Documenting Software Architectures
Topics

- The purpose for and audience of architecture documentation
- Templates to capture the key documentation contents
  - Views, behavior, and interfaces
- [Architecture Description Languages]
  - Including UML (in your reading)
Documenting Software Architecture

- Recall the definition of Software Architecture
  - “The software architecture … structures … comprise software elements… properties … relationships among them.”

- To be useful, this needs to be communicated
  - In documentation
  - Leverage the concept of architecture views

- Write from perspective of the reader (stakeholder)
  - Potentially more than one document for different stakeholders
Uses of Architecture Documentation

<table>
<thead>
<tr>
<th>Role</th>
<th>Use Case</th>
</tr>
</thead>
<tbody>
<tr>
<td>Analysts</td>
<td>Validate qualities, tradeoff negotiation</td>
</tr>
<tr>
<td>Software engineers</td>
<td>Design and implementation</td>
</tr>
<tr>
<td>Testers</td>
<td>Test development</td>
</tr>
<tr>
<td>Maintainers</td>
<td>Change impact analysis</td>
</tr>
<tr>
<td>Quality assurance</td>
<td>Validation of system as built</td>
</tr>
<tr>
<td>Users</td>
<td>System usability assessment</td>
</tr>
<tr>
<td>Managers</td>
<td>Work organization and planning</td>
</tr>
<tr>
<td>New personnel</td>
<td>Training</td>
</tr>
<tr>
<td>Follow-on architects</td>
<td>Design rationale</td>
</tr>
</tbody>
</table>

- **Prescriptive** – what should be true by placing *constraints on future decisions* (e.g., implementer)
- **Descriptive** – what is true by communicating *decisions already made* (e.g., project manager)
## Stakeholders and Views

<table>
<thead>
<tr>
<th>Stakeholder</th>
<th>Module Views</th>
<th>C&amp;C Views</th>
<th>Allocation Views</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Decomposition</td>
<td>Uses</td>
<td>Class</td>
</tr>
<tr>
<td>Project Manager</td>
<td>s</td>
<td>s</td>
<td>s</td>
</tr>
<tr>
<td>Member of Development Team</td>
<td>d</td>
<td>d</td>
<td>d</td>
</tr>
<tr>
<td>Testers and Integrators</td>
<td>d</td>
<td>d</td>
<td>d</td>
</tr>
<tr>
<td>Maintainers</td>
<td>d</td>
<td>d</td>
<td>d</td>
</tr>
<tr>
<td>Product Line Application Builder</td>
<td>d</td>
<td>d</td>
<td>s</td>
</tr>
<tr>
<td>Customer</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>End User</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Analyst</td>
<td>d</td>
<td>d</td>
<td>s</td>
</tr>
<tr>
<td>Infrastructure Support</td>
<td>s</td>
<td>s</td>
<td>s</td>
</tr>
<tr>
<td>New Stakeholder</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Current and Future Architect</td>
<td>d</td>
<td>d</td>
<td>d</td>
</tr>
</tbody>
</table>

**Key:**
- d = detailed information
- s = some details
- o = overview information
- x = anything
Notations

- **Informal**
  - Views depicted using *general-purpose diagramming tools*
  - **Natural language** semantics
  - Cannot be formally analyzed

- **Semiformal**
  - Views depicted using *standardized notation*
  - **Rudimentary semantic analysis** can be applied
  - **UML** is a semiformal notation in this sense.

- **Formal**
  - Views are described in a notation that has a *precise* (usually mathematically based) **semantics**.
  - **Formal analysis** of both syntax and semantics is possible.
  - **Architecture description languages** (ADLs)
  - Support automation through associated tools.
The Architecture Document

1. Views
2. Interfaces
3. The “big picture”

Reference template
1. Views

- **Choose** relevant **views** based on **stakeholders and uses**
  - Module, component-connector, allocation, data
  - Prioritize – top-down, **breadth first** is best
- **Document each view with a consistent template**
A View Document Template

Template for a View

Section 1. Primary Presentation

Section 2. Element Catalog
Section 2.A. Elements and Their Properties
Section 2.B. Relations and Their Properties
Section 2.C. Element Interfaces
Section 2.D. Element Behavior

* Section 3. Context Diagram

* Section 4. Variability Guide
Section 5. Rationale

* Optional
Documenting Behavior

- Structural information does not capture sequences of interactions (e.g., real time dependencies, concurrency)
- Relevant UML diagrams
  - Sequence diagrams
  - Communication diagrams
  - Activity diagrams
  - State charts
2. Documenting Interfaces: Interface Specification Template

<table>
<thead>
<tr>
<th>Identity</th>
<th>Meaningful name</th>
</tr>
</thead>
<tbody>
<tr>
<td>Syntax</td>
<td>The signature – arguments, data types</td>
</tr>
<tr>
<td>Semantics (usage guide)</td>
<td>Pre and post conditions, return values, exceptions, call orchestration, event call backs, atomic/interruptible</td>
</tr>
<tr>
<td>Variability</td>
<td>Configuration, binding</td>
</tr>
<tr>
<td>Quality attributes</td>
<td>Quality implications such as performance, security</td>
</tr>
<tr>
<td>Resource requirements</td>
<td>Computational and memory usage</td>
</tr>
<tr>
<td>Rationale</td>
<td>Why is it designed this way?</td>
</tr>
</tbody>
</table>

Architecturally significant component interfaces are best candidates
3. Document Across Views – Big Picture

- Information that applies to the architecture and architecture documentation package as a whole

Template for Documentation Beyond Views

Section 1: Documentation Roadmap
Section 2: How a View is Documented

Section 3: System Overview
Section 4: Mapping Between Views
Section 5: Rationale
Section 6: Glossary, Acronym List
Document Across Views – Big Picture

- **Roadmap** – background scope and summary, document and view overview
- **View template** description
- **System overview** – give users a **consistent mental model** of the **system** and **purpose**
  - High level **system context diagram** in relationship to external systems
  - Short **description** of the **system’s function** and **users**
- **Mapping between views**
- **Rationale** – explain how design pattern and tactics decisions satisfy architecturally significant requirements
Mapping Between Views

- How does the architecture work as a unified whole?
- Element **associations** across views are **many-to-many**.
- Capture view-to-view associations as **tables**.
  - Name the correspondence between elements across views.
  - Examples
    - “is implemented by” for mapping from a component-and-connector view to a module view
    - “implements” for mapping from a module view to a component-and-connector view
    - “included in” for mapping from a decomposition view to a layered view
Vehicle HVAC System

Diagram of Vehicle HVAC System components:
- ReferenceModel
  - setRequiredTemperature
- Display
  - display()
- TemperatureSensor
  - senseData
- Controller
  - start()
  - stop()
- Actuator
  - on()
  - off()
- Cooler
- Heater
- Fan
  - speed
- Microcontroller
  - TemperatureController
  - GUI
- Physical Sensors
- Physical Actuators
- Controller
  - sense
  - actuate
  - display
- Sensor
- Actuator
- GUI

Diagram showing interactions and connections between components.
# Example View Association Table

<table>
<thead>
<tr>
<th>Module</th>
<th>C-C Controller</th>
<th>C-C Sensor</th>
<th>C-C Actuator</th>
<th>C-C Display</th>
</tr>
</thead>
<tbody>
<tr>
<td>Controller</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>TempSensor</td>
<td></td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ref Model</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Display</td>
<td></td>
<td></td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Actuator</td>
<td></td>
<td></td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Cooler</td>
<td></td>
<td></td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Heater</td>
<td></td>
<td></td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Fan</td>
<td></td>
<td></td>
<td>X</td>
<td></td>
</tr>
</tbody>
</table>

**Module to Component-Connector “Implements”**
Practitioner Guidelines for Software Architecture Documents

- 50 pages or less
- Use a “standard” template
- Describe the architecture top down, abstract to concrete
- Requirements traceability is evident
- Glossary and references to other documents
- Version control
- Good naming – contextual meaning, avoid jargon, consistent; good names end up in code

Documenting Architecture in an Agile Development Project

- Some architecture necessary as a project roadmap and to capture design decisions
- Adopt a template or standard organization to document
- Document views if (but only if) a strongly identified stakeholder constituency.
  - Fill in view template sections when information becomes available
- Document just enough design to enable coding
Supplemental Material
Architecture Description Languages
Architecture Description Languages (ADLs)

- **Documenting elements and relationships** “demands” a **graphical notation** (sophisticated, formal box-and-arrow diagrams)
- An ADLs “is a computer language used to describe and represent software architectures”
  - “... form of expression used for the description of architectures”
  - Specifies minimum requirements for ADLs
  - Based on IEEE Standard 1471 “Architecture Description”
ADL Positives

- Provide a **formal** way of representing architecture
- Intended to be **human and machine readable**
- Support describing a system at a higher level than previously possible
- Permit **analysis** of architectures – completeness, consistency, ambiguity, performance, etc.
- Can support **automatic generation** of software systems
ADL Negatives

- No **universal agreement** on what ADLs should represent, particularly as regards the behavior of the architecture
- Representations currently in use are relatively **difficult to parse** and are **not supported** by commercial tools
- Most ADL work today has been undertaken with **academic** rather than commercial goals in mind
- Most ADLs tend to be very **vertically optimized** toward a particular kind of analysis
Some ADLs

- **Leading candidates**
  - ABACUS
  - ACME (CMU/USC)
  - Rapide (Stanford)
  - Wright (CMU)
  - Unicon (CMU)

- **Secondary candidates**
  - Aesop (CMU)
  - MetaH (Honeywell)
  - C2 SADL (UCI)
  - SADL (SRI)

- Bass, Clements, and Kazman have adopted UML as an ADL
- A key goal of defining UML 2.0 was to enable better architecture description