

Modeling and Analysis: System Model

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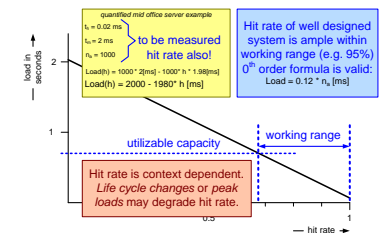
Abstract

This presentation uses a web shop service as example system to construct a system model. The caching of pictures of the products in the shop is modeled to analyze performance, robustness, scalability and reliability of the system.

Distribution

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August 16, 2025
status: preliminary
draft
version: 0.4



content

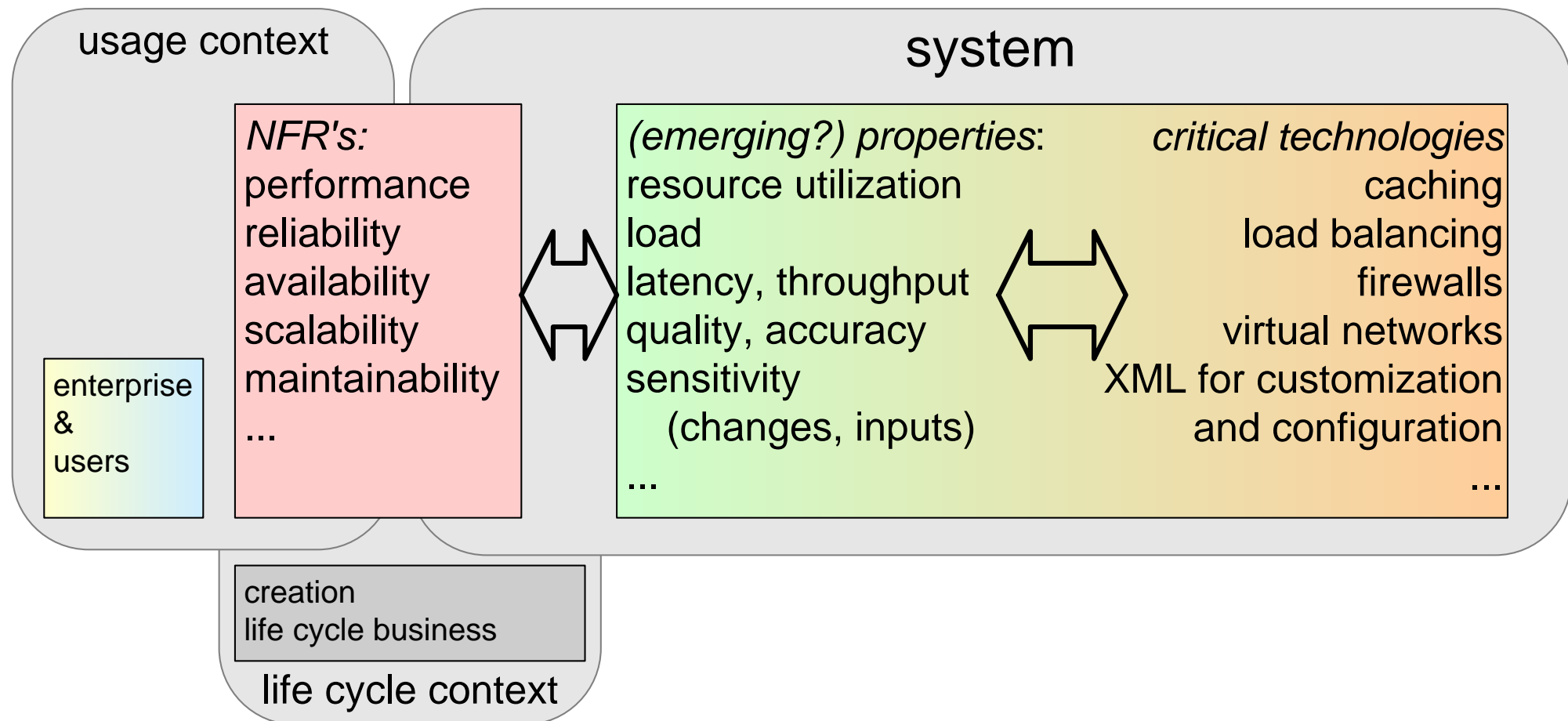
What to model of the system

Stepwise approach to system modeling

Non Functional requirements (NFR), System Properties and Critical Technologies

Examples of web shop case

What to Model in System Context?



1. determine relevant Non Functional Requirements (NFR's)

2. determine relevant system design properties

3. determine critical technologies

4. relate NFR's to properties to critical technologies

5. rank the relations in relevancy and criticality

6. model relations with a high score

Web Shop: NFR's, Properties and Critical Technologies

1

2

system

3

NFR's:

performance browsing
initial cost
running costs
reliability/availability
scalability order rate
maintainability
effort product changes
effort staff changes
security

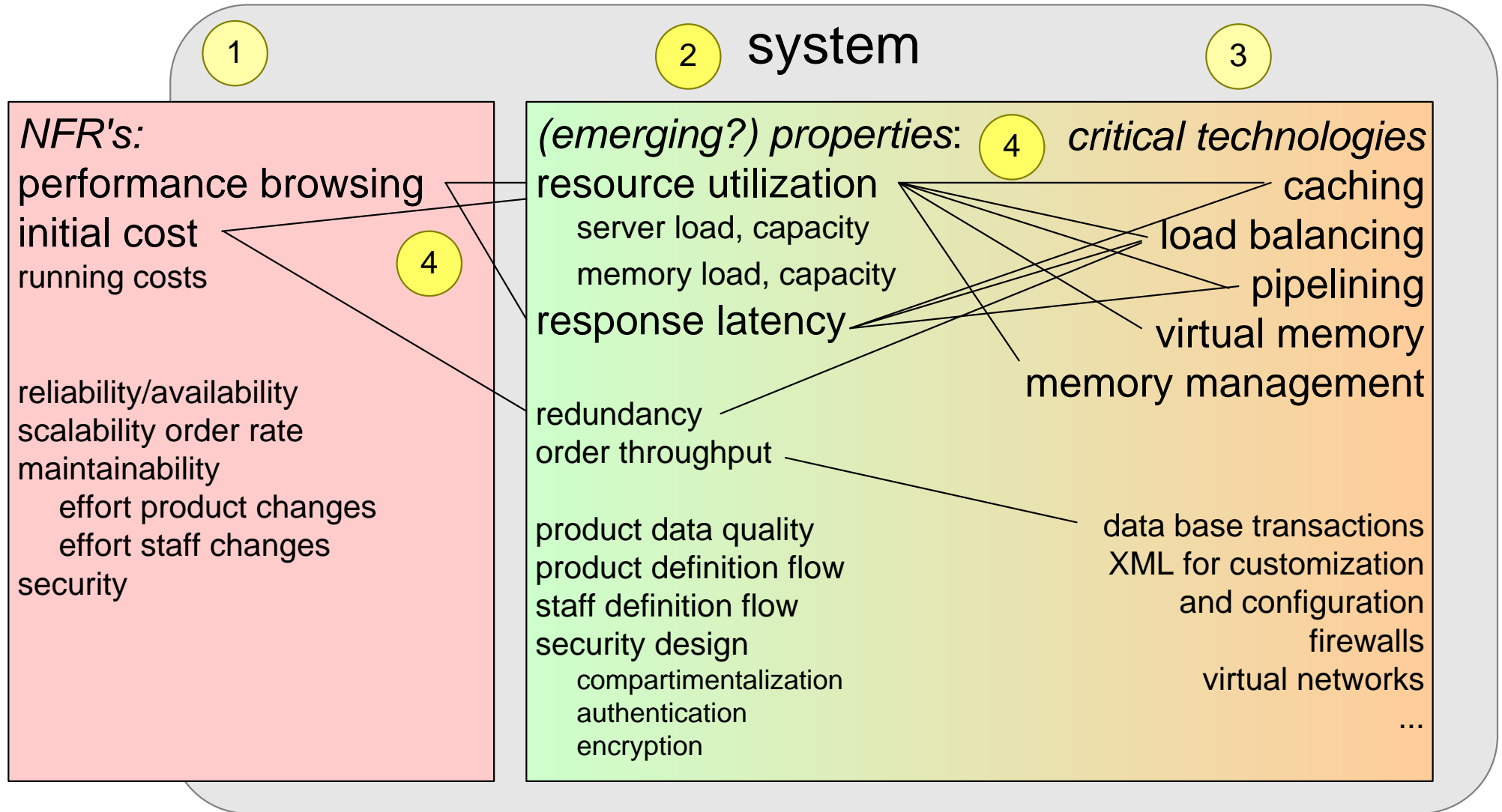
(emerging?) properties:

resource utilization
server load, capacity
memory load, capacity
response latency
redundancy
order throughput
product data quality
product definition flow
staff definition flow
security design
compartmentalization
authentication
encryption

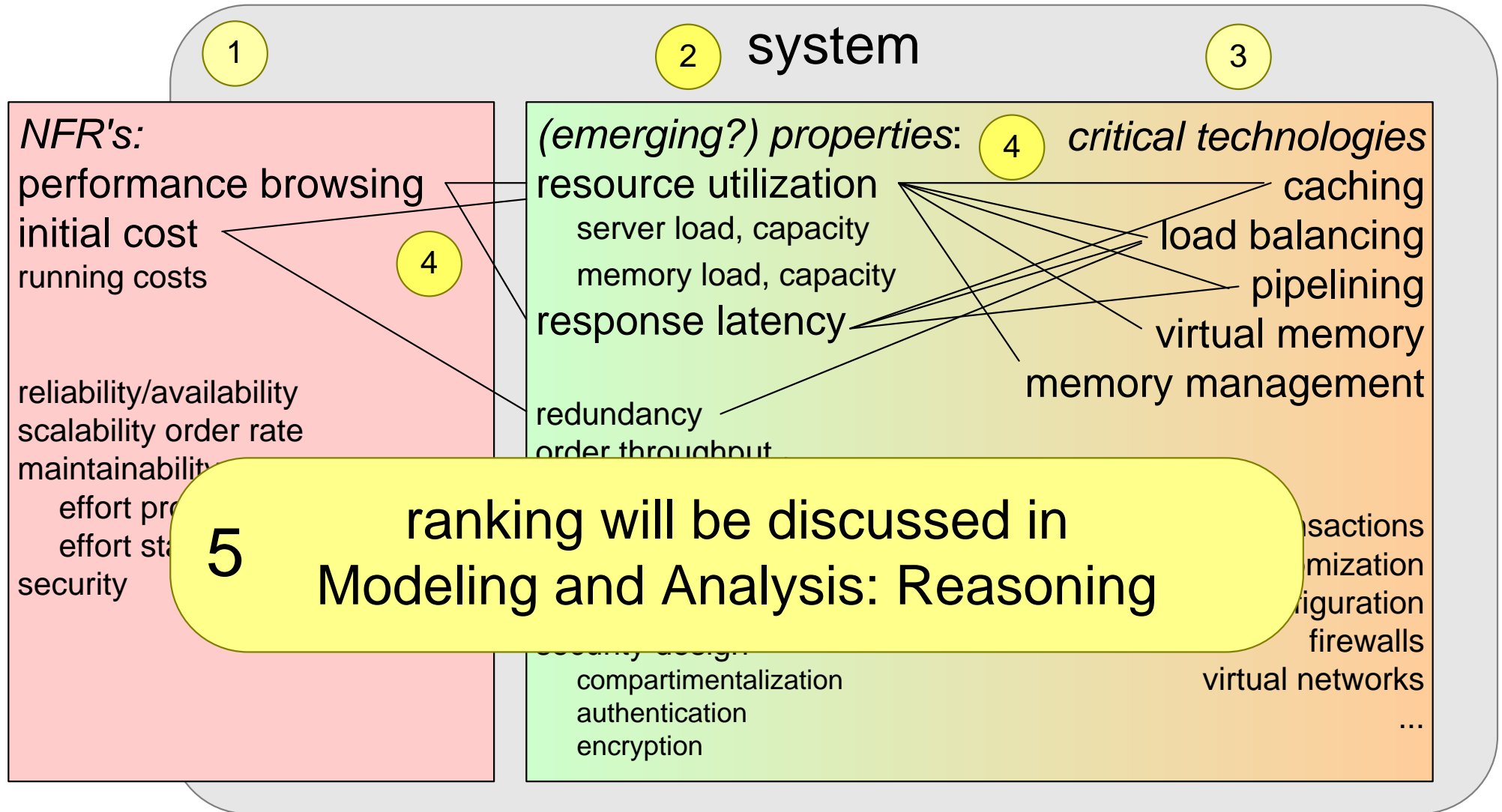
critical technologies

caching
load balancing
pipelining
virtual memory
memory management
data base transactions
XML for customization
and configuration
firewalls
virtual networks
...

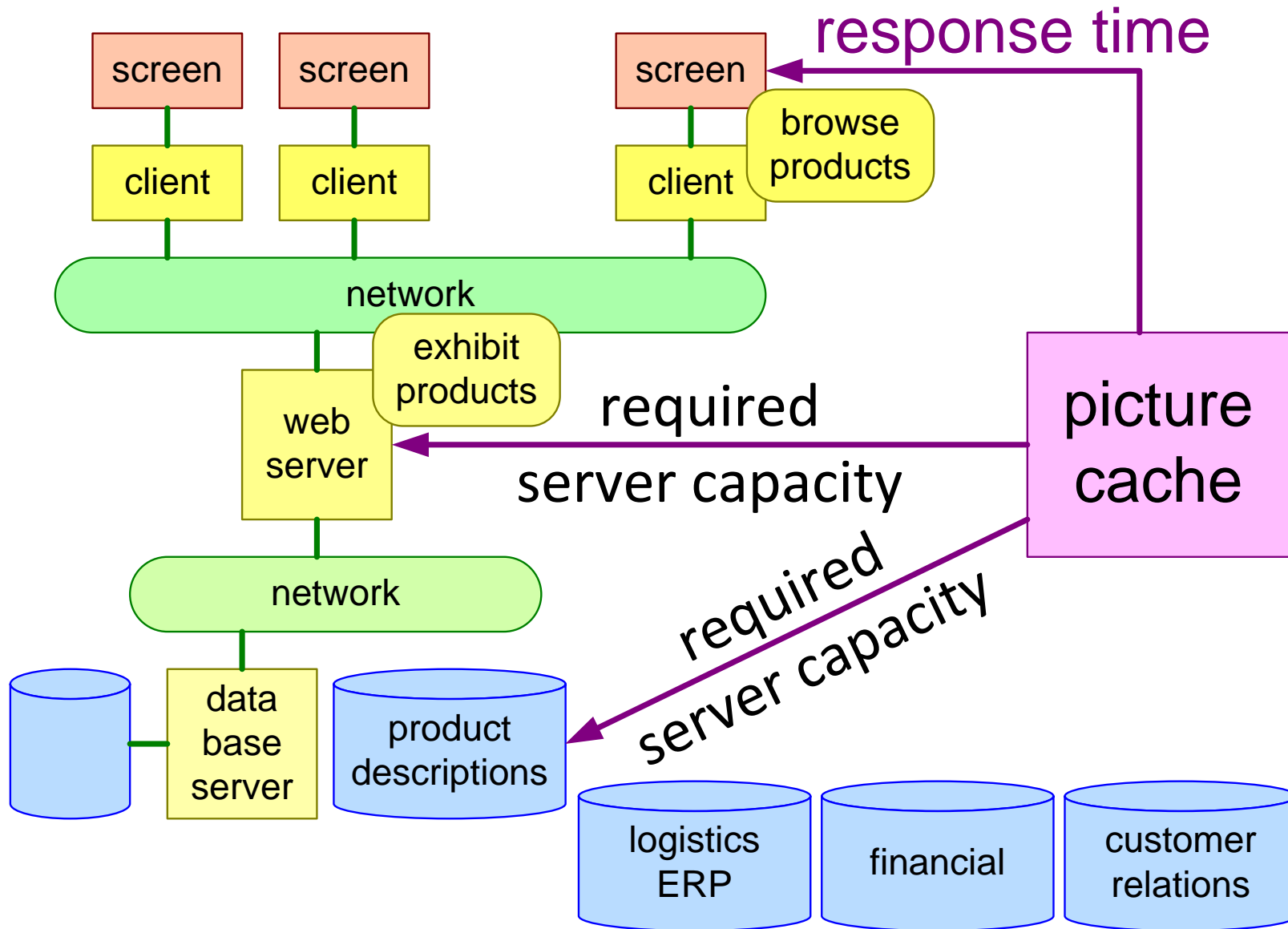
4. Determine Relations



5. Rank Relations



Purpose of Picture Cache Model in Web Shop Context



zero order web server load model

$$\text{Load} = n_a * t_a$$

n_a = total requests

t_a = cost per request

First Order Load Model

first order web server load model

$$\text{Load} = n_{a,h} * t_h + n_{a,m} * t_m$$

$n_{a,h}$ = accesses with cache hit

$n_{a,m}$ = accesses with cache miss

t_h = cost of cache hit

t_m = cost of cache miss

$$n_{a,h} = n_a * h$$

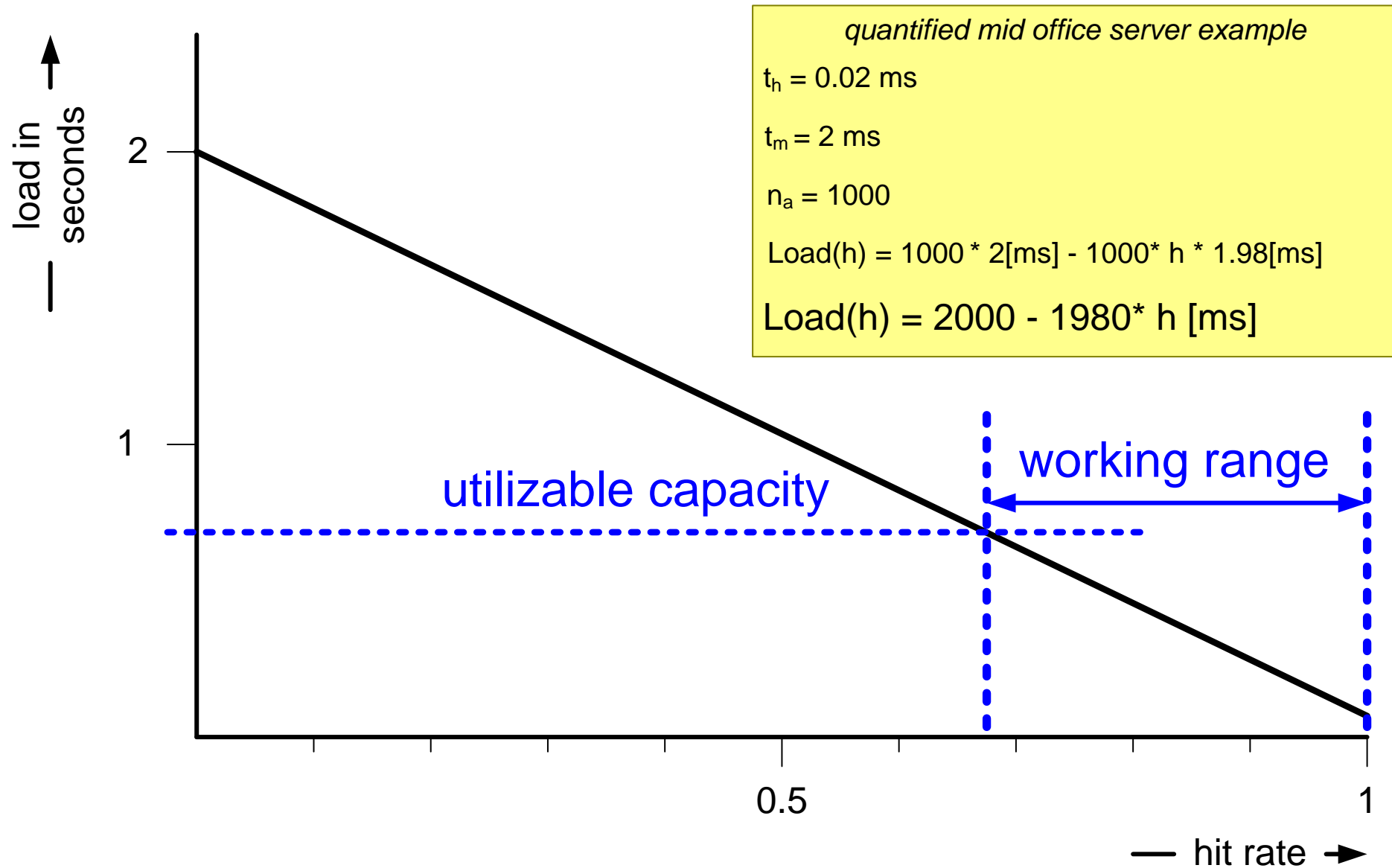
$$n_{a,m} = n_a * (1-h)$$

n_a = total accesses

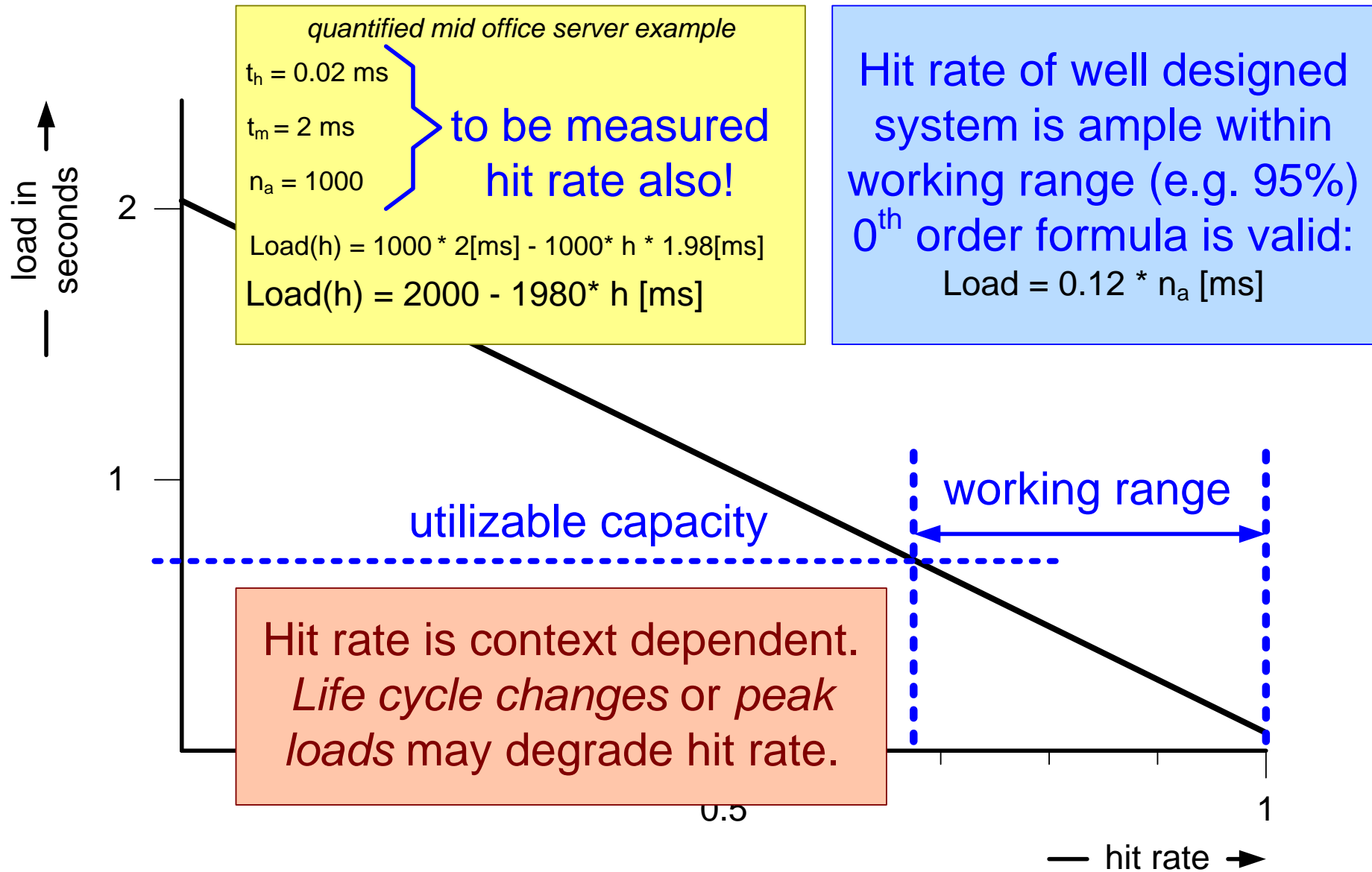
h = hit rate

$$\text{Load}(h) = n_a * h * t_h + n_a * (1-h) * t_m = n_a * t_m - n_a * h * (t_m - t_h)$$

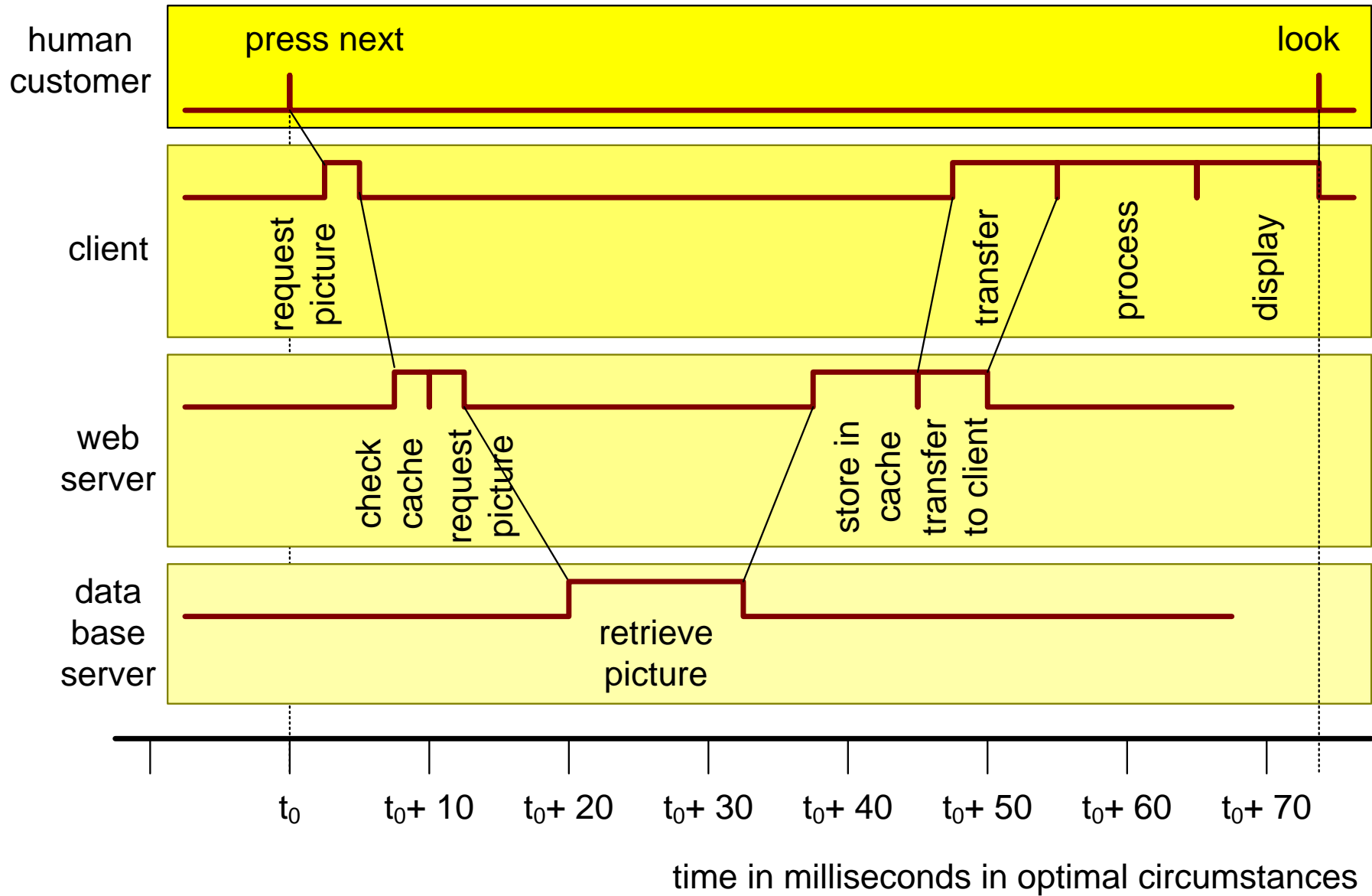
Quantification: From Formulas to Insight



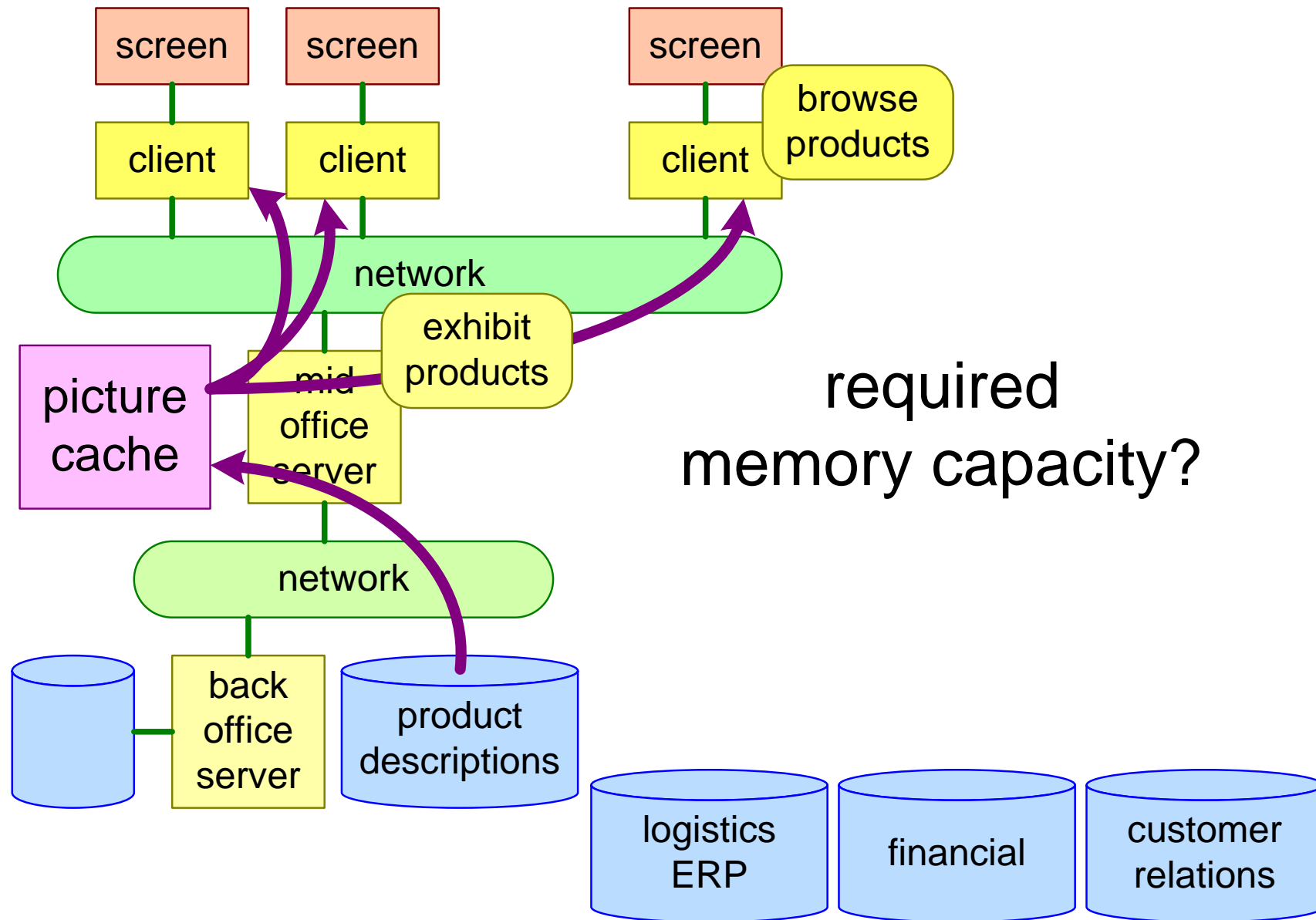
Hit Rate Considerations



Response Time

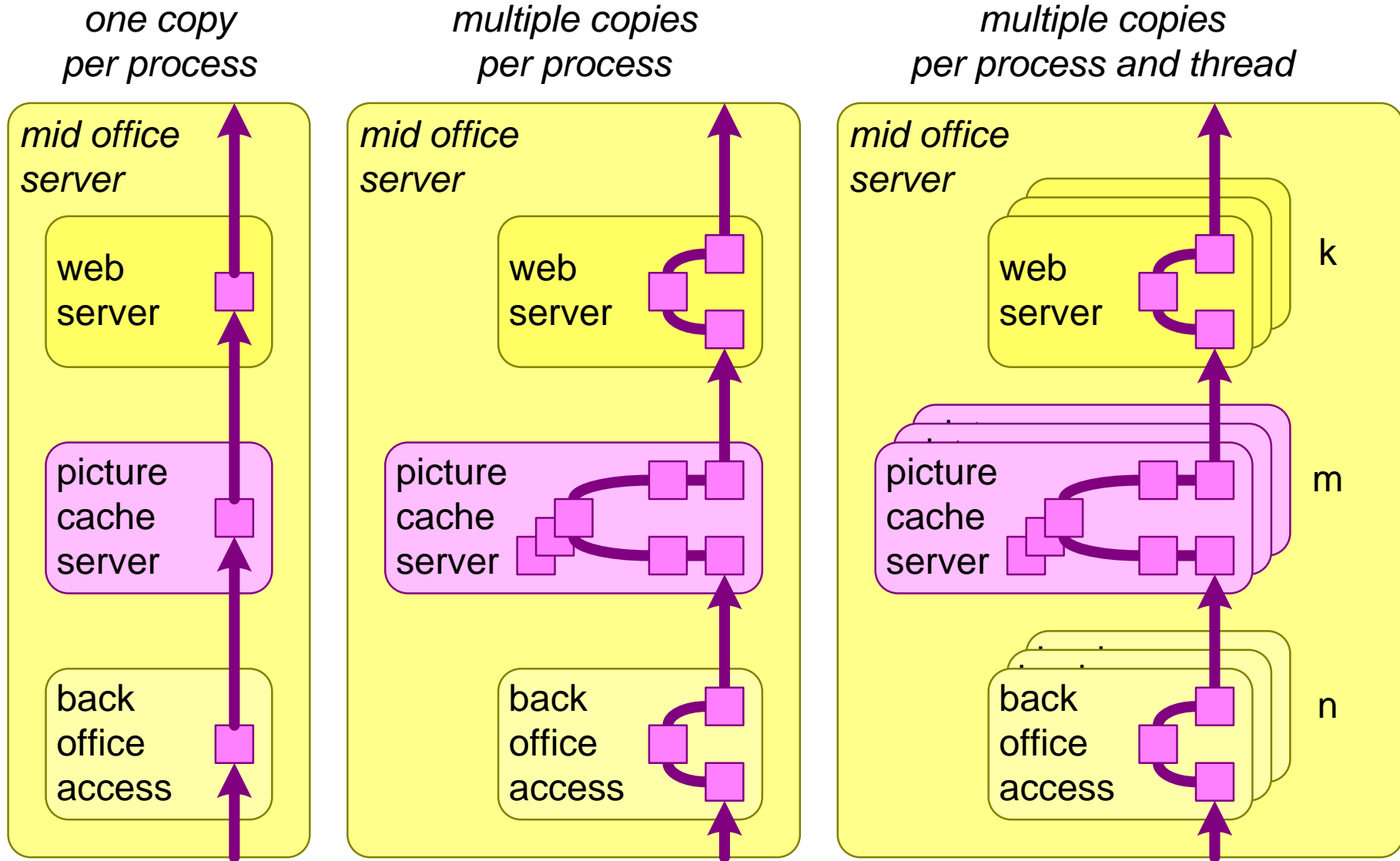


What Memory Capacity is Required for Picture Transfers?



required
memory capacity?

Process View of Picture Flow in Web Server



Formula memory Use Web Server

picture memory =

$$3 * n * s +$$

$$5 * m * s + c * s +$$

$$3 * k * s$$

where

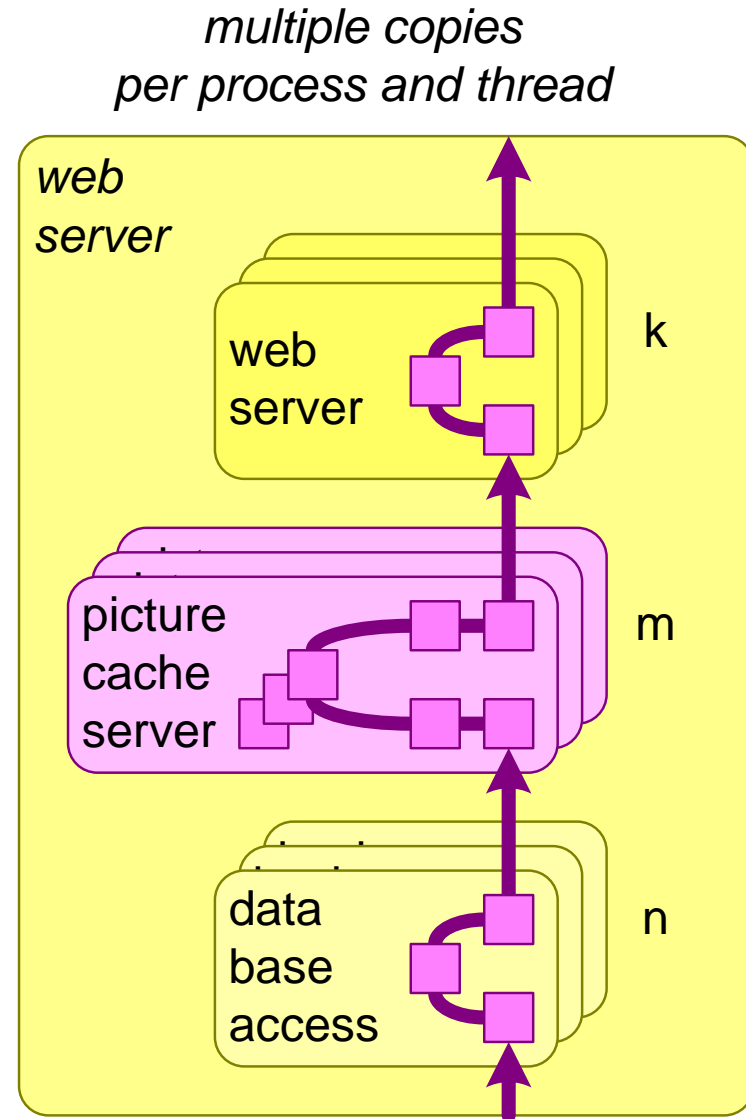
n = # data base access threads

m = # picture cache threads

k = # web server threads

s = picture size in bytes

c = in memory cache capacity in # pictures



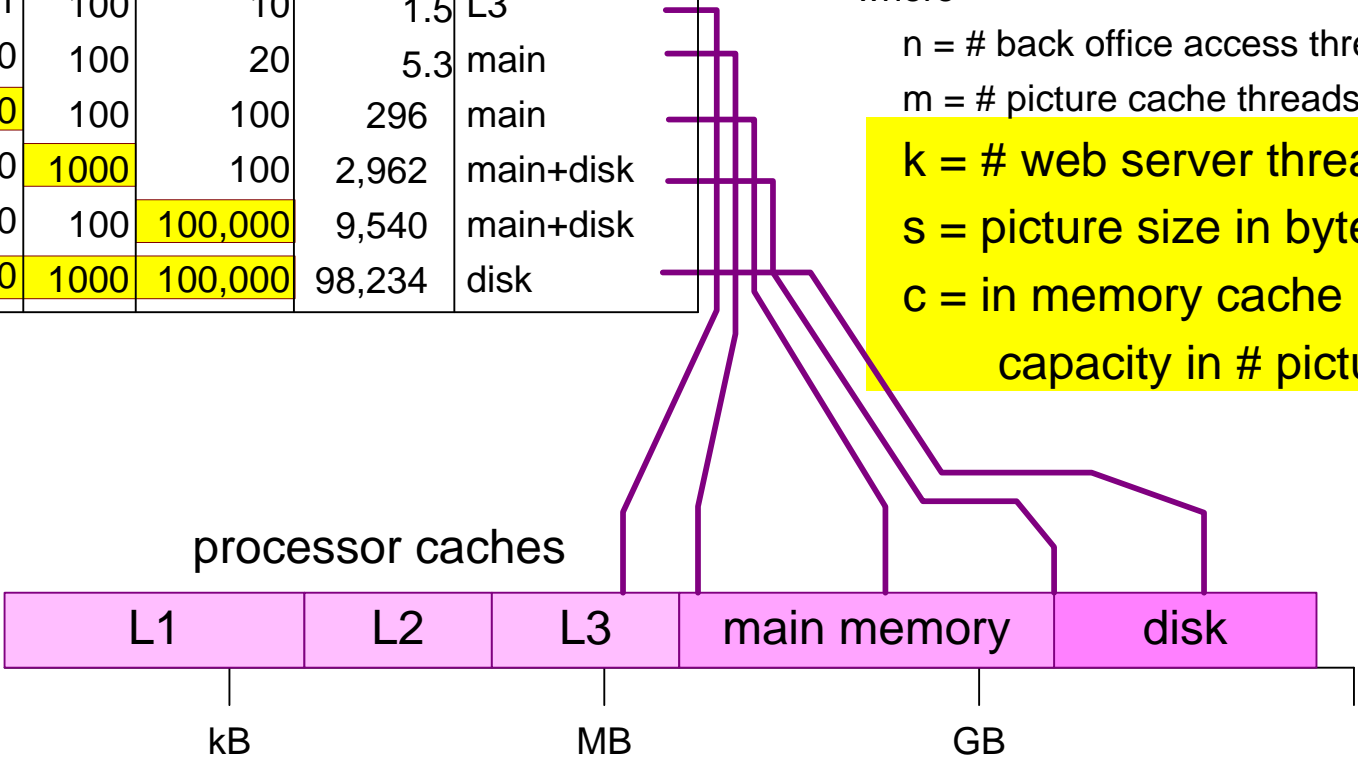
Web Server Memory Capacity

use case	n	m	k	s	c	MB	storage type	picture memory = 3 n s + 5 m s + c s + 3 k s
small shop	1	1	1	100	10	1.5	L3	
	2	4	10	100	20	5.3	main	
highly concurrent	2	4	1000	100	100	296	main	
large pictures	2	4	1000	1000	100	2,962	main+disk	
many pictures	2	4	10	100	100,000	9,540	main+disk	
all at once	2	4	1000	1000	100,000	98,234	disk	

where

- n = # back office access threads
- m = # picture cache threads
- k = # web server threads
- s = picture size in bytes
- c = in memory cache capacity in # pictures

memory use
 product browsing only
 pictures only
 single server



What is the performance impact of memory use on other processing?

We Have only Modeled a Small Part of the System...

function	browse/exhibit products	sales, order intake, payments track, order handling stock handling financial bookkeeping customer relation management update catalogue advertize after sales support
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data	picture	structured (product attributes, logistics, ...) program code
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aspect	server memory use response time server load	network use reliability any resource, any NFR
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aspect result	=	$\sum_{d = \text{all data}}$	$\sum_{f = \text{all functions}}$	aspect(d, f)
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ignoring other dimensions such as applications, users, circumstances

static

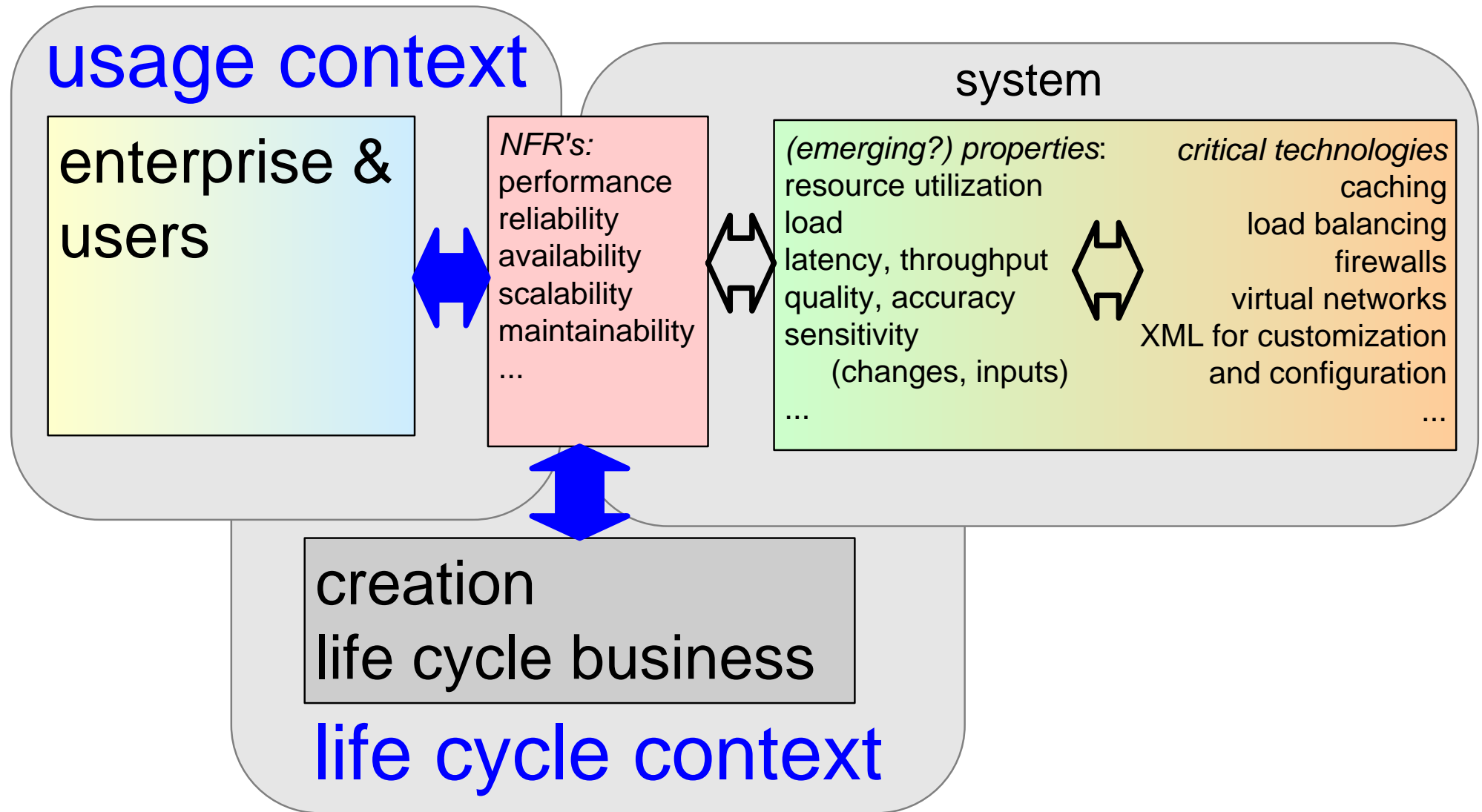
mostly assumptions and coarse estimates

some insight in:

what are key design issues

what are relevant use case areas

Refinement After Context Modeling



Conclusions

Non Functional Requirements are the starting point for system modeling

Focus on highest ranking relations between NFR's and critical technologies

Make simple mathematical models

Evaluate quantified instantiations

Techniques, Models, Heuristics of this module

Non functional requirements

System properties

Critical technologies

Graph of relations