



# Software Architecture

<https://app.schoology.com/course/383006041/>

*Software Architecture: Introduction to the abstraction*

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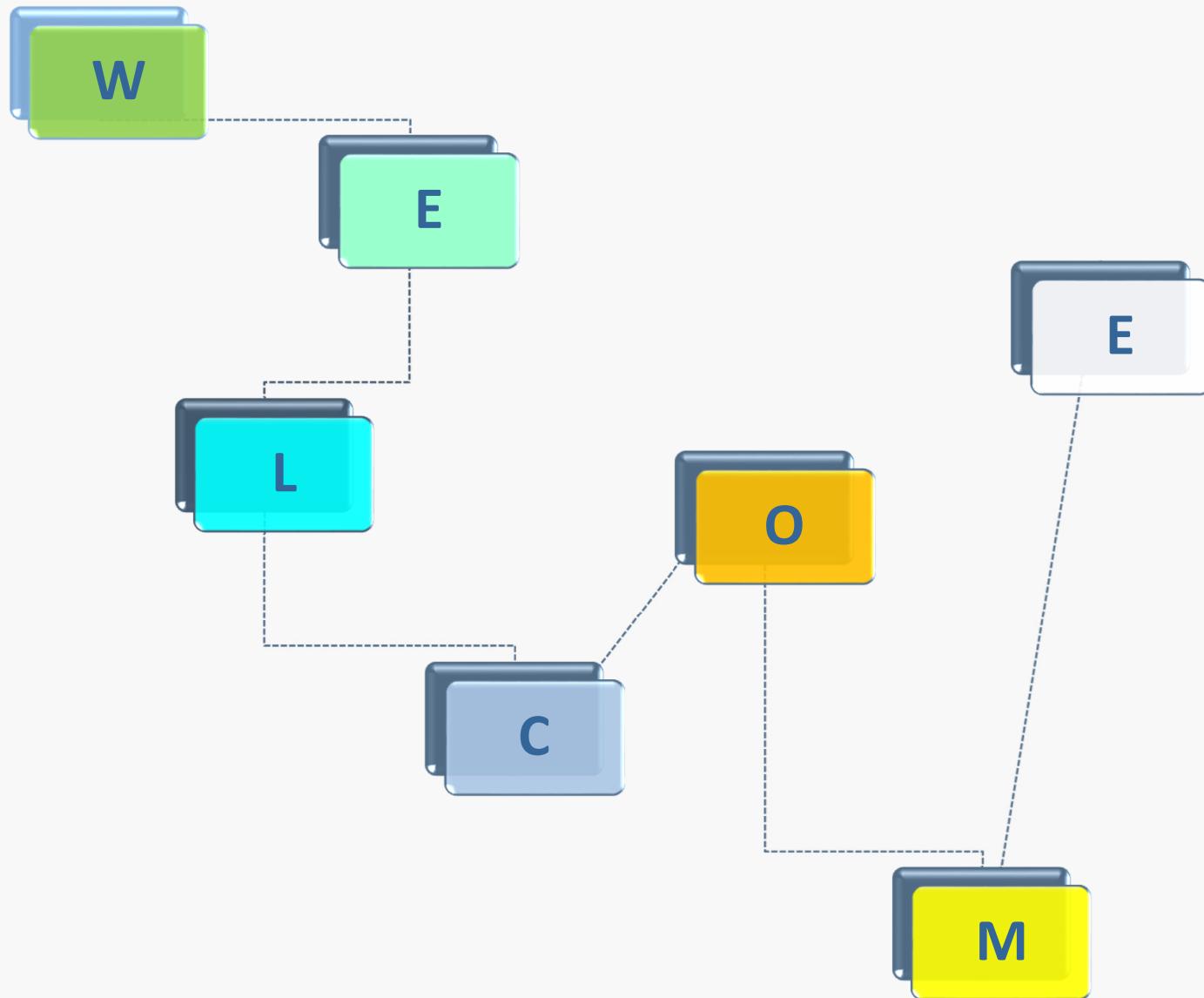


DISIM

Dept. of Information Engineering, Computer Science and Mathematics  
University of L'Aquila, Italy

Welcome

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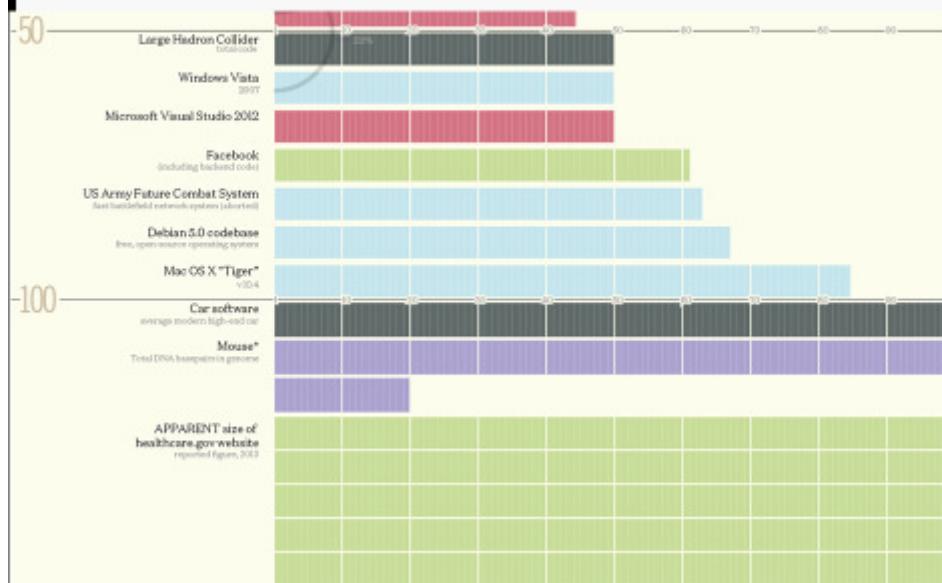
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<http://www.informationisbeautiful.net/visualizations/million-lines-of-code/>



## Implications....

### Standish Findings By Year Updated for 2009

	1994	1996	1998	2000	2002	2004	2009
Succeeded	16%	27%	26%	28%	34%	29%	32%
Failed	31%	40%	28%	23%	15%	18%	24%
Challenged	53%	33%	46%	49%	51%	53%	44%

- See more at: <http://www.projectred.org/latest-news/190-software-project-failure-costs-billions-better-estimation-planning-can-help.html>



## Final Version



## From my closet to... Software Design

Buy vs. Build

Design Patterns

Design Decisions

Environmental Constraints

Risk mitigation

Incremental design

Resources

mistakes -> learn -> fix -> mistakes ->



## Textbook + Linkedin Groups

**Software Architecture in Practice (3rd Edition) (SEI Series in Software Engineering)** Hardcover – October 5, 2012,  
by Len Bass , Paul Clements, Rick Kazman

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### LinkedIn groups on Software Architecture

- **SATURN**  
<https://www.linkedin.com/groups?home=&gid=153925>
- **Software Engineering Productivity – Software Architecture**  
<https://www.linkedin.com/groups?home=&gid=2967358>
- **97 Things Every Software Architect Should Know**  
[https://www.linkedin.com/groups?mostRecent=&gid=1835657&trk=my\\_groups-tile-flipgrp](https://www.linkedin.com/groups?mostRecent=&gid=1835657&trk=my_groups-tile-flipgrp)



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# Research interests

on developing methods and tools for the analysis and design of software architectures

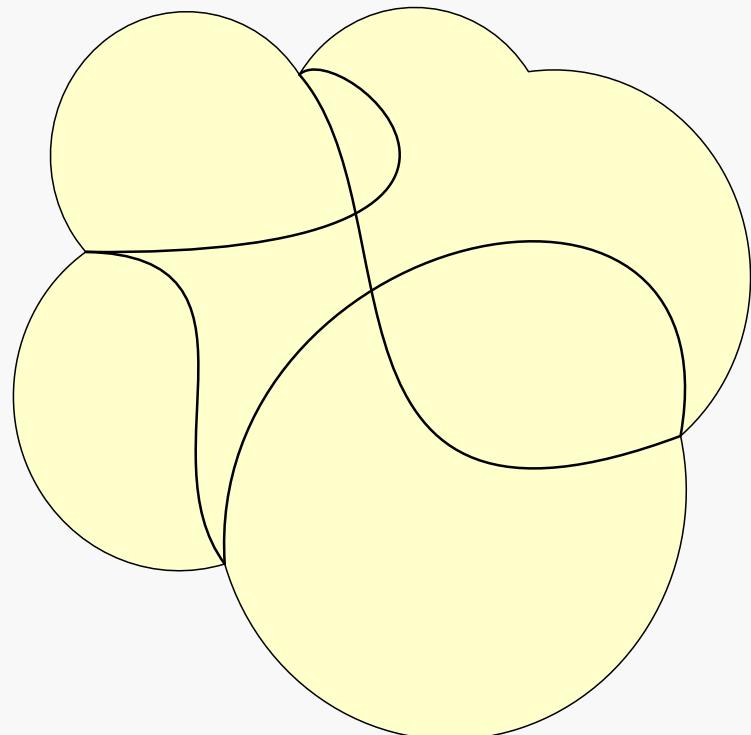
- Architecture-driven Model-based Testing
- Model-checking Architectures
- Architecting Fault Tolerant Systems
- Interoperable and Multi-view Software Architecture Descriptions

## Other

- Global Software Engineering Education
- Architecting Wireless Sensor Network
- Model Driven Engineering



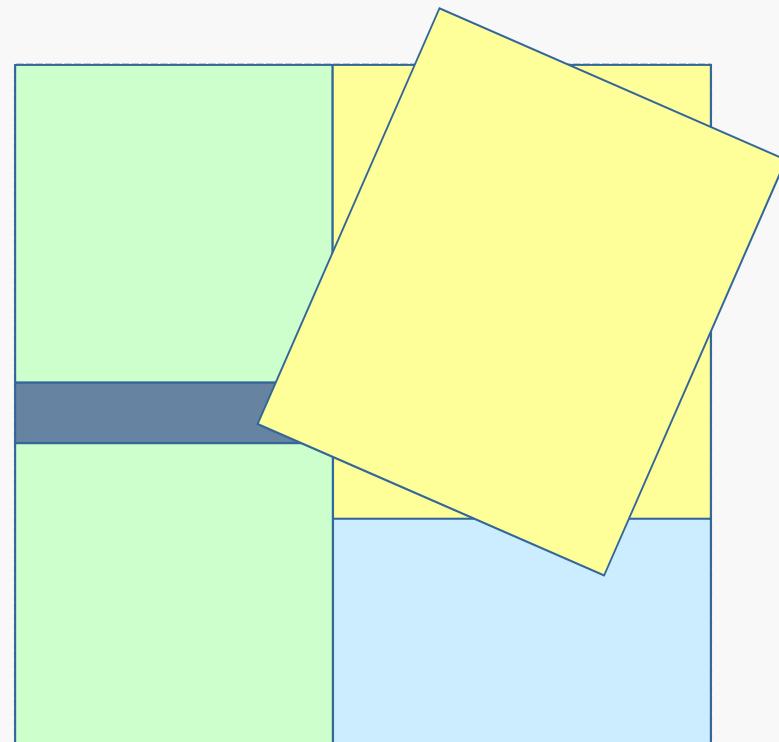
# Software Engineering



**Software System**



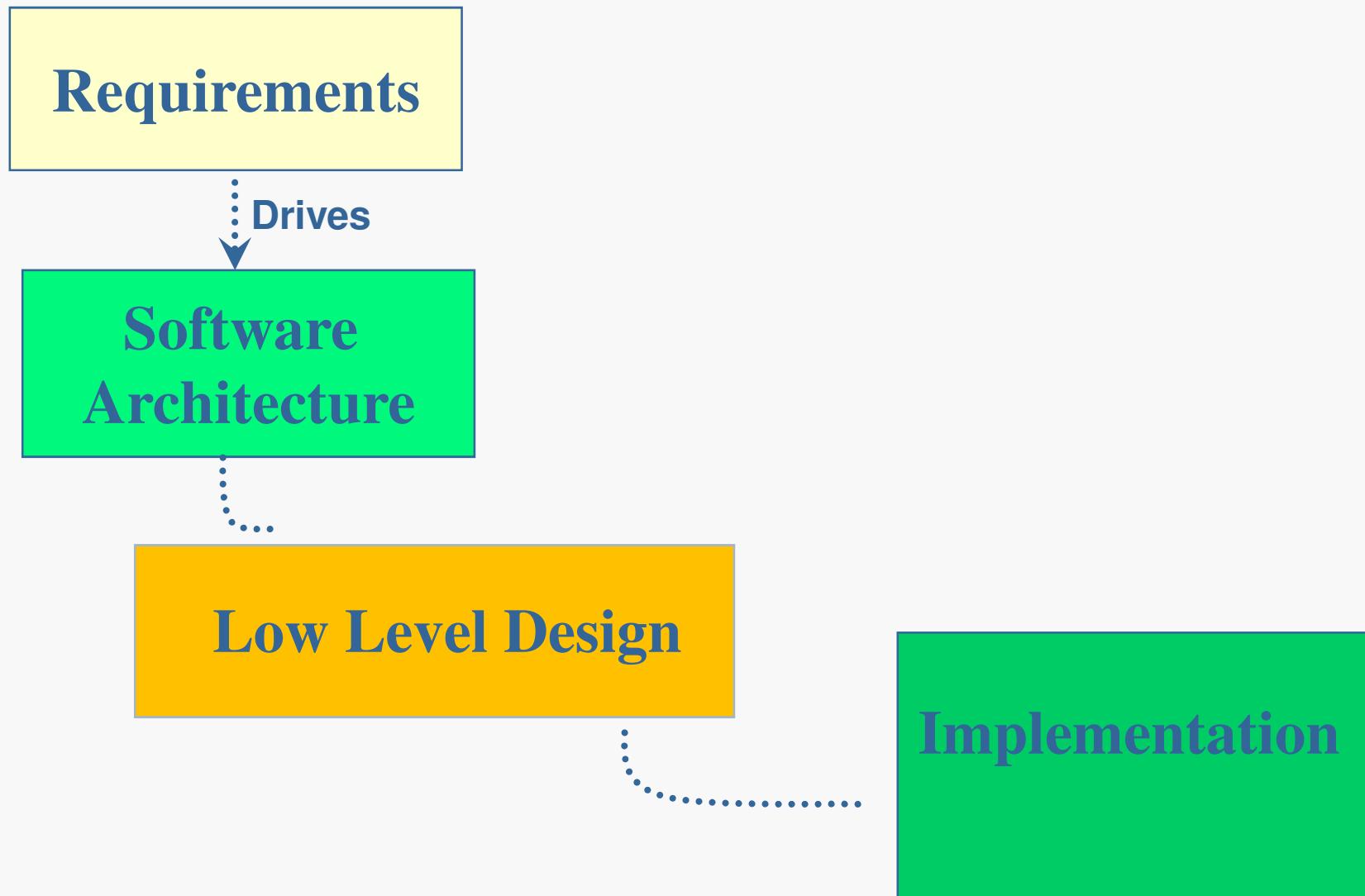
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**Engineered Software System**

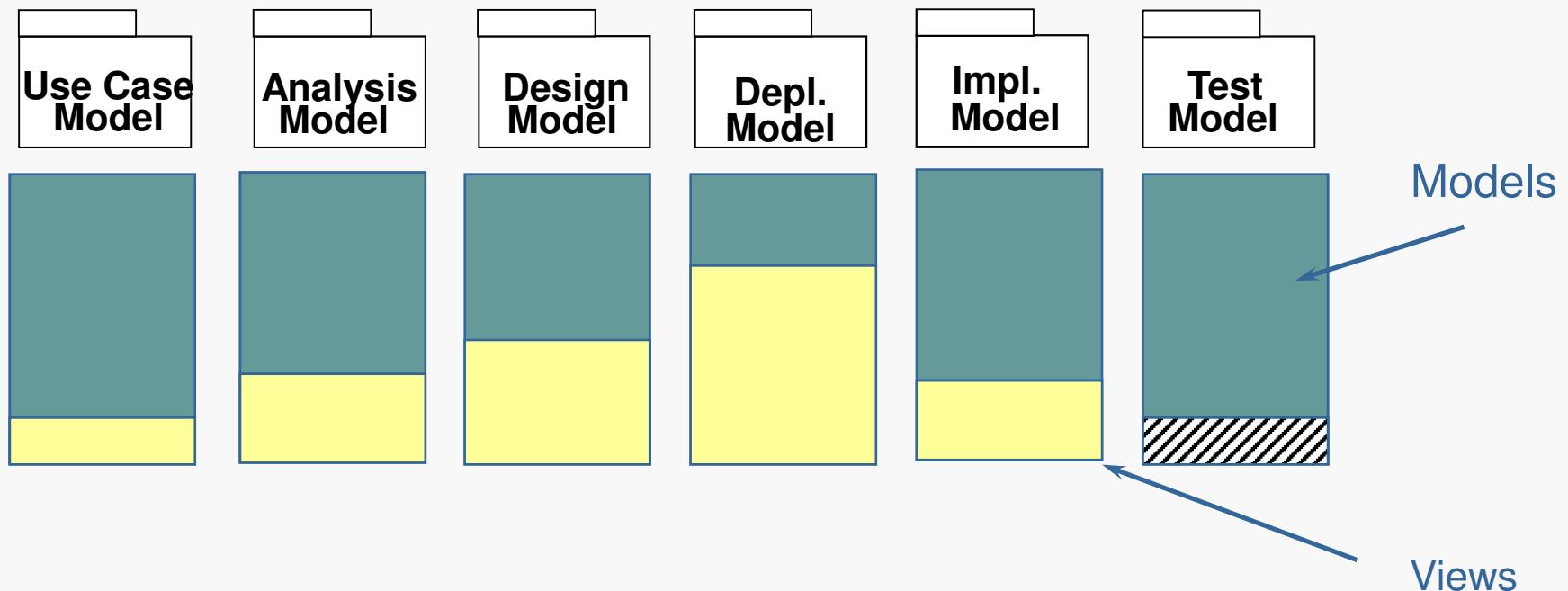


# Process: Architecture as an artefact



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# Process: Architecture towards the process



- The architecture includes a collection of views
- The architecture is NOT a single fase in the software development process



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**Ok, but, ...**  
**What is an architecture?!!**

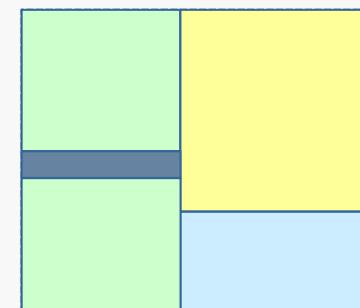


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The Software Architecture is the earliest model of the whole software system created along the software lifecycle

- A set of components and connectors communicating through interfaces
- A set of architecture design decisions
- Focus on set of views and viewpoints
- Written according to architectural styles



# Software Architecture definitions

Perry and Wolf, '92 (aspects):

- “Architecture is concerned with the **selection** of architectural elements, their **interactions**, and the **constraints** on those elements and their interactions necessary to provide a framework in which **to satisfy the requirements and serve as a basis for the design.**”
- Elements are divided into **processing** elements, **data** elements and **connection** elements

Garlan and Shaw, '93 (elements):

- Architecture for a specific system may be captured as “**a collection of computational components** - or simply components - together with a description of the interactions between these components - the **connectors**”



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em Architecture



## Let us reason about the Gaudi's Sagrada Familia



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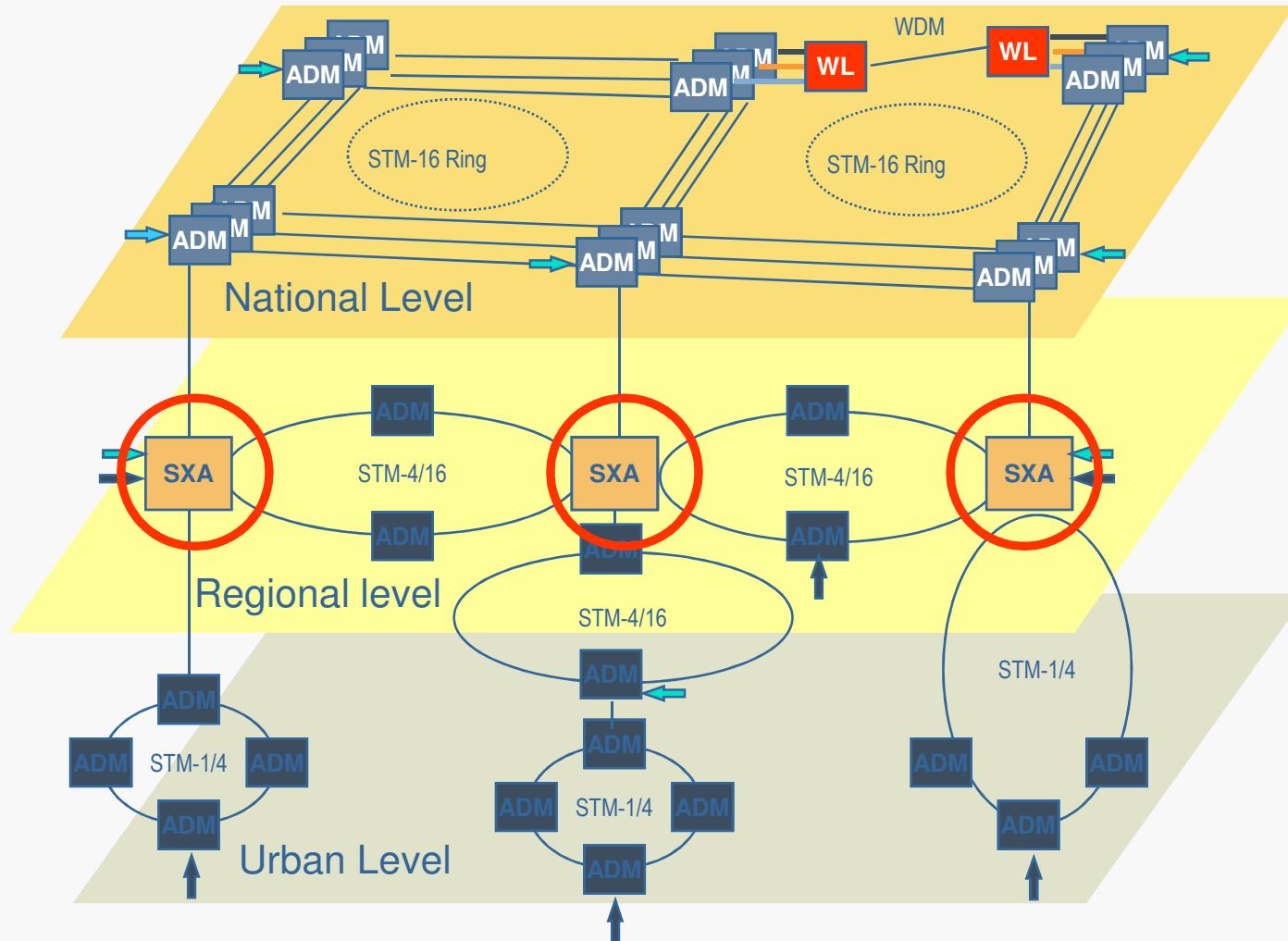
The power of abstraction...



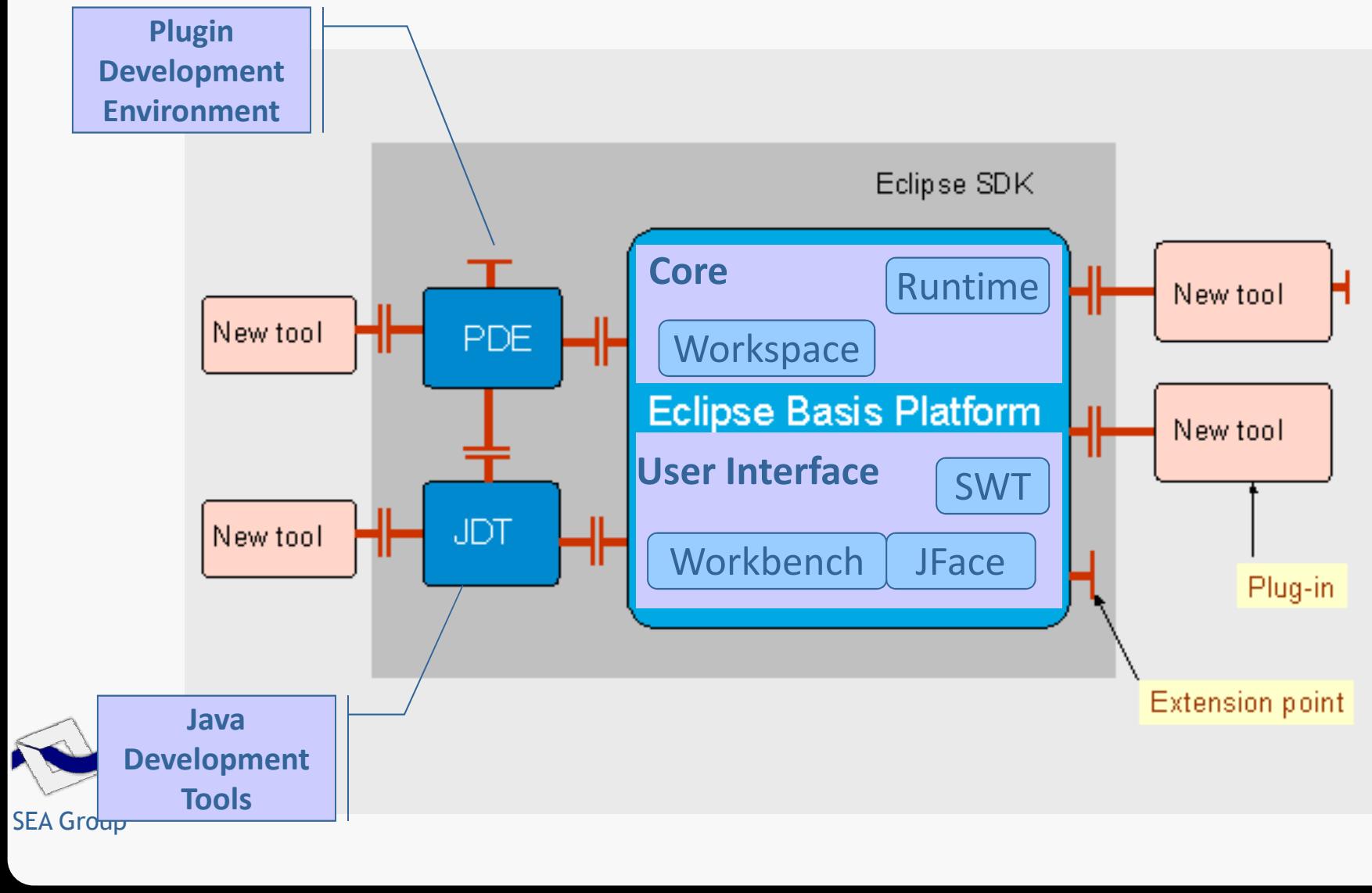
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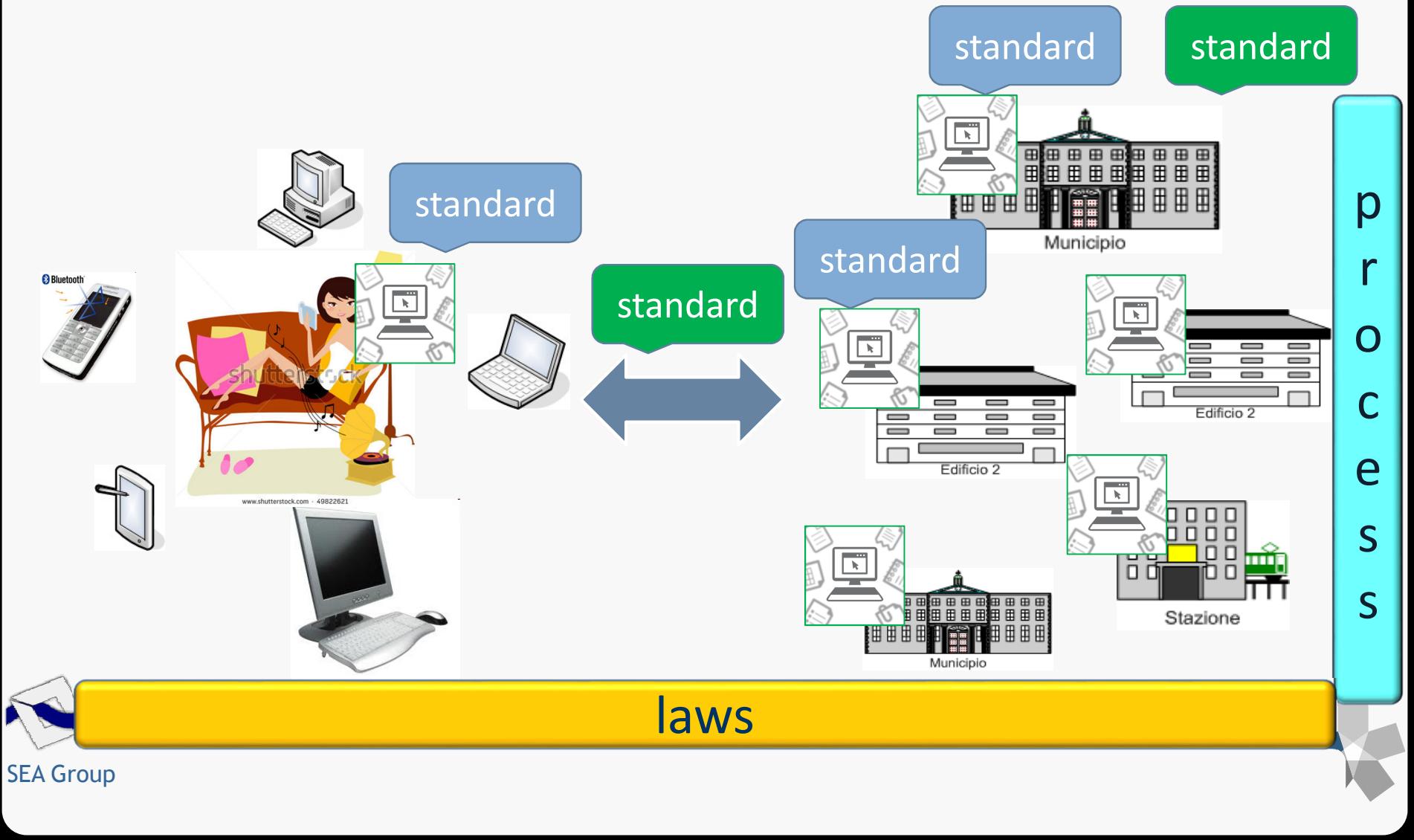
# TELECOM ITALIA NETWORK ARCHITECTURE



## Example: Eclipse Architecture



# eGov Architecture: basics



# (some of the) Requirements for e-Gov

**Privacy e confidentiality**

**Autenticity**

**Need of Standards**

**Shared Process Management**

**Scalability**

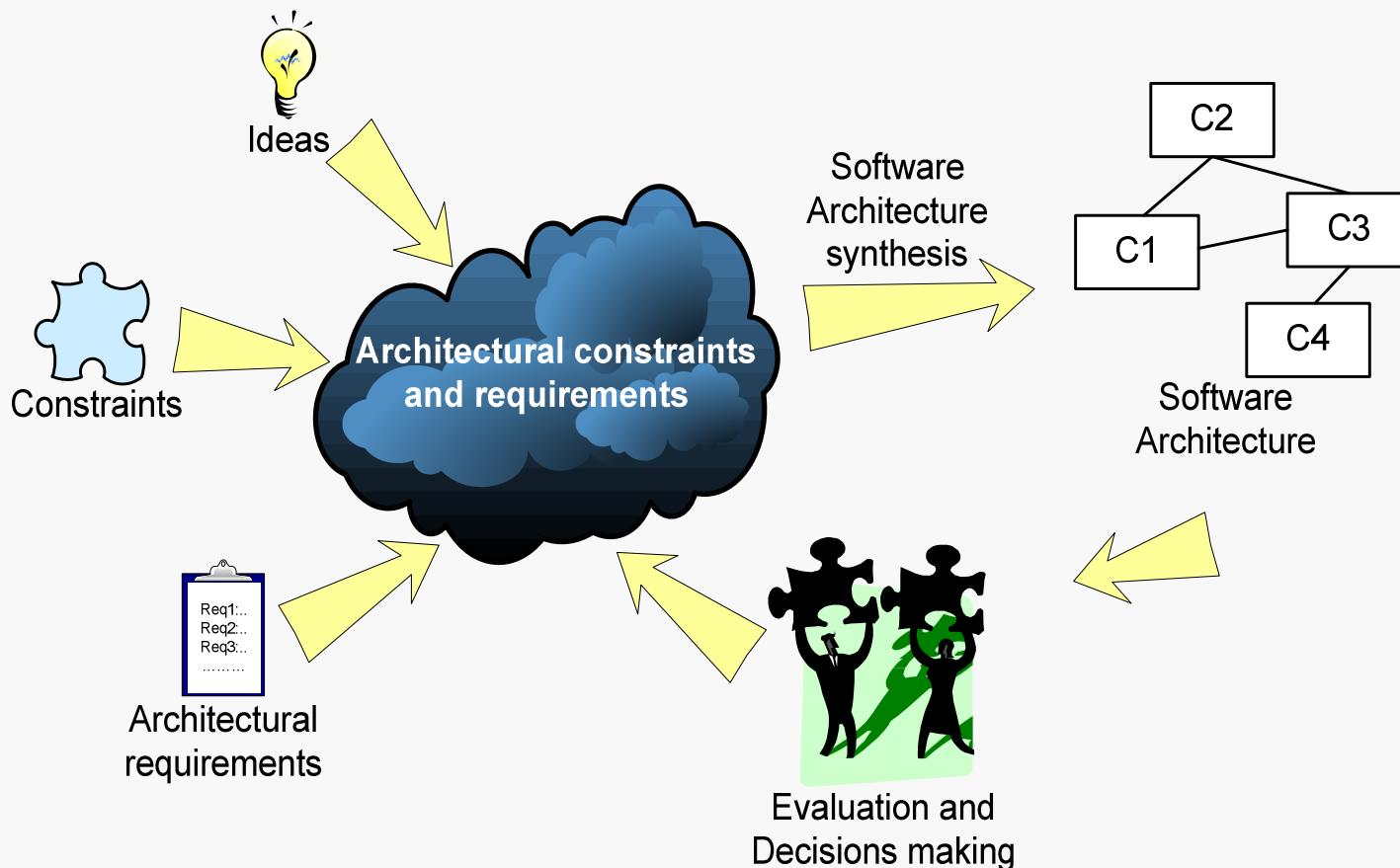
**Docs digitalization**



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# SA General workflow

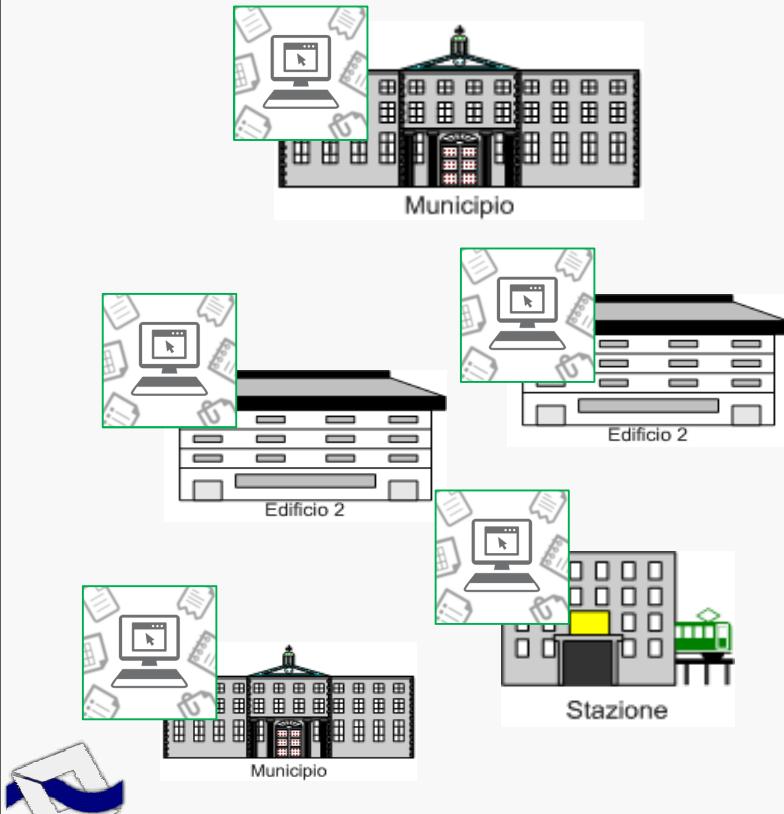


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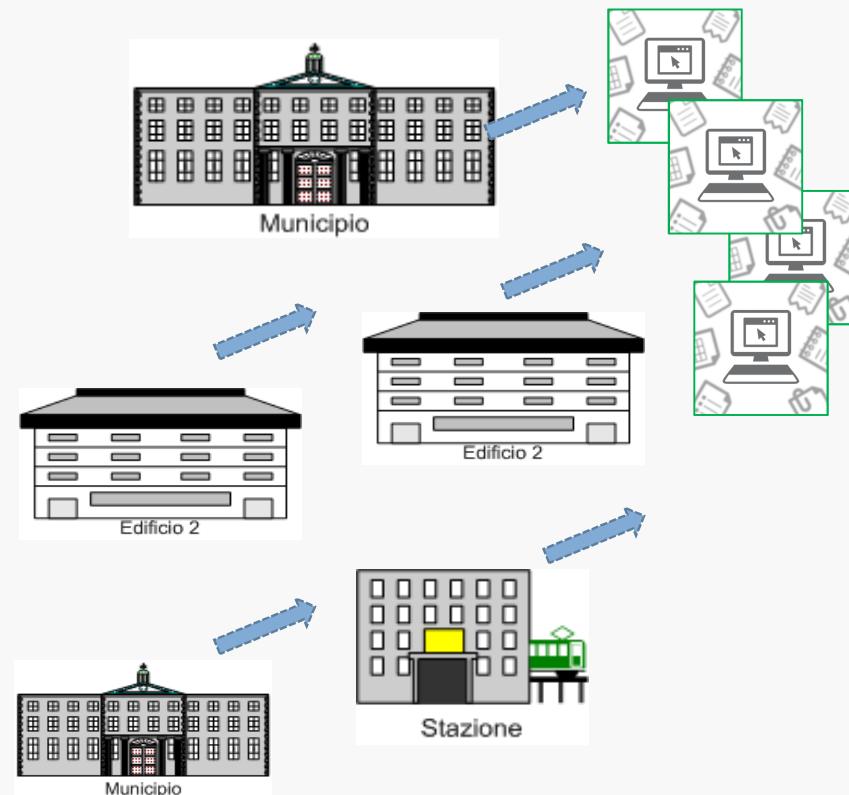


# But which Architecture?

## SA with Decentralized data



## SA with Centralized Data



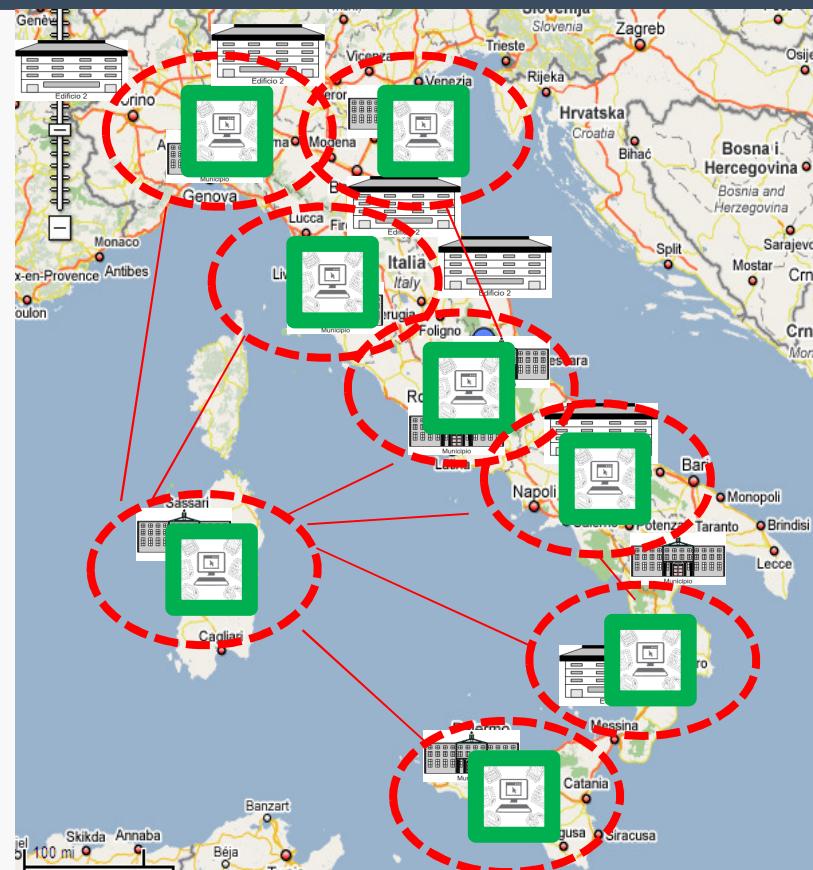
Implications on privacy, confidentiality, performance, scalability, maintainability, etc.

# But which Architecture?

SA with Centralized Data, v1



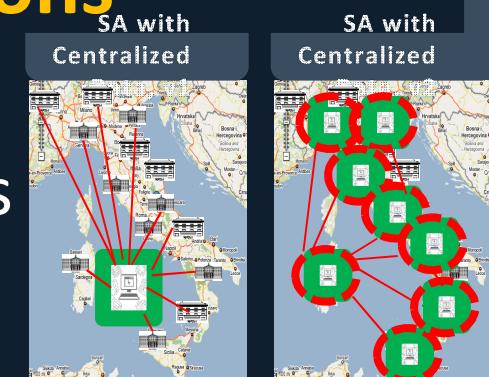
SA with Centralized Data, v2



Implications on privacy, confidentiality, performance, scalability, maintainability, etc.

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# Architecture Design Decisions

Decisions about:

Selected components/interfaces/connectors

Distribution/Configuration of  
components/connectors

Expected behavior

SA Styles, Patterns and Tactics

HW/SW/Deployment and other views

Components' Nesting and sub-systems

NF attributes

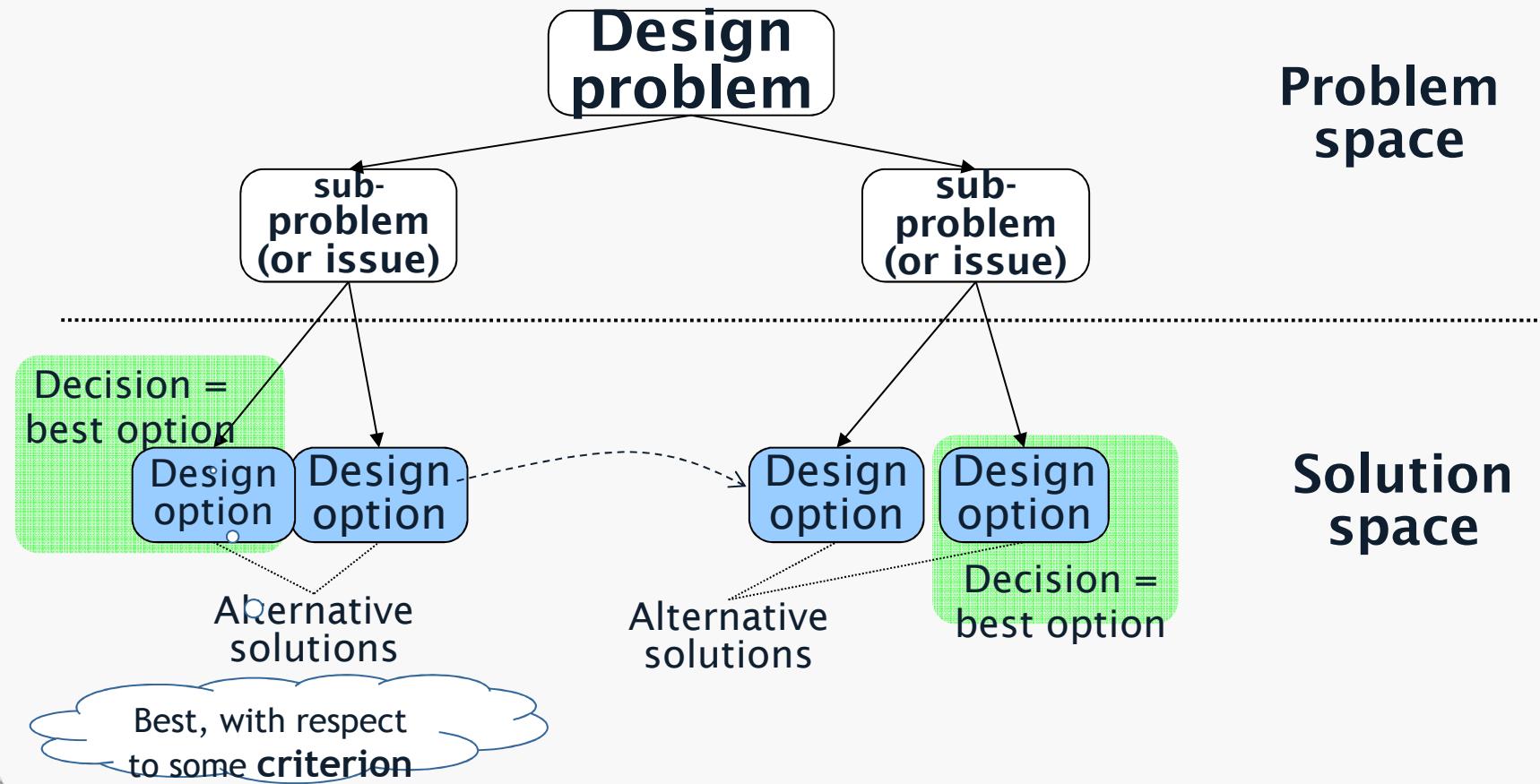


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# Architecture as a set of design decisions

A set of architecture design decisions taken to generate the architecture artifact



Jansen, A.; Bosch, J., "Software Architecture as a Set of Architectural Design Decisions," *Software Architecture, 2005. WICSA 2005. 5th Working IEEE/IFIP Conference on*, vol., no., pp.109,120, 2005. doi: 10.1109/WICSA.2005.61



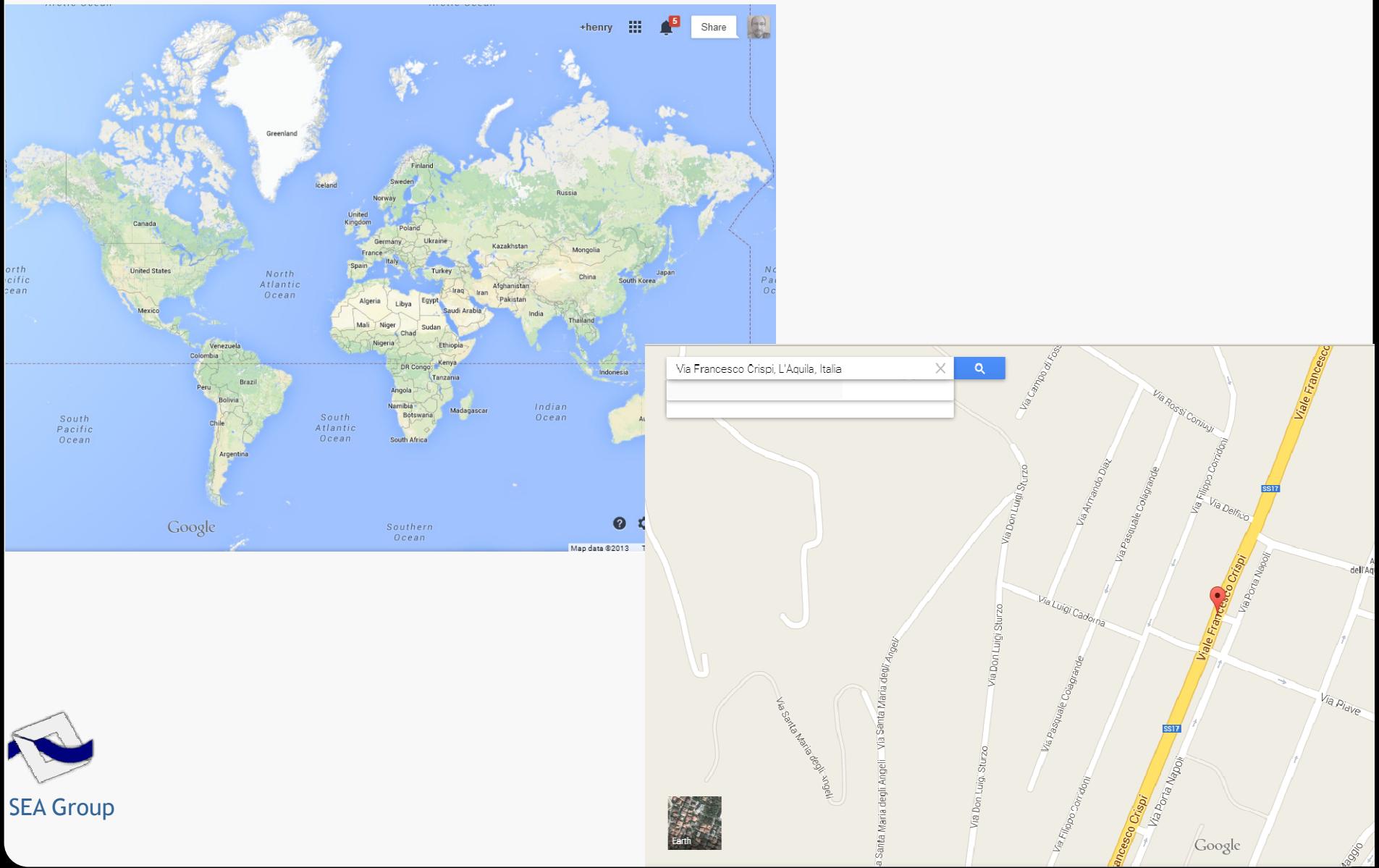
**But, which is the right abstraction!?!**



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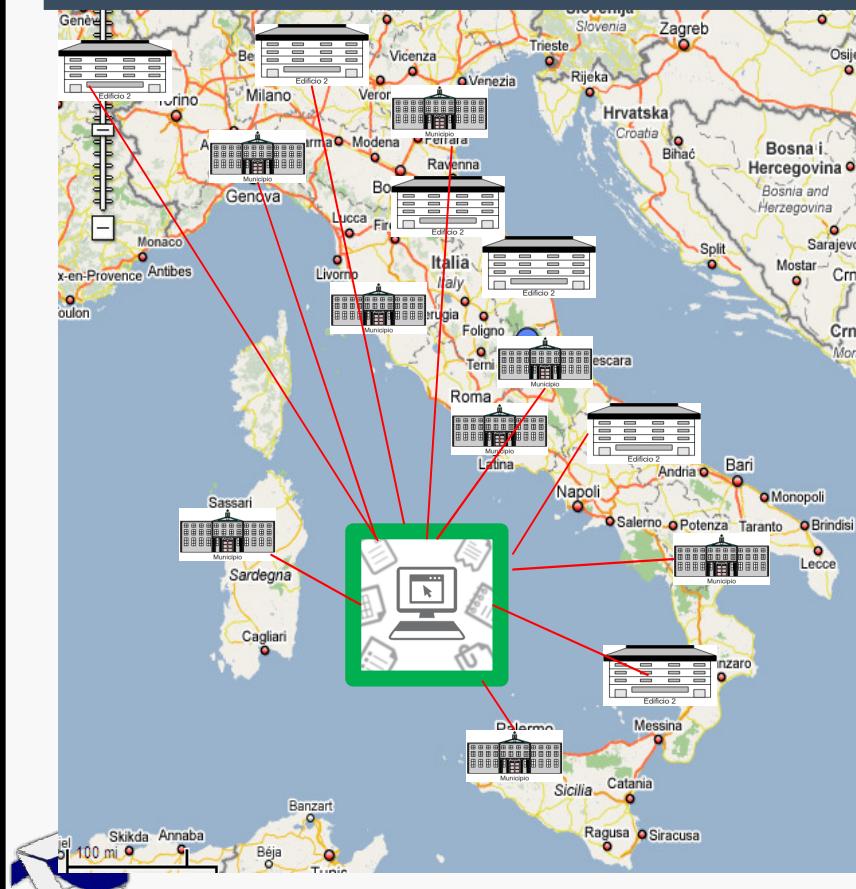
# the right abstraction...



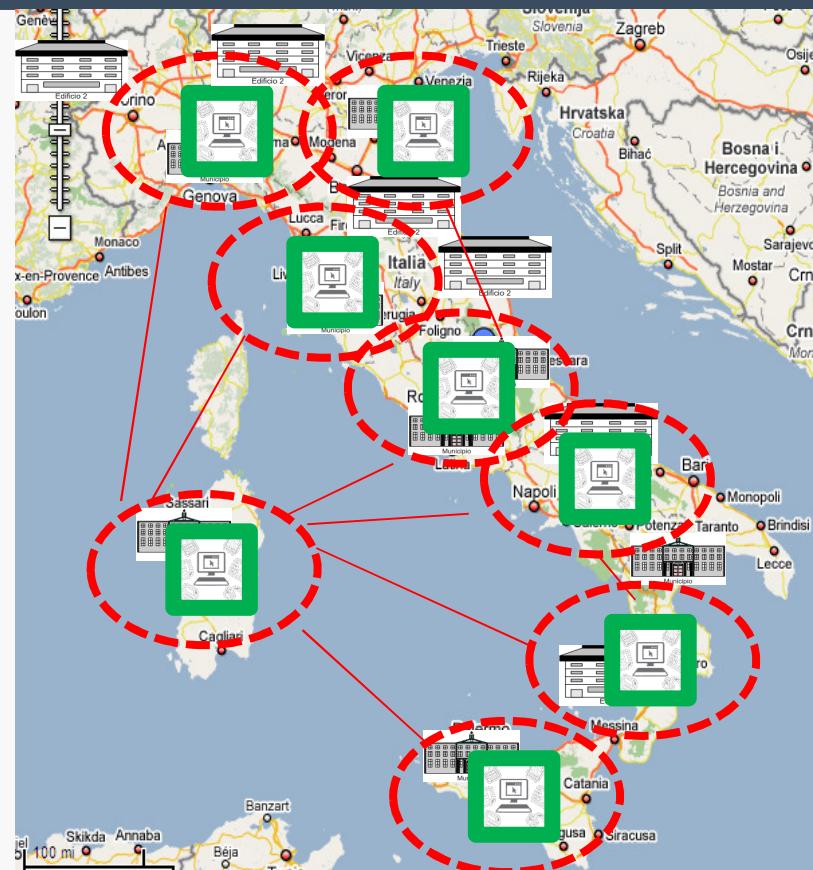
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# At which abstraction?

SA with Centralized Data, v1

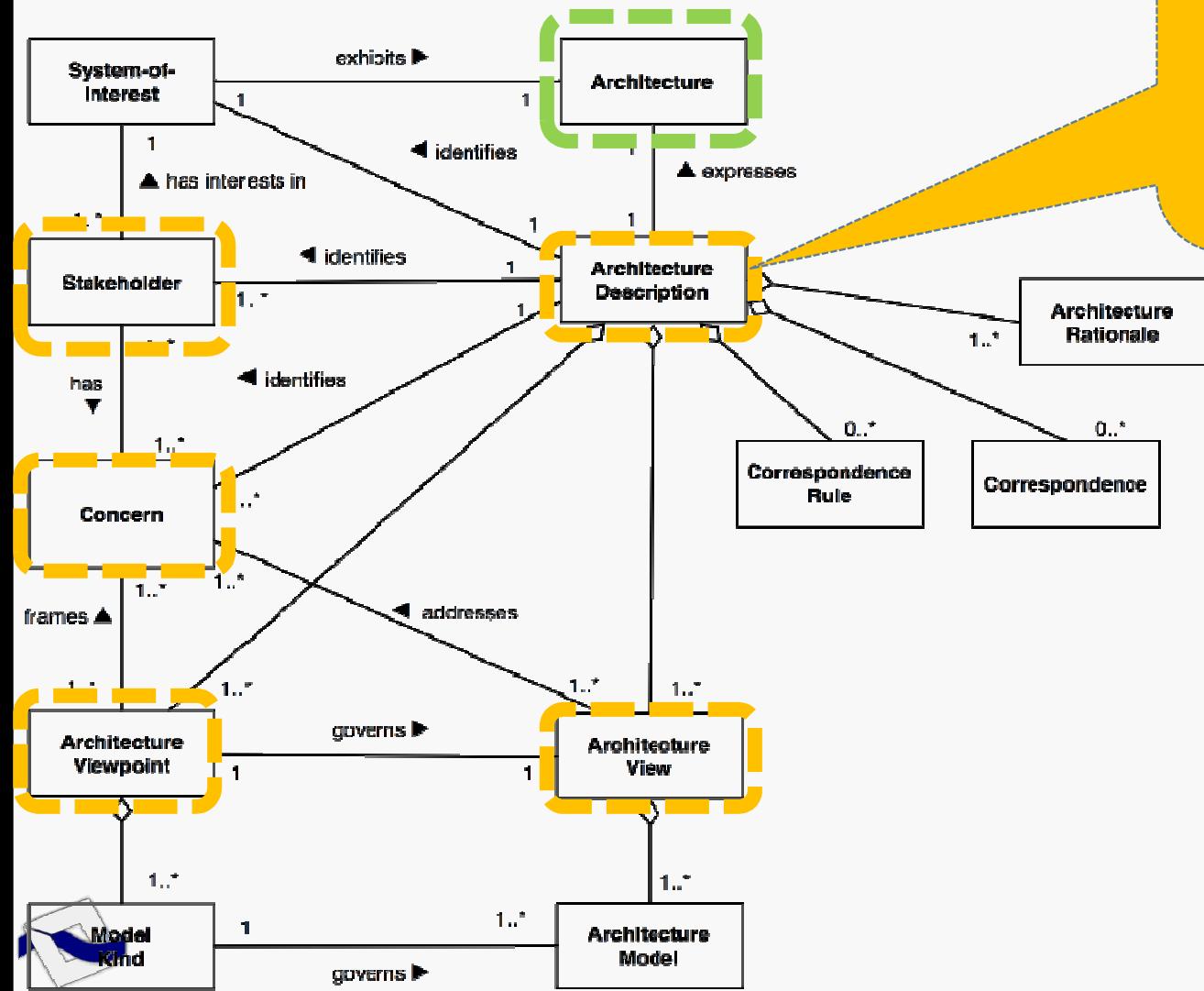


SA with Centralized Data, v2



Implications on privacy, confidentiality, performance, scalability, maintainability, etc.

# Architecture Descriptions



*"The practices of recording software, system and enterprise architectures so that architectures can be understood, documented, analysed and realized."*

and, which is the right architecture!?!



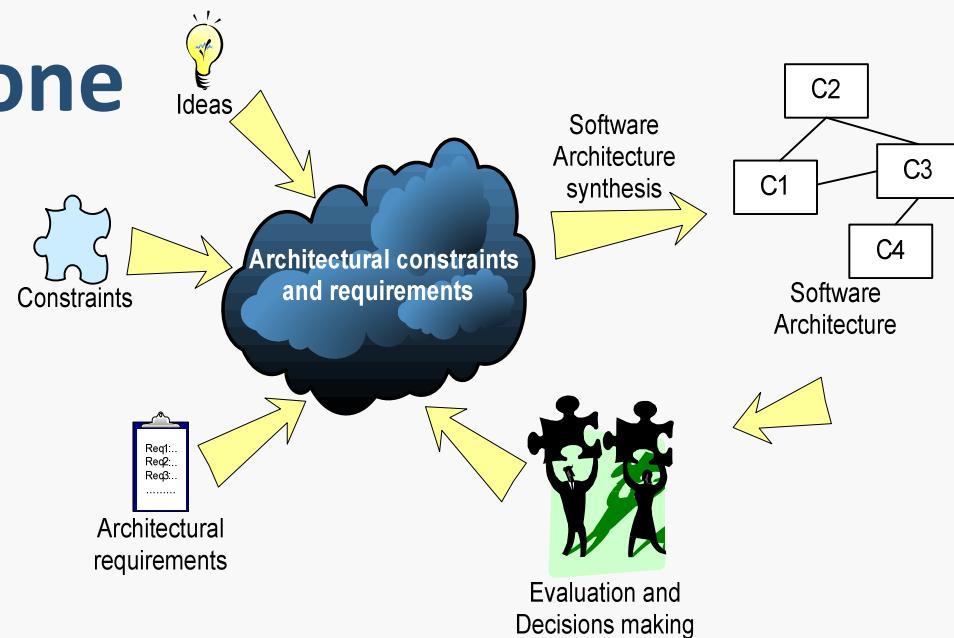
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# the right architecture...

The one that satisfies at best the requirements and constraints

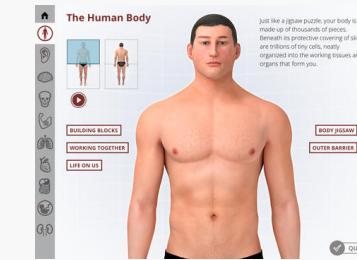
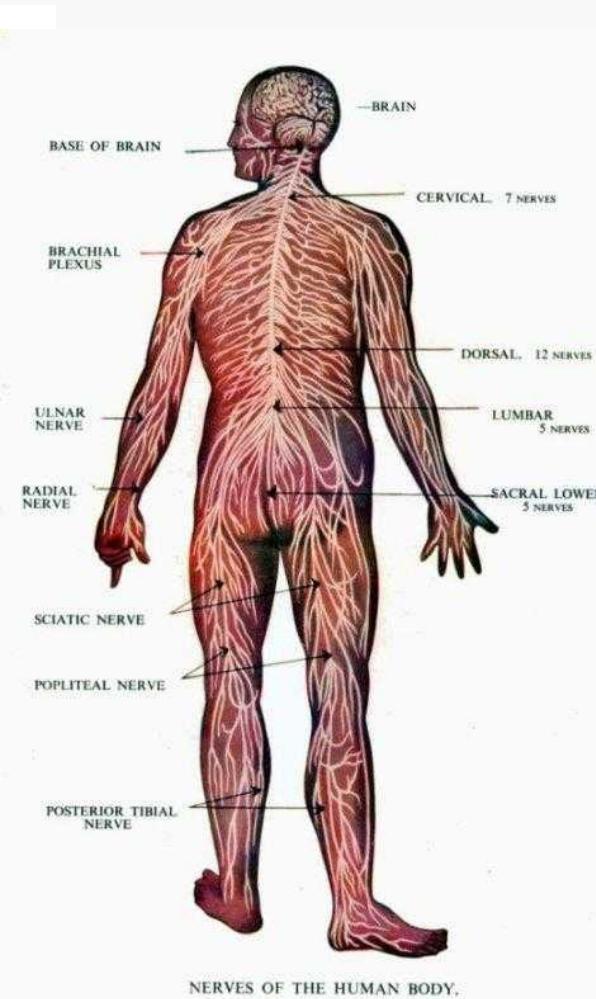
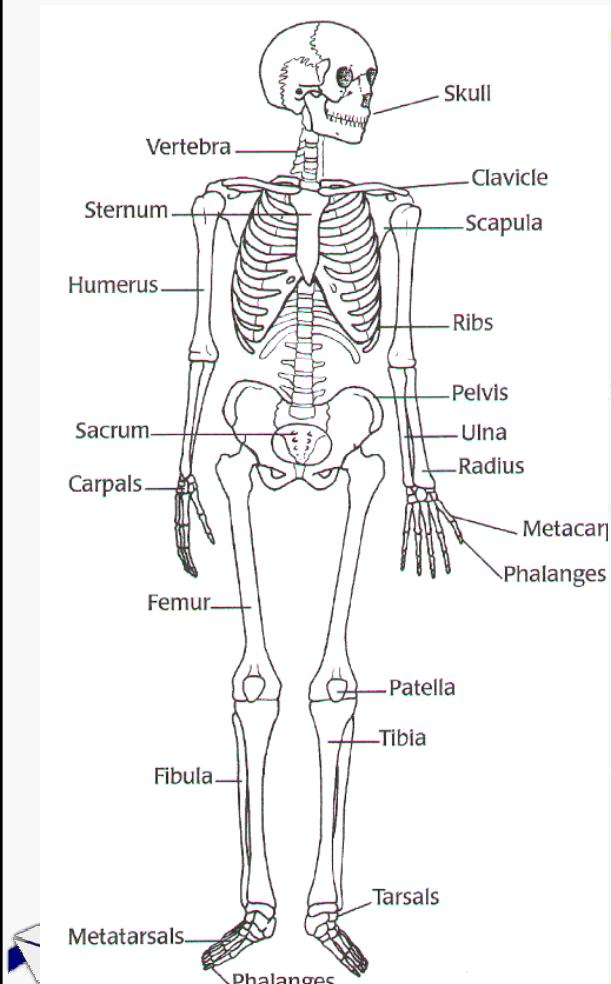
The “less” risky one



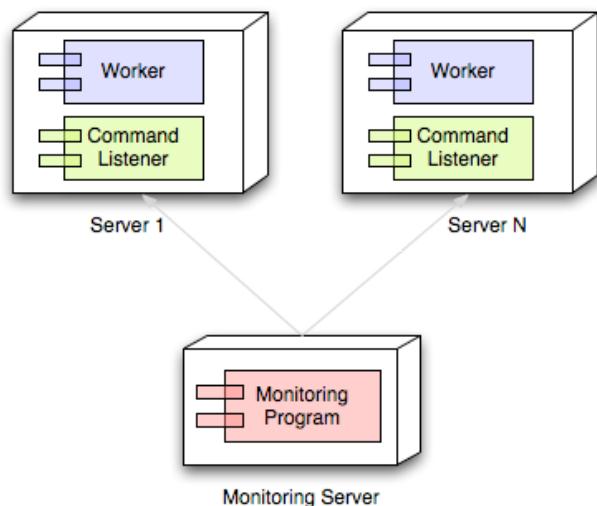
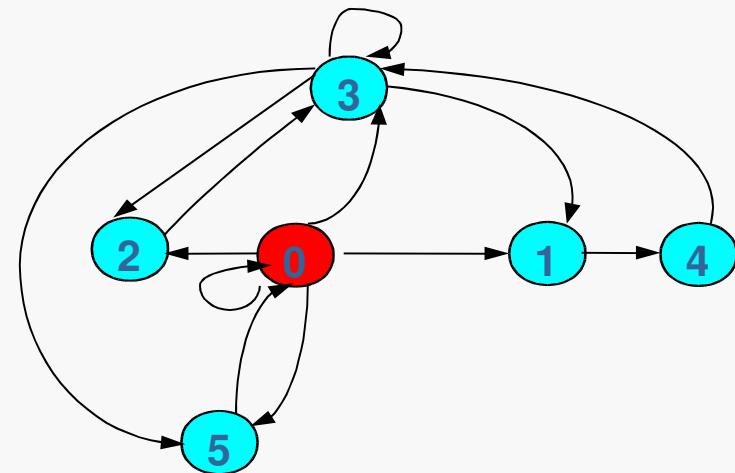
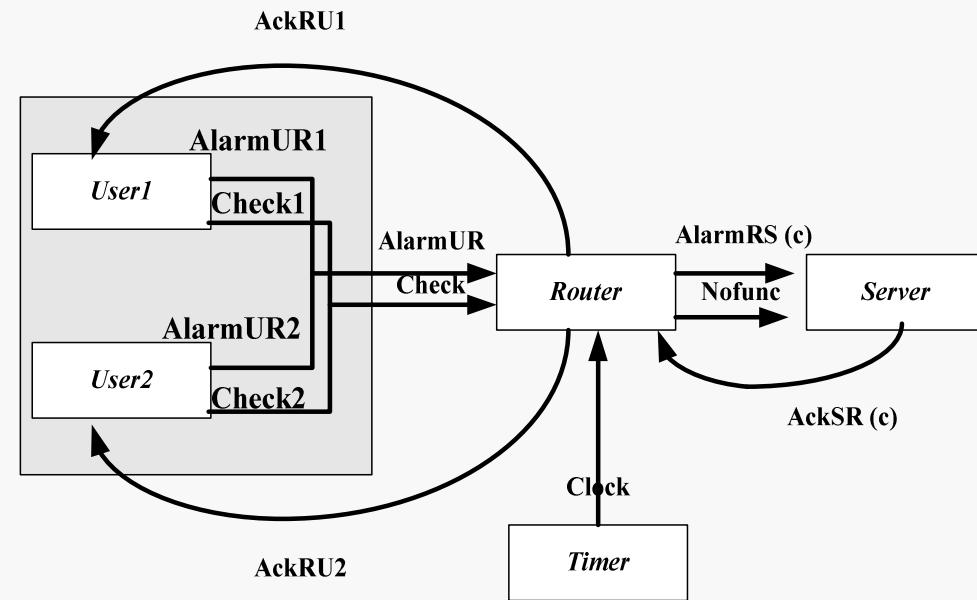
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# Views and Viewpoints

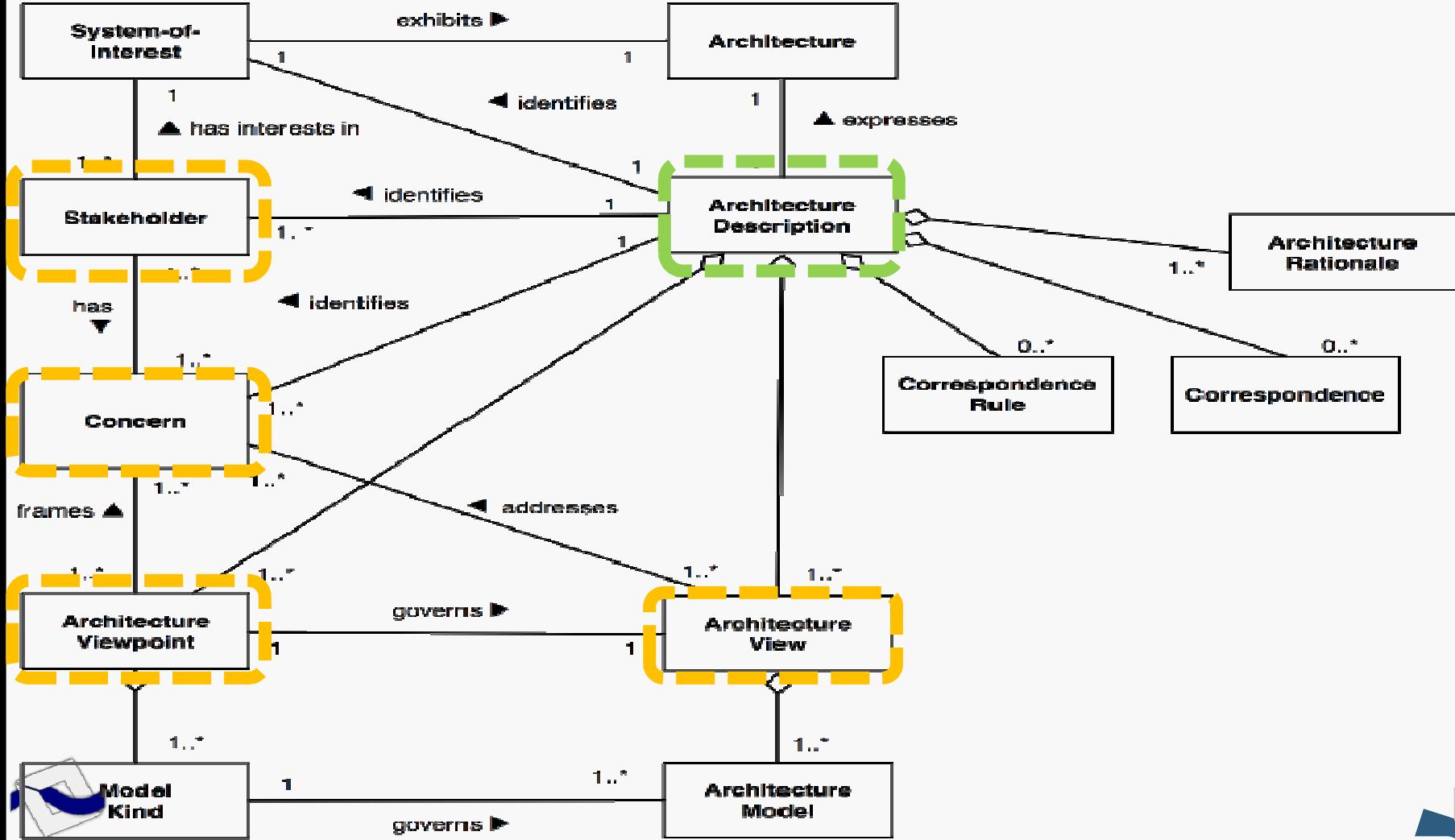


# Architectural Views



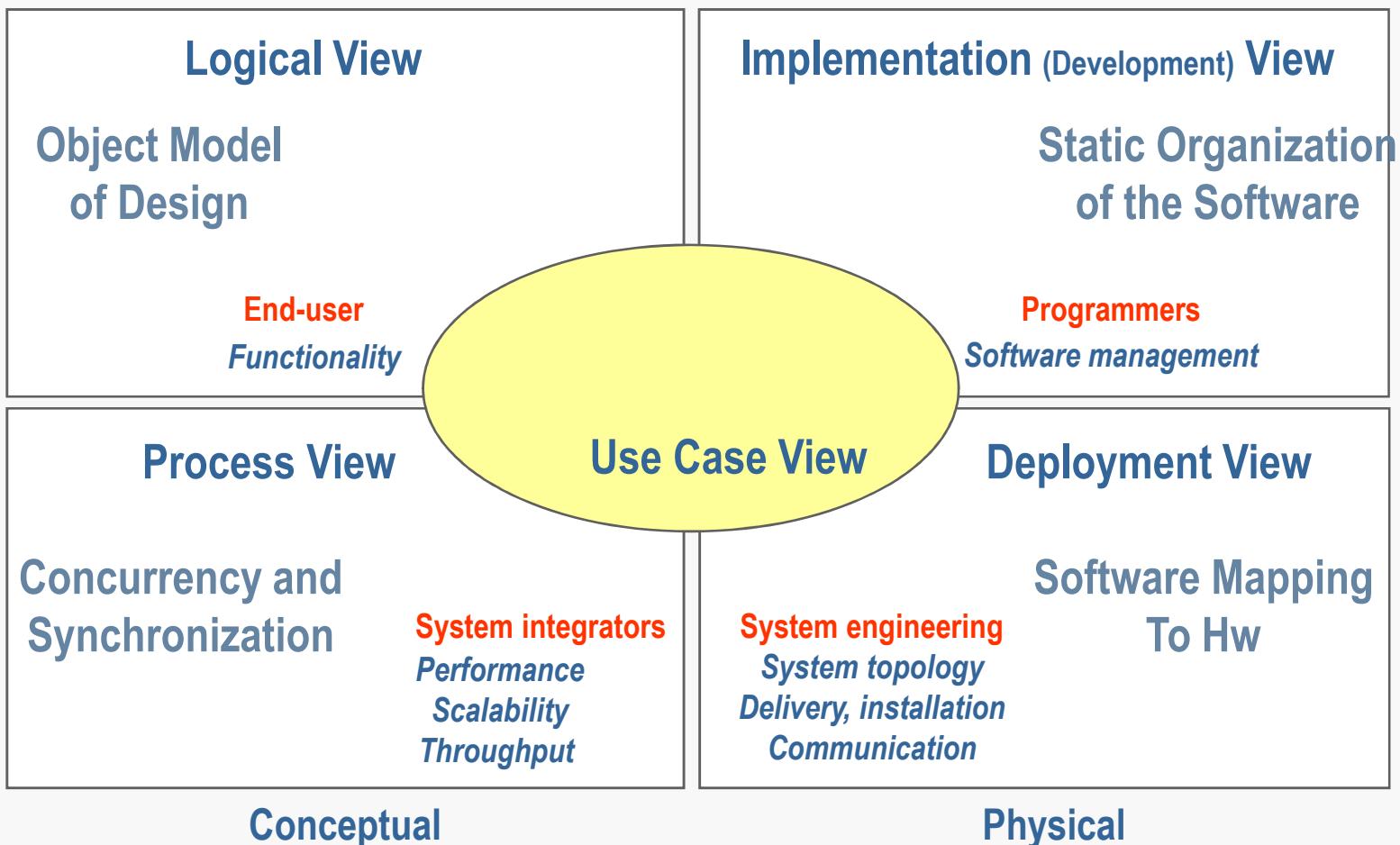
Year	2010	2011	2012	2013	2014	2015	2016	2017	2018
<b>Income</b>	0	2	4	6	8	12	14	16	18
<b>Expenses</b>	(13)	(1)	(1)	(1)	(2)	(15)	(3)	(4)	(5)
<b>Profit</b>	(13)	1	3	5	6	(3)	11	12	13
<b>ROI</b>	(13)	(12)	(9)	(4)	2	(1)	10	22	35

# ISO/IEC/IEEE 42010: 2011



ISO/IEC/IEEE 42010 - International Standard for Systems and Software Engineering – Architectural Description, 2011

# RUP 4+1 views



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# Multiple views

## Using multiple views has become standard practice in industry

- IEEE Std 1471 (2000) -> ... -> ISO/IEC/IEEE 42010 (2011)
- Based on a survey we conducted with 48 practitioners [Survey2012], and about the usage of ALs in industry
  - 85% uses multiple views

	Useful in past projects							Useful for future projects						
	-2	-1	0	+1	+2	No exp.	Blank	-2	-1	0	+1	+2	Don't know	Blank
Support for multiple architectural views	2	2	4	11	18	2	9	1	0	4	5	27	1	10



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## The Classical Style



## The Gothic Style



## The Californian Style



**but... why to care?**



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## Why to care?

- All the software systems have an architecture
  - All the **critical/complex** systems must have it carefully and explicitly specified
- Architecture-level decisions impact the **scalability, performance, testability, functioning** of the produced system
- Even if the code is perfectly written, a wrong architecture produces a wrong system



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# Why to care?

## *A wrong architecture produces a wrong system*

- **Electronic Voting Systems**
- **Bad architecting of FT software:**
  - Tens of thousands of people around the large cities weren't able to travel by train Thursday morning. No trains from and to Amsterdam and Airport Schiphol from early morning until after the morning rush hour. **A failure in the back-up system was the cause.** The system therefore didn't start. And then the signals and switches could not be operated. **Both primary and backup failed, hence no operations.** (april 2012)
  - the Interim Report on Causes of the August 14th 2003 Blackout in the US and Canada clearly shows that the problem was mostly caused by badly designed fault tolerance, including various **architectural issues**: poor diagnostics of component failures, longer-than-estimated time for component recovery, failure to involve all necessary components in recovery, inconsistent system state after recovery, failures of alarm systems. (2003)
- **Denver Airport**



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# Why to care?

## The Best Jobs of 2014

*"For the first time, our No. 1 job overall isn't from the health care industry, it's a tech job."*

[<http://goo.gl/WdxMjh>]



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**CNNMoney**  **FORTUNE** ▾

Home Video Markets Term Sheet Economy Tech

### BEST JOBS IN AMERICA

*Money/Payscale.com's list of great careers* 2010 ▾

Full List High Pay Job Growth Quality of Life Sectors

**1. Software Architect** fb Recommend 5.8k 1 of 100 Next

**Top 100 rank:** 1  
**Sector:** Information Technology

**What they do:** Like architects who design buildings, they create the blueprints for software engineers to follow -- and pitch in with programming too. Plus, architects are often called on to work with customers and product managers, and they serve as a link between a company's tech and business staffs.

**What's to like:** The job is creatively challenging, and engineers with good people skills are liberated from their screens. Salaries are generally higher than for programmers, and a typical day has more variety.

"Some days I'll focus on product strategy, and other days I'll be coding down in the guts of the system," says David Chaiken, 46, of Yahoo in Sunnyvale, Calif., whose current projects include helping the web giant customize content for its 600 million users. Even though programming jobs are moving overseas, the face-to-face aspect of this position helps cement local demand.

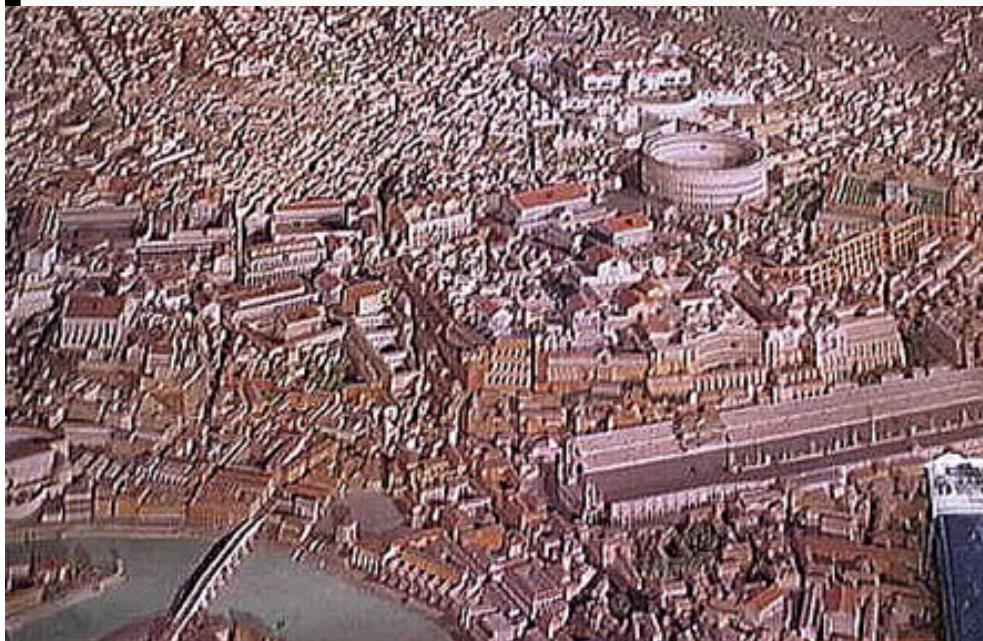


PHOTO: DAVID LAURIDSEN

Chaiken, a software engineer for more than two decades, relishes the more collaborative work.

# “Bad” Architecturing

A bad architecture can imply a spaghetti code system



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# Some References

- Perry, D. E.; Wolf, A. L. (1992). "Foundations for the study of software architecture". *ACM SIGSOFT Software Engineering Notes* **17** (4): 40.[doi:10.1145/141874.141884](https://doi.org/10.1145/141874.141884).
- Garlan & Shaw (1994). "An Introduction to Software Architecture". Retrieved 2012-09-13.
- ISO/IEC/IEEE (2011). "ISO/IEC/IEEE 42010:2011 Systems and software engineering -- Architecture description". Retrieved 2012-09-12.
- Kruchten, Philippe (1995, November). Architectural Blueprints — The “4+1” View Model of Software Architecture. *IEEE Software* 12 (6), pp. 42-50.
- Len Bass, Paul Clements, Rick Kazman: *Software Architecture in Practice, Third Edition*. Addison Wesley, 2012, [ISBN 0-321-81573-4](#) (This book, now in third edition, eloquently covers the fundamental concepts of the discipline. The theme is centered around achieving quality attributes of a system.)



# To STUDY

**Software Architecture in Practice (3rd Edition) (SEI Series in Software Engineering)** Hardcover – October 5, 2012, by Len Bass , Paul Clements, Rick Kazman

Chapter 1



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