

## Errata

- Projects: still need some team meetings
- Standup reports: proposal status?

## Achieving System Qualities Through Software Architecture

What is “software architecture?”

Role in determining system qualities

Architectural views



## Working Definition

“The software architecture of a program or computing system is the structure or structures of the system, which comprise software components, the externally visible properties of those components, and the relationships among them.”

From *Software Architecture in Practice*, Bass, Clements, Kazman

Remember as: **Components, Interfaces, and Relations**

## Examples

- **An architecture comprises a set of**
  - Software components
  - Component interfaces
  - Relationships among them
- **Examples**

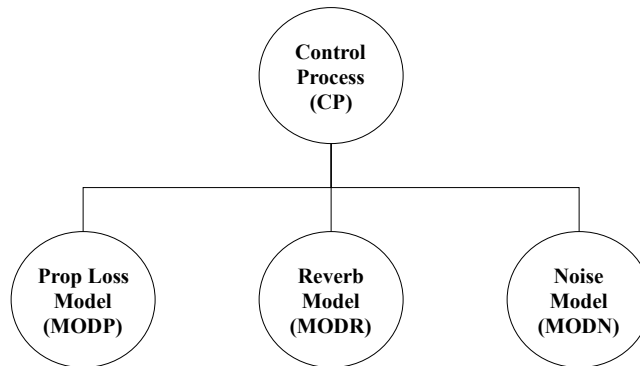
Structure	Components	Interfaces	Relationships
Calls Structure	Programs	Program interface and parameter declarations.	Invokes with parameters (A calls B)
Data Flow	Functional tasks	Data types or structures	Sends-data-to
Process	Sequential program (process, thread, task)	Scheduling and synchronization constraints	Runs-concurrently-with, excludes, precedes

## Implications of the Definition

“The software architecture of a program or computing system is the structure or structures of the system, which comprise software components, the externally visible properties of those components, and the relationships among them.” - Bass, Clements, Kazman

- **Systems typically comprise more than one architecture**
  - There is more than one useful decomposition into components and relationships
  - Each addresses different system properties or design goals
- **It exists whether any thought goes into it or not!**
  - Decisions are necessarily made if only implicitly
  - Issue is who makes them and when
- **Many “architectural specifications” aren’t**

## Is it Architecture?

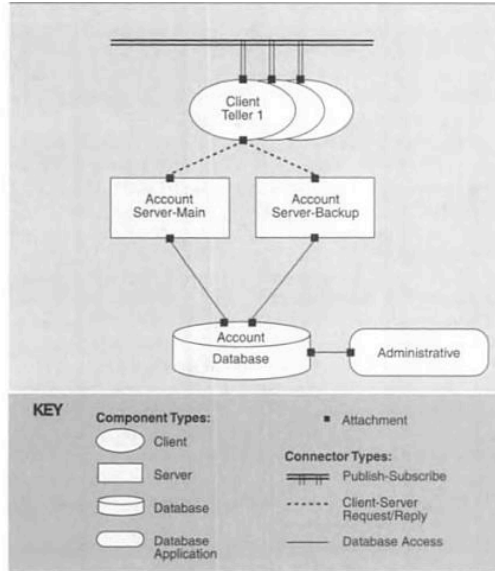


Typical (but uninformative) architectural diagram

- What is the nature of the components?
- What is the significance of the link?
- What is the significance of the layout?

## Better

A bird's-eye-view of a system as it might appear during runtime. This system contains a shared repository that is accessed by servers and an administrative component. A set of client tellers can interact with the account repository servers and communicate among themselves through a publish-subscribe connector.



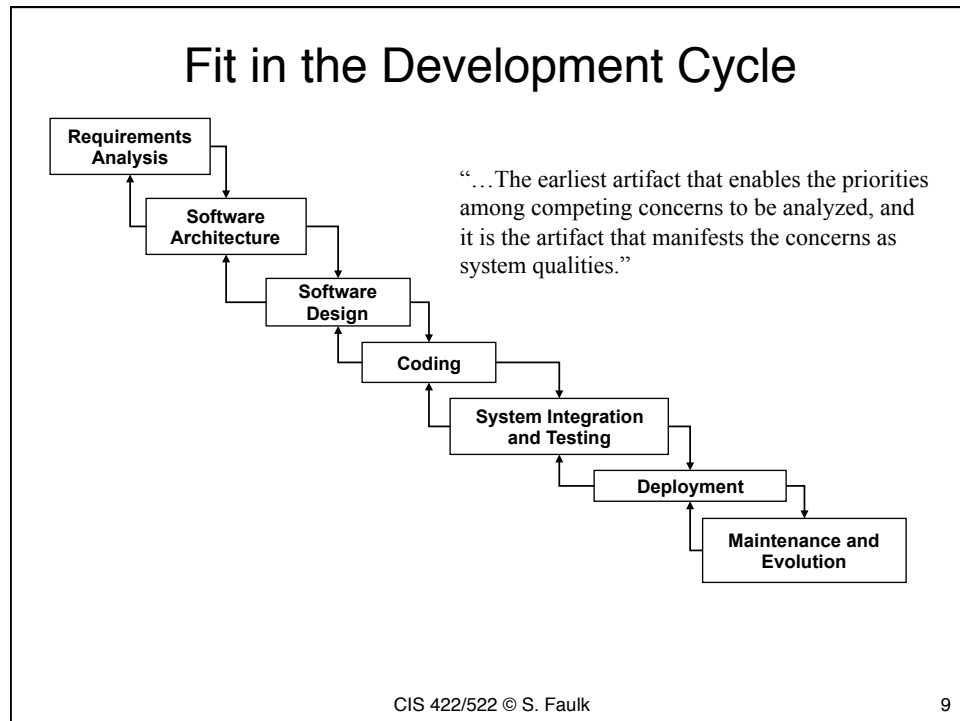
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## The Role of Architecture

Which system or development characteristics are determined by architecture?

What is the source of requirements?



## Effects of Architectural Decisions

- What kinds of system and development properties are and are not affected by architecture?
- System run-time properties
  -
- System static properties
  -
- Production properties? (effects on project)
  -
- Business/Organizational properties?
- What is not affected?

## Effects of Architectural Decisions

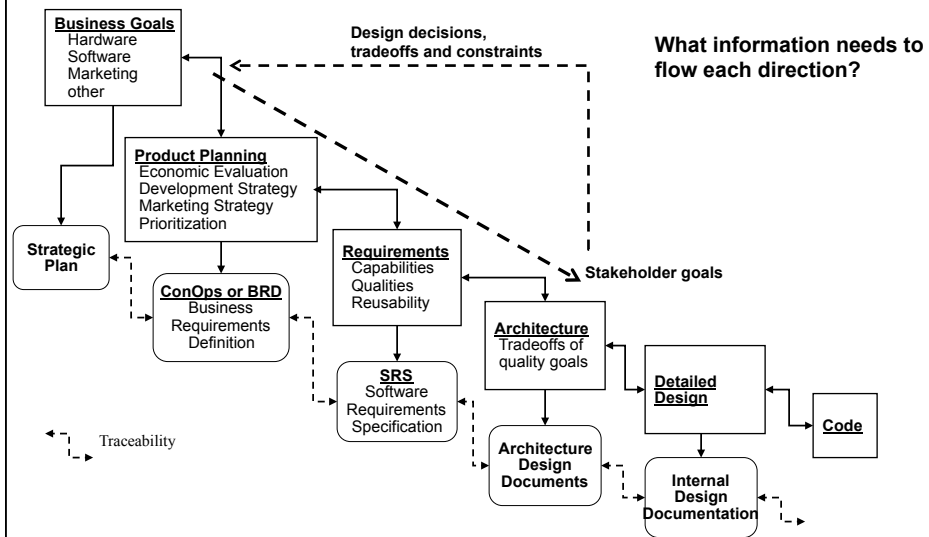
- What kinds of system and development properties are and are not affected by architecture?
- System run-time properties
  - Performance, Security, Availability, Usability
- System static properties
  - Modifiability, Portability, Reusability, Testability
- Production properties? (effects on project)
  - Concurrent development, Scheduling, Time-to-market
- Business/Organizational properties?
  - Lifespan, Versioning, Interoperability

## Importance to Stakeholders

- Which stakeholders have a vested interest in the architectural design?
  - Management, marketing, end users
  - Maintenance organization, IV&V, Customers
  - Regulatory agencies (e.g., FAA)
- There are many interested parties (stakeholders) with many diverse and often conflicting interests
- Important because their interests may defy mutual satisfaction
  - There are inherently tradeoffs in most architectural choices
  - E.g. Performance vs. security, initial cost vs. maintainability
- Making successful tradeoffs requires understanding the nature, source, and priority of these constraints

## Role of Architecture in Controlled Development

## Product Development Cycle and Architecture



## Engineering Software Architecture

- What are we trying to gain/maintain control of in the Architectural Design phase?
  - Profoundly effect system and business qualities
  - Requires making tradeoffs
- Control implies *achieving system qualities by choice not chance*
  - Understanding what the tradeoffs are
  - Understanding the consequences of each choice
  - Making appropriate choices at appropriate times
  - Choices made by people with appropriate skills and authority

## Implications for the Development Process

Implies need to address architectural concerns throughout the development process:

- Understanding the “business case” for the system
- Understanding the quality requirements
- Designing the architecture to meet quality goals
- Representing and communicating the architecture
- Analyzing or evaluating the architecture
- Implementing the system based on the architecture
- Ensuring the implementation conforms to the architecture



## Related Design Questions

- Create business case for the system
  - What is the “business” rationale or goal?
- Understanding the quality requirements
  - What are the design goals?
- Creating or selecting the architecture
  - What are appropriate components and relations?
  - What are the decomposition principles?
- Representing and communicating the architecture
  - How are the components and relations represented?
- Analyzing or evaluating the architecture
  - How do we decide if the architecture is any good?

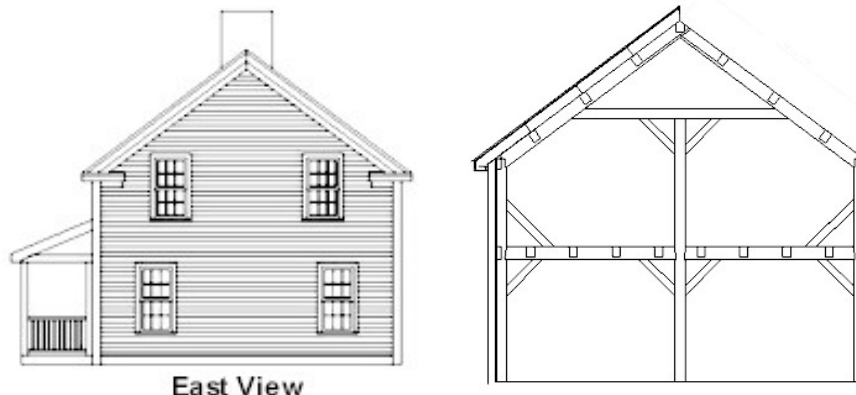
## Architectural Views

## Which structures should we use?

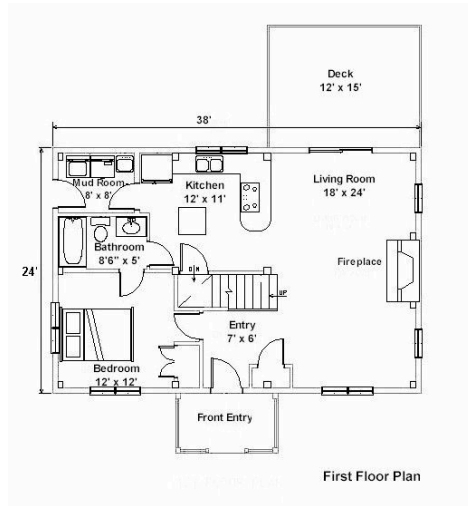
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- Choice of structure depends the *specific design goals*
- Compare to architectural blueprints
  - Different blueprint for load-bearing structures, electrical, mechanical, plumbing

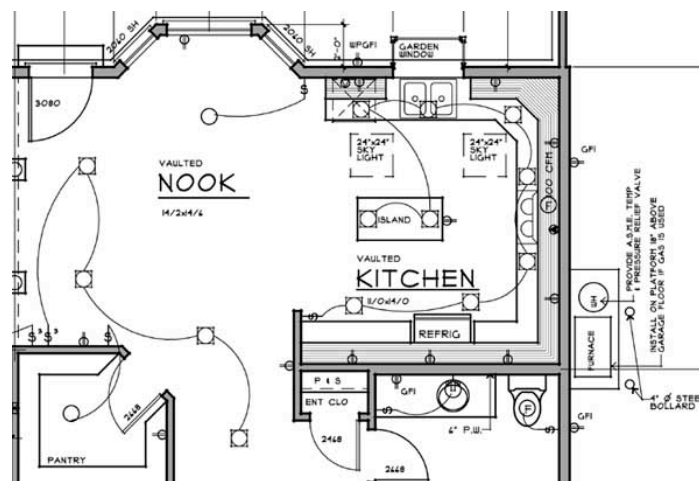
## Elevation/Structural



## Floor Plan



## Electrical Plan



# Models/Views

- Each is a view of the same house
- Different views answer different kinds of questions
  - How many electrical outlets are available in the kitchen?
  - What happens if we put a window here?
- Designing for particular software qualities also requires the right architectural model or “view”
  - Any model can present only a subset of system structures and properties
  - Different models allows us to answer different kinds of questions about system properties
  - Need a model that makes the properties of interest and the consequences of design choices visible to the designer, e.g.
    - Process structure for run-time property like performance
    - Module structure for development property like maintainability

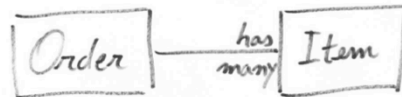


Figure 2: Conceptual Data Model – First Draft

## Example: Data Model View

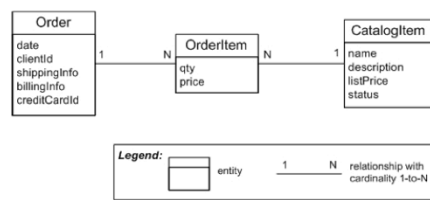


Figure 3: Logical Data Model

- Data Model Architecture
  - Entities: data structures
  - Relations: cardinality, aggregation, generalization/specialization
  - Interface: attributes
- Model/communicate structure of complex data
  - What data is kept?
  - How is it related?
  - How is it structured and accessed in the system?

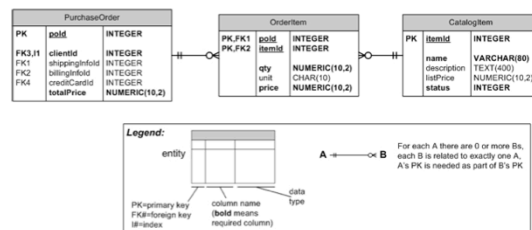


Figure 4: Physical Data Model

## For Your Projects

### Behavioral Qualities

- Performance
- Security
- Availability
- Reliability
- Security
- Usability

### Developmental Qualities

- Modifiability(ease of change)
- Portability
- Reusability
- Ease of integration
- Understandability
- Independent work assignments
- Subsetability

Which qualities are of interest for your projects?  
Which structures should you use?

## Summary

- Earliest set of design decisions – hence, most influential and hardest to change
- Determines a wide range of critical system, production, and business properties
- A product of tradeoffs between conflicting demands by different stakeholders
- Requirements come from product/business goals and subsequently affect them
- Realized at design time in different views

## Questions?

## Quality Requirements

### **Behavioral (observable)**

- Performance
- Security
- Availability
- Reliability
- Usability

Properties resulting from the properties of components, connectors and interfaces that exist at run time.

### **Developmental Qualities**

- Modifiability(ease of change)
- Portability
- Reusability
- Ease of integration
- Understandability
- Provide independent work assignments

Properties resulting from the properties components, connectors and interfaces that exist at design time *whether or not they have any distinct run-time manifestation.*

## Examples of Key Architectural Structures

- **Module Structure**
  - Decomposition of the system into work assignments or information hiding modules
  - Most influential design time structure
    - Modifiability, work assignments, maintainability, reusability, understandability, etc.
- **Uses Structure**
  - Determine which modules may use one another's services
  - Determines subsetability, ease of integration (e.g. for increments)
- **Process Structure**
  - Decomposition of the runtime code into threads of control
  - Determines potential concurrency, real-time behavior