Chapter 13

Architectural Design

Slide Set to accompany Software Engineering: A Practitioner's Approach, 8/e by Roger S. Pressman and Bruce R. Maxim

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Why Architecture?

The architecture is not the operational software. Rather, it is a representation that enables a software engineer to:

(1) analyze the effectiveness of the design in meeting its stated requirements,

(2) consider architectural alternatives at a stage when making design changes is still relatively easy, and

(3) reduce the risks associated with the construction of the software.

Why is Architecture Important?

- Representations of software architecture are an enabler for communication between all parties (stakeholders) interested in the development of a computer-based system.
- The architecture highlights early design decisions that will have a profound impact on all software engineering work that follows and, as important, on the ultimate success of the system as an operational entity.
- Architecture "constitutes a relatively small, intellectually graspable mode of how the system is structured and how its components work together" [BAS03].

Architectural Descriptions

- The IEEE Computer Society has proposed IEEE-Std-1471-2000, Recommended Practice for Architectural Description of Software-Intensive System, [IEE00]
 - to establish a conceptual framework and vocabulary for use during the design of software architecture,
 - to provide detailed guidelines for representing an architectural description, and
 - to encourage sound architectural design practices.
- The IEEE Standard defines an *architectural description* (AD) as a "a collection of products to document an architecture."
 - The description itself is represented using multiple views, where each *view* is "a representation of a whole system from the perspective of a related set of [stakeholder] concerns."

Architectural Genres

- Genre implies a specific category within the overall software domain.
- Within each category, you encounter a number of subcategories.
 - For example, within the genre of *buildings*, you would encounter the following general styles: houses, condos, apartment buildings, office buildings, industrial building, warehouses, and so on.
 - Within each general style, more specific styles might apply. Each style would have a structure that can be described using a set of predictable patterns.

Architectural Styles

Each style describes a system category that encompasses: (1) a set of components (e.g., a database, computational modules) that perform a function required by a system, (2) a set of connectors that enable "communication, coordination and cooperation" among components, (3) constraints that define how components can be integrated to form the system, and (4) semantic models that enable a designer to understand the overall properties of a system by analyzing the known properties of its constituent parts.

- Data-centered architectures
- Data flow architectures
- Call and return architectures
- Object-oriented architectures
- Layered architectures

Data-Centered Architecture



Data Flow Architecture



Call and Return Architecture



Layered Architecture



Architectural Patterns

- Concurrency—applications must handle multiple tasks in a manner that simulates parallelism
 - operating system process management pattern
 - task scheduler pattern
- Persistence—Data persists if it survives past the execution of the process that created it. Two patterns are common:
 - a database management system pattern that applies the storage and retrieval capability of a DBMS to the application architecture
 - an application level persistence pattern that builds persistence features into the application architecture
- Distribution— the manner in which systems or components within systems communicate with one another in a distributed environment
 - A *broker* acts as a 'middle-man' between the client component and a server component.

Architectural Design

- The software must be placed into context
 - the design should define the external entities (other systems, devices, people) that the software interacts with and the nature of the interaction
- A set of architectural archetypes should be identified
 - An archetype is an abstraction (similar to a class) that represents one element of system behavior
- The designer specifies the structure of the system by defining and refining software components that implement each archetype

Architectural Context



Archetypes



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Component Structure



Refined Component Structure



Architectural Considerations

- Economy The best software is uncluttered and relies on abstraction to reduce unnecessary detail.
- Visibility Architectural decisions and the reasons for them should be obvious to software engineers who examine the model at a later time.
- Spacing Separation of concerns in a design without introducing hidden dependencies.
- Symmetry Architectural symmetry implies that a system is consistent and balanced in its attributes.
- Emergence Emergent, self-organized behavior and control.

Architectural Decision Documentation

- 1. Determine which information items are needed for each decision.
- 2. Define links between each decision and appropriate requirements.
- Provide mechanisms to change status when alternative decisions need to be evaluated.
- 4. Define prerequisite relationships among decisions to support traceability.
- 5. Link significant decisions to architectural views resulting from decisions.
- 6. Document and communicate all decisions as they are made.

Architectural Tradeoff Analysis

1. Collect scenarios.

2. Elicit requirements, constraints, and environment description.

3. Describe the architectural styles/patterns that have been chosen to address the scenarios and requirements:

- module view
- process view
- data flow view

4. Evaluate quality attributes by considered each attribute in isolation.

5. Identify the sensitivity of quality attributes to various architectural attributes for a specific architectural style.

6. Critique candidate architectures (developed in step 3) using the sensitivity analysis conducted in step 5.

Architectural Complexity

- the overall complexity of a proposed architecture is assessed by considering the dependencies between components within the architecture [Zha98]
 - Sharing dependencies represent dependence relationships among consumers who use the same resource or producers who produce for the same consumers.
 - Flow dependencies represent dependence relationships between producers and consumers of resources.
 - Constrained dependencies represent constraints on the relative flow of control among a set of activities.

ADL

- Architectural description language (ADL) provides a semantics and syntax for describing a software architecture
- Provide the designer with the ability to:
 - decompose architectural components
 - compose individual components into larger architectural blocks and
 - represent interfaces (connection mechanisms) between components.

Architecture Reviews

- Assess the ability of the software architecture to meet the systems quality requirements and identify potential risks
- Have the potential to reduce project costs by detecting design problems early
- Often make use of experience-based reviews, prototype evaluation, and scenario reviews, and checklists

Patter-Based Architecture Review

- 1. Identify and discuss the quality attributes by walking through the use cases.
- Discuss a diagram of system's architecture in relation to its requirements.
- Identify the architecture patterns used and match the system's structure to the patterns' structure.
- Use existing documentation and use cases to determine each pattern's effect on quality attributes.
- 5. Identify all quality issues raised by architecture patterns used in the design.
- 6. Develop a short summary of issues uncovered during the meeting and make revisions to the walking skeleton.

Agility and Architecture

- To avoid rework, user stories are used to create and evolve an architectural model (walking skeleton) before coding
- Hybrid models which allow software architects contributing users stories to the evolving storyboard
- Well run agile projects include delivery of work products during each sprint
- Reviewing code emerging from the sprint can be a useful form of architectural review