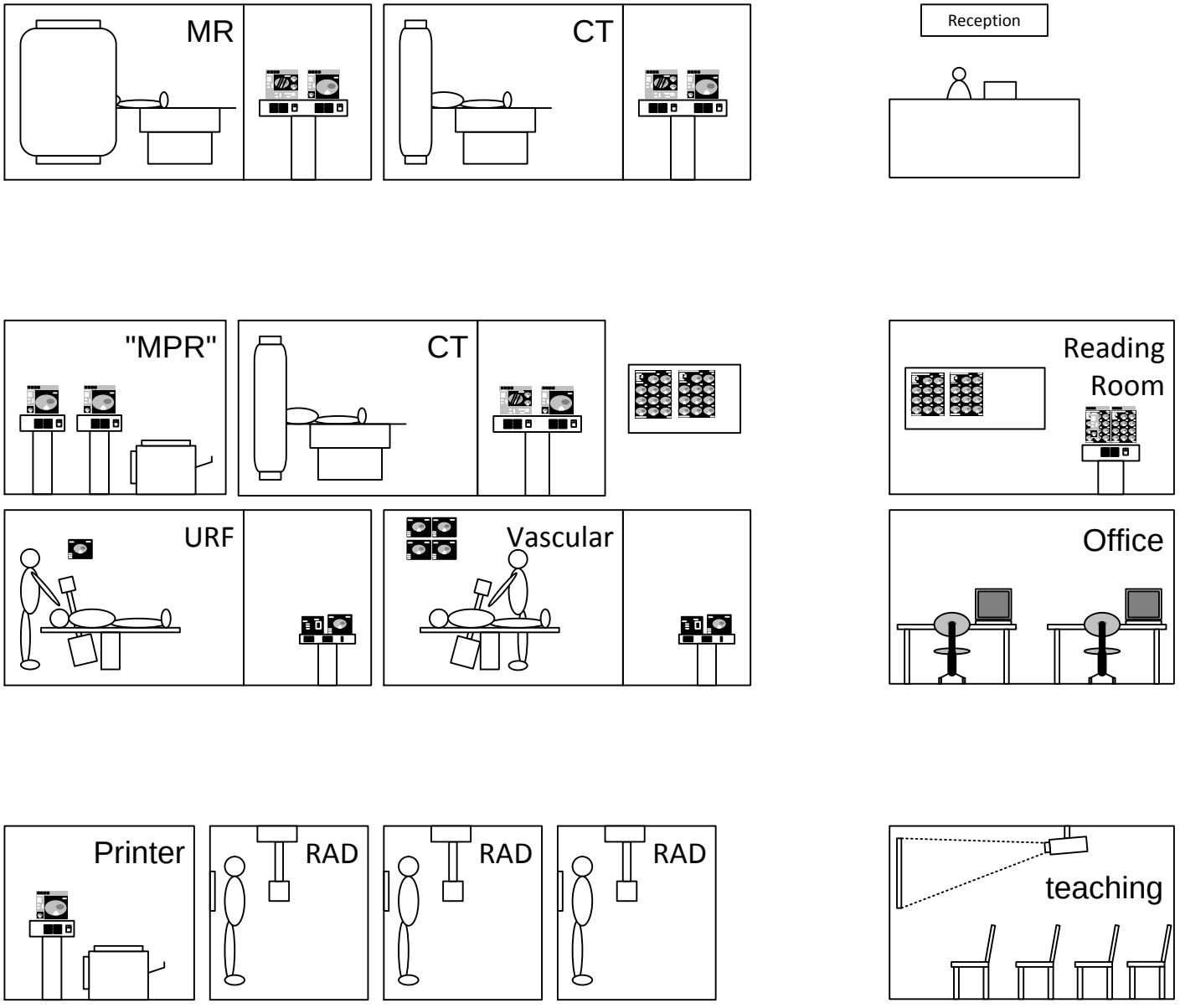




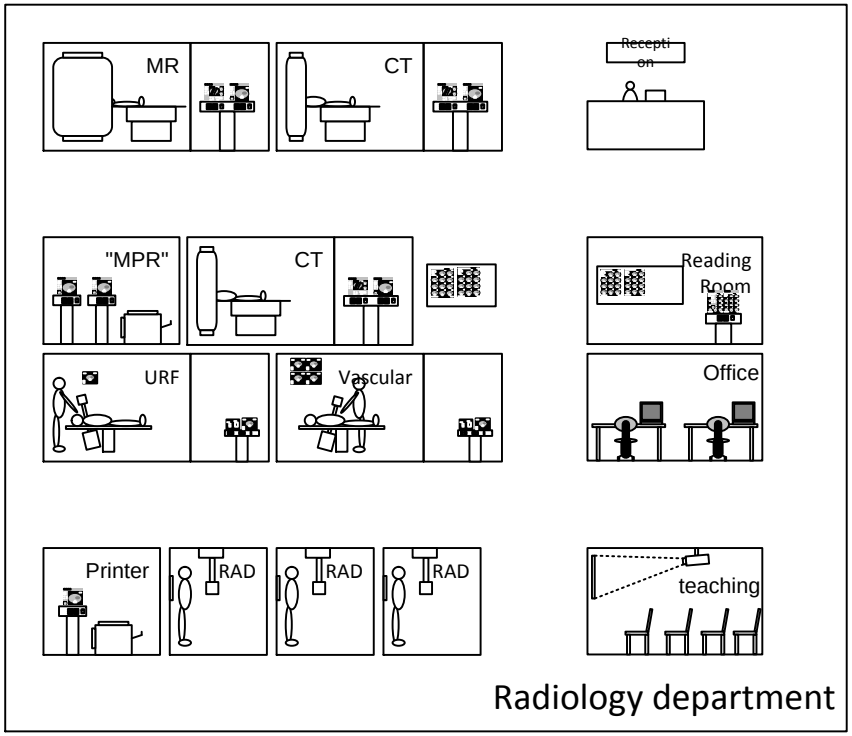
Medical Imaging Competitive Positioning



Radiology Department

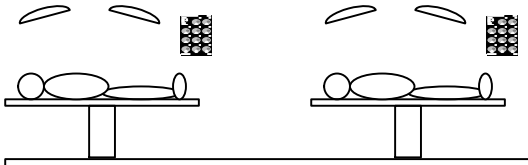


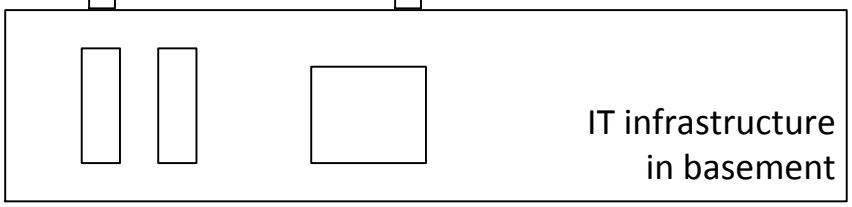
Vision: Medical Imaging in Healthcare



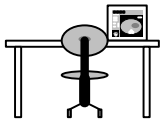
Operating theatre

trauma room



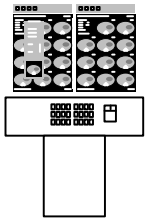


Radiologist at home

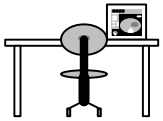


Radiologist somewhere in the hospital

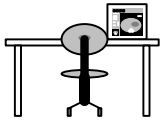
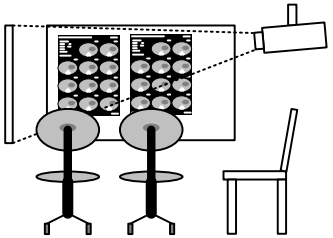
Radiologist at other hospital



Referring Physician



Referring Physician



Conference room