

Software Architectures

Software architectures
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Eiffel tower - from PO1

- 18,038 metallic parts
- 5,300 workshop drawings
- 50 engineers and designers
- 150 workers in the Levallois-Perret factory
- Between 150 and 300 workers on the construction site
- 2,500,000 rivets



- 7,300 tonnes of iron
- 60 tonnes of paint
- 2 years, 2 months and 5 days of construction
- History here



La tour Eiffel prise du Champ-de-Mars - Exposition universelle de 1889 © Parisienne de photographie - Neurdein / Roger-Viollet https://artsandculture.google.com/asset/ /hQEdYmo3Gzetsw



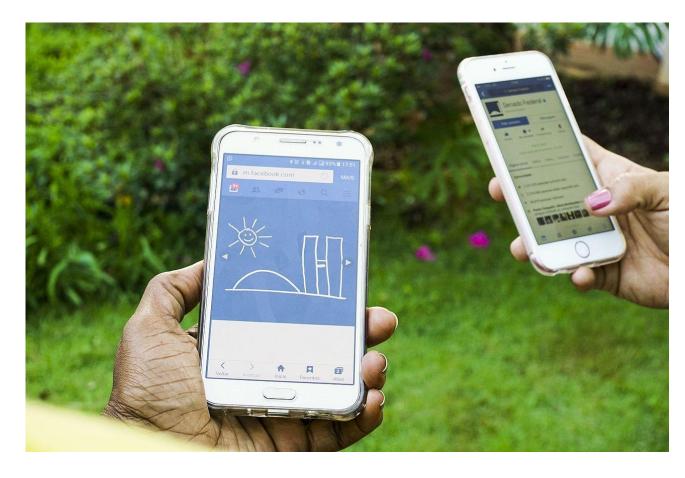
Engineering - from PO1

- Most of the tower was built somewhere else from some workers
- On the site pieces were only assembled, not constructed!
 - With first temporary rivets and then assembled rivets
 - But still, only a third of the rivets were used on site!
- About 500 workers involved in the construction with different skills
- They "communicated" through some standard means
 - Such as rivets, drawings, etc...
- A worker using some results of other works did not need to know the details of what the others have done!



Smartphone (just as an example) - from PO1

- ... what do we mean by smart?
- Android operating system
 - https://source.android.com/
 - https://github.com/aosp-mirror
- 99 GitHub repositories
- "Main" repository
 - ~ 280 branches
 - > 30K commits
 - Almost 150 contributors
 - > 10MLOCs



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Technologies

- https://www.youtube.com/watch?v=QgnJ8GpsBG8
 - Forrest Gump, 1994
- I'll feel often like Forrest Gump while running
 - Teaching technologies that I don't master
 - Indeed, often just with an high level idea of them!
 - To master a technology one needs months/years of experience
 - See job announcements
- But please... never be like the people following Forrest Gump!
 - Neither professors nor colleagues nor "experts" nor ...
 - Always question yourself if this technology is what you need and why

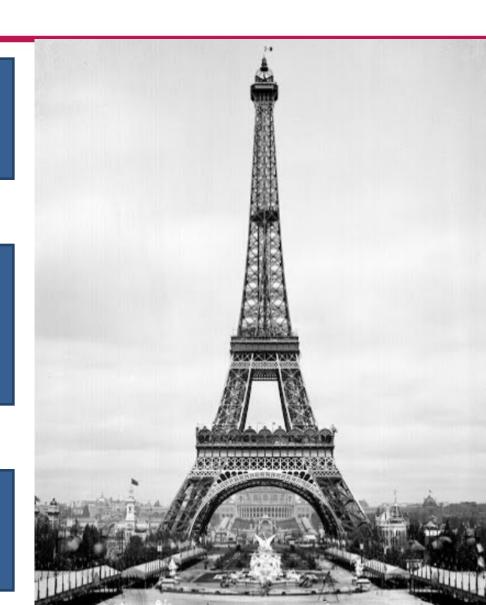


A typical Eiffel tower for sw developers

how to supervise the construction of the tower **Software architectures**, **Development Methodologies**, ...

how to build up more complex systems packaging and assembling basic blocks
Software engineering, Project management, Cloud computing, Web application ...

how to build the basic blocks of the tower Programming, Computer architecture, Object-oriented programming, Databases, Operating Systems





Software developers career

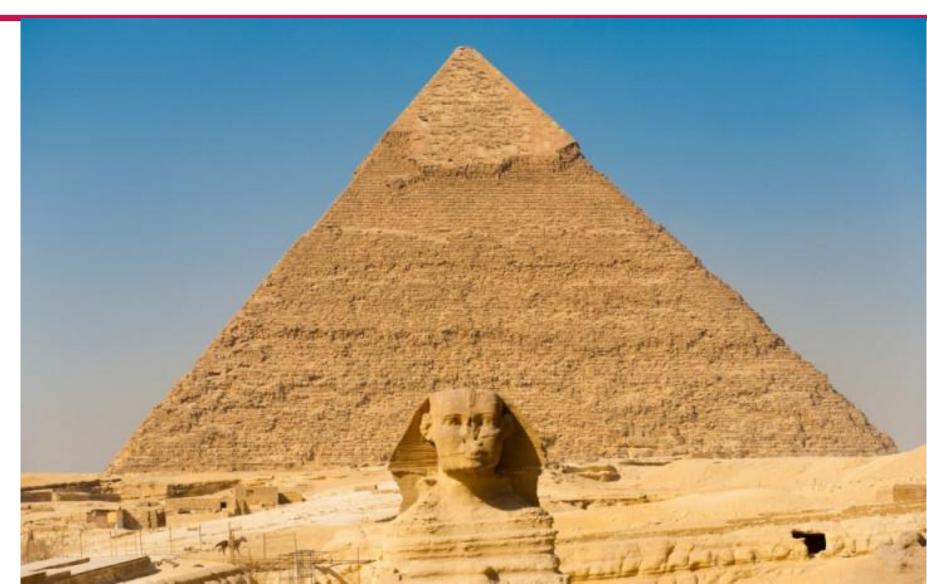
CTOs

Software architects

Project managers

Software engineers

Software developers



Content of the course

- Software architecture is a very practical topic
 - People tried many solutions
 - They started to copy each other
 - The most effective solutions took the lead
- Not always clear why a solution was preferred
 - Or better, a lot of speculation and different opinions
- Always think with your brain!
- The main goals of the course are to provide you
 - An overview of the main architectures adopted in the history
 - Critical thinking about architectures
- In 5 years software architectures will be different from today!



What is software architecture?

"Software architecture refers to the **fundamental structures of a software system** and the discipline of creating such structures and systems. (...) Software architecture is about making **fundamental structural choices** that are **costly to change** once implemented."



- High level thinking about software systems
 - Not about programming languages, type of databases, etc...
- Make decisions before writing code (design)
 - That cannot be easily changed later on



Concept vs technology

- Concept: abstract ideas that can be applied to different contexts and are not bound to specific situations
- Technology: the application of concepts for practical purposes, especially in industry
- University is about teaching concepts
- Enterprise is about developing and applying technologies
- Concepts are better understood and remembered if practiced
 - We need (some) technology to exemplify concepts
 - But which technology? Why?
- Lectures will be split between concepts and technologies

Blended course

- Technologies will be covered with online material
 - ~10-15 minutes youtube video
 - Introducing the main points of the technology and connecting it with the conceptual part of the course
 - HTML pages with guided tutorials
 - Exercises at the end of the tutorials
 - To be done BEFORE moving to the next online lectures
- 12 online lectures on Friday 3:45-5:15
 - No need to be connected or whatever
 - I'll be always available by email to answer any questions



- ~ 10 in-presence lectures on concepts
- 12 online lectures on technologies
- 2 lectures on practical experience (with invited speakers)
 - Unox https://www.unox.com/us_us/
 - Gianluca Caiazza, Secura Factors, Zamperla project

Choosing a technology

- https://www.google.com/search?q=popularity+of+technologi es+for+developing+microservices
- A lot of confusion, nothing really widely accepted
- Already from a programming language point of view
 - Java, Python, node.JS, ...
- Need to make a completely arbitrary choice!
 - Is it the right one? The best one? … who knows!
- We'll go with Java and Spring (and some other technologies)
 - But feel free to experiment with others!!!
 - Especially if you are already familiar with other technologies

- Third year I am teaching this course
 - Second year blended
- Topics might change during the course for different reasons
 - Maybe I'll be slower or faster than expected
 - Other topics might arise while teaching the lectures
 - Feel free to propose topics!
- We'll combine theory and practice
 - Theory: frontal lectures aligned with the textbook
 - Practice (a kind of lab): mostly coding and tutorials using different technologies
 - Online!



Software architecture characteristics:

- Modularity and coupling
- Operational characteristics: availability, performance, scalability, recoverability
- Structural characteristics: deployability, configurability, extensibility, upgradeability
- Measurement of characteristics



Architectural patterns (tentative list):

- Monolithic vs. distributed architectures
- Ball of Mud
- Layered
- Pipeline
- Microkernel
- Service-based
- Event-driven
- Space based
- Microservice



Technologies (tentative list):

- Docker[compose]: from artifact to [virtual] machines/containers
- Gradle: from code to artifact
- Spring [Web]: hosted artifacts
- Hibernate: connecting code to data
- Camel: pipeline architecture
- REST: communications between distributed components
- RabbitMQ: asynchronous communication through messages
- Kubernetes: automatic replication and orchestration of machines
- AWS Lambda (?): serverless computing



Textbook

- Mark Richards, Neal Ford: "Fundamentals of Software Architecture", O'Reilly Media, January 2020
 - http://fundamentalsofsoftwarearchitecture.com/
 - Available in the library (BAS), only about concepts (no code!)
- Additional material: Chris Richardson, "Microservices patterns: with examples in Java"
 - Available in the library (BAS)
 - Not needed, just if you want to deepen some topics for your interests
 - But this contains code!!!
 - And a lot of more details about popular architectural patterns

Preface: Invalidating Axioms. 1. Introduction	Analyzing Trade-Offs Understanding Business Drivers Balancing Architecture and Hands-On Coding 3. Modularity. Definition Measuring Modularity Cohesion Coupling Abstractness, Instability, and Distance from the Main Sequence Distance from the Main Sequence Connascence Unifying Coupling and Connascence Metrics From Modules to Components 4. Architecture Characteristics Defined. Architectural Characteristics (Partially) Listed Operational Architecture Characteristics Structural Architecture Characteristics Cross-Cutting Architecture Characteristics Trade-Offs and Least Worst Architecture	Architectural Quanta and Granularity Case Study: Going, Going, Gone 8. Component-Based Thinking. Component Scope Architect Role Architecture Partitioning Case Study: Silicon Sandwiches: Partitioning Developer Role Component Identification Flow Identifying Initial Components Assign Requirements to Components Analyze Roles and Responsibilities Analyze Architecture Characteristics Restructure Components Component Granularity Component Design Discovering Components Case Study: Going, Going, Gone: Discovering Components Architecture Quantum Redux: Choosing Between Monolithic Versus Distributed Architectures
	Extracting Architecture Characteristics from Domain Concerns Extracting Architecture Characteristics from Requirements Case Study: Silicon Sandwiches Explicit Characteristics Implicit Characteristics 6. Measuring and Governing Architecture Characteristics Measuring Architecture Characteristics Operational Measures Structural Measures Process Measures Governance and Fitness Functions Governing Architecture Characteristics Fitness Functions	Monolithic Versus Distributed Architectures Fallacy #1: The Network Is Reliable Fallacy #2: Latency Is Zero Fallacy #3: Bandwidth Is Infinite Fallacy #4: The Network Is Secure Fallacy #5: The Topology Never Changes Fallacy #6: There Is Only One Administrator Fallacy #7: Transport Cost Is Zero

Architectural Quanta and Granularity Case Study: Going, Going, Gone 8. Component-Based Thinking. Component Scope Architect Role Architecture Partitioning Case Study: Silicon Sandwiches: Partitioning Developer Role Component Identification Flow Identifying Initial Components Assign Requirements to Components Analyze Roles and Responsibilities Analyze Architecture Characteristics Restructure Components	11.	Pipeline Architecture Style	15.	Broadcast Capabilities Request-Reply Choosing Between Request-Based and Event-Based Hybrid Event-Driven Architectures Architecture Characteristics Ratings Space-Based Architecture Style. General Topology Processing Unit Virtualized Middleware Data Pumps Data Writers Data Readers Data Collisions Cloud Versus On-Premises Implementations
Component Granularity Component Design Discovering Components Case Study: Going, Going, Gone: Discovering Components Architecture Quantum Redux: Choosing Between Monolithic Versus Distributed Architectures	12.	Microkernel Architecture Style. Topology Core System Plug-In Components Registry Contracts Examples and Use Cases Architecture Characteristics Ratings	16.	Replicated Versus Distributed Caching Near-Cache Considerations Implementation Examples Concert Ticketing System Online Auction System Architecture Characteristics Ratings Orchestration-Driven Service-Oriented Architecture
9. Foundations. Fundamental Patterns Big Ball of Mud Unitary Architecture Client/Server Monolithic Versus Distributed Architectures Fallacy #1: The Network Is Reliable Fallacy #2: Latency Is Zero Fallacy #3: Bandwidth Is Infinite Fallacy #4: The Network Is Secure Fallacy #5: The Topology Never Changes Fallacy #6: There Is Only One Administrator Fallacy #7: Transport Cost Is Zero Fallacy #8: The Network Is Homogeneous Other Distributed Considerations		Service-Based Architecture Style. Topology Topology Variants Service Design and Granularity Database Partitioning Example Architecture Architecture Characteristics Ratings When to Use This Architecture Style Event-Driven Architecture Style. Topology Broker Topology Mediator Topology Asynchronous Capabilities Error Handling Preventing Data Loss	17.	History and Philosophy Topology Taxonomy Business Services Enterprise Services Application Services Infrastructure Services Orchestration Engine Message Flow Reuseand Coupling Architecture Characteristics Ratings Microservices Architecture. History Topology Distributed Bounded Context

Granularity
Data Isolation
API Layer
Operational Reuse
Frontends
Communication
Choreography and Orchestration
Transactions and Sagas
Architecture Characteristics Ratings
Additional References

18. Choosing the Appropriate Architecture Style.....
Shifting "Fashion" in Architecture
Decision Criteria
Monolith Case Study: Silicon Sandwiches

Distributed Case Study: Going, Going, Gone

Part III. Techniques and Soft Skills

Modular Monolith

Microkernel

20. Analyzing Architecture Risk...Risk Matrix
Risk Assessments

Example

Risk Storming

Identification

Consensus Agile Story Risk Analysis Risk Storming Examples Availability Elasticity Security

21. Diagramming and Presenting Architecture.....

Diagramming
Tools
Diagramming Standards: UML, C4, and ArchiMate
Diagram Guidelines
Presenting
Manipulating Time
Incremental Builds
Infodecks Versus Presentations
Slides Are Helf of the Story

Slides Are Half of the Story Invisibility

22. Making Teams Effective.....

Team Boundaries
Architect Personalities
Control Freak
Armchair Architect
Effective Architect
How Much Control?
Team Warning Signs
Leveraging Checklists
Developer Code Completion Checklist
Unit and Functional Testing Checklist
Software Release Checklist
Providing Guidance
Summary

23. Negotiation and Leadership Skills.....

Negotiation and Facilitation
Negotiating with Business Stakeholders
Negotiating with Other Architects
Negotiating with Developers
The Software Architect as a Leader

The 4 C's of Architecture
Be Pragmatic, Yet Visionary
Leading Teams by Example
Integrating with the Development Team
Summary

24. Developing a Career Path.....

The 20-Minute Rule
Developing a Personal Radar
The ThoughtWorks Technology Radar
Open Source Visualization Bits
Using Social Media
Parting Words of Advice

Appendix. Self-Assessment Questions.....

Index.....





Pietro Ferrara



Unsafe C# code Aug-Nov 2007: intern

Thesis about Java multithreading PhD in CS

Thesis about JavaCard Master in CS





OO programming and Scala <u>Postdoc and lecturer</u>



Android and JavaScript

Research Staff <u>Member</u>



.NET and Java

Head of R&D



<u>Assistant</u> professor **Associate** professor





2000 2009 2013 2016 2020

2023

2003 2005

Communicating with the professor

- Moodle Forum
 - Then the same forum, then the same forum...
- Obviously, you are still free to send me emails!
 - But please use the forum if it is a generic questions about the content of the course, sw architectures, etc..
 - And for questions about exams, grades, etc.. please always give a look to these slides before asking, usually the answer is already here
- E-mail address: <u>pietro.ferrara@unive.it</u>
- Linkedin: https://www.linkedin.com/in/pietroferrara/
 - Feel free to connect with me!



Tutor 1

- Giacomo Zanatta
 - giacomo.zanatta@unive.it
 - PhD student in my research group
- He'll prepare most of the online material
- Reply to some of the questions in the forum
 - ... and in Telegram!
 - https://t.me/+0-muEARUK9QwMjdk







Telegram group

- For general Q&A about both in presence lectures and online material
- https://t.me/+0-muEARUK9QwMjdk



Your woodlap poll will be displayed here



Install the Chrome or Firefox extension



Make sure you are in **presentation mode**

woodlap

https://app.wooclap.com/events/SADM (questions from 1 to 7)

Project and written exam (1/2)

- 3 group tasks during the course (two thirds of the grade)
 - 2 small ones at the beginning
 - To define the context and characteristics of the software architecture
 - 1 big task at the end implementing the architecture
 - Using any technology, not only the ones I'll introduce you
 - Part time students can instead submit a unique final project
 - Groups composed by 3 to 5 students, tell me the composition in the forum
- Topic: implement an IT system to <do something>
 - Still under discussion
 - It might be used as a baseline for projects of other courses!

Project and written exam (2/2)

- You will have to deliver at the end of the project
 - A GitHub repository containing the code of your software (architecture)
 - The history of the repo should make clear the contribution of the different students in the group
 - It must contain a description (pdf, markdown, ...) of the structure of the architecture with references to the code
- Written exam at the end of the course (one third of the grade)
 - Only after submitting and passing the tasks/project
 - Example from last year in Moodle
 - About <u>only all</u> the in presence lectures



Tutor 2

- Filippo Vladimir Scapin
 - <u>879809@stud.unive.it</u>
 - Master student in Computer Science
 - Took Software Architecture course last year

He'll focus on the project structure



Using SA project in other courses

- Development Methodologies (1st semester)
 - Only written exam
 - But you are highly encouraged to use the DevOps concepts you'll see in this course during the development of the SA project
- Software correctness, security and reliability (2nd semester)
 - Develop and apply some static analyses on some code
 - You can use the SA project as target application
 - Technical constraint: need to have Python or Go code!
- Software performance and scalability (2nd semester)
 - Project about the assessment of performances of an application
 - You can use the SA project as target application



Software Architecture + Development Methodologies

- Some of you need to take also the Development Methodologies exams
 - Two modules of a 12 ECTS course
- In this case
 - You need to pass <u>both</u> the modules in the <u>same academic year</u>
 - i.e., if you pass one module but not the other one you'll need to retake the full exam next year
 - The final grade will be the average of the two grades
- The written exam of the two modules will be at the same time
 - Split in two sessions with a short break in the middle to allow people that take only one module to enter and exit the exam room



Additional material

- We must provide additional material to some students
 - Working
 - With difficulties in learning
 - See here https://www.unive.it/pag/42819/
- As additional material, those students will have access to the recording of my lectures in the Moodle space
 - Note that I cannot decide who is allowed to have access
 - In case you think you should have access but you don't have it, contact directly Ca' Foscari offices



Calendar

- (almost) All in presence lectures will take place in Aula B
 - Nov. 11th in Lab. 3
- Regular schedule
 - One in presence lectures on Thursday from 2pm to 3:30pm
 - One online lecture
 - Asynchronous lectures (even if scheduled in the calendar Fri 3:45-5:15pm)
 - Usually published at the beginning of the week



Save the date! 16/11/2024 Google DevFest @ Campus

- Organized already last year and the year before
 - https://gdg.community.dev/events/details/google-gdg-venezia-presents-devfest-triveneto-2022/
 - https://www.devfest-triveneto.it/
- 15 enterprises will be at the event
 - Open for interviews for stages, jobs, etc etc...
- More details will follow in about a month

Technologies

- We will use various technologies (in addition to the ones aforementioned)
 - IDE (IntelliJ IDEA in particular)
 - Java
 - Git[Hub]
 - Premium account of GitHub for free for students and professors, <u>https://education.github.com/benefits</u>
 - Maven
 - Stackoverflow 😌 or ChatGPT?
 - And much more TBD

Integrated Development Environment

- IDEs are a fundamental tool for developers nowadays
- There are many different IDEs
 - Eclipse, IntelliJ IDEA, NetBeans, Visual Studio [Code]
- They are (more or less) the same
- I will use IntelliJ IDEA
 - Ultimate Edition for free for students and professors
 - https://www.jetbrains.com/community/education/#students
- GitHub repo
 - https://github.com/pietroferrara/SoftwareArchitectures 2024

