

# Modeling and Analysis: System Model

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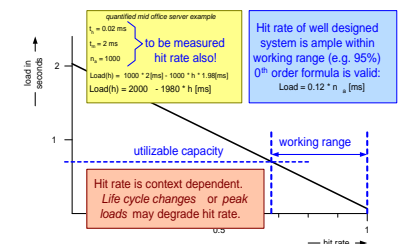
## Abstract

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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## *content*

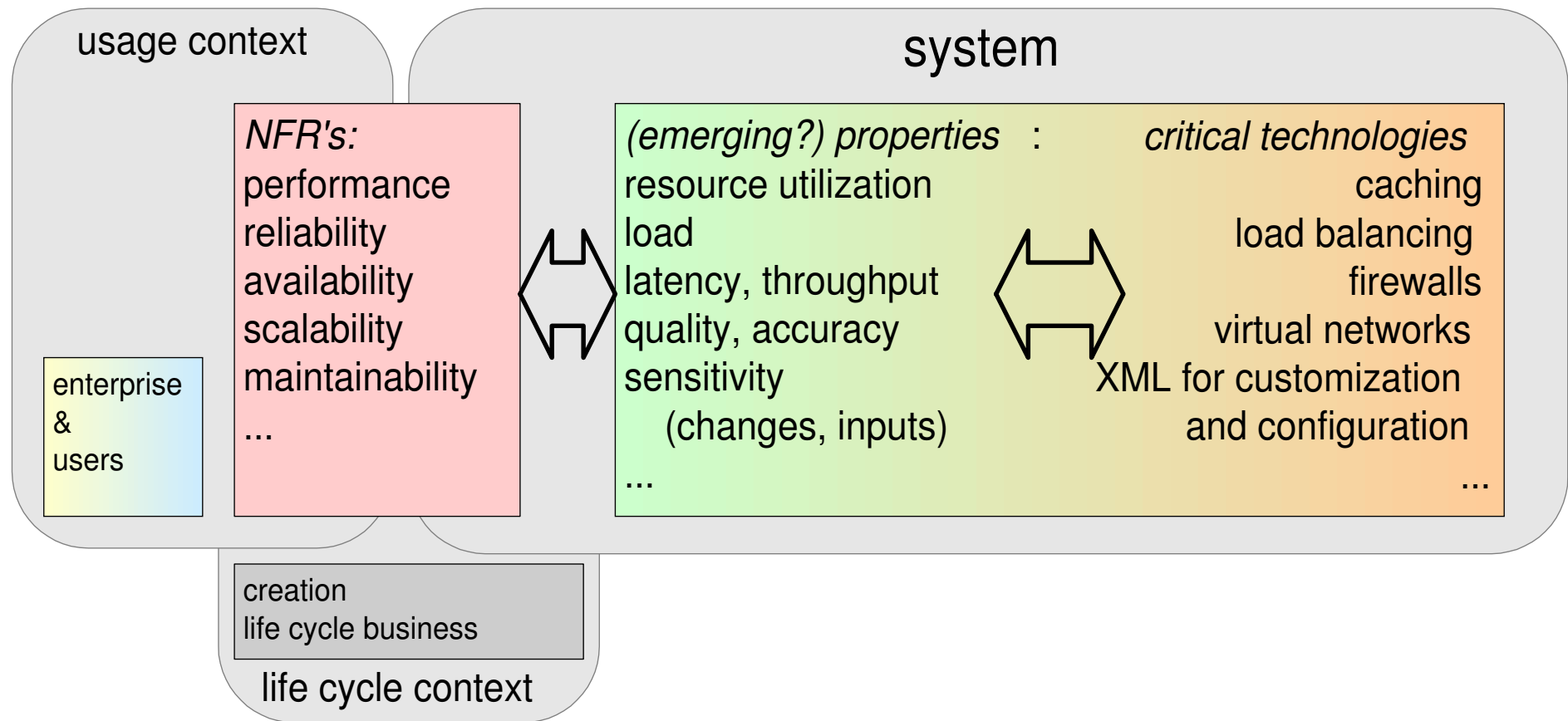
What to model of the system

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?

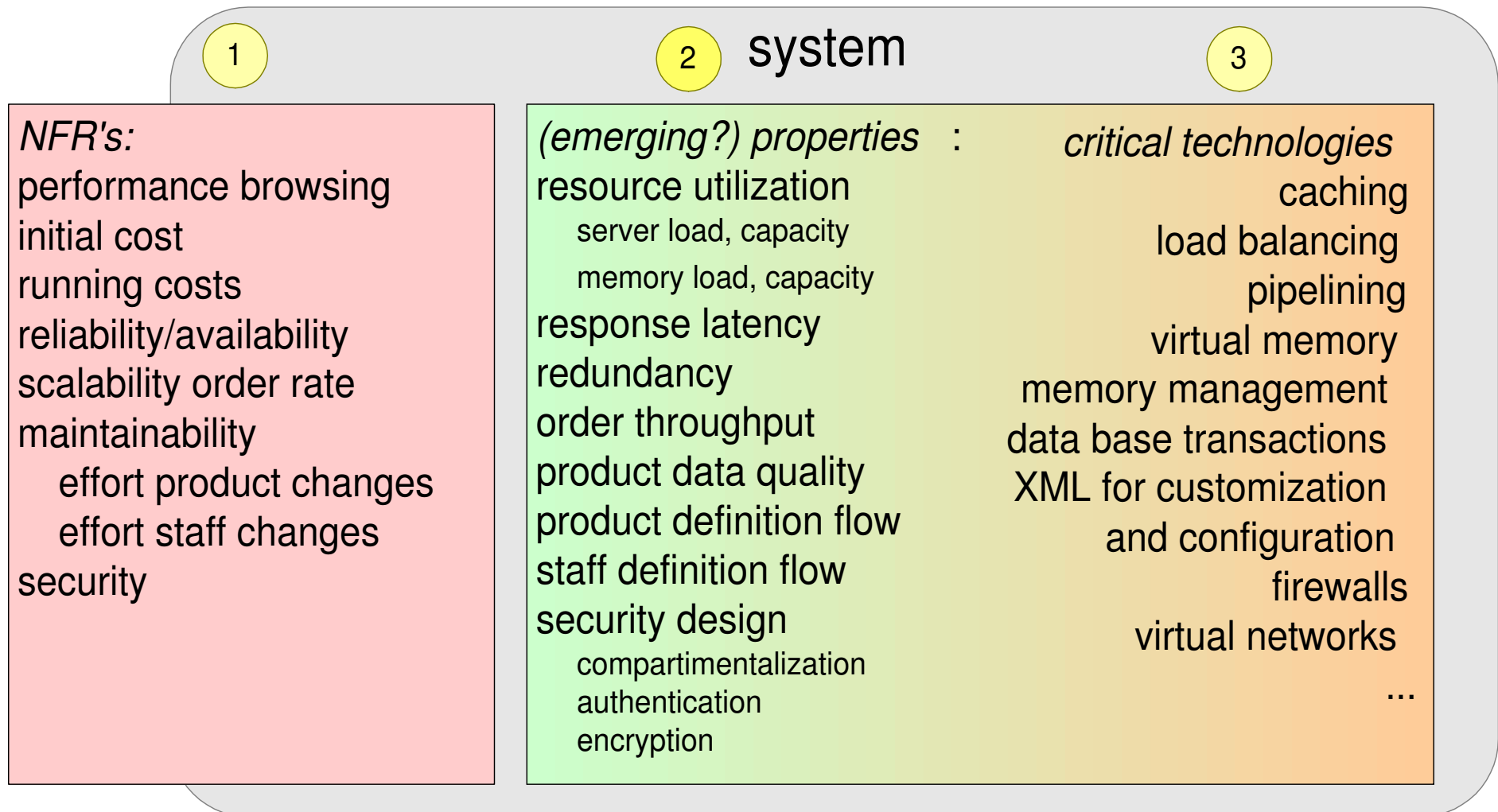


# Approach to System Modeling

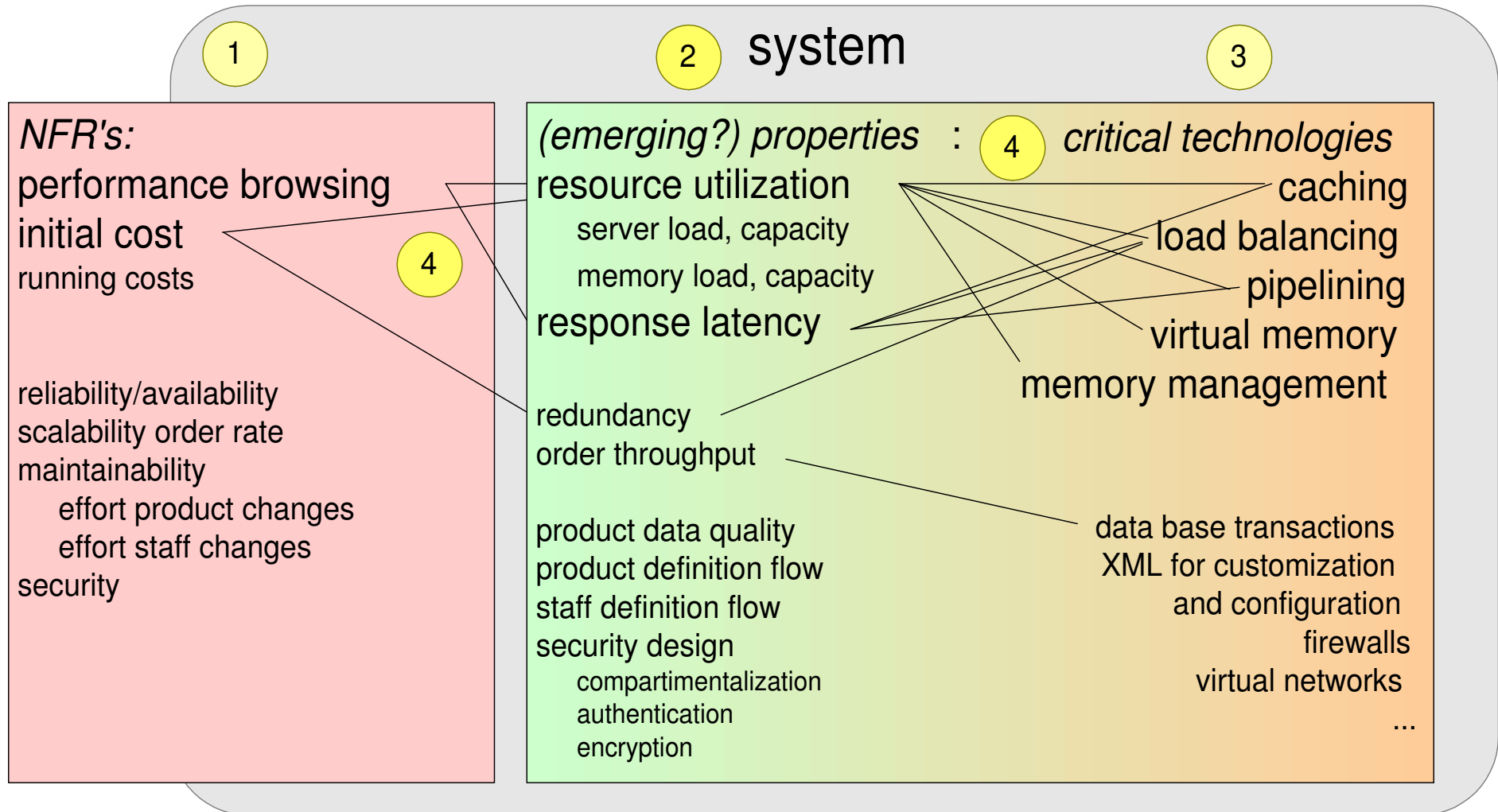
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1. determine relevant Non Functional Requirements (NFR's)
2. determine relevant system design properties
3. determine critical technologies
4. relate NFR's to properties to critical technologies
5. rank the relations in relevancy and criticality
6. model relations with a high score

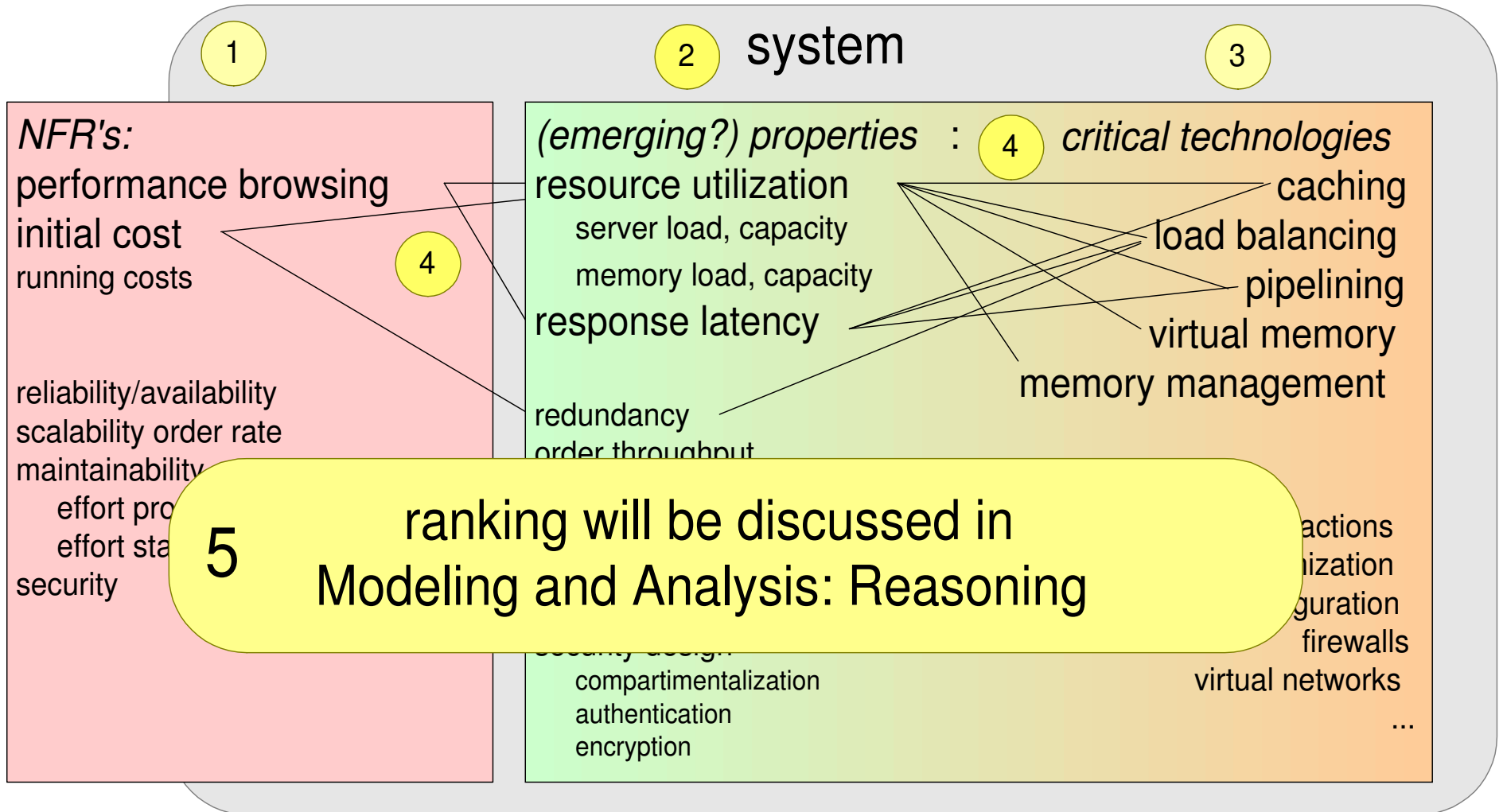
# Web Shop: NFR's, Properties and Critical Technologies



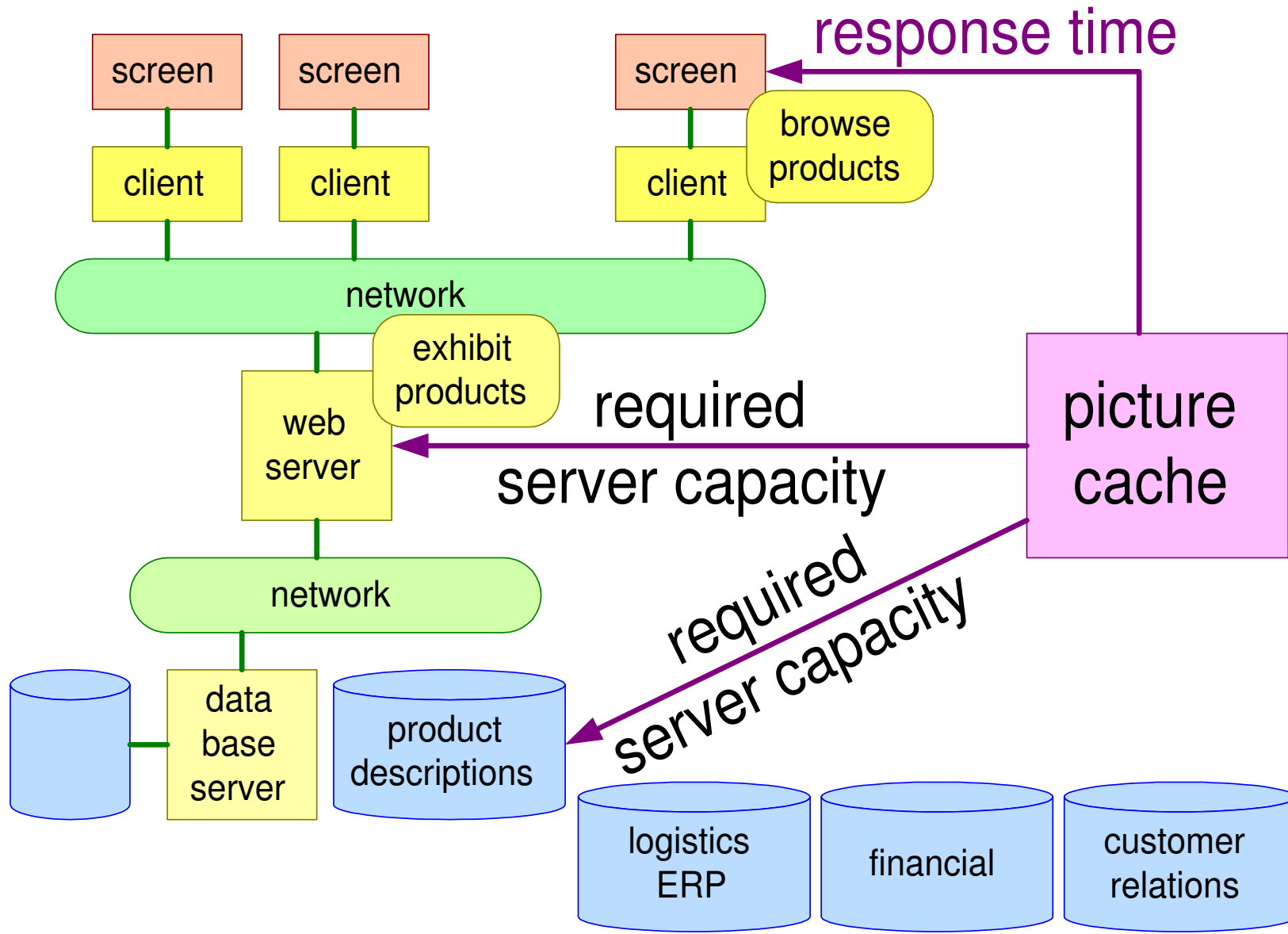
# 4. Determine Relations



# 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

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

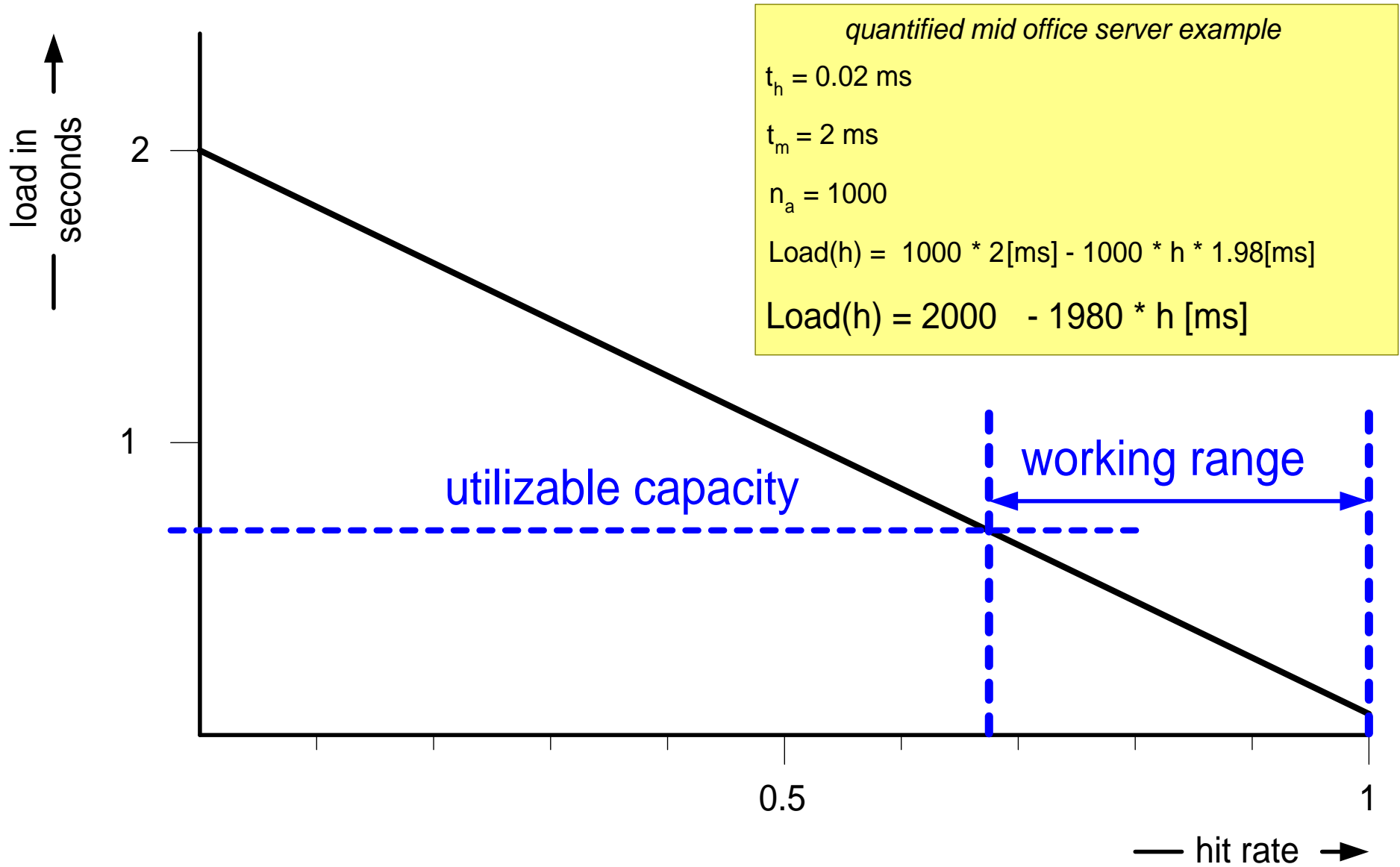
$$n_{a,m} = n_a * (1-h)$$

$n_a$  = total accesses

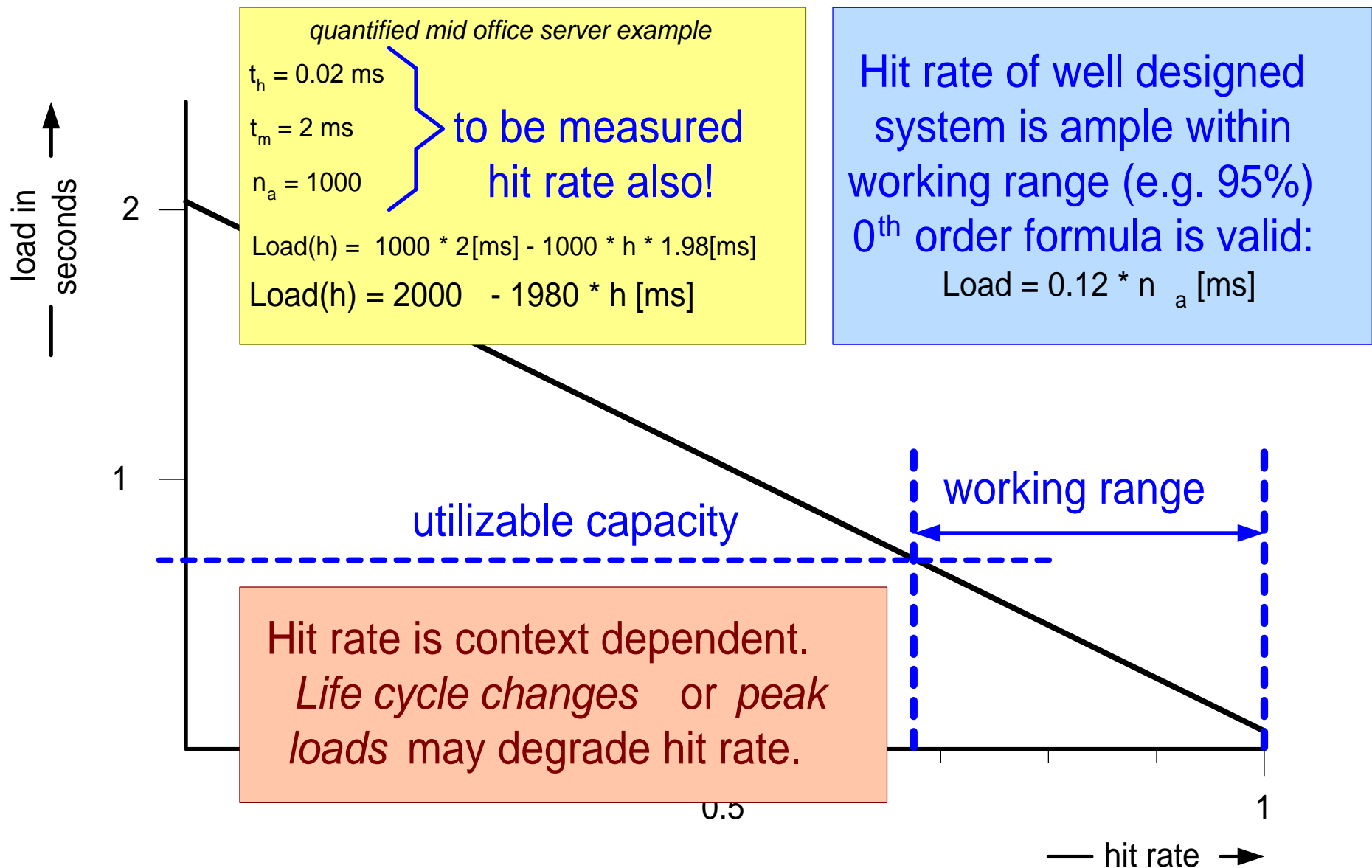
$h$  = hit rate

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

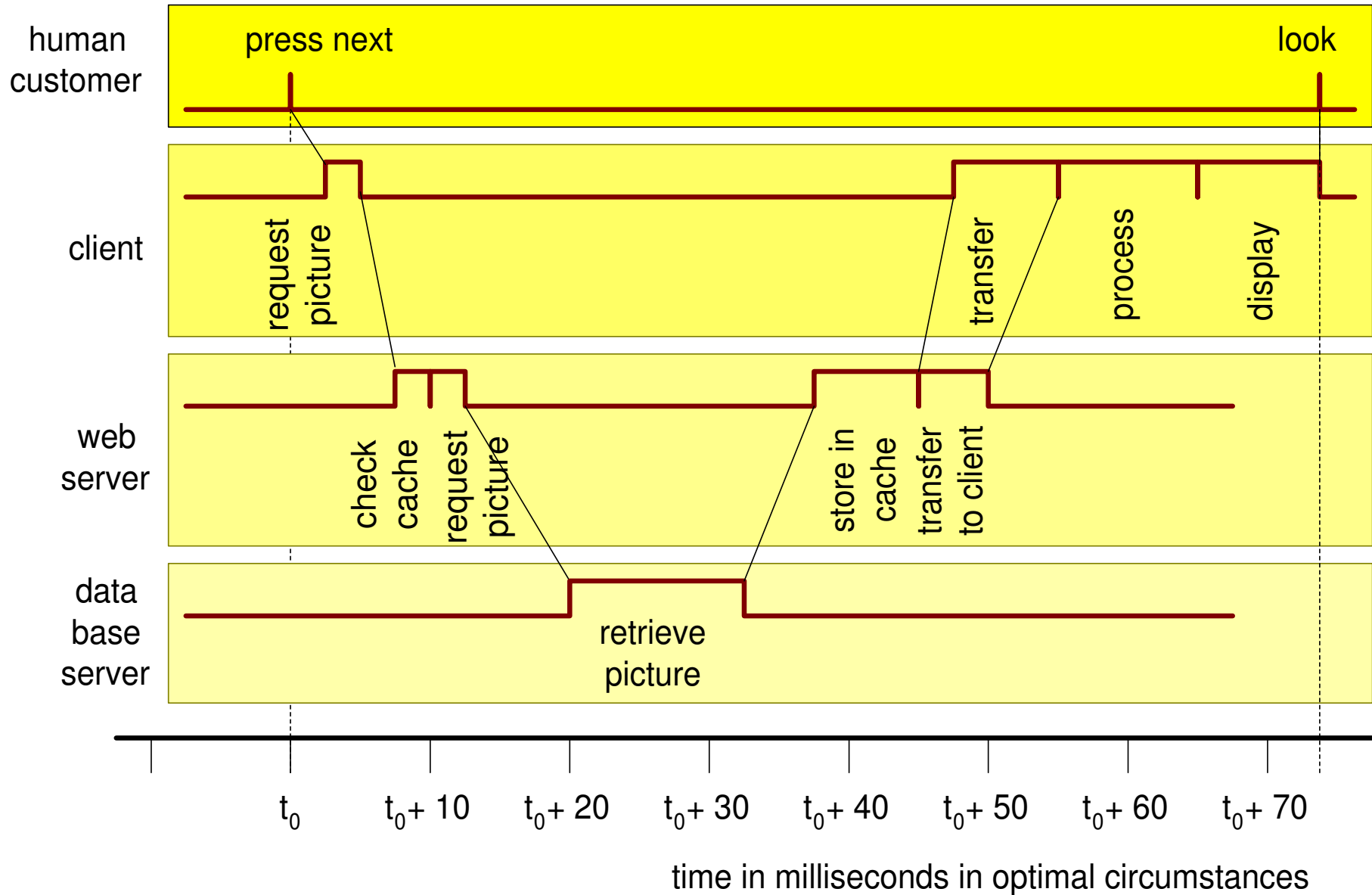
# Quantification: From Formulas to Insight



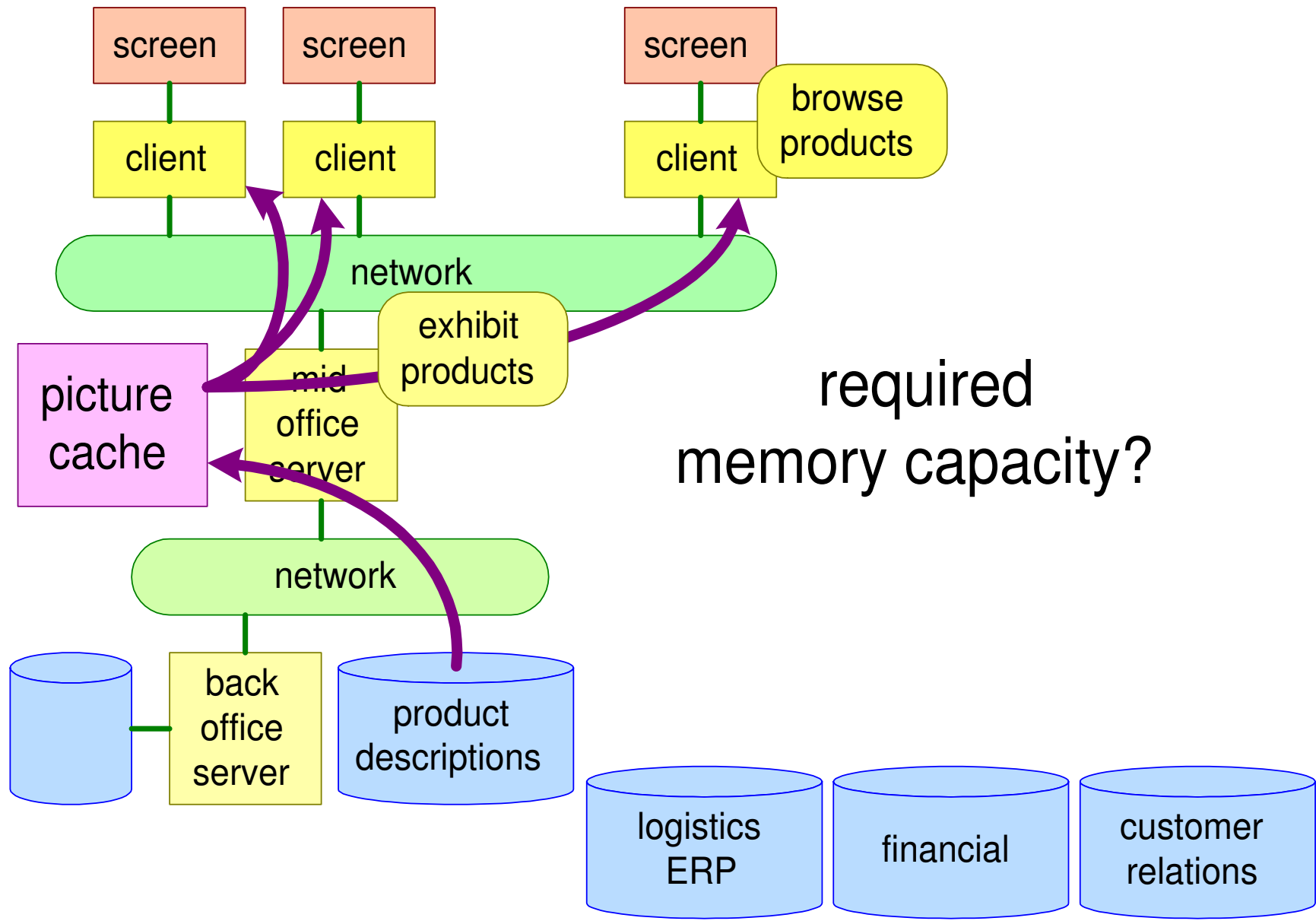
# Hit Rate Considerations



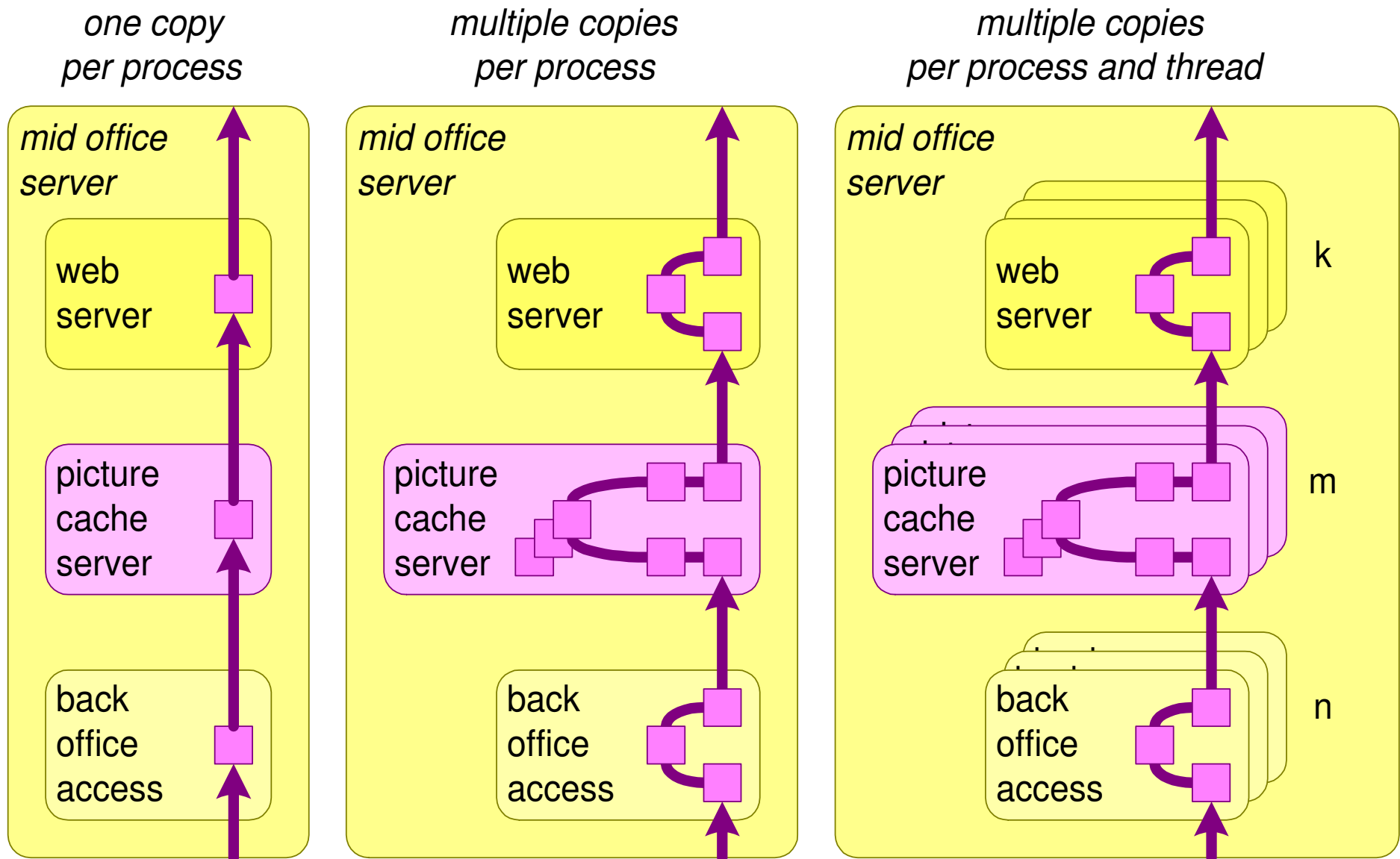
# Response Time



# What Memory Capacity is Required for Picture Transfers?



# 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

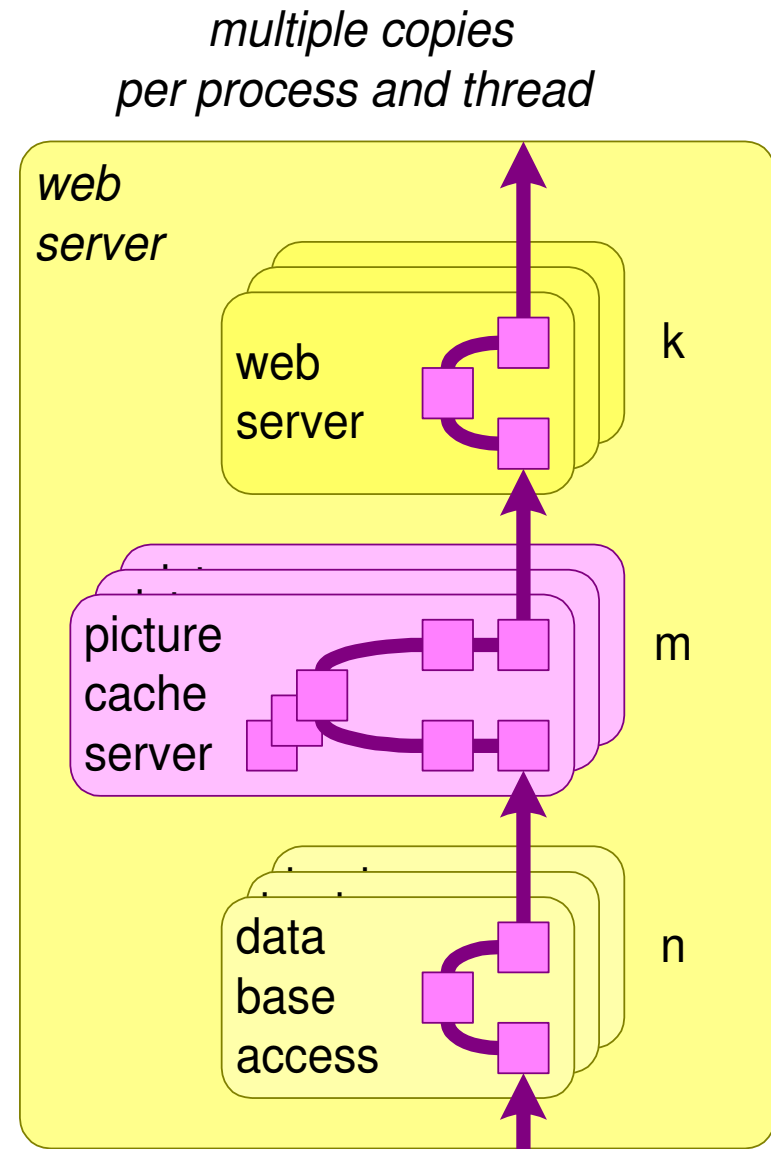
$n$  = # data base access threads

$m$  = # 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
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

$$\text{picture memory} = 3 n s + 5 m s + c s + 3 k s$$

where

n = # back office access threads

m = # picture cache threads

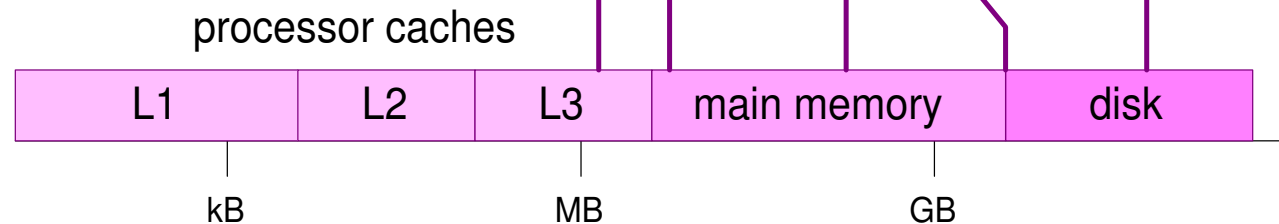
k = # web server threads

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

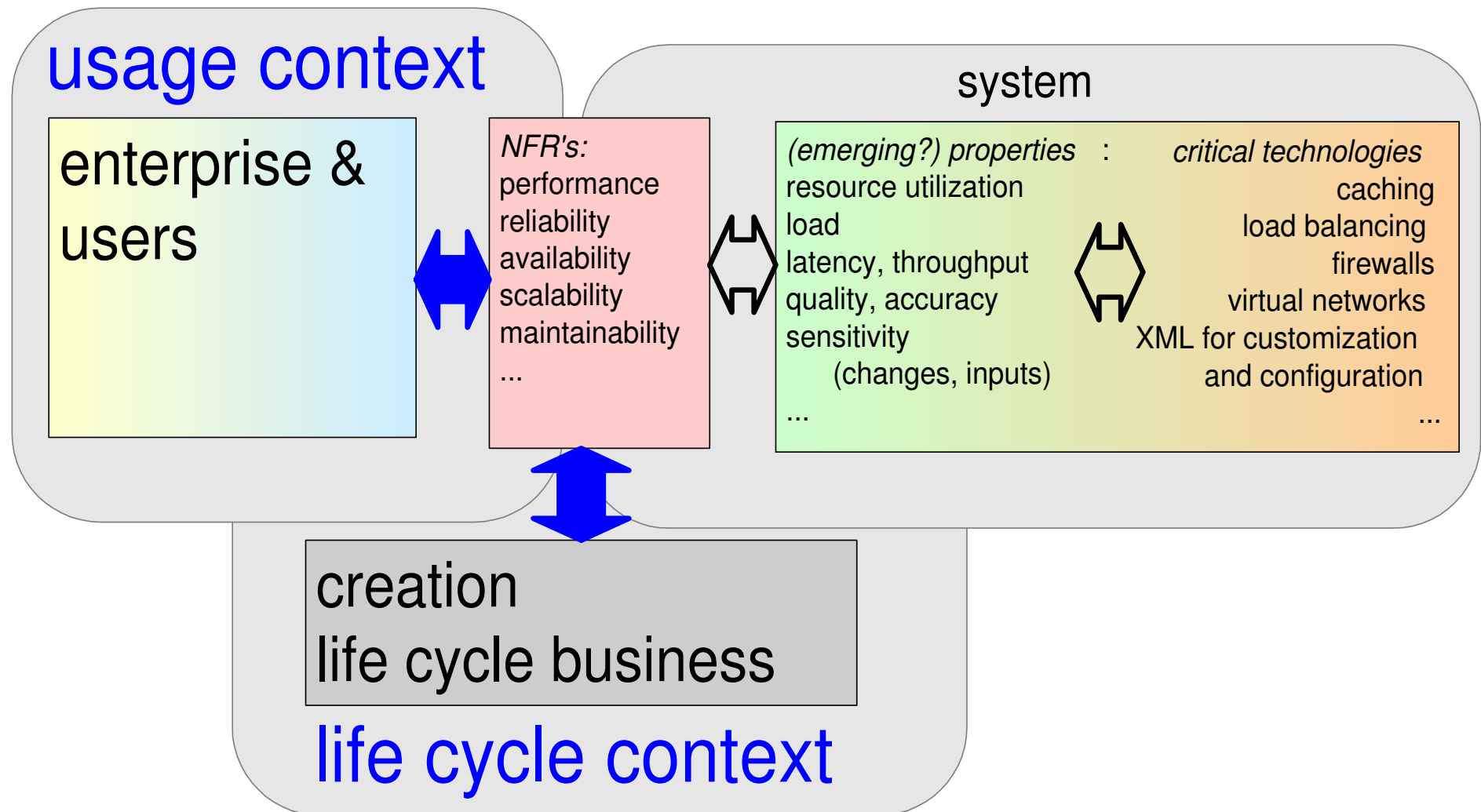
mostly assumptions and coarse estimates

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