Architectures in Context

Software Architecture
Lecture 2

Learning Objectives

- Understand architecture in its relation to project phases
- Distinguish between OOD and S/W architecture
- List implementation techniques for S/W architecture
- Understand role of analysis in architecture

Fundamental Understanding

- Architecture is a set of principal design decisions about a software system
- Three fundamental understandings of software architecture
  - Every application has an architecture
  - Every application has at least one architect
  - Architecture is not a phase of development

Wrong View: Architecture as a Phase

- Treating architecture as a phase denies its foundational role in software development
- More than "high-level design"
- Architecture is also represented, e.g., by object code, source code, …

Context of Software Architecture

- Requirements
- Design
- Implementation
- Analysis and Testing
- Evolution
- Development Process

Requirements Analysis

- Traditional SE suggests requirements analysis should remain unsullied by any consideration for a design
- However, without reference to existing architectures it becomes difficult to assess practicality, schedules, or costs
  - In building architecture we talk about specific rooms…
  - …rather than the abstract concept "means for providing shelter"
- In engineering new products come from the observation of existing solution and their limitations

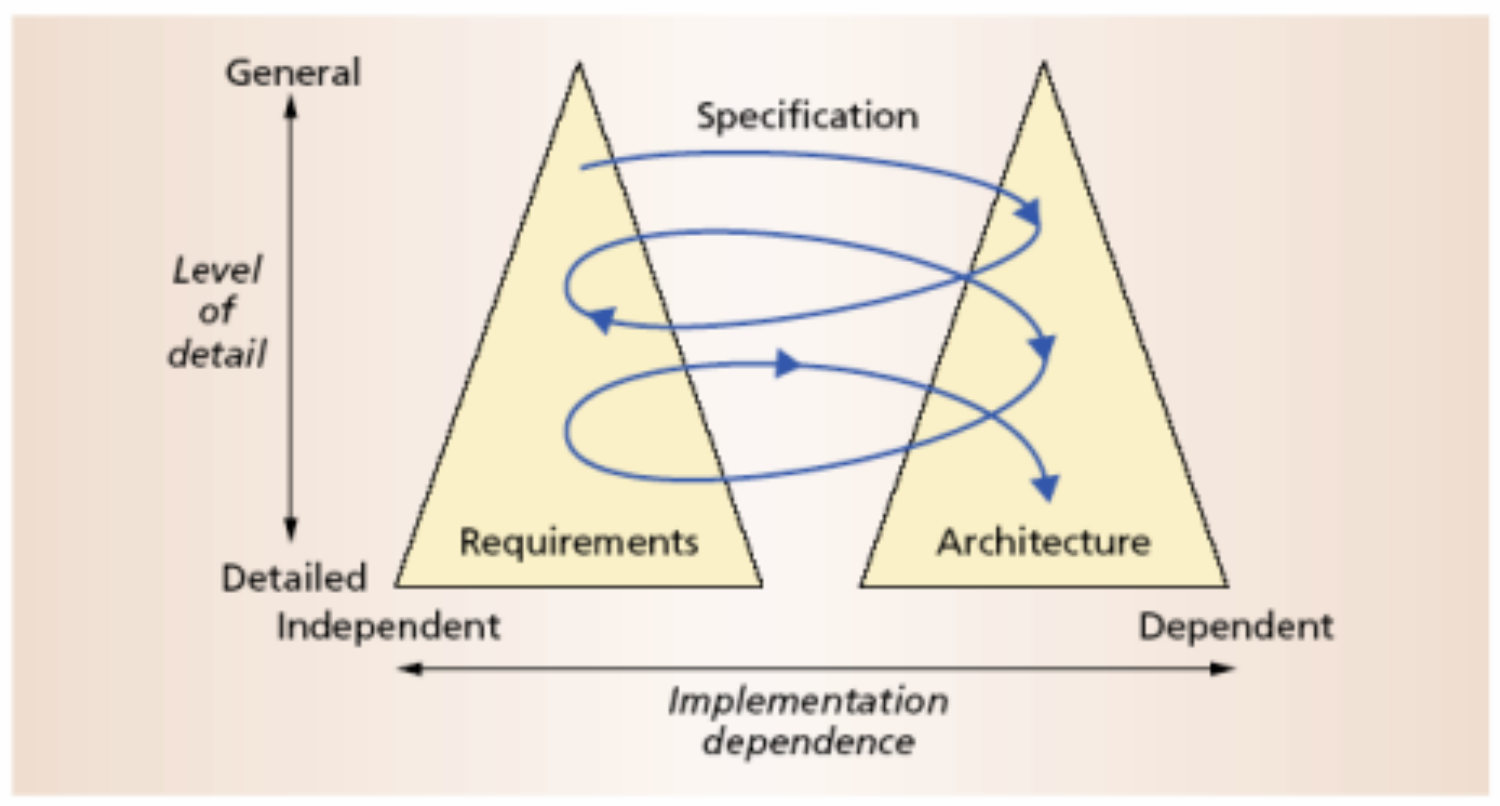
New Perspective on Requirements Analysis

- Existing designs and architectures provide the solution vocabulary
- Our understanding of what works now, and how it works, affects our wants and perceived needs
- The insights from our experiences with existing systems
  - helps us imagine what might work and
  - enables us to assess development time and costs
- → Requirements analysis and consideration of design must be pursued at the same time

Non-Functional Properties (NFP)

- NFPs are the result of architectural choices
- NFP questions are raised as the result of architectural choices
- Specification of NFP might require an architectural framework to even enable their statement
- An architectural framework will be required for assessment of whether the properties are achievable

The Twin Peaks Model



Design and Architecture

- Design is an activity that pervades software development
- It is an activity that creates part of a system's architecture
- Typically in the traditional Design Phase decisions concern
  - A system's structure
  - Identification of its primary components
  - Their interconnections
- Architecture denotes the set of principal design decisions about a system
  - That is more than just structure

Architecture-Centric Design

- Traditional design phase suggests translating the requirements into algorithms, so a programmer can implement them
- Architecture-centric design
  - stakeholder issues
  - decision about use of COTS component
  - overarching style and structure
  - package and primary class structure
  - deployment issues
  - post implementation/deployment issues

Design Techniques

- Basic conceptual tools
  - Separation of concerns
  - Abstraction
  - Modularity
- Two illustrative widely adapted strategies
  - Object-oriented design
  - Domain-specific software architectures (DSSA)

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Object-Oriented Design (OOD)

- Objects
  - Main abstraction entity in OOD
  - Encapsulations of state with functions for accessing and manipulating that state

Pros and Cons of OOD

- Pros
  - UML modeling notation
  - Design patterns
- Cons
  - Provides only
    - One level of encapsulation (the object)
    - One notion of interface
    - One type of explicit connector (procedure call)
      - Even message passing is realized via procedure calls
  - OO programming language might dictate important design decisions
  - OOD assumes a shared address space

DSSA

- Capturing and characterizing the best solutions and best practices from past projects within a domain
- Production of new applications can focus on the points of novel variation
- Reuse applicable parts of the architecture and implementation
- Applicable for product lines
  - →Recall the Philips Koala example discussed in the previous lecture

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Implementation

- The objective is to create machine-executable source code
  - That code should be faithful to the architecture
    - Alternatively, it may adapt the architecture
    - How much adaptation is allowed?
    - Architecturally-relevant vs. -unimportant adaptations
  - It must fully develop all outstanding details of the application

Faithful Implementation

- All of the structural elements found in the architecture are implemented in the source code
- Source code must not utilize major new computational elements that have no corresponding elements in the architecture
- Source code must not contain new connections between architectural elements that are not found in the architecture
- Is this realistic?
  Overly constraining?
  What if we deviate from this?

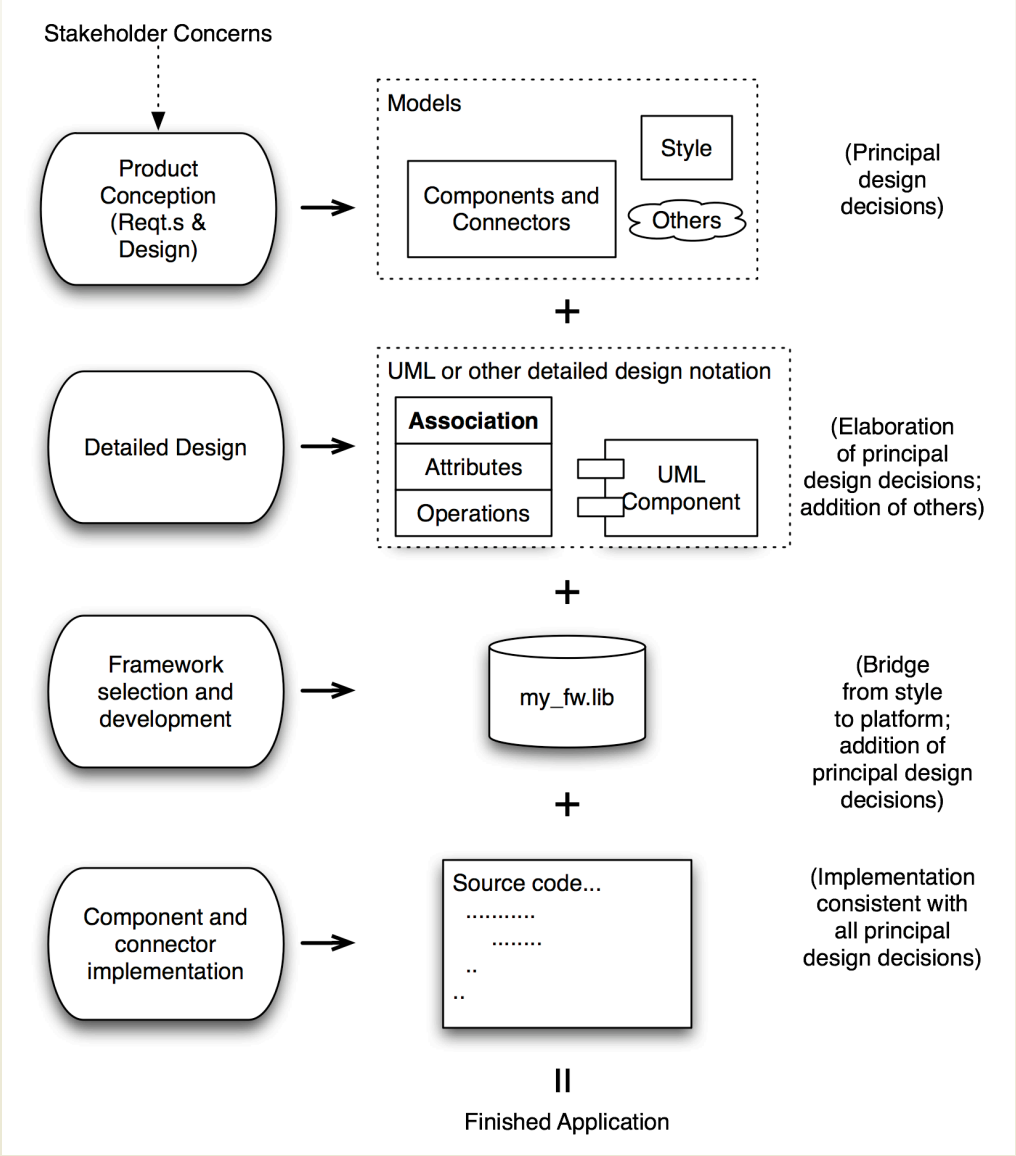
Unfaithful Implementation

- The implementation does have an architecture
  - It is latent, as opposed to what is documented.
- Failure to recognize the distinction between planned and implemented architecture
  - robs one of the ability to reason about the application's architecture in the future
  - misleads all stakeholders regarding what they believe they have as opposed to what they really have
  - makes any development or evolution strategy that is based on the documented (but inaccurate) architecture doomed to failure

Implementation Strategies

- Generative techniques
  - e.g. parser generators
- Frameworks
  - collections of source code with identified places where the engineer must "fill in the blanks"
- Middleware
  - CORBA, DCOM, RPC, …
- Reuse-based techniques
  - COTS, open-source, in-house
- Writing all code manually

How It All Fits Together



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Analysis and Testing

- Analysis and testing are activities undertaken to assess the qualities of an artifact
- The earlier an error is detected and corrected the lower the aggregate cost
- Rigorous representations are required for analysis, so precise questions can be asked and answered

Analysis of Architectural Models

- Formal architectural model can be examined for internal consistency and correctness
- An analysis on a formal model can reveal
  - Component mismatch
  - Incomplete specifications
  - Undesired communication patterns
  - Deadlocks
  - Security flaws
- It can be used for size and development time estimations

Analysis of Architectural Models (cont'd)

- Architectural model
  - may be examined for consistency with requirements
  - may be used in determining analysis and testing strategies for source code
  - may be used to check if an implementation is faithful

Evolution and Maintenance

- All activities that chronologically follow the release of an application
- Software will evolve
  - Regardless of whether one is using an architecture-centric development process or not
- The traditional software engineering approach to maintenance is largely ad hoc
  - Risk of architectural decay and overall quality degradation
- Architecture-centric approach
  - Sustained focus on an explicit, substantive, modifiable, faithful architectural model

Architecture-Centric Evolution Process

- Motivation
- Evaluation or assessment
- Design and choice of approach
- Action
  - includes preparation for the next round of adaptation

Summary (1)

- A proper view of software architecture affects every aspect of the classical software engineering activities
- The requirements activity is a co-equal partner with design activities
- The design activity is enriched by techniques that exploit knowledge gained in previous product developments
- The implementation activity
  - is centered on creating a faithful implementation of the architecture
  - utilizes a variety of techniques to achieve this in a cost-effective manner

Summary (2)

- Analysis and testing activities can be focused on and guided by the architecture
- Evolution activities revolve around the product's architecture.
- An equal focus on process and product results from a proper understanding of the role of software architecture