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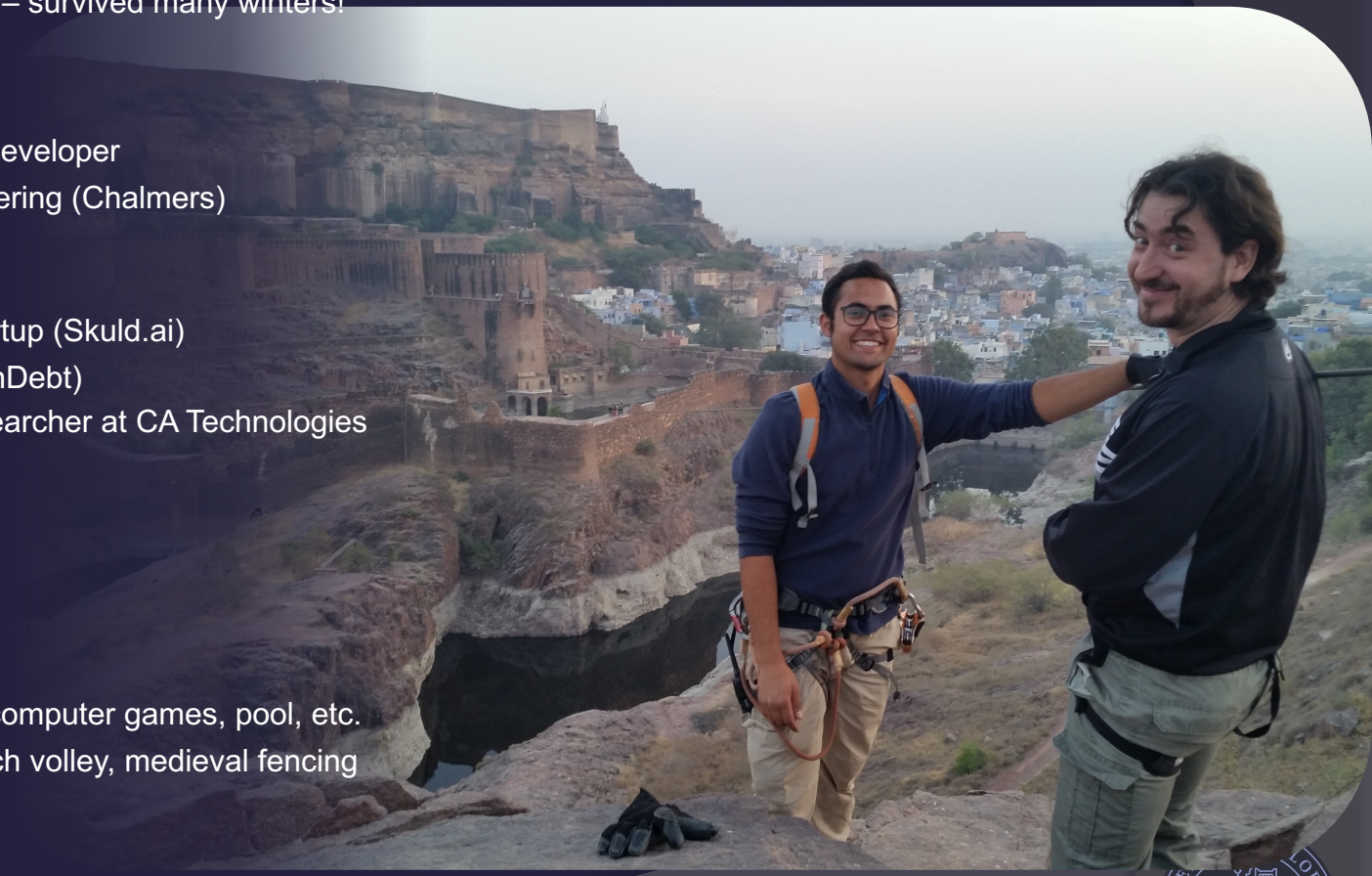
Course IN5140
2024-10-03

LARGE-SCALE AGILE AND ARCHITECTURE

Who is Antonio Martini?

- Italian
  - No kebab pizza! ☺
  - 13 years in Scandinavia – survived many winters!
- Previously
  - Worked as a Software Developer
  - PhD in Software Engineering (Chalmers)
  - Postdoc (Chalmers)
  - Independent Consultant
  - Advisory board on a startup (Skuld.ai)
  - My own startup (AnaConDebt)
  - Principal, Strategic Researcher at CA Technologies
- Currently:
  - Professor at UiO
- Hobbies
  - Board games, strategy computer games, pool, etc.
  - Football, volleyball, beach volley, medieval fencing
  - Piano, Drumset, etc.
  - Travel!
  - …and no time for them! ☺



Results from 13 years of collaboration with industry

Agenda

- Recap from IN2000
  - What is software architecture?
  - How to think about architecture?
- Agile and Architecture
  - A complicated relationship
  - Current state of the art
- Agile Architecting
  - Process
  - Product
  - Organization
- Agile and architects
  - Industrial case study
- Summary

- We will use mentimeter during the lecture, participate!
  - Check the following symbol during the lecture

Recap from IN2000

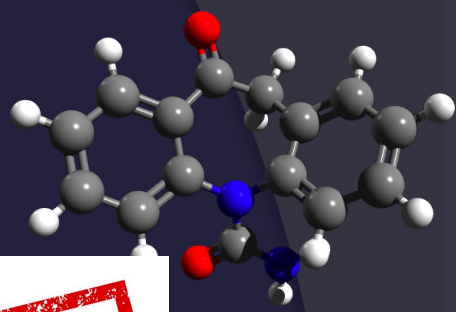
What is Software Architecture?

For a more in-depth recap, see lecture from IN2000

- https://www.mn.uio.no/ifi/english/people/aca/antonima/presentations/in2000-arkitekturogtekniskgjeld-2024.31.02_default.mp4?vrtx=view-as-webpage

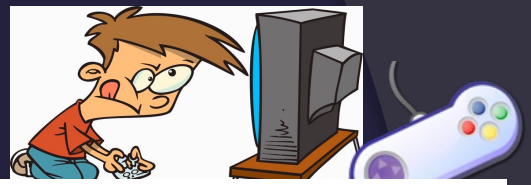
Software architecture is…

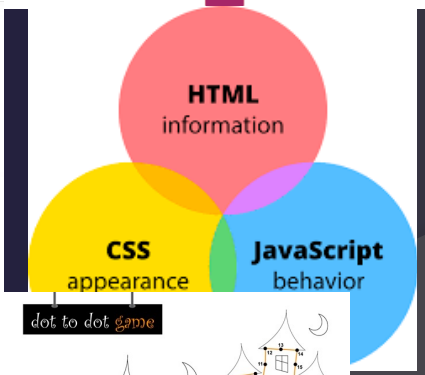
- All of the followings:
  - Overall system structure
  - The important stuff – whatever that is
  - Things that people perceive as hard to change
  - A set of architectural design decisions

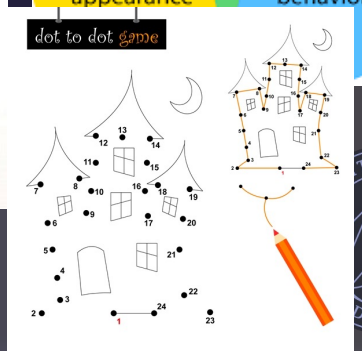


Software Architecture characteristics

- Multitude of stakeholders
- Quality driven (tradeoff)
- Separation of concerns
- Recurring styles (patterns)
- Conceptual integrity (vision)







Why software architecture?

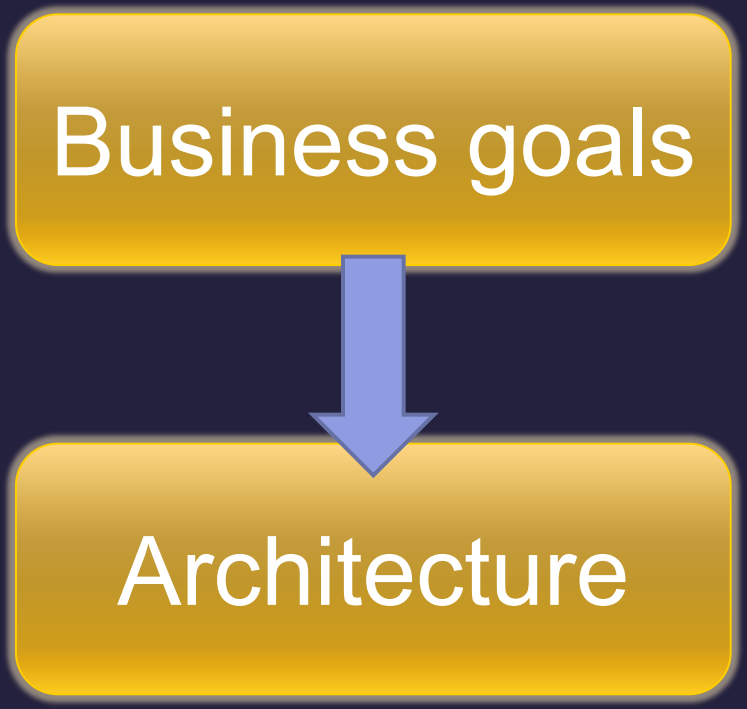
- To get a grasp of a complex system
- Facilitates the communication among the stakeholders about their needs
- Supports decisions about future development and maintenance
  - Reuse
  - Budget
- Analysis of the product before it's built
  - Cost reduction
  - Risk reduction

You can't ignore architecture

- All products HAVE an architecture
  - It can be bad
  - It can be good
- In all projects we SHOULD think about architecture
  - Maybe less in small projects
  - Maybe more in large projects
- Thinking about the architecture is a necessary (and smart) process

How to think about Architecture

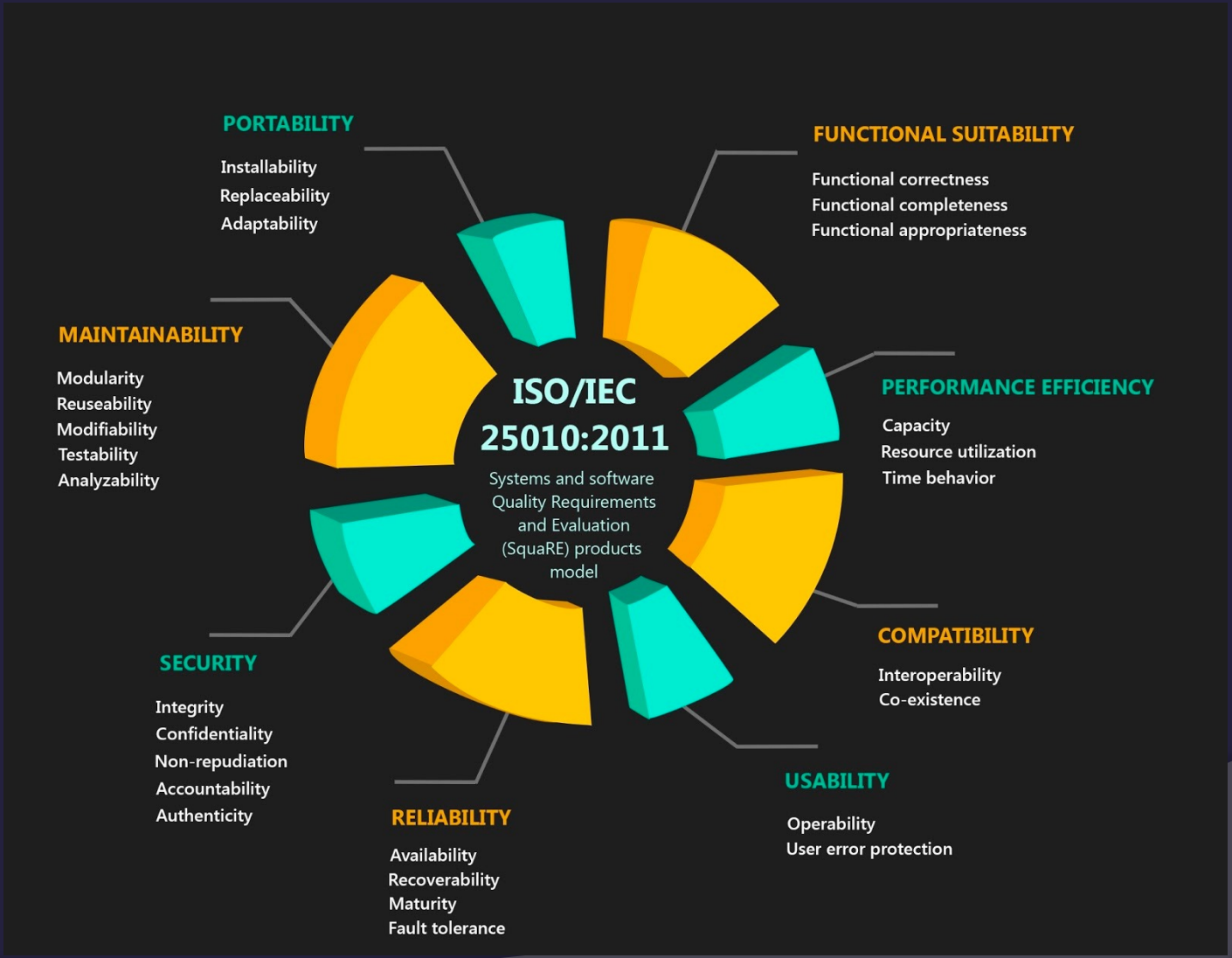
Business drives architecture



A process to think about architecture

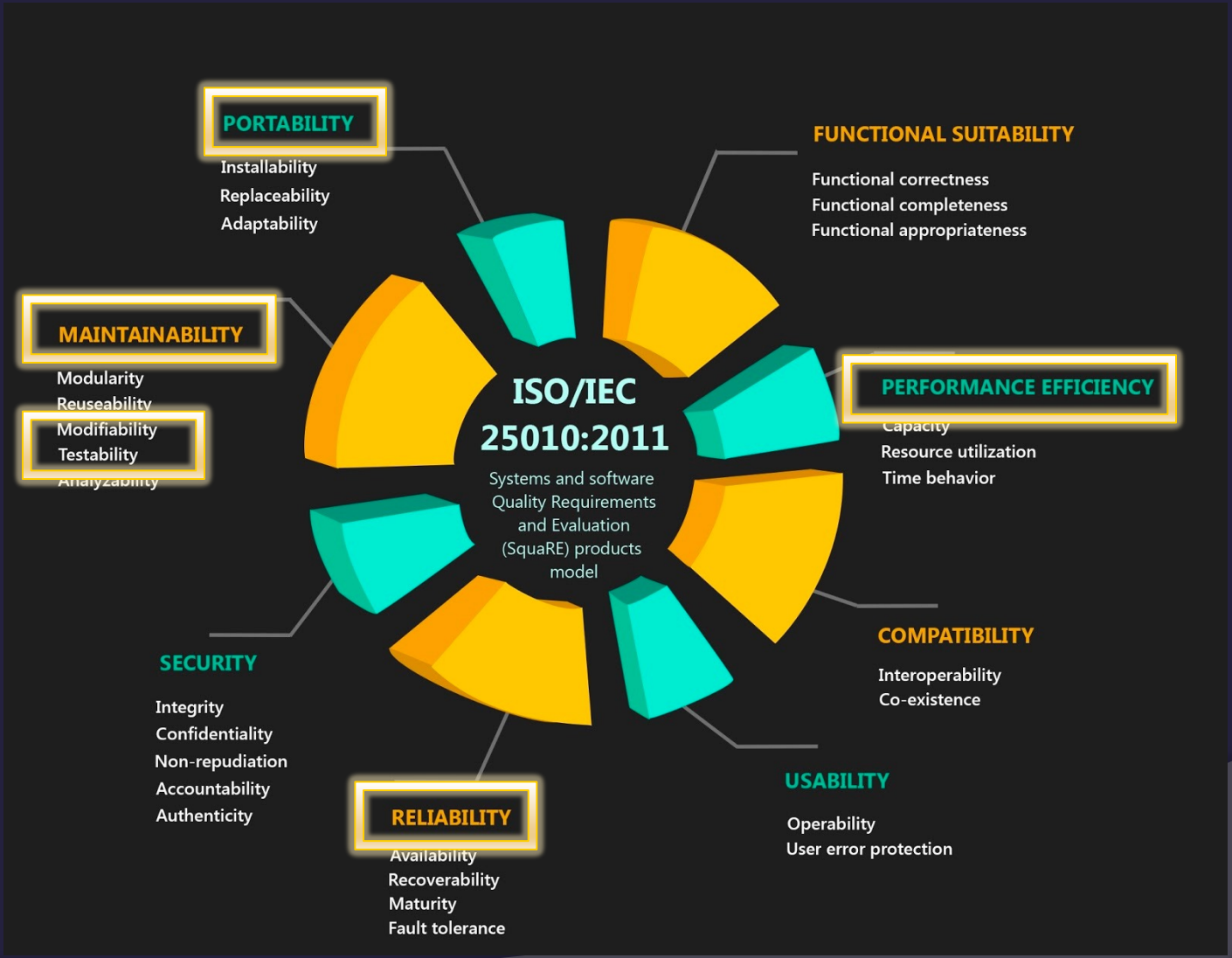
Stakeholders analysis	Who?
Business goals	What do they need?
Architectural Significant requirements (concerns)	What should the system do?
Qualities	What qualities are important?
Tradeoffs	What should we focus on?
Solution	How should we implement it?

System Qualities



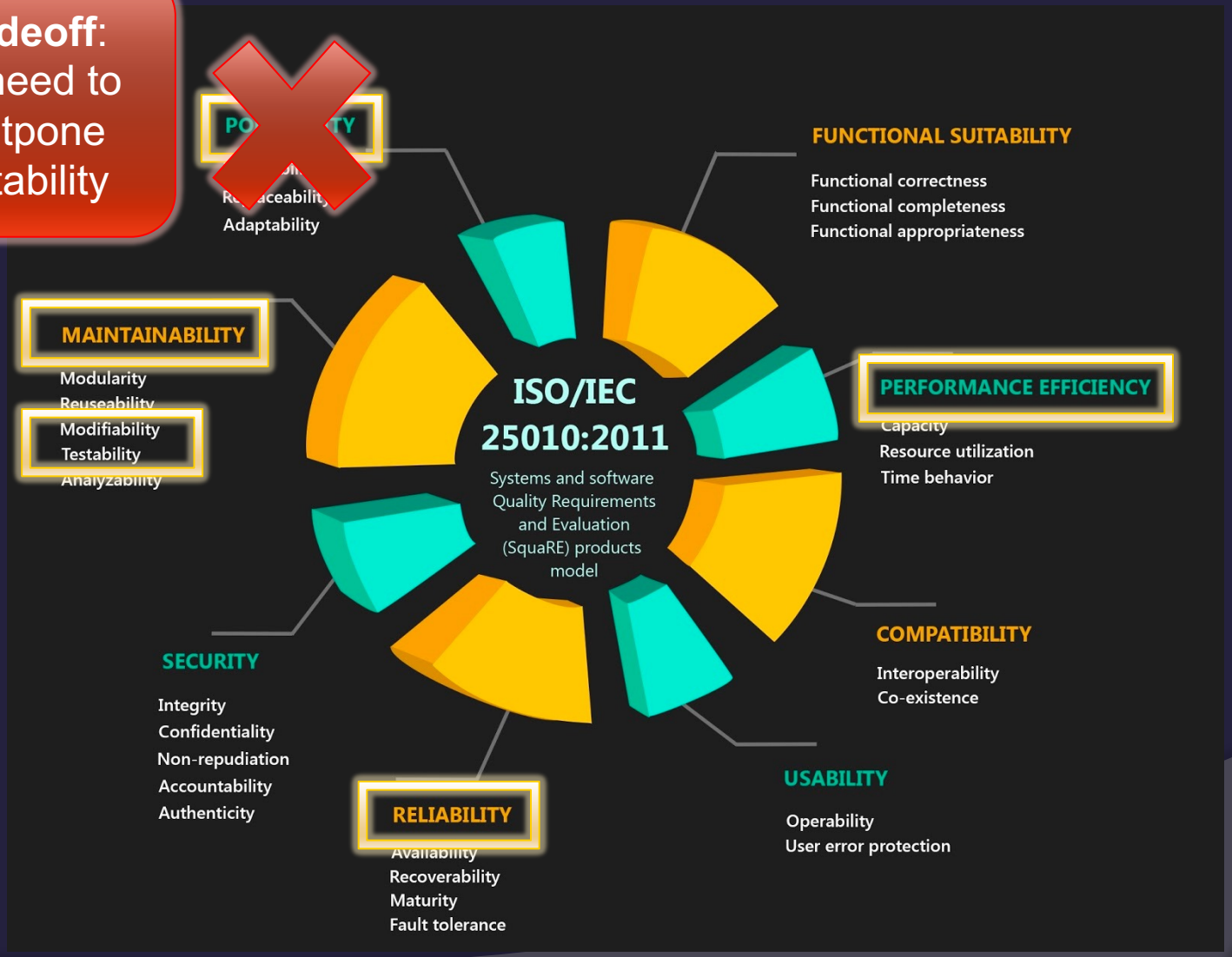
https://www.iso.org/standard/22749.html

System Qualities – All stakeholders



System Qualities – Trade-off

Tradeoff: we need to postpone portability

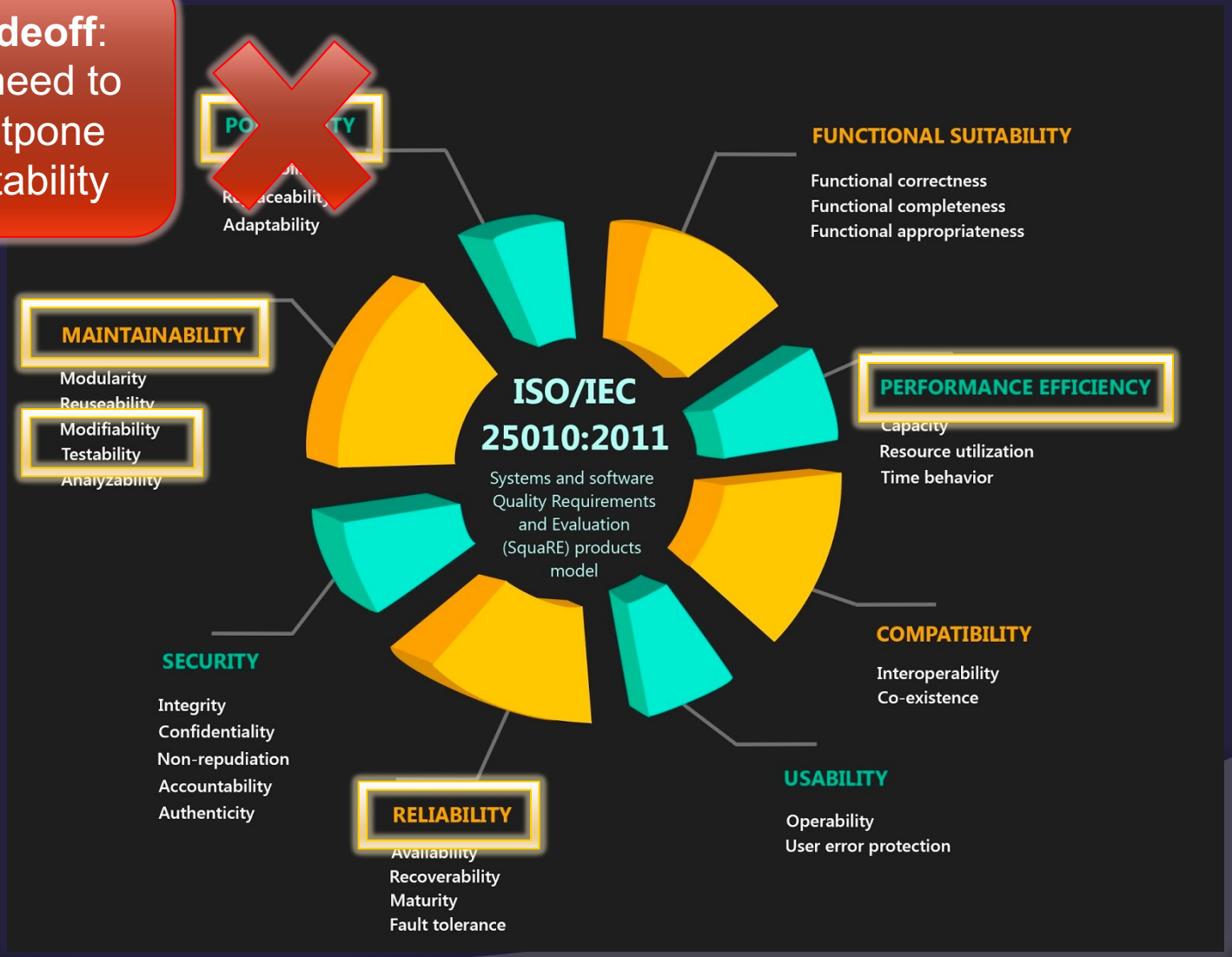


Cost/benefits scenarios and analysis (simplified example)

	Benefit: Users short-term	Benefit: User long-term	Cost	Total
Solution 1	-- (vs competitor)	++ (both platforms) - (lack of visibility)	+ (cheaper in total)	0
Solution 2	++ (vs competitor)	+ (visibility) - (no users in one platform)	- (rewrite)	+1

System Qualities – Trade-off

Tradeoff: we need to postpone portability

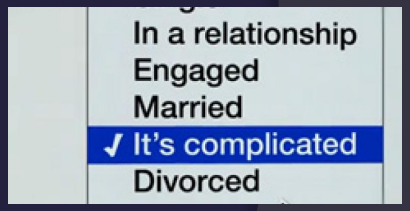


Architecture = Tradeoff

- It will never be perfect
- It's all about doing the best tradeoff

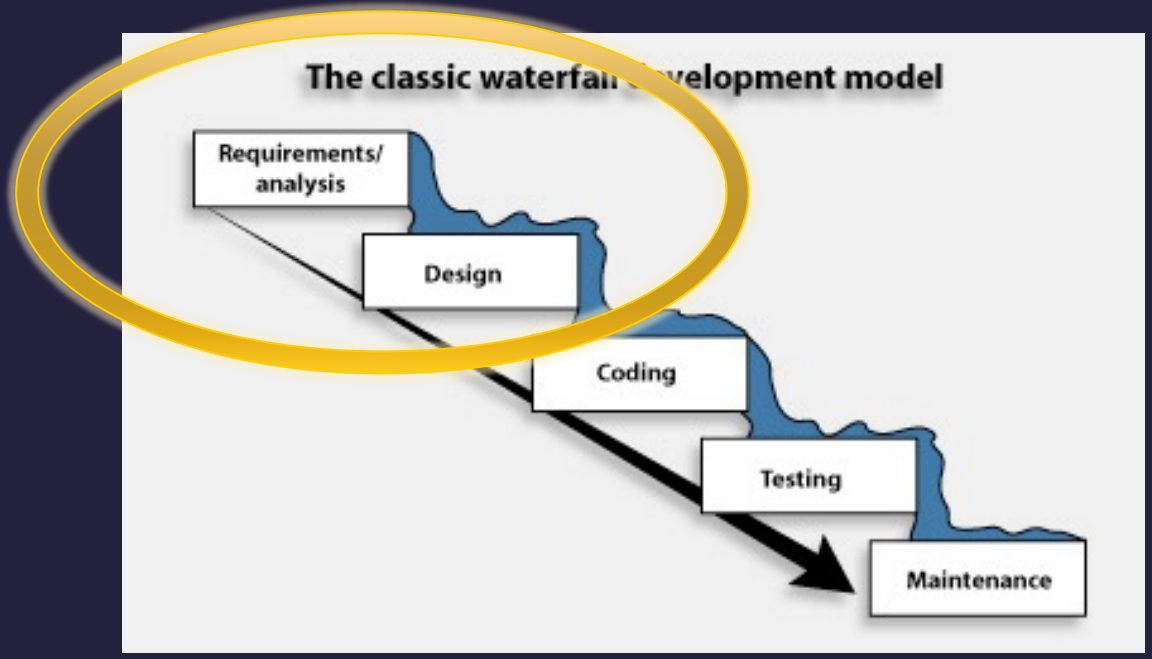
- But what if the best tradeoff is a... moving target?

Agile and Architecture: a complicated relationship



Once upon a time it was Waterfall…

Architecture



The enemy: Big Upfront Anything*

- Requirement engineering
  - Should we do upfront requirement engineering?
    - Yes
      - We need to understand what the users want
      - We need to understand the domain and its constraints
    - No
      - Too much documents and time spent are a waste
      - Requirements change anyways
  - There is a middle ground, we don't have to be extreme

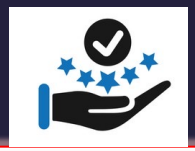
* Book Chapter 3 (up to 3.3 included)

Architecture in waterfall: 3 problems

- Upfront design
  - assumes a "perfect" architecture is already known
- Is this advisable/possible/realistic?
  - Problem 1: Arch. / Reqs. / Impl. first?
    - Some Architecture Reqs emerge from implementation*
    - The earlier the Arch decision, the more the probability that is wrong because of lack of information**
  - Problem 2: Architects are humans
    - Several bias: some decisions are not rational*
      - Anchoring
        - Let's use microservices! Let's design OO!
        - First decisions have a strong effect on other decisions

* Van Vliet, Tang: *Decision making in software architecture,* JSS, 2016
** Poort, van Vliet: *Architecting as a Risk- and Cost Management Discipline*

Problem 3: Focus on the Wrong Outcome



Little delivered value!

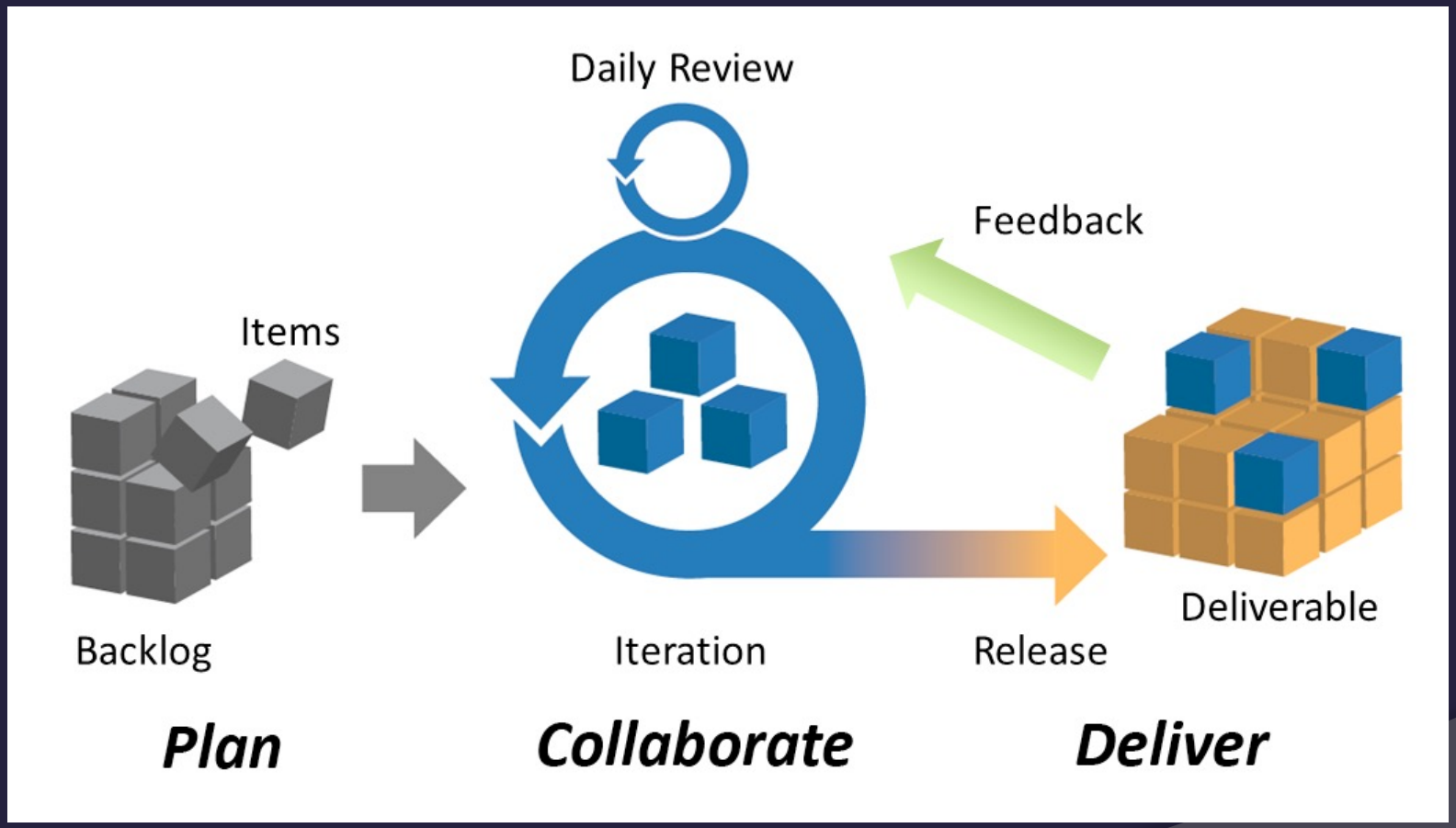
Substantial focus on the technical system

But the solution of problem 3 is not just doing the opposite! You need a balance…

Too much focus on delivering short-term value!

Little focus on the technical system

...then the Agile revolution happened



Spot what can affect architecture in the agile manifesto

1. Our highest priority is to satisfy the customer through early and continuous delivery of valuable software.
2. Welcome changing requirements, even late in development. Agile processes harness change for the customer's competitive advantage.
3. Deliver working software frequently, from a couple of weeks to a couple of months, with a preference to the shorter timescale.
4. Business people and developers must work together daily throughout the project.
5. Build projects around motivated individuals. Give them the environment and support they need, and trust them to get the job done.
6. The most efficient and effective method of conveying information to and within a development team is face-to-face conversation.
7. Working software is the primary measure of progress.
8. Agile processes promote sustainable development. The sponsors, developers, and users should be able to maintain a constant pace indefinitely.
9. Continuous attention to technical excellence and good design enhances agility.
10. Simplicity--the art of maximizing the amount of work not done--is essential.
11. The best architectures, requirements, and designs emerge from self-organizing teams.
12. At regular intervals, the team reflects on how to become more effective, then tunes and adjusts its behavior accordingly.

Spot what can affect architecture

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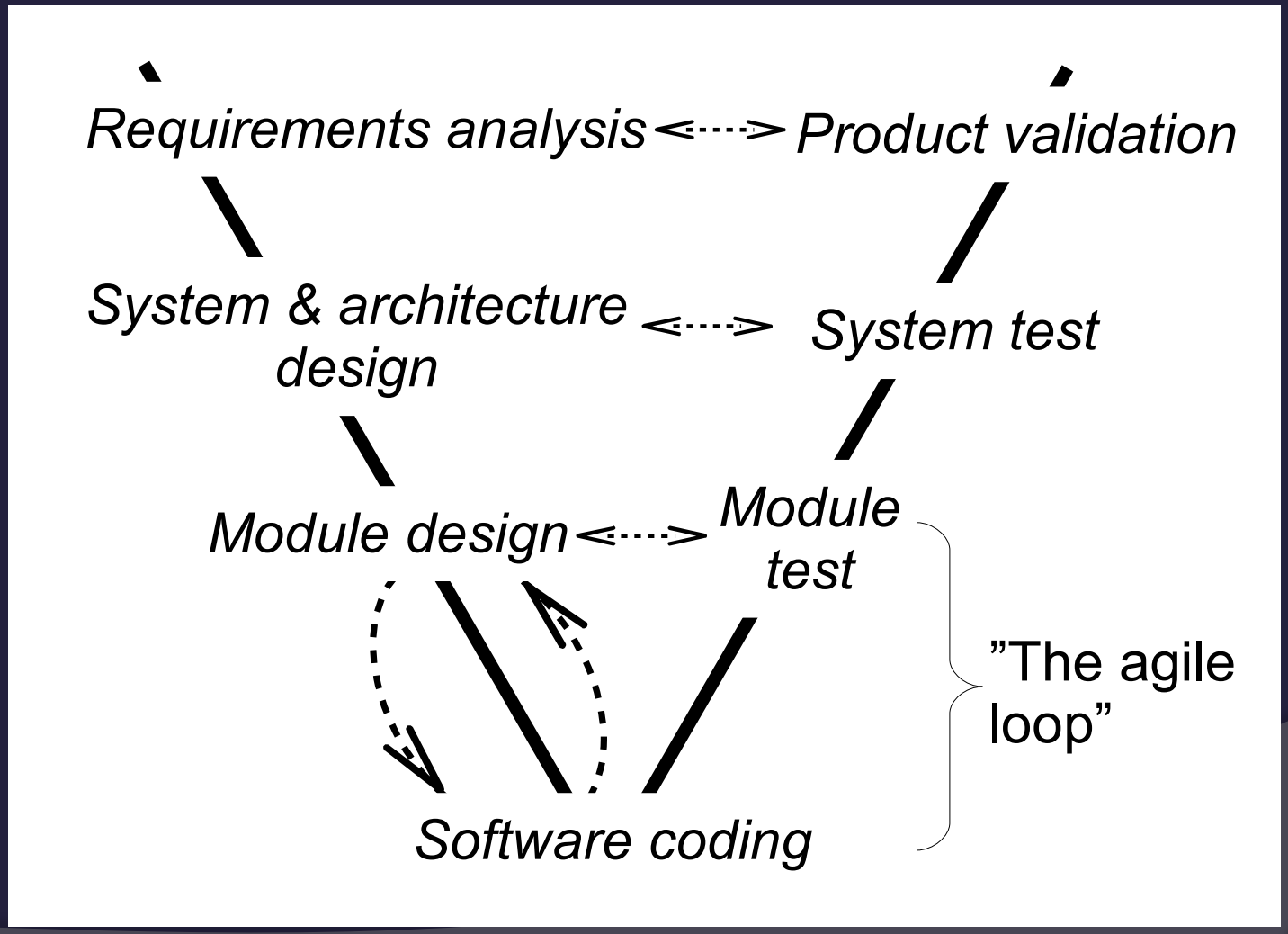
Necessary but not sufficient

- The best architectures, requirements, and designs emerge from self-organizing teams

Different architecture management in different contexts…

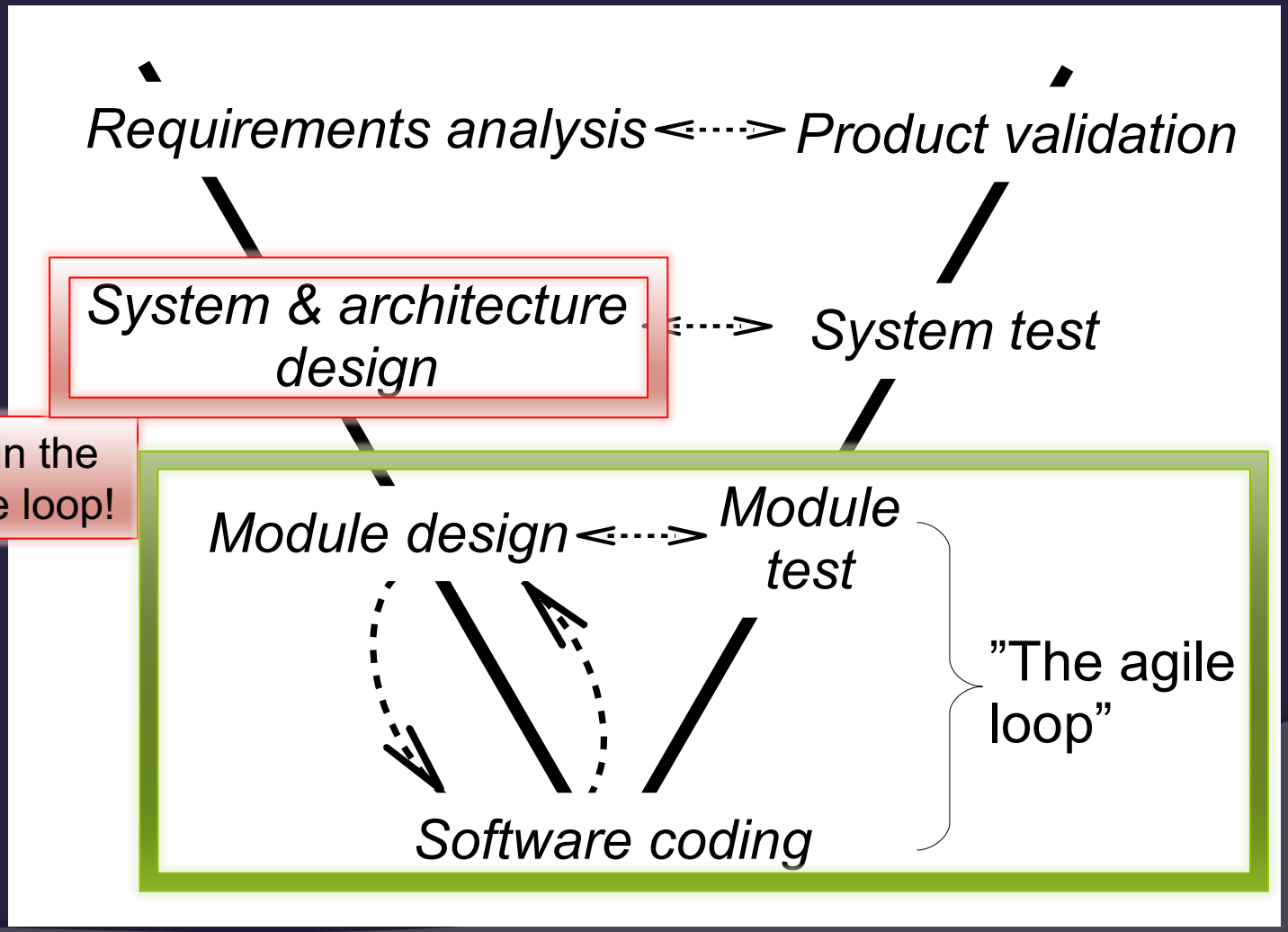
- Small projects:
  - 1 team can
    - understand few stakeholders
    - manage their concerns
    - handle complexity
    - grasp the overall view
- Large projects:
  - Many teams need to coordinate on
    - understanding many stakeholders
    - tradeoff among many concerns
    - handle high complexity
    - share the same view

Meanwhile, in practice...



* Eklund, Olsson, Strøm - *Industrial Challenges of Scaling Agile in Mass-Produced Embedded Systems,* 2014

What about architecture?



Not in the Agile loop!

* Eklund, Olsson, Strøm - *Industrial Challenges of Scaling Agile in Mass-Produced Embedded Systems*, 2014

Architecture in Agile?

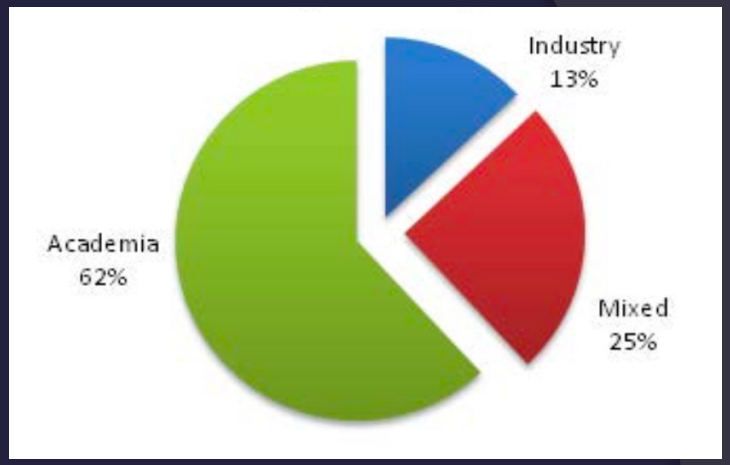
- Not emphasized in Agile practices
- "Just enough architecture/design"

- But what does that mean?
- Are there studies?

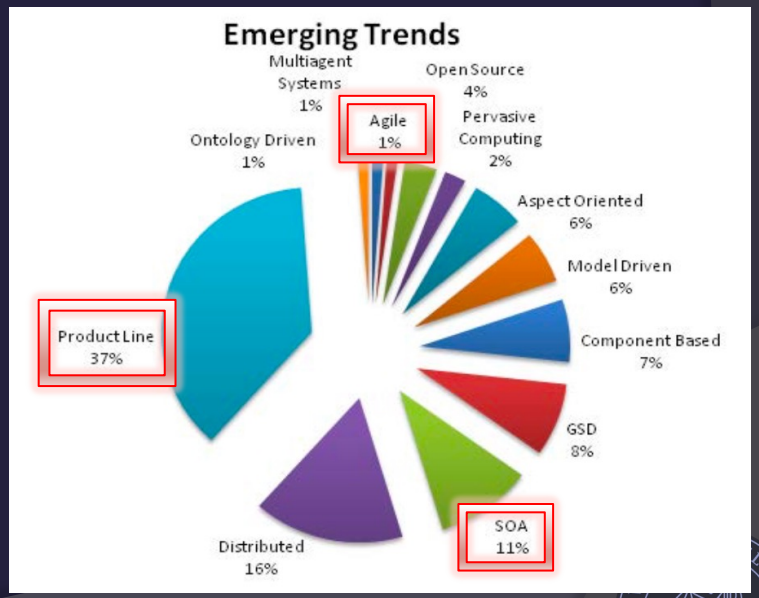
Agile and Architecture: what do we know?

Current studies

- Most of the papers are not based on industrial experience or evaluation



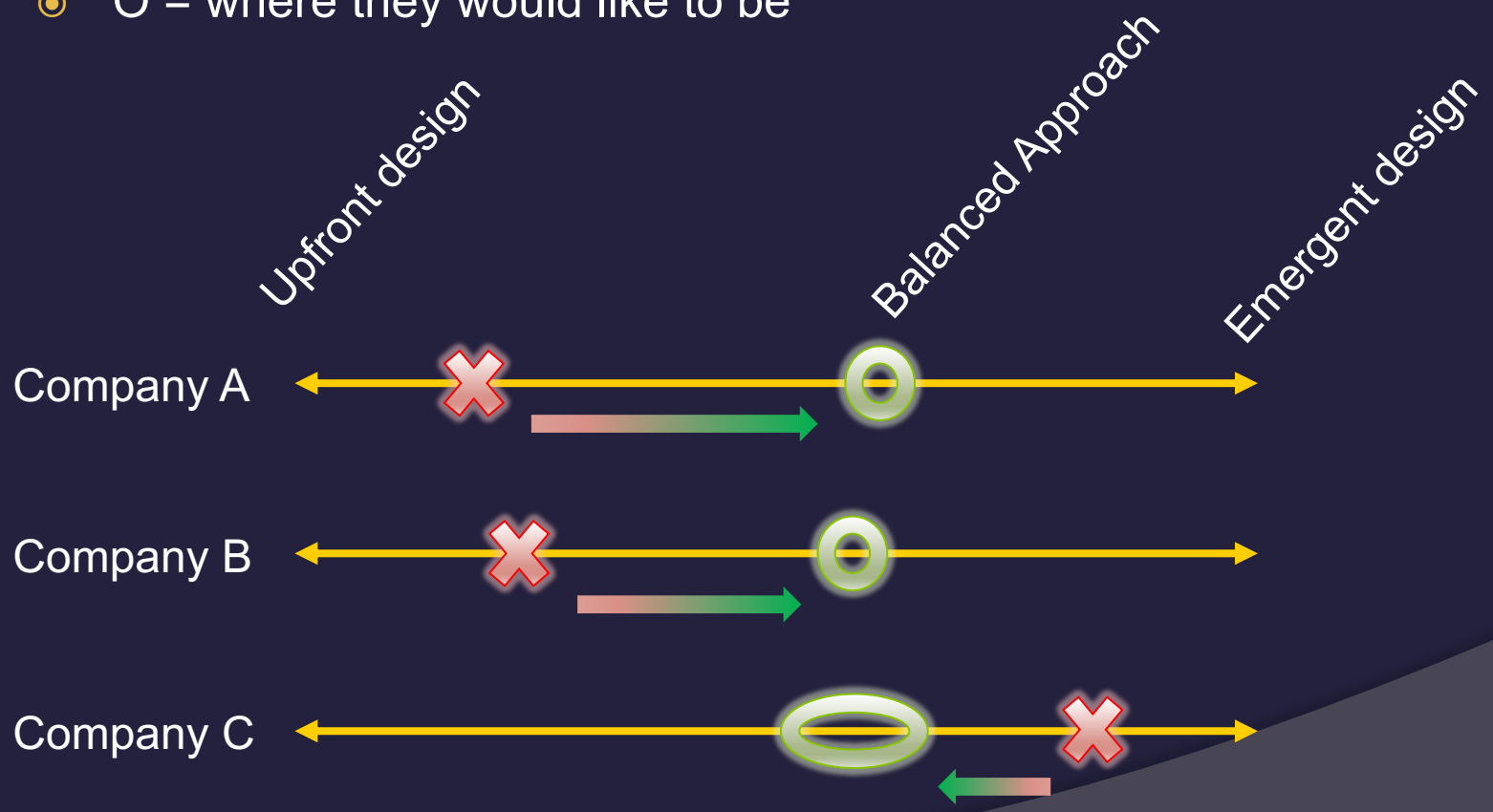
- Not much on “Continuous” and “Agile”
  - 1% Agile
  - 11% SOA
  - 37% Software Product Lines
    - require upfront design



* Qureshi, Usman, Ikram: *Evidence in Software Architecture, a Systematic Literature Review,*

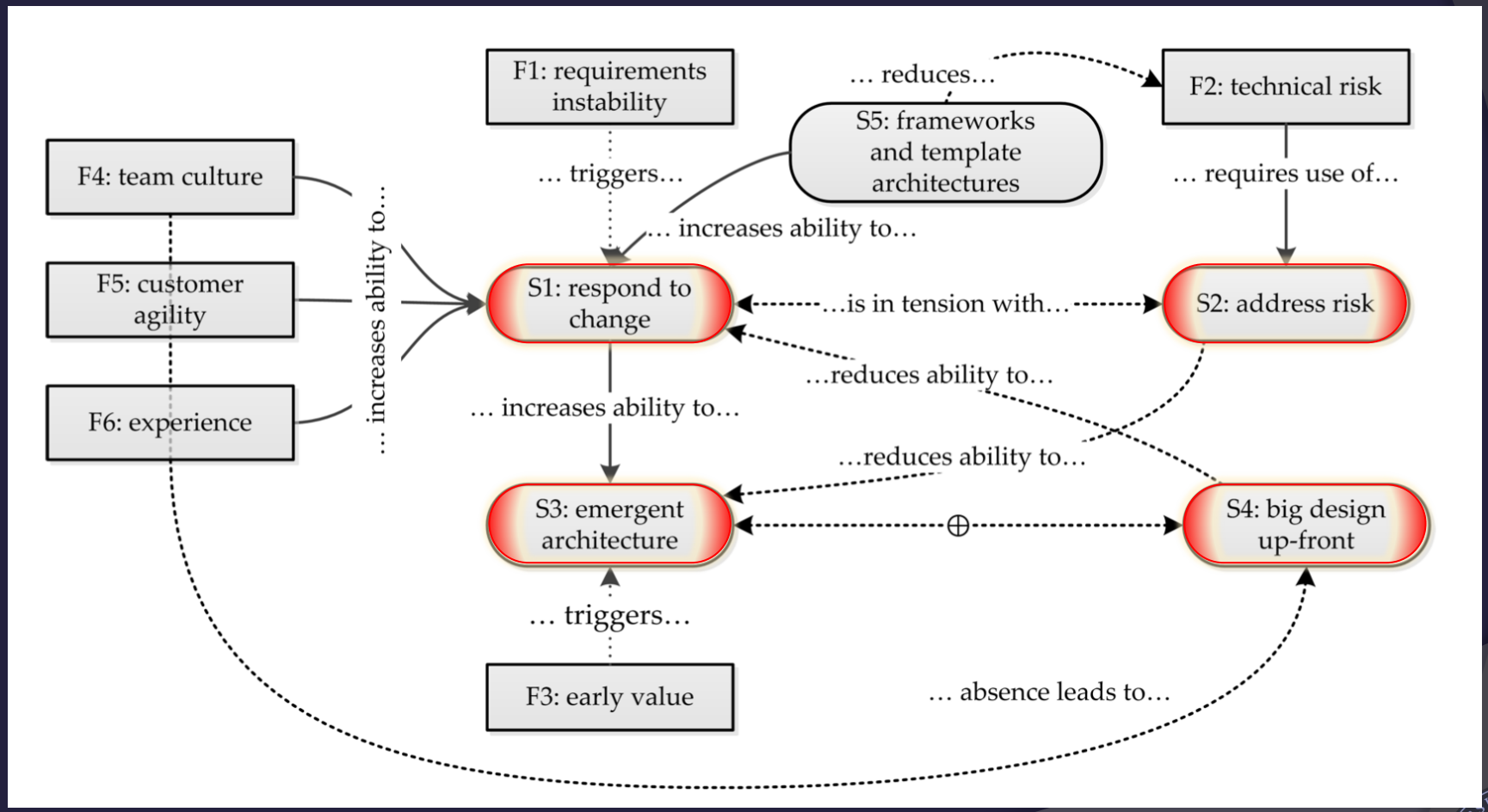
What do companies want? A balanced approach*

- X = where they are now
- O = where they would like to be



T. Mårtensson, D. Ståhl, A. Martini and J. Bosch, "*Continuous Architecture: Towards the Goldilocks Zone and Away from Vicious Circles*" 2019 IEEE International Conference on Software Architecture (ICSA) 2019

Why is it so difficult to balance the right upfront design?



* Waterman, Noble, Allan - *How Much Up-Front? A Grounded Theory of Agile Architecture,* ICSE, 2015

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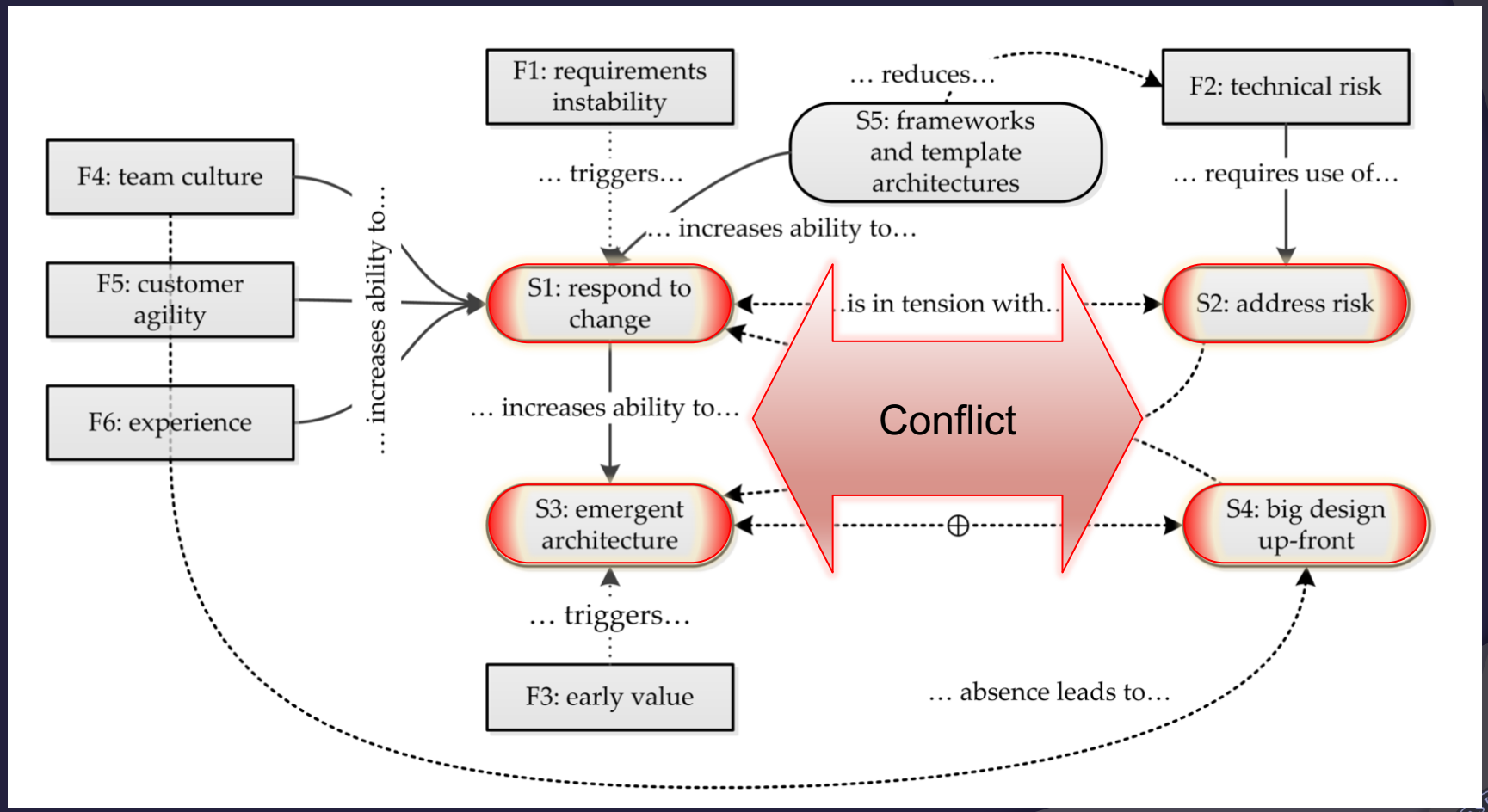

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Frameworks embed architectural decisions and help agility

- *"many of the architectural decisions are embedded in the framework, and hence architectural changes can be made with a lot less effort"*

- Examples:
  - Apache Kafka – message streaming
  - JUnit – Java unit testing framework
  - Django – python web applications
  - …

What is our biggest problem?

Prioritizing architectural significant concerns (backlog)

- Architecture is a risk- and cost management activity*
- Significance depends on Risk (Decision)
- Risk:
  - Prob (Failure) x Impact (Failure)
    - An example of impact is the necessity of re-architecting because of a probable failure

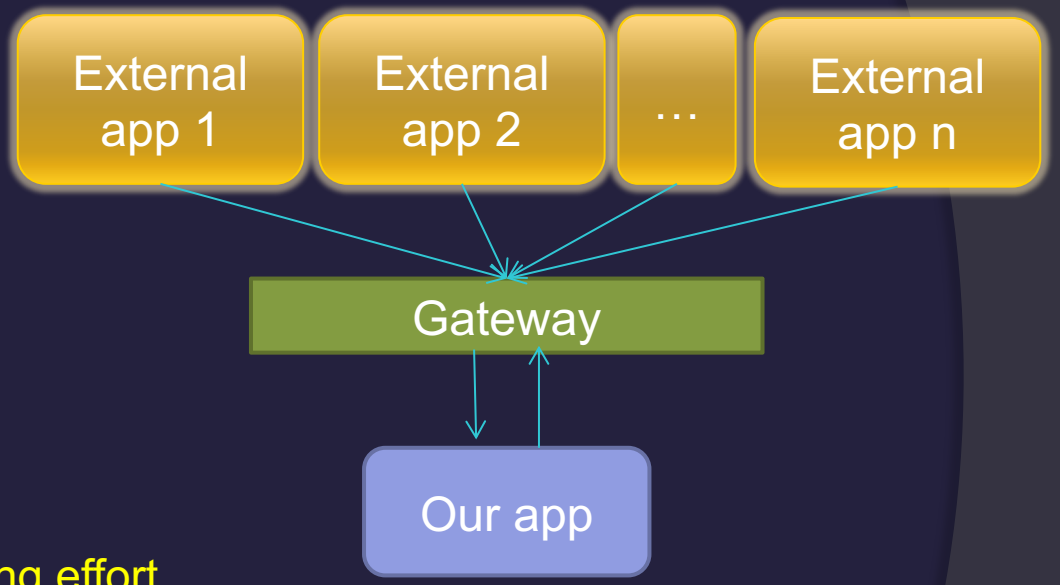
* Poort, van Vliet: *Architecting as a Risk- and Cost Management Discipline*

Example of risk

- Is it higher the risk to suffer from a flu or from malaria taking a bus in Oslo?
  - Disclaimer: numbers are just examples, they are not real
  - Impact is represented as 1-5 (5 = worst)
- Malaria
  - Prob (Malaria) = 0.0000001
  - Impact (Malaria) = 4
  - Risk = 0 x 4 = 0.0000004
- Flu
  - Prob (Flu) = 0.6
  - Impact (Flu) = 1
  - Risk = 0.6 x 1 = 0.6
- When taking the subway in Oslo, one should be more worried to get a flu than to get malaria
  - 0.6 >> 0.0000004

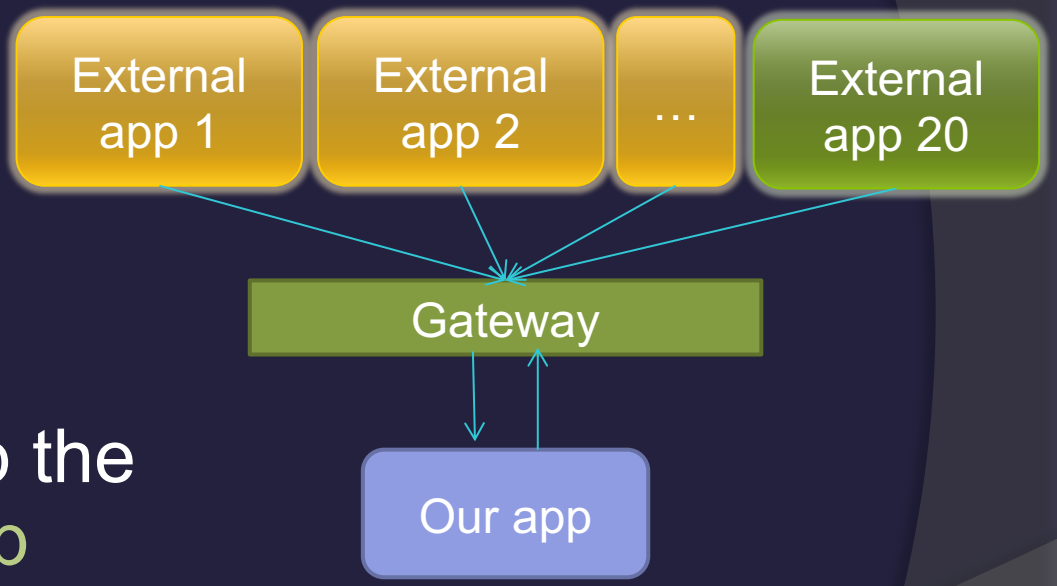
Architectural example (1)

- We build an app that supports other apps
- We need to develop a gateway
- Architectural concern: scalability
  - Significant?
- We don't know how many apps we will need to support
  - Is it going to be 1 or 100?
- We might waste a lot of engineering effort in planning a scalable gateway that is not used
- The risk of not being able to support apps (unhappy customers) has
  - A high impact (4)
  - A low probability at this stage (0.3)
- Result: at the moment the risk of this concern is low
  - 0.3 (probability of failure) x 4 (high impact) = 1.2



Architectural example (2)

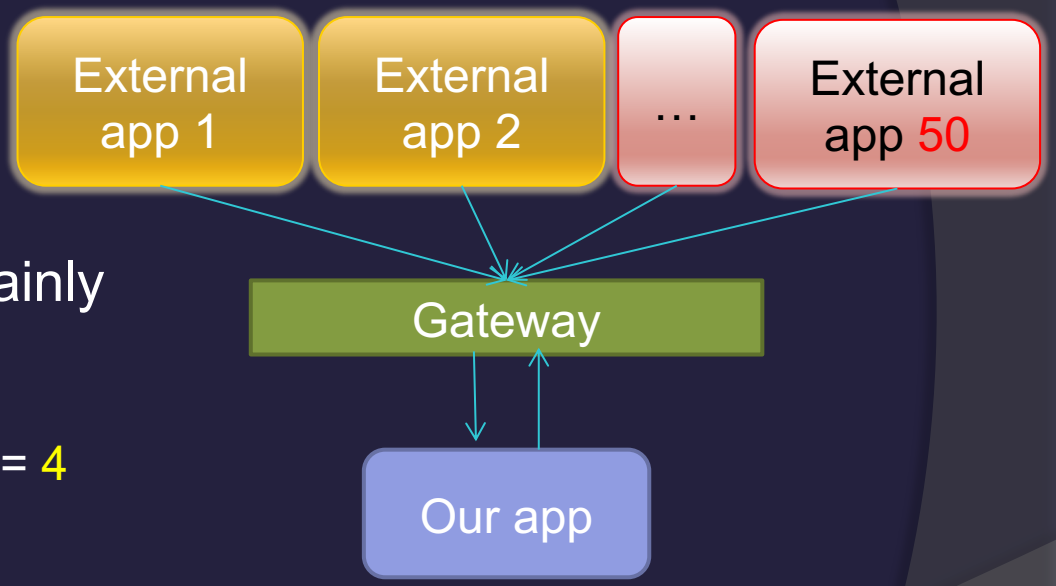
- The risk is low, so the scalability concern is not significant



- We decide to develop the gateway to support up to 20 apps
  - Architectural decision that costs less and doesn't address the scalability concern

Architectural example (3)

- After some time, we receive new information: now more than 30 new apps want to use our gateway
- What happens now?
- Now our solution will be certainly wrong (failure)
- The risk is high
  - 1 (prob of failure) x 4 (impact) = 4
  - 4 >> 1.2 (previous risk)
  - The concern is significant
- We need to re-architect as soon as possible to address the scalability concern
  - The more we wait the more re-architecting costs
  - The more we wait the more customers could experience connectivity issues



Taking architectural decisions

- When should we take a decision?
- If and when should we change it?
- Can we be agile with architecture?

Deciding too fast: The Great Emu War

- Western Australia 1932
- 20000 emus destroying crops
- Decision: deploy army with machine guns to cull the birds
- Response: after the first fire, birds run away and organized in distant, small groups.
- Effect: Machine guns became ineffective. Several wasted resources and only a few birds were hit
- What they could have done? Get information on wildlife before deciding

Ineffective

Deciding too slow: The Great Emu War (2)

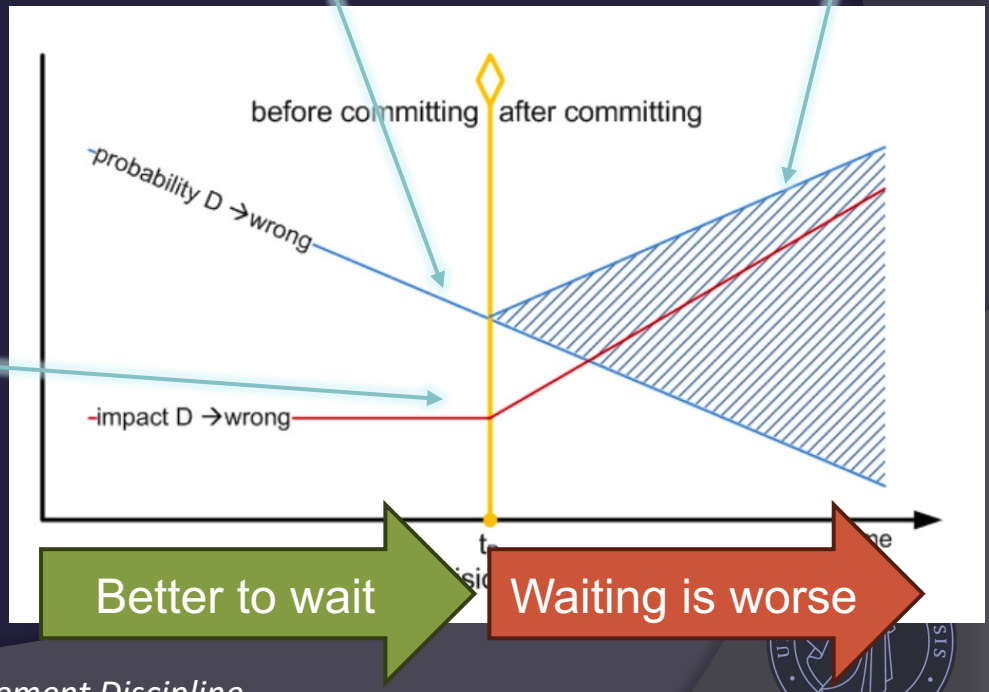
- ... Continue ...
- ... Did they revert the bad decision and found another one?
- No: they kept going for two months
- Out of the 20000 only 1000 emus were killed (5%)
- Many ammunitions were wasted
- The «war» was ridiculized internationally

New information when implementing

- Example
  - The team decides to use a specific database (architectural decision)
  - During implementation, they try to populate the databased with a large number of entries
  - The database is too slow
  - They need to change database

When to decide?

- The probability of an architectural decision D to be wrong decreases over time
  - More information can become available
- At the same time, the probability of D to be wrong can increase over time after we have taken a decision
  - More information can become available from implementation
- The impact of failure increases over time after we have taken a decision D
  - If we need to change such decision, it has a cost of re-architecting

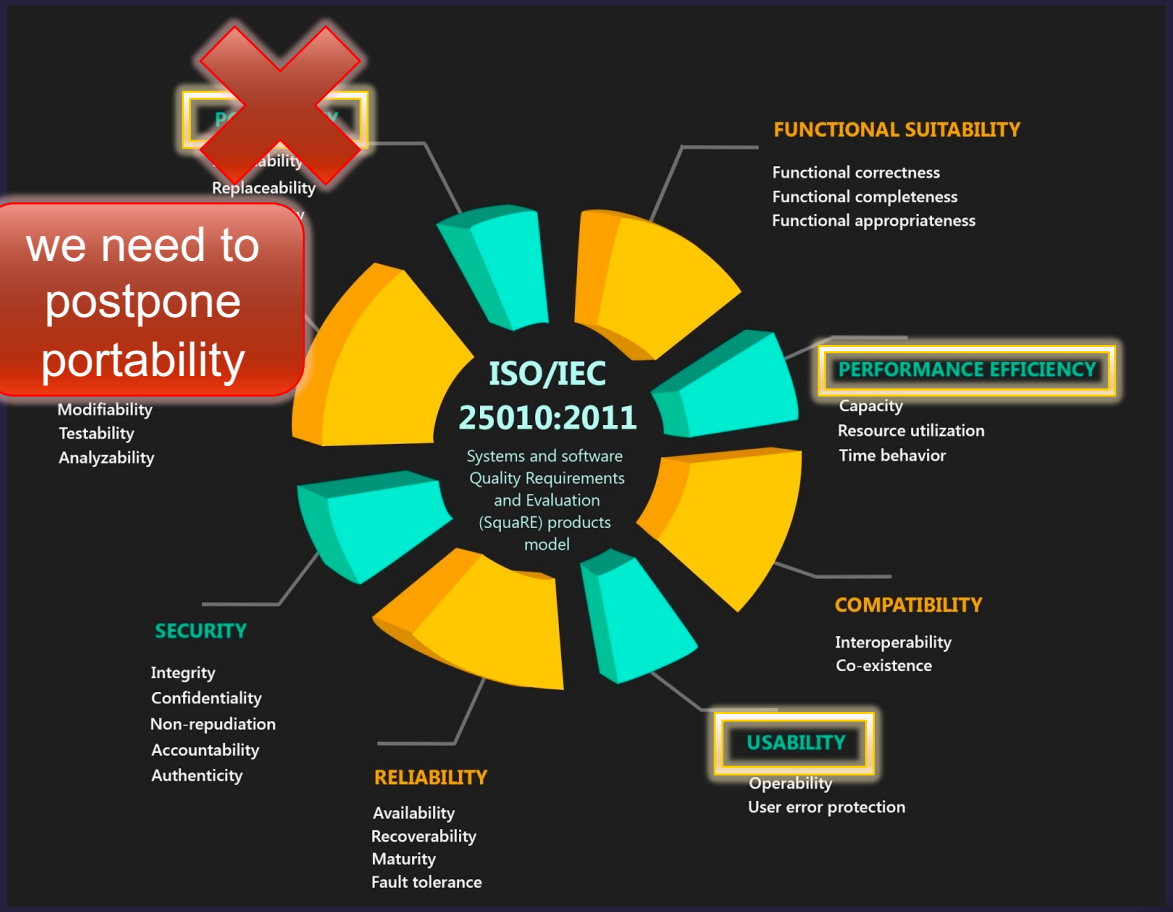


* Poort, van Vliet: *Architecting as a Risk- and Cost Management Discipline*

Summary: should we postpone an architectural decision?

- Postponing architectural decisions can increase the probability of being correct
  - But we cannot wait for all the decisions!
  - Only if possible and in case there is uncertainty and risk
- More information can change our perception of the risks
  - Architectural decisions need to be monitored and revisited
- Architectural Backlog should be continuously re-prioritized based on risk (and cost)

Re-prioritize your architecture backlog



Concern	Rank
Scalability	1
Maintainability	2
Performance	3
Portability	4
…	…

Continuous Re-prioritization

Agile Architecting

What is Agile Architecting?

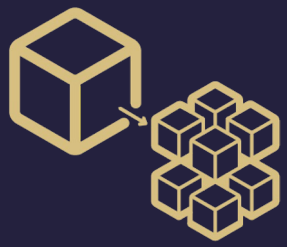
- Architecting that supports Continuous Delivery *
  - Continuous Delivery is:
    - *"Continuous Delivery is the ability to get changes of all types—including new features, configuration changes, bug fixes and experiments—into production, or into the hands of users, safely and quickly in a sustainable way."*

* Murat Erder, Pierre Pureur "*Continuous Architecture*", Elsevier, 2015
* various blogs online, https://continuousdelivery.com/

Agile Architecting: 3 dimensions

Agile Architecting

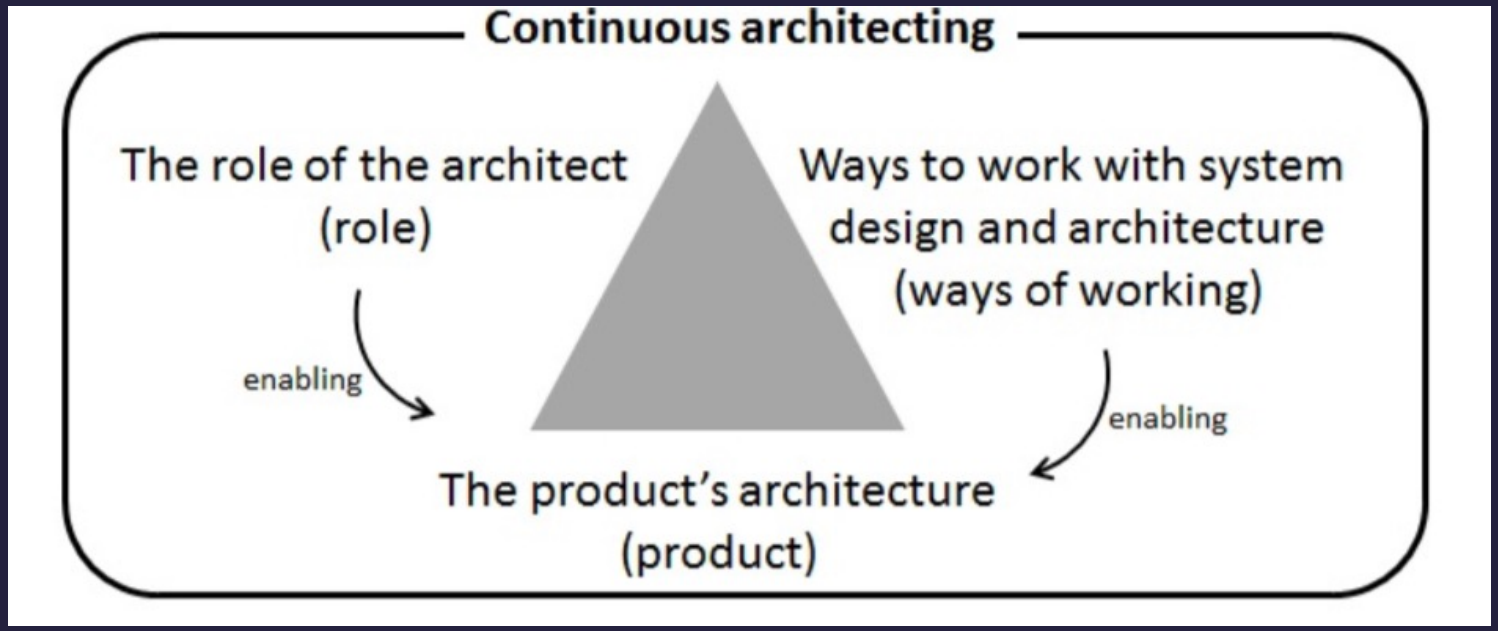
- Agile Architecting * (Process)
- Agile Architects ** (Organization)
- Agile Architecture * (Product)



* Bellomo, Kruchten, Nord, Ozkaya: *How to Agilely Architect an Agile Architecture*

** A. Martini and J. Bosch, "*A Multiple Case Study of Continuous Architecting in Large Agile Companies: Current Gaps and the CAFFEA Framework*,"

Product architecture needs support



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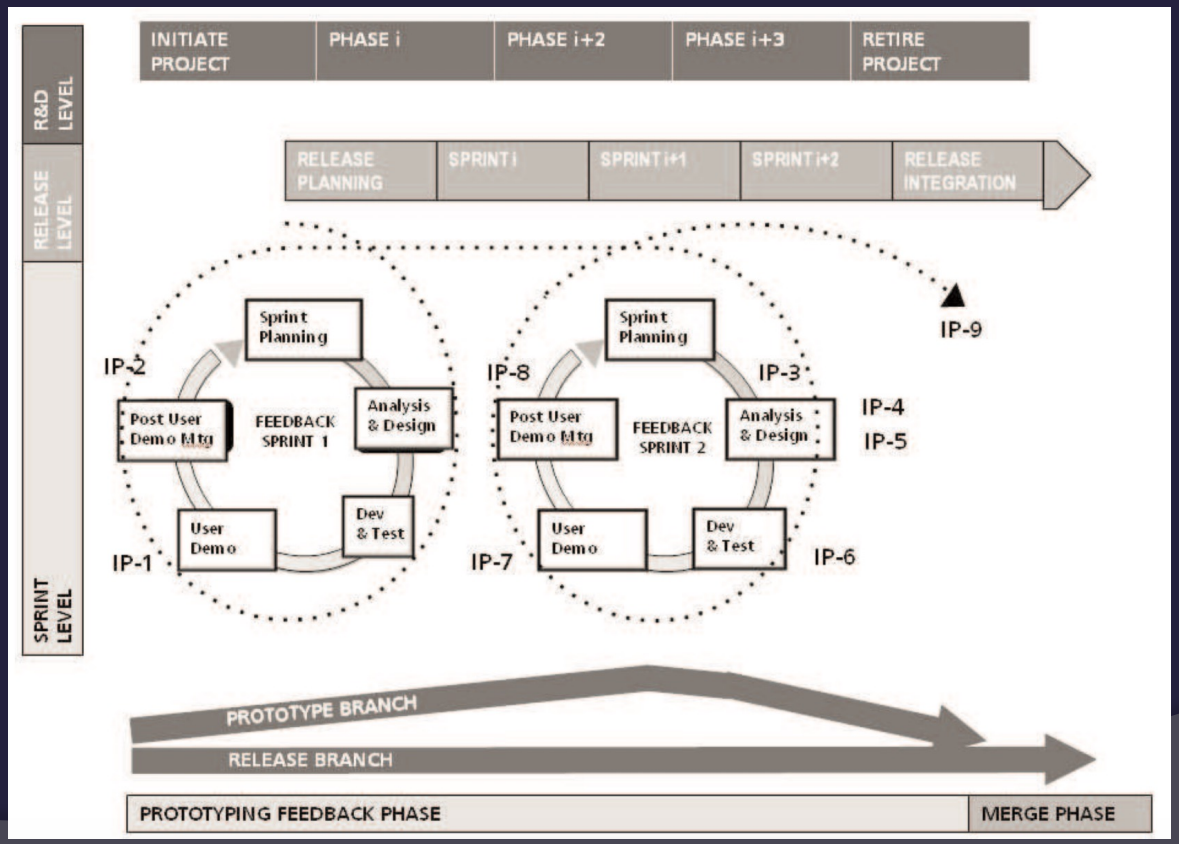
Agile Architecting – Process*

- An Agile way to define an architecture, using an iterative lifecycle, allowing the architectural design to tactically evolve over time, as the problem and the constraints are better understood



* Bellomo, Kruchten, Nord, Ozkaya: *How to Agilely Architect an Agile Architecture*

Continuous Re-prioritization

Agile Architecting – Product*

- Product Architecture enables Agility
  - Layered architecture
  - Service Oriented Architecture
    - Microservices
  - Frameworks
  - Other tactics*

* Bellomo, Kruchten, Nord, Ozkaya: *How to Agilely Architect an Agile Architecture*

Organization: who is in charge of the overall design?

Agile and Architects: a case study*

* A. Martini and J. Bosch, “A Multiple Case Study of Continuous Architecting in Large Agile Companies: Current Gaps and the CAFFEA Framework”, Working International Conference on Software Architecture, 2016, Venice, Italy

Research Design – gaps and framework

Literature

"What do software architects really do?" *

literature review

* P. Kruchten, "What do software architects really do?" *Journal of Systems and Software*, Dec. 2008

Research Design – Gaps and Solution

Literature

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Architecture Activities

* P. Kruchten, "What do software architects really do?" *Journal of Systems and Software*, Dec. 2008

Architecture activity examples

Activity: Architecture Knowledge Production	
Sub-Activities	**Meaning**
Architect	Examines concerns and context in order to compe up with architectureally significant requirements.
Integrate	Integrates software engineering and knowledge engineering tools and repositories into the development process.
Share	Shares the AK with implementers to facilitate their understanding.
Trace	Creates necessary links (fwd., bwd., formal, informal) between reasoning-, design-, genera-, and context knowledge.
Synthesize	Extends or modifies the design knowlede through creation of detailed design for the architecture.
Distill	Examines design to turn patterns therein into general knowledge for future reuse.
Apply	Uses existing solutions, patterns, templates (general knowledge) to solve problems at hand.

Research Design – Gaps and Solution

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Context

Architecture Activities

Mapping

Roles

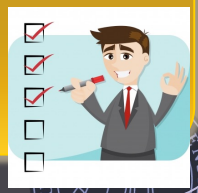
Chief Arch. CA

Governance Arch. GA

Team Arch. TA

Product Manager PM

Product Owner PO



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Interactive mapping in 5 companies

- Who is responsible now?
- Is this activity missing?
- Who should do it?

Activity	Meaning
Architect	Examines concerns and context in order to compe up with architectureally significant requirements.
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Relationship

A a A*

Gap

a A

Gaps and Solution

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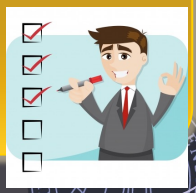

Gaps:

Activities
Roles

Relationships

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Gaps and Solution

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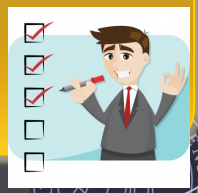


Gaps:

Activities

Roles

Relationships

Solution:

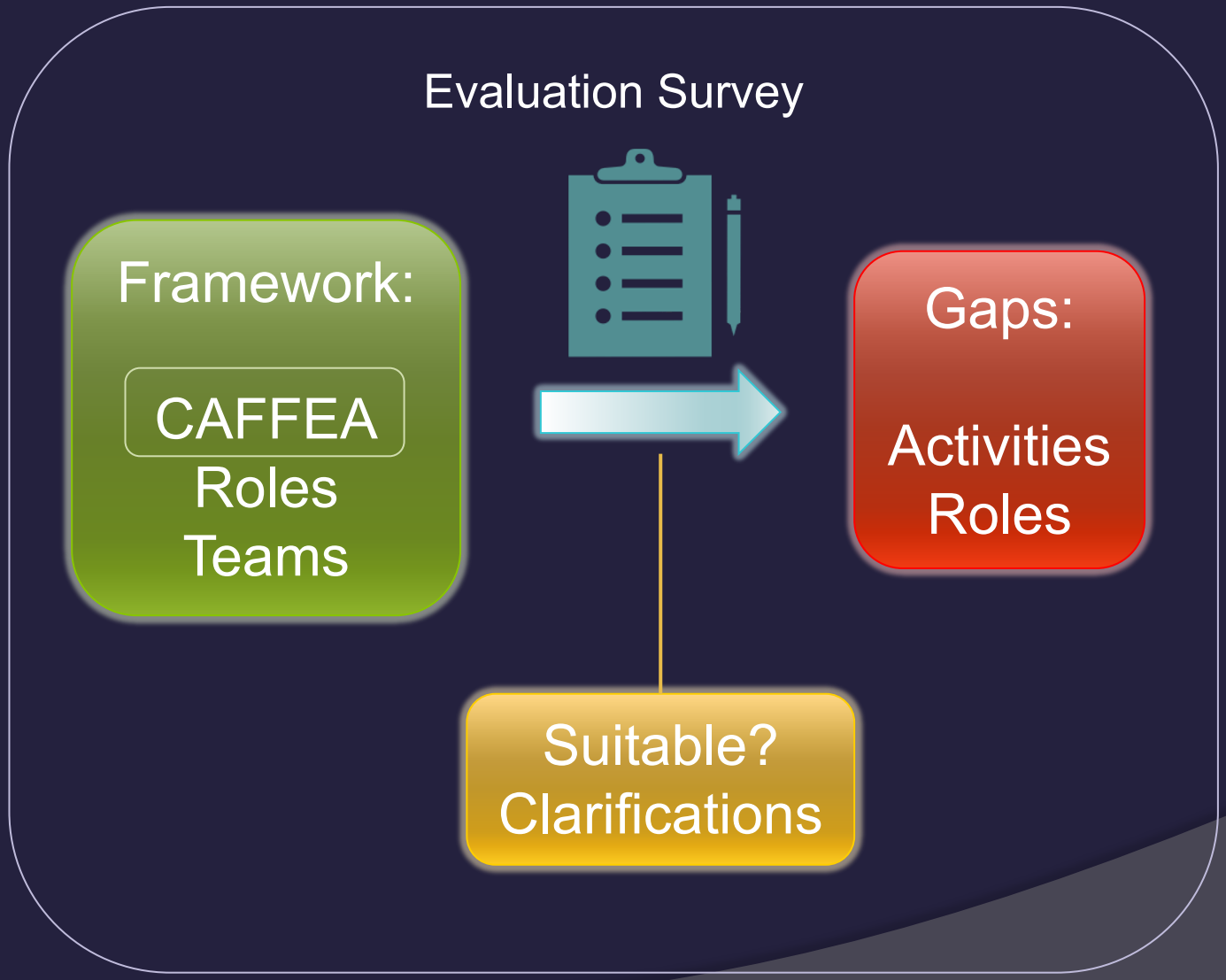
CAFFEA

Roles

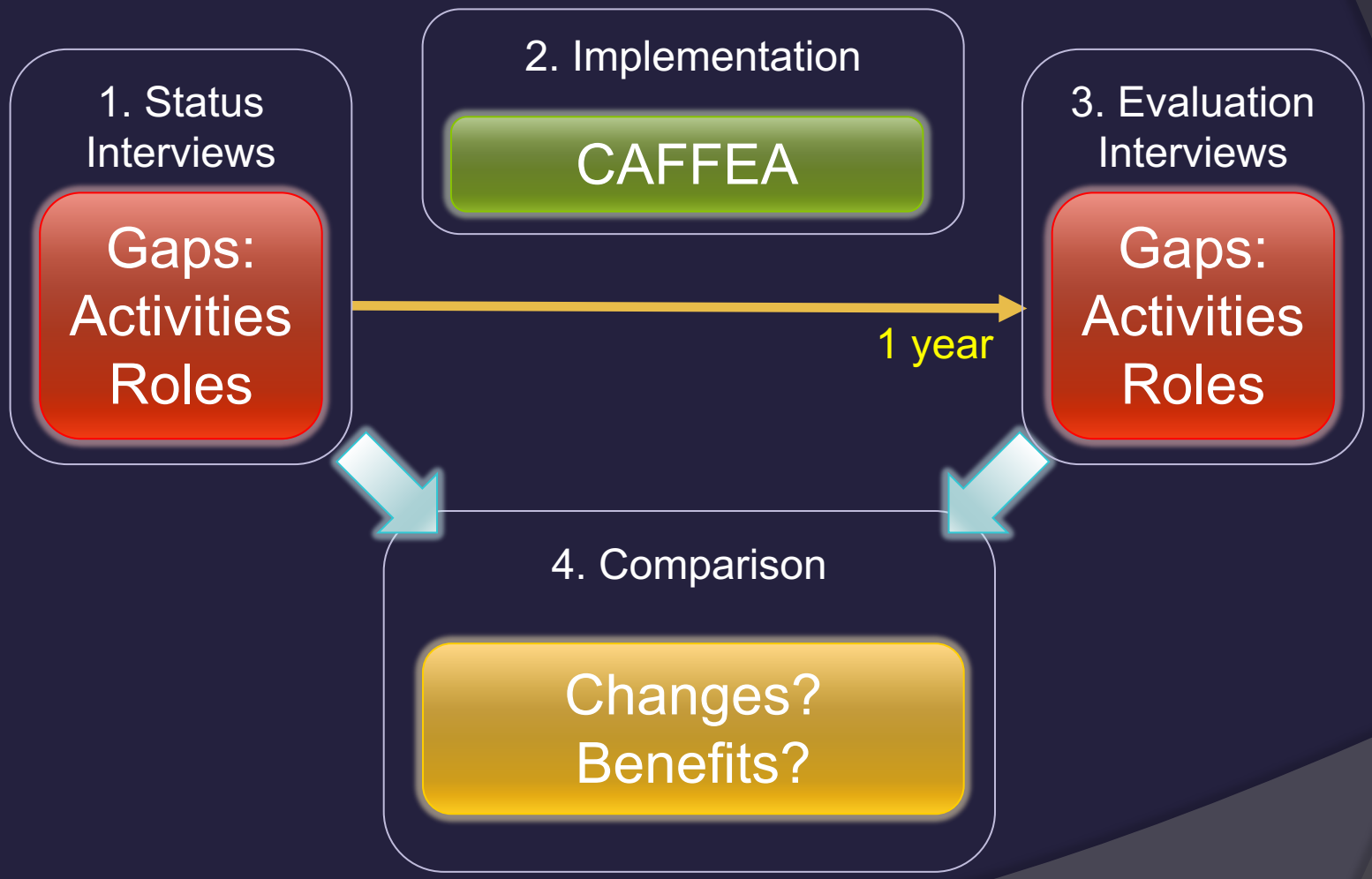
Teams

* P. Kruchten, "What do software architects really do?" *Journal of Systems and Software*, Dec. 2008

Did it work? – First Evaluation



Did it work? – Empirical Evaluation



What we found– Gaps and CAFFEA

Findings: challenges in activities

- Risk management
- Architectural decisions and changes
- Providing architectural knowledge
- Monitor the current status of the system

Short-term or long-term value delivery?

What is worth changing in our architecture?

What qualities are really important?

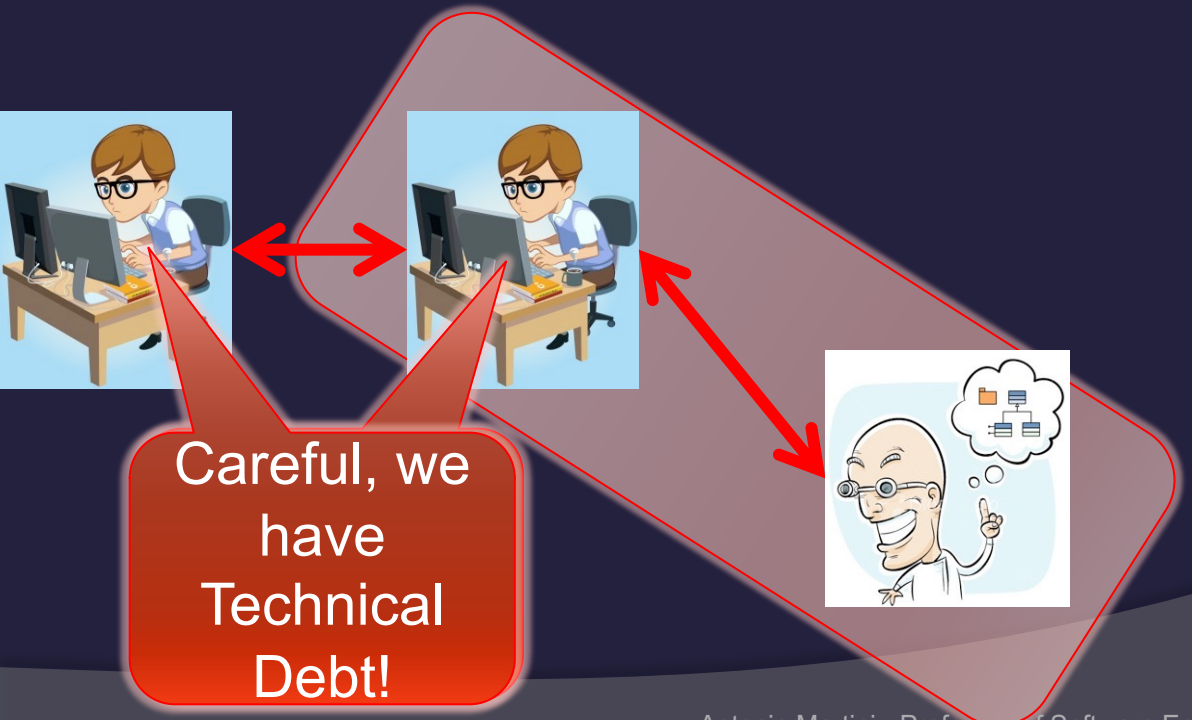
How much technical debt do we have?

Findings: roles in CAFFEA

- Missing activities (and needed!) due to:
  - Roles not present in the organization
  - Roles overloaded with activities
  - Roles not aware of the need for the activities
- Needed roles:
  - Chief Architect CA
  - Governance Architect GA
  - Team Architect TA

Findings: Teams in CAFFEA

- Risk management
- Architectural decisions and changes
- Providing architectural knowledge
- Monitor the current status of the system



Findings: Teams in CAFFEA

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- Architectural decisions and changes
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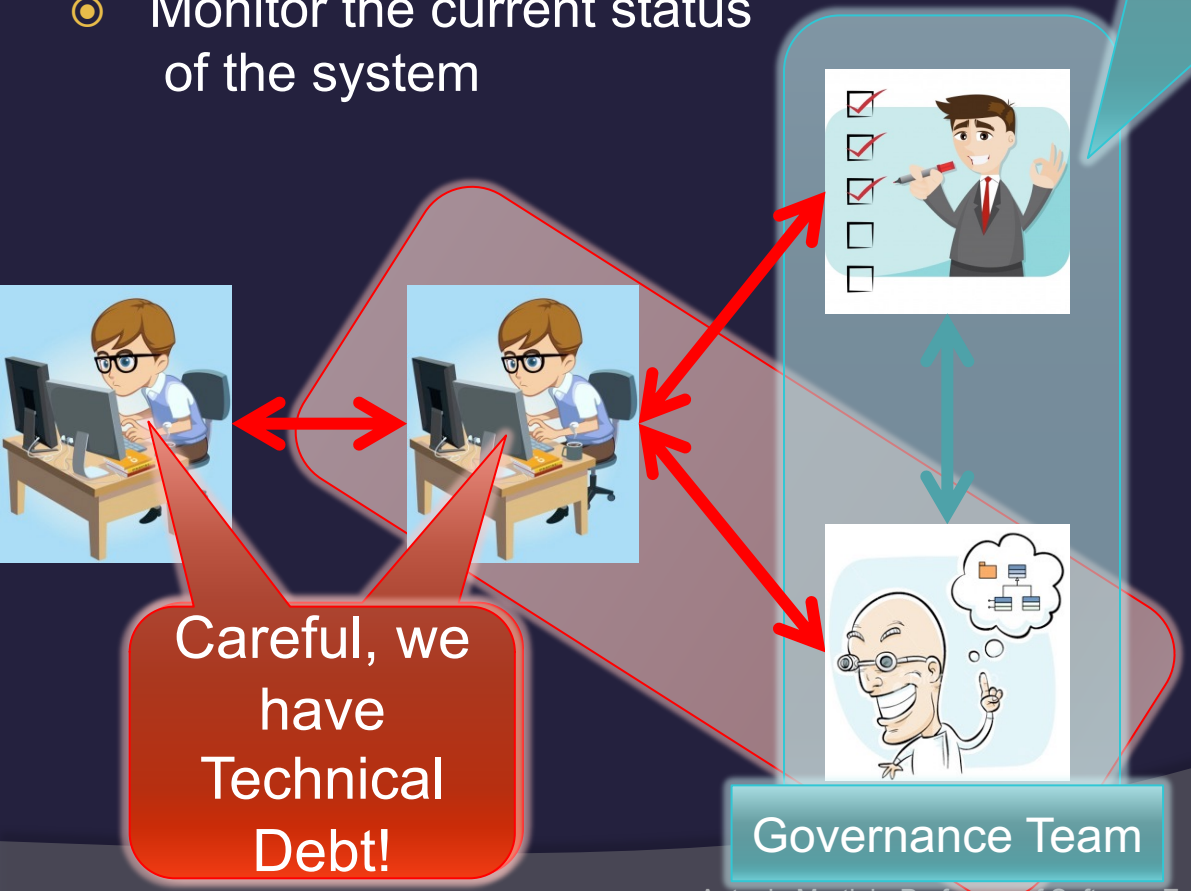

Findings: Teams in CAFFEA

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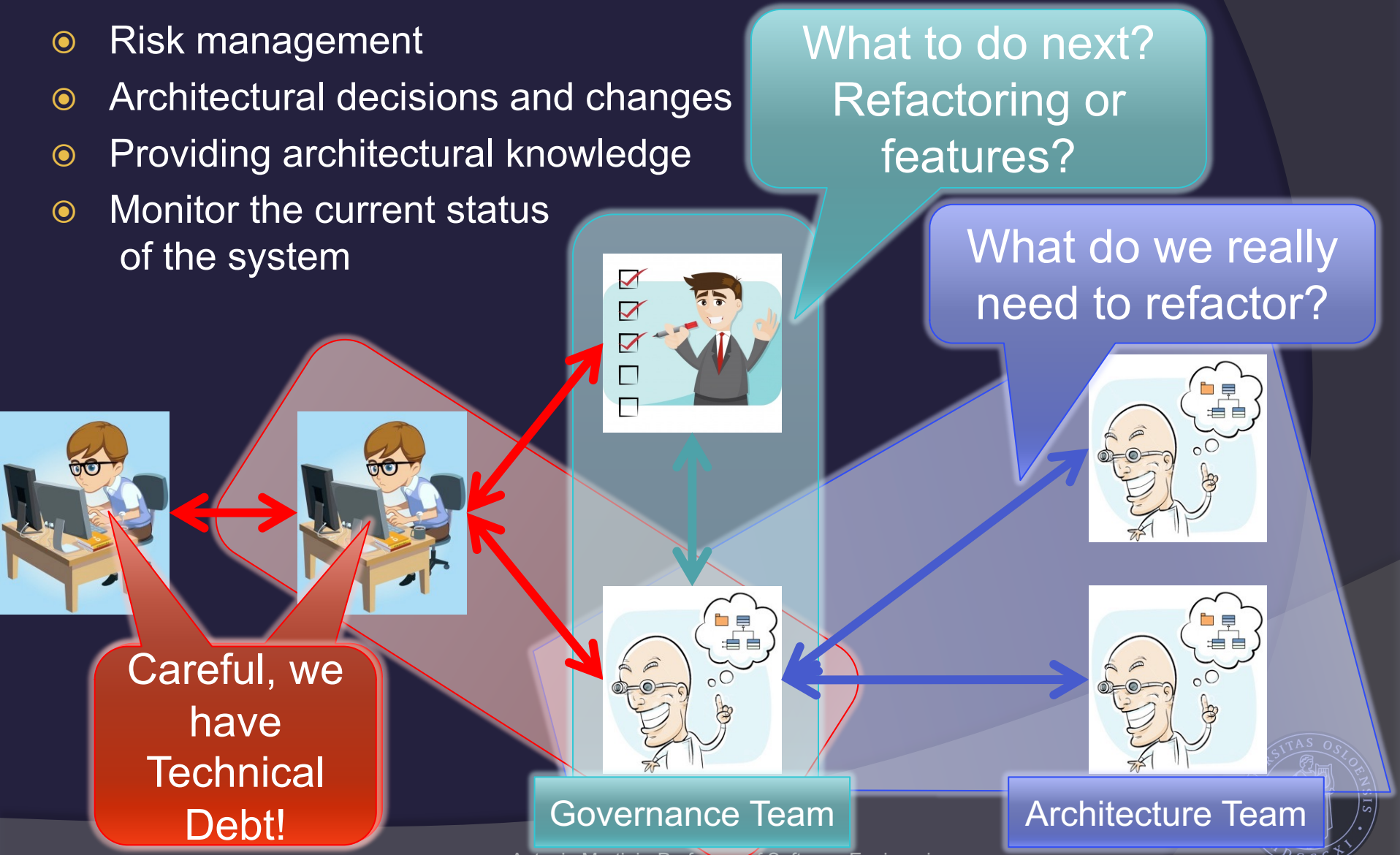
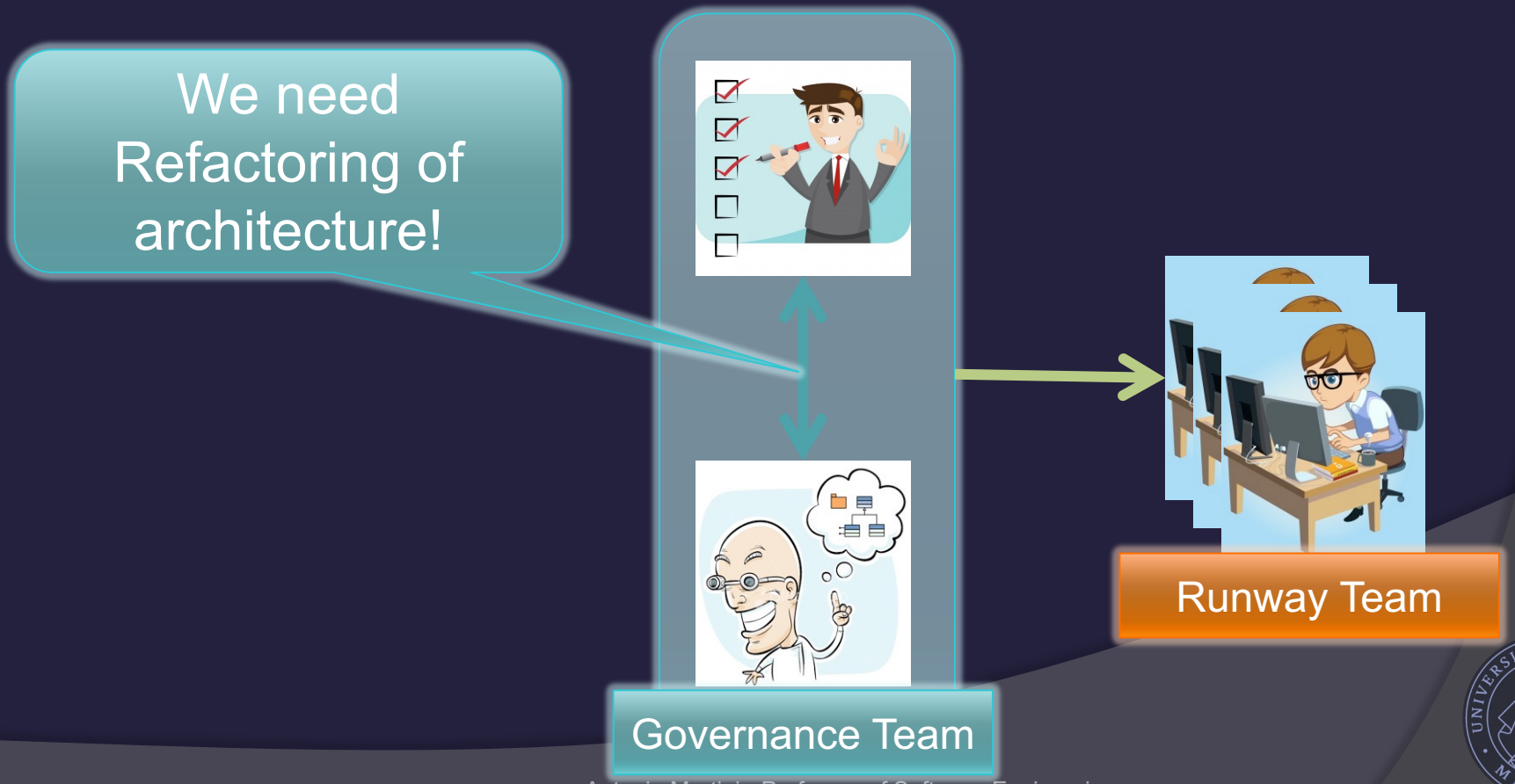
- Monitor the current status of the system

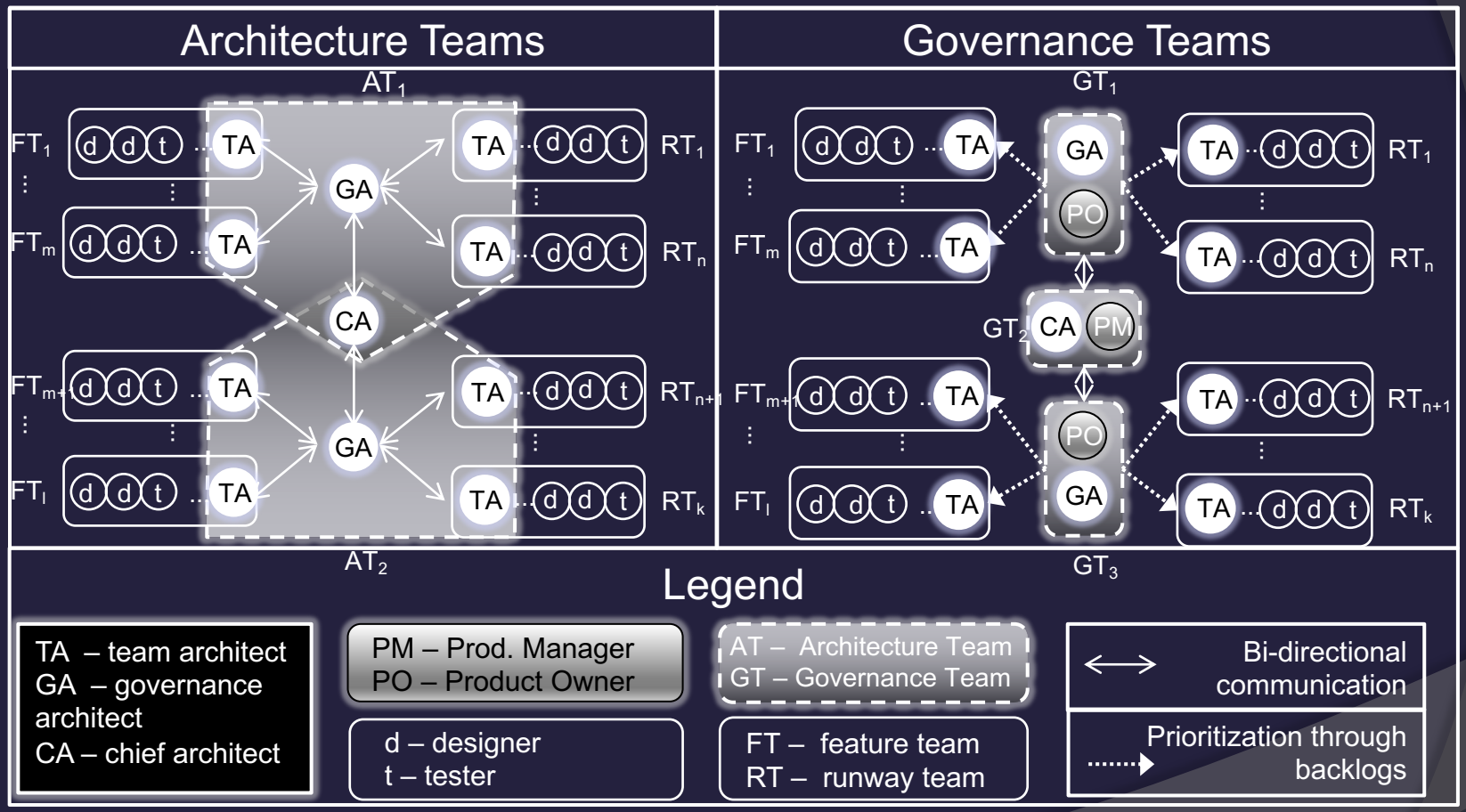


Findings: Runway Team in CAFFEA

- A feature team dynamically appointed when the architecture needs improvement



Overall CAFFEA framework



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Did it work? – Evaluation

Improvement in risk management

- Architectural Technical Debt discovered and managed
  - Architecture Team
- Long-term perspective
  - Governance Team
  - Allocation of Runway Team

Improvement in managing decisions

- Informal tracking of decisions during meetings
- Conflicts discovered and solved
  - Between architects related to different teams and different views
- Follow up on “bad” decisions

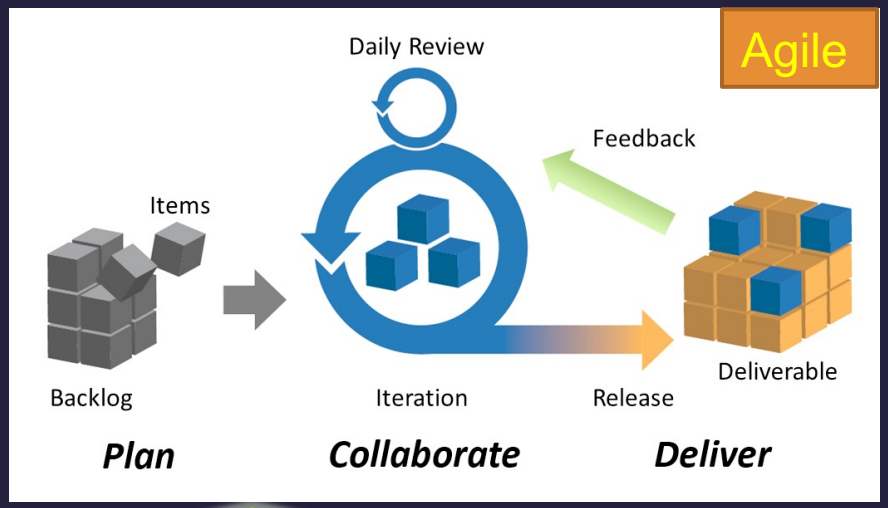
Improved communication

- Necessary inter-team socio-technical communication facilitated
  - Architecture Team as opportunity to share
    - Improvements
    - Needs
- Better communication about the current status of the system
- Enforcement and capillary distribution of Architectural Knowledge

Other improvements

- The formalized framework in place provided:
  - Clear knowledge references
  - Clear architecture responsibilities
  - Architecture activities not overlooked

Summary



Changes in
- Practices
- Organization

Lack of focus
- Architecture

Compliant

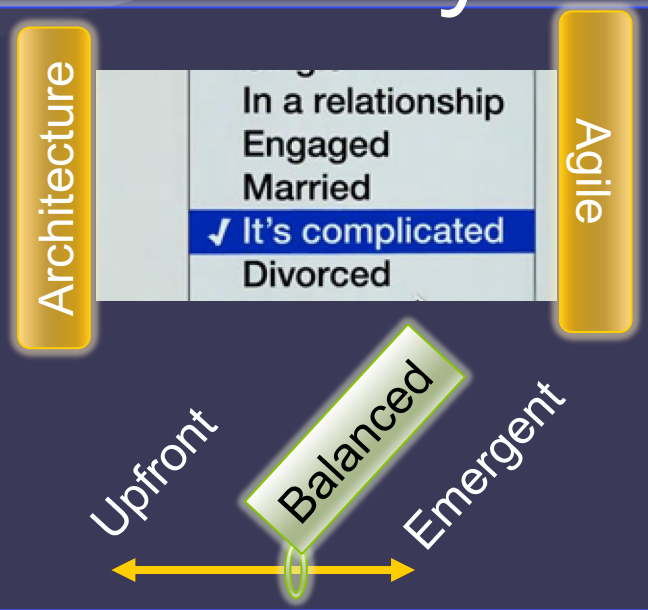
CAFFEA Framework
- Roles
- Teams
- Responsibilities

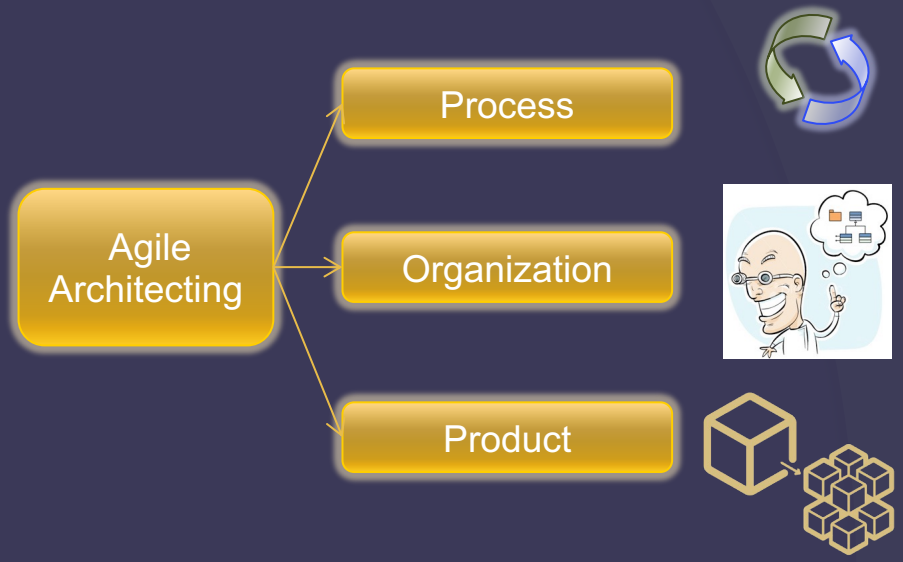
Improves

Gaps in Architecture Practices
- Risk management
- Architectural decisions and changes
- Providing architectural knowledge
- Monitor the current status of the system

Take aways

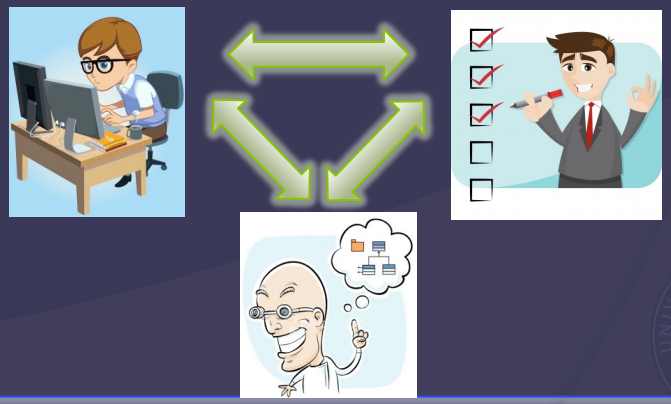
Summary



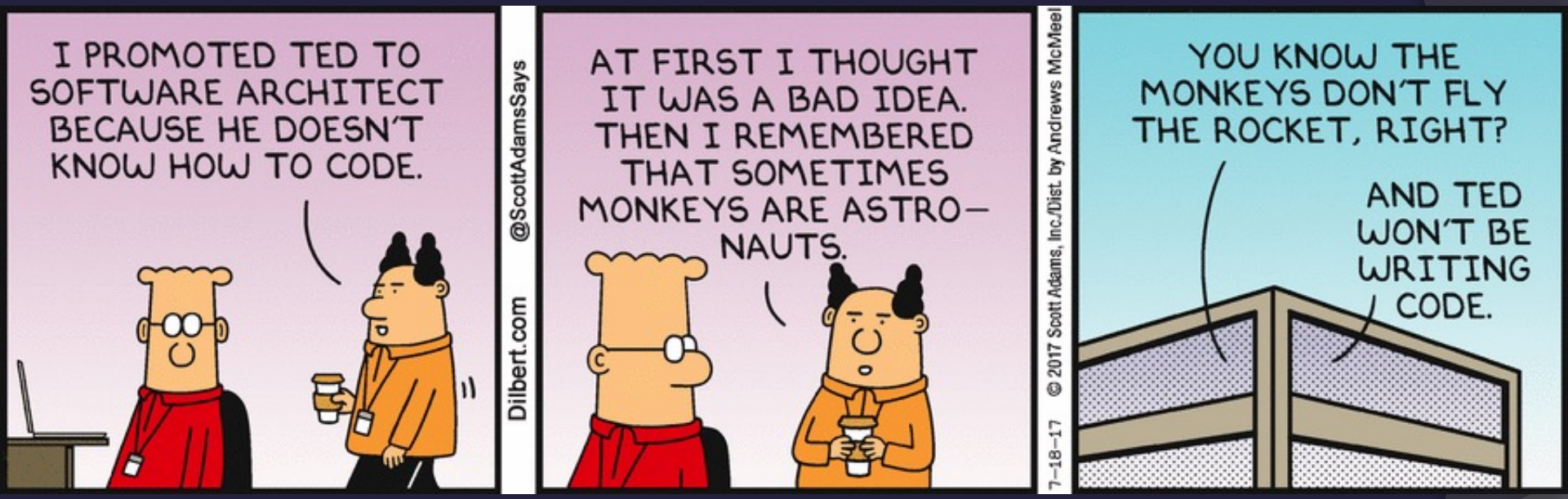


- Continuously re-prioritize architectural concerns according to risks
- Use frameworks

Communication among roles and stakeholders is key



Don’t underestimate architecture (and architects)…



Questions?

Comments?

- antonio.martini@ifi.uio.no