CSC40232: SOFTWARE ENGINEERING

Professor: Jane Cleland-Huang
Architecture
Wednesday, April 19th
sarec.nd.edu/courses/SE2017

Department of
Computer Science and
Engineering

Dog Houses to sky scrapers

WHY ARCHITECTURE?

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What is Architecture?

- The software architecture of a program or computing system is the **structure or structures of the system**, which comprises software elements, the externally visible properties of those elements, and the relationships among them.
- An abstract view of the system that distills away implementation, algorithm, and data details – focusing instead on **behavior** and **interaction** of black box elements.

- (Bass definition)

INTRODUCTION

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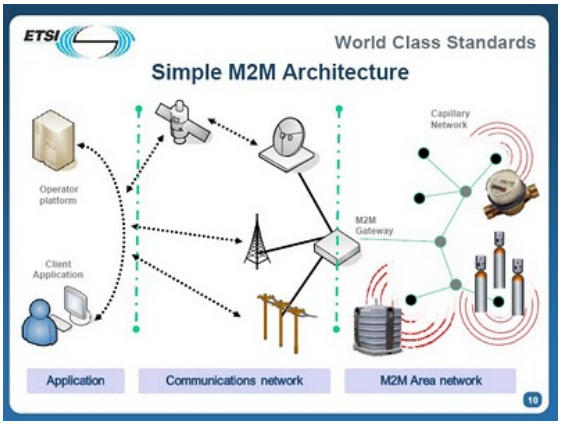
Marchitectures



No nutritional value.
Great for 'marketing' the architecture, but provides little information to the developers.

INTRODUCTION

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An Architecture must answer these questions:

- Which requirements are the structuring and decisions based on?
- Which are the major logical and physical system building blocks?
- How are the system building blocks related to one another?
- What responsibilities do the system building blocks have?
- What interfaces do the system building blocks have?
- How are the system building blocks grouped or layered?
- What are the specifications and criteria used to divide the system into building blocks?

https://www.healthcare.gov/

"Other" definitions ???

- Architecture is **high level design**
- Architecture is the **overall structure** of the system (which structure?)
- Architecture is the structure of the components, their interrelationships, AND the **principles and guidelines** governing their design and evolution.
- Architecture is **purely a description of components and connectors**. (i.e. focus on runtime architecture).
- Architecture is the **composition of a set of architectural design decisions**. (Jan Bosch)

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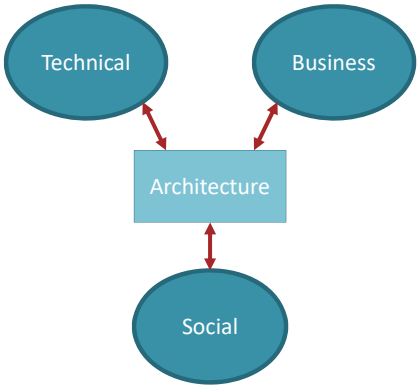
What drives architectural solutions?

- NOT requirements alone! Different architects would produce different solutions from the same requirements.



- Architecture is influenced by technical, business, and social influences.
- ….and conversely, it influences technical, business, and social environments.

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INTRODUCTION

A Lesson from History

- 1625 the Swedish king Gustavus Adlophus ordered new warships.
- The VASA was built in Stockholm. It was to be the mightiest warship in the world, armed with 64 guns on 2 gundecks.

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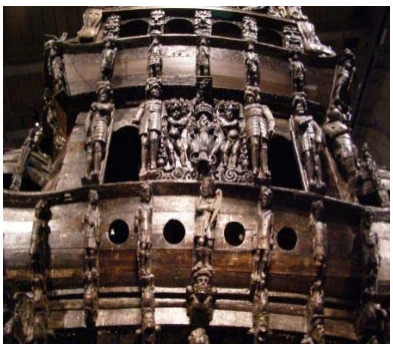
INTRODUCTION

A Lesson from History



- The architect, Hybertsson had to balance many concerns:
  - Swift time to deployment
  - Performance
  - Functionality
  - Safety
  - Reliability
  - Cost
- His experience told him to design the VASA as though it were a single-gun-deck ship and then extrapolate.
- "Luckily" for Hybertsson he died one year before the final launch!

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A Lesson from History

- The project was completed to specifications.
- On Sunday, August 10th, 1628 the ship set sale, waddled out into Stockholm's deep water harbor, fired her guns in salute, and promptly rolled over and sank.
- A post mortem analysis showed that:
  - The ship was well built but badly proportioned.
  - Hybertsson failed to balance conflicting constraints, failed to manage risks, and failed to manage his customers (especially the king!)

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The architecture life-cycle

- Create the business case.
- Understand the requirements.
- Create or select the architecture.
- Document and communicate the architecture.
- Analyze or evaluate the architecture.
- Implement the system based on the architecture.
- Ensure that the implemented system conforms to the architecture.

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A second look at the definition of SA

- Software Elements – the Software architecture defines **how elements interact**, and suppresses details that are purely internal to an element.
- Architectural structure is represented through **multiple views**.
- **Every software system has an architecture** (whether formally documented or not)
- The **behavior of each element** is part of the architecture.
- There are good and bad architectures!

  See examples

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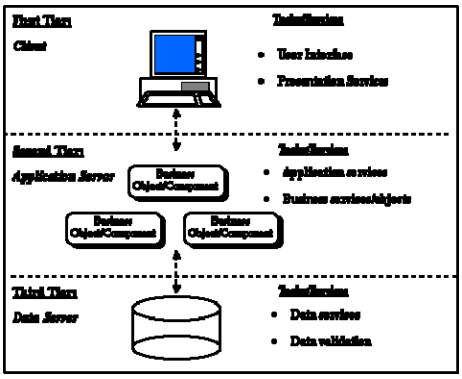
Architectural Patterns, reference models, & reference architectures

- An architectural pattern is a description of **element** and **element types** together with a set of **constraints** on how they are used.



Example: Client server, blackboard, pipe-and-filter.

Architectural patterns exhibit known quality attributes.

Also referred to as architectural style.

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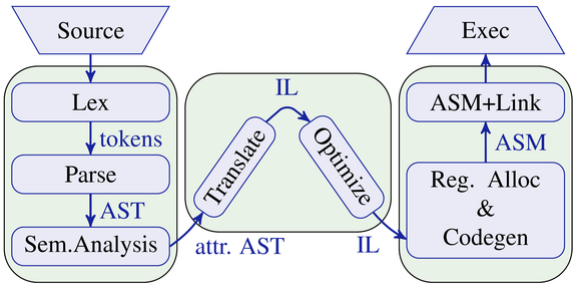
Architectural Patterns, reference models, & reference architectures

- A reference model provides a decomposition of functionality together with the data flow.
- Found in mature domains.



Example: Compiler or DBMS

No need to recreate the architecture from the ground up.

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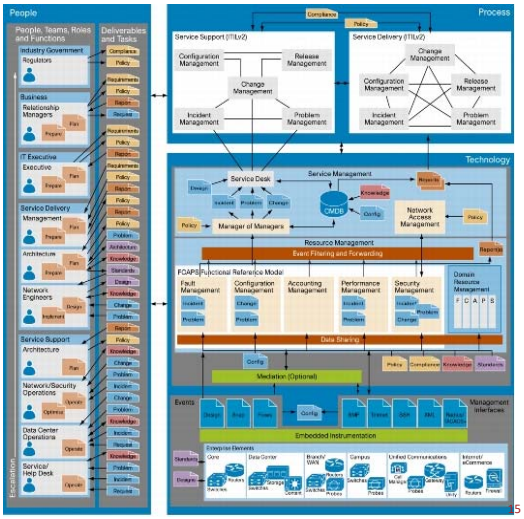
Architectural Patterns, reference models, & reference architectures

INTRODUCTION

A reference architecture maps a reference model onto software elements.



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Why is Software Architecture Important?

INTRODUCTION

Communication between stakeholders (although there are other non-Software Architecture-centric techniques for communicating too).

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What makes a good architecture?

- The architecture should be the product of a **single architect** or a small group of architects.
- The architect should have the **functional requirements** for the system and an articulated, prioritized, **list of quality attributes** that the architecture is expected to satisfy.
- The architecture should be **well documented** with at least one static view and one dynamic view (using understandable, agreed upon notation).
- The architecture should lend itself to **incremental implementation** via the creation of a 'skeletal' system in which communication paths are exercised but which starts out with minimal functionality.

Stories from the trenches: https://www.infoq.com/ebay

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QUALITIES OF A GOOD ARCHITECTURE

What makes a good architecture?

- Well defined modules (information hiding and separation of concerns).
- Well defined interface for each module.
- Quality concerns achieved using well-known architectural tactics.
- Architecture should be independent of specific versions of commercial products.
- Producers and consumers of data should be separated from each other.

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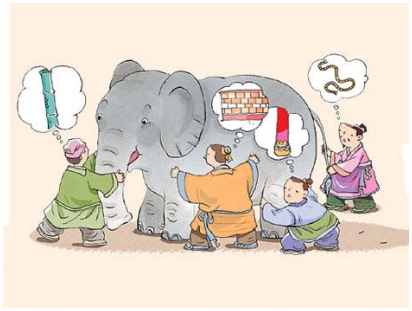
QUALITIES OF A GOOD ARCHITECTURE

Multiple views



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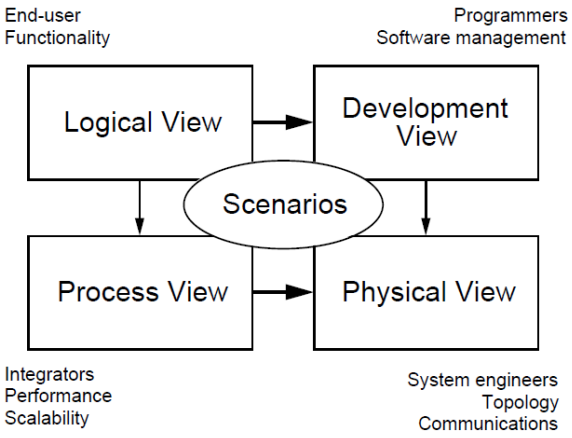
ARCHITECTURAL STRUCTURES

4+1 Approach



Software architecture = {Elements, Forms, Rationale/ Constraints}

Formula applied separately to each view.

Different styles can be applied to each view.

Philippe Kruchten: The 4+1 View Model of Architecture. IEEE Software 12(6): 42-50 (1995)

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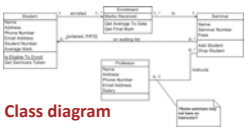
ARCHITECTURAL VIEWS

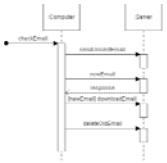
4+1 Approach: Logical view

- Primarily supports **functional requirements** i.e. what the system should provide to its users.
- System decomposed into a set of **key abstractions** (primarily from problem domain) in the form of objects or object classes.
- Exploits abstraction, encapsulation, inheritance.
- Representations: Class diagrams, E-R Diagrams, State transition diagrams, state charts.



Class diagram

Communication Diagram



Sequence Diagram

Note: Diagrams can be used for Architecture or design.

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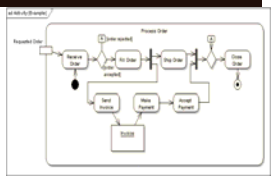
4+1 Approach: Process view



Activity Diagram

- Models NFRs such as performance, availability, & fault-tolerance.
- A process **groups tasks into an executable unit**, which can be scheduled, started, recovered, reconfigured, shut down, or replicated.
- Major tasks communicate via a set of well-defined **inter-task communication mechanisms**: synchronous and asynchronous message-based communication services, remote procedure calls, etc.
- Minor tasks communicate via shared memory and rendezvous etc.

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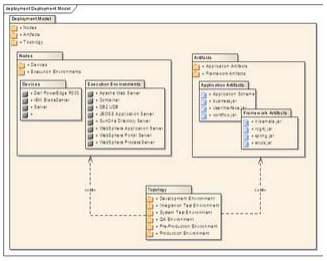
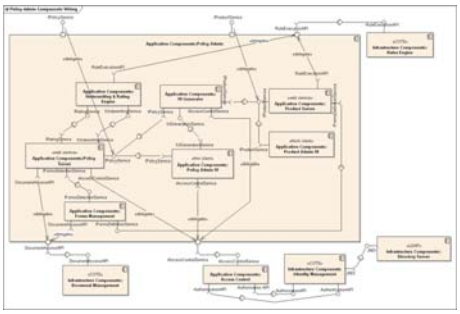
4+1 Approach: Development View

ARCHITECTURAL VIEWS

- Also referred to as **implementation view**.
- Shows organization of software modules, libraries, subsystems, and units of development.
- Serves as an allocation view.



Package Diagram



Component Diagram

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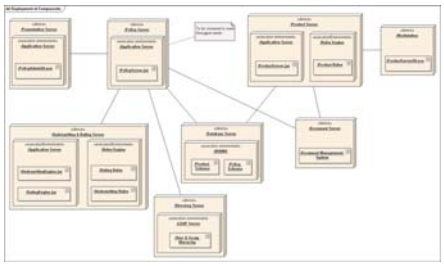
4+1 Approach: Physical View

ARCHITECTURAL VIEWS

- Also referred to as **deployment view**.
- Takes into account NFRs such as availability, reliability (fault-tolerance), performance (throughput), and scalability.
- Various **elements** i.e. processes, tasks, and objects—need to be **mapped onto various nodes**.
- Different configurations for development and testing, deployment etc. Mapping needs to be flexible.



Deployment Diagram

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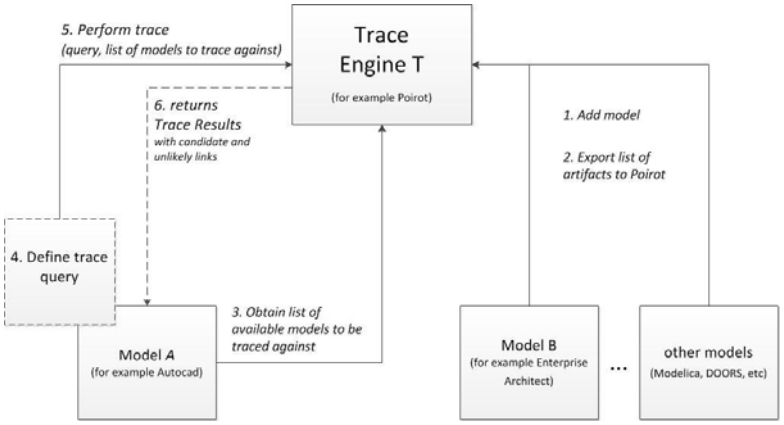
The good, the bad, and the ugly…

EXTRA MATERIALS

Push Architecture



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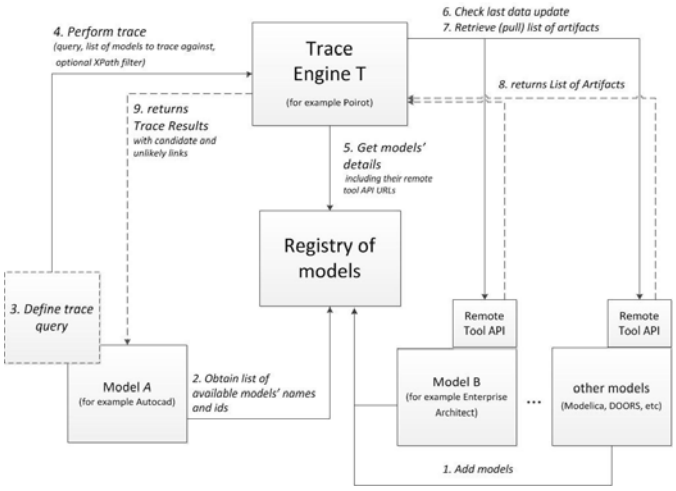
The good, the bad, and the ugly…

EXTRA MATERIALS

Pull Architecture



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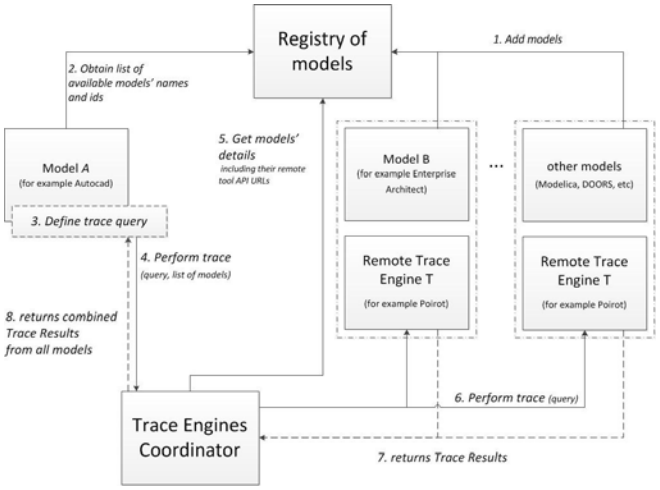
The good, the bad, and the ugly…

EXTRA MATERIALS

Distributed Architecture with Central Coordination



Return to slide sequence

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