SOFTWARE ARCHITECTURAL DESIGN

Software Engineering Process and Practice

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What is Engineering?

The application of scientific and mathematical principles to practical ends such as the design, manufacture, and operation of efficient and economical structures, machines, processes, and systems.

EXPECTATIONS

- To learn what is meant by “Software Architecture”, its importance in the software development process, and how to recognise the good and bad characteristics of different software architectures.
- Don't expect you to be world leading software designers at the end of this class; this will come with experience and lots of practice.

WHAT IS SOFTWARE ARCHITECTURE?

- **Software architecture** refers to the theory behind the actual design of computer software. In the same way as a building architect sets the principles and goals of a building project as the basis for the draftsman's plans, so too, a software architect sets out the software architecture as a basis for the actual design specifications. **http://www.wikipedia.org/wiki/Software_architecture**
- A Software Design must be **documented** to exist.
- A Software Architecture must describe both the **STRUCTURE** and the **BEHAVIOUR** of a software system.

WHY IS SOFTWARE ARCHITECTURE IMPORTANT?

Barry Boehm

If a project has not achieved a system architecture, including its rationale, the project should not proceed to full-scale system development. Specifying the architecture as a deliverable enables its use throughout the development and maintenance process.

- Mutual Communication
- Early Design Decisions
- Transferable Abstraction of a System

ARCHITECTURAL VIEWS

- Functional/Logic View
- Code View
- Development/Structural View
- Concurrency/Process/Thread View
- Physical/Deployment View
- User Action/Feedback View

WHY DO WE NEED A SOFTWARE ARCHITECTURE?

- To understand how the system is intended to work.
- To organise software development.
- To foster reuse.
- To evolve the system.

WHAT INFLUENCES THE SOFTWARE ARCHITECTURE

Requirements and Software Patterns

- Requirements and use cases
- Experience -- previous architectures and architectural patterns

Constraints and Enablers

- System software
- Middleware (e.g. frameworks)
- Legacy systems
- Standards and policies
- Non functional requirements
- Distribution needs

ARCHITECTURAL DESCRIPTION

- Architecture should be developed after requirements have been gathered and analysed.
- Architecture should be documented and should remain relatively stable throughout the life of the project.
- Architecure may be updated, but shouldn't grow dramatically. Changes may include:
  - Finding new abstract classes and interfaces
  - Adding new functionality to existing sub-systems/modules
  - Upgrading to new versions of re-useable components
  - Re-arranging the process structure.

ARCHITECTURAL EXAMPLES

- Pipeline
- Transaction
- Layered
- Repository
- Client-server
- Distributed computing
- Peer-to-peer system
- Model-View-Controller
- Monolithic system
- Three-tier model
- Structured
- Component architecture

MODULAR SOFTWARE DESIGN

- Reduces Complexity.
- Facilitates Change (Easier Maintainability).
- Easier Implementation by encouraging parallel development.
- Module is the basic unit of software used in a design description.
- Determined using step-wise refinement (logical parts)
- Modules, sub-systems, components, packages, and classes are all software elements used for **abstraction** and **information hiding** [1].

[1] Pressman 3rd Edition (Section 10.4 pg 332)

LEVELS OF ABSTRACTION

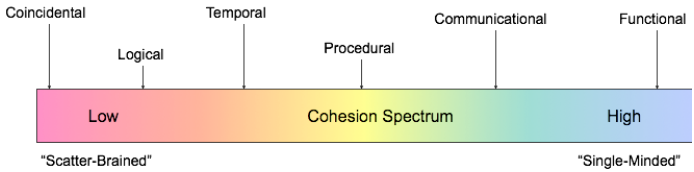
- Data Structures and Algorithms
- Classes (data structures and many algorithms)
- Packages/Modules (groups of related, possibly interacting classes through design patterns).
- Modules/Subsystems (interacting modules each containing many classes, but only the public interfaces interact with other modules/subsystems).
- Systems (systems interacting with other systems, hardware, software and human).

Software architecture tends to be concerned with the last two.

MODULE COHESION

- A measure of how functionally coherent a software module is.
- A software module should have **High Cohesion**.
- This means that a software module is concerned with only doing one thing – and doing that thing well.
- For large modules, their components/classes should be functionally related.

TYPES OF COHESION



A measure of the relative functional strength of a software module

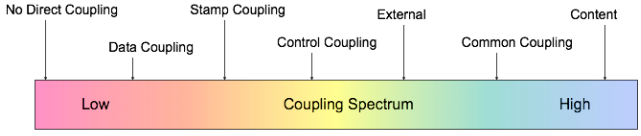
Software Module Cohesion...

- **Coincidental:** multiple, completely unrelated actions or components
- **Logical:** series of related actions or components (e.g. library of IO functions)
- **Temporal:** series of actions related in time (e.g. initialisation modules)
- **Procedural:** series of actions sharing sequences of steps.
- **Communicational:** procedural cohesion but on the same data.
- **Functional:** one action or function

MODULE COUPLING

- Coupling is a measure of how inter-related or interdependent software modules are.
- There should be **LOW COUPLING** between software modules.
- This means that should be only a few well defined, functionally relevant dependencies between software modules.
- Highly coupled software is BAD software. (difficult to understand, maintain, debug etc…)

TYPES OF COUPLING



A measure of the interdependence among software modules

Software Module Coupling...

- **Content:** one module directly references the content of another
- **Common:** both modules have access to the same global data.
- **Control:** One module passes the element of control to another.

DESIGN FOR REUSE

- Reusable Components/Modules are general
- Reusable Components are Loosely Coupled
- Requires High Cohesion and Published Interface

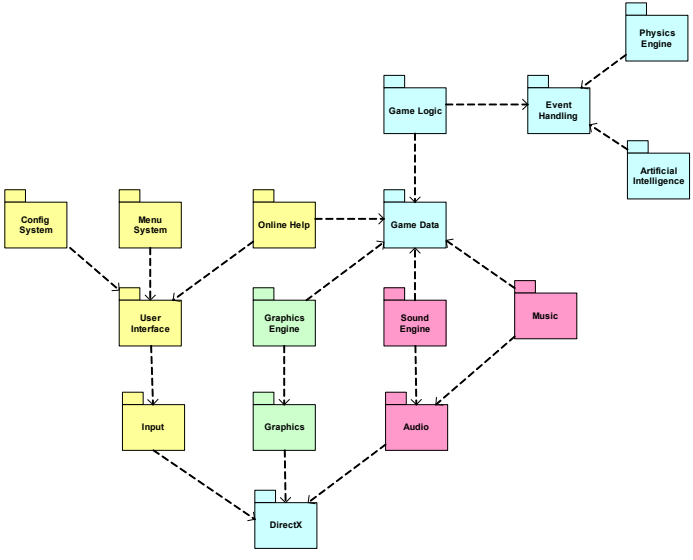
PERFORMANCE CONSTRAINTS

- Having lots of layers can result in performance issues.
- It is a good idea to generally design your architecture with high cohesion and low coupling and then adapt it to iron out performance issues.

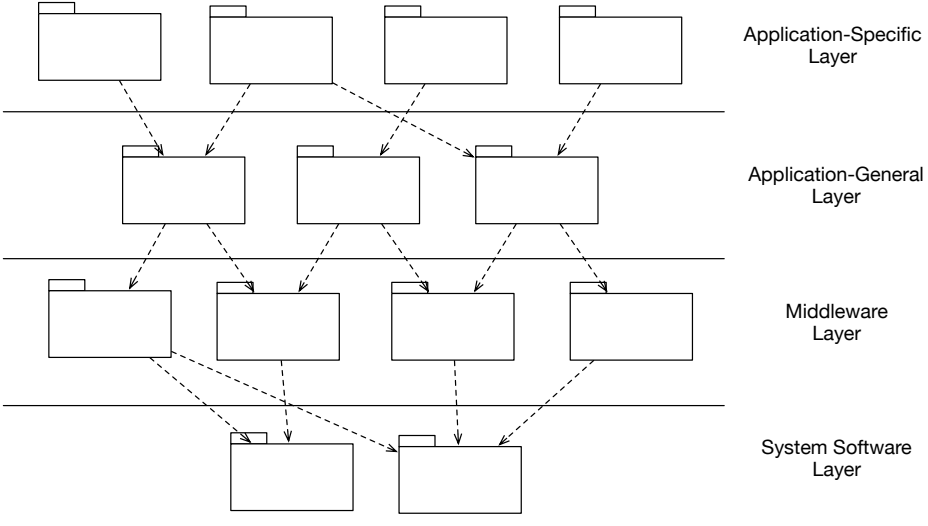
STEPS IN CREATING A SOFTWARE ARCHITECTURE

- Identify major modules (or sub-systems) and sub-modules.
- Identify interactions with external actors and systems.
- Identify dependencies between modules.
- Determine the public classes, functions or sub-modules for each module.
- Identify which public classes from each module will interact with each other.
- Determine the interaction order between the modules.
- Determine how two modules will interact using experience and design patterns.
- Identify the methods (functions) used that will interact with other modules methods (functions).
- Determine the dynamic interactions (run-time)
- Prototype the architecture
- Document it.
- Review it.
- Iterate through it a couple of times to make sure it is modular, extensible, satisfies requirements (including performance etc).
- Compile it...

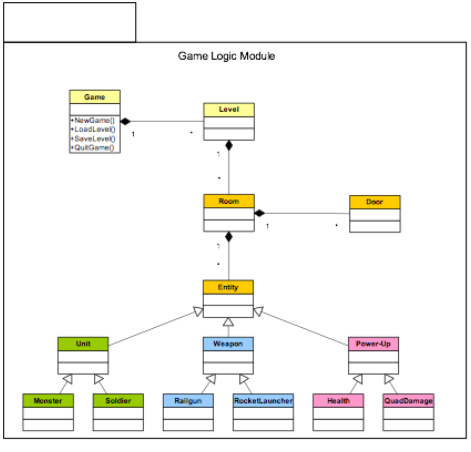
EXAMPLE GAME ARCHITECURE: MODULE DEPENDENCIES

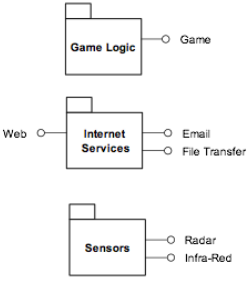


LAYERED ARCHITECTURE

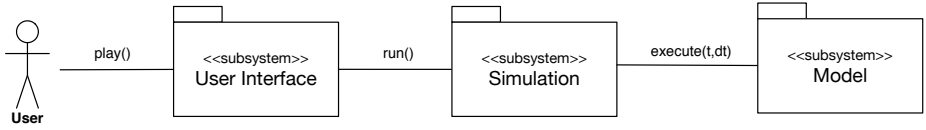


MODULE INTERFACES





ARCHITECTURAL BEHAVIOUR



DETAILED DESIGN: MODULE SPECIFICATION

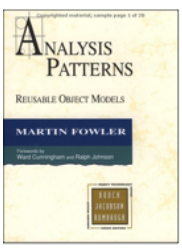
- What the function of a module is:
- Description of what the purpose and function of a module is.
- Inputs and Outputs
- Dependencies
- Errors and Exceptional Conditions

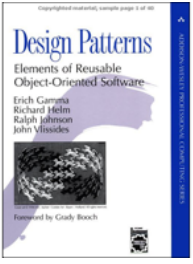
SOME QUESTIONS FOR THE PRELIMINARY ARCHITECTURAL DESIGN REVIEW

- Does the architecture satisfy the requirements?
- Is effective modularity achieved?
- Are interfaces defined for modules and external system elements?
- Is the structure of the data and it's organisation consistent with the domain of the requirements?
- Is the structure of the data consistent with the requirements?
- Has maintainability been considered?
- Have quality factors been explicitly assessed?

BOOKS ABOUT SOFTWARE DESIGN

- Design Patterns: Elements of Reusable Object Oriented Software (Gamma et. al)
- Pattern-Oriented Software Architecture,
  Vol.1: □ A System of Patterns (Buschmann et. al)
- Software Engineering : A Practitioner's Approach (Pressman)
- The Unified Software Development Process (Jacobson, Booch, Rumbaugh)
- Use Case Driven Object Modelling and Design with UML: A Practical Approach (Rosenberg)
- UML Distilled (Fowler)
- Analysis Patterns (Fowler)





BOOKS ABOUT SOFWARE ARCHITECTURE

- Applied Software Architecture (Hofmeister)
- Evaluating Software Architectures: Methods and Case Studies (Clements)
- Design and Use of Software Architecture (Bosch)
- The Software Architect's Profession: An Introduction (Sewell et al)
- Software Architecture: Organizational Principles and Patterns (Dikel)
- Documenting Software Architectures: Views and Beyond (Clements)
- Software Fortresses: Modeling Enterprise Architectures (Sessions)
- Beyond Software Architecture: Creating and Sustaining Winning Solutions (Hohmann)