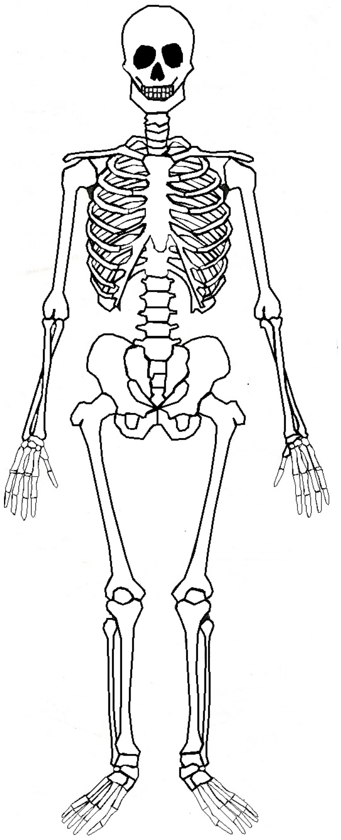


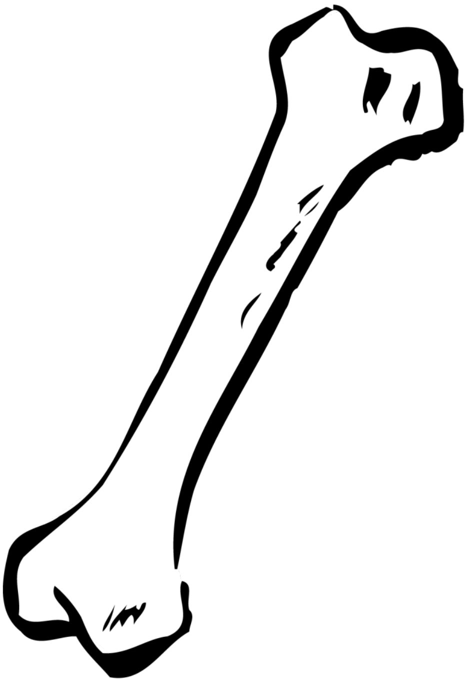
Architecture Design

- Changes slowly
- Speaks about **Components**
- Says how components **connect** and **interact** with others

- Rapid change through refactoring
- Speaks about **Classes**
- Solves **recurrent implementation problems**

Acronyms ...

YAGNI likes a DRY KISS



Some buzzwords and acronyms for today

YAGNI You aren't gonna need it

KISS Keep it simple, stupid

DRY Don't repeat yourself

IoC Inversion of Control

DI Dependency injection

DAO Data Access Object

MVC Model View Controller

BDUF Big Design Upfront

- Software architecture patterns
- Design patterns
- Separation of concerns
- Hollywood principle
- Encapsulation

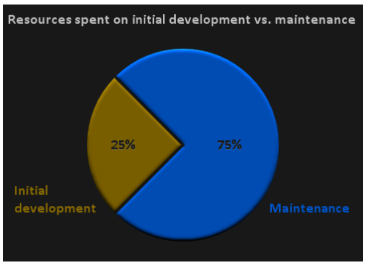


Figure 1: `http://clarityincode.com/software-maintenance`

- High cohesion, loose coupling
- Don't talk to strangers (Demeter's law)

SOLID

Single-responsibility A class/component should take care of and encapsulate a *single* state and functionality.

Open–closed principle A class/component should be open for extension, but closed for modification.

Liskov substitution principle Instances of a class should be replaceable with instances of its subclasses without altering the correctness of that program.

Interface segregation principle Many client-specific interfaces are better than one general-purpose interface.

Dependency inversion principle One should depend upon abstractions (interfaces), not implementations.

1 Why?

Why should we think about architecture/design?

Development
- Adding new features into a mess is more difficult (and is more likely to end-up as more mess)
- Debugging is easier for a well-designed application
- Accommodating new requirements is easier for a well-designed application

Maintenance
- More resources are spent on maintenance than development

Which maintenance tasks are performed?

corrective = fix defects

adaptive = adapt to environment change (new OS, HW)

perfective = function changes

preventive = improve maintainability itself

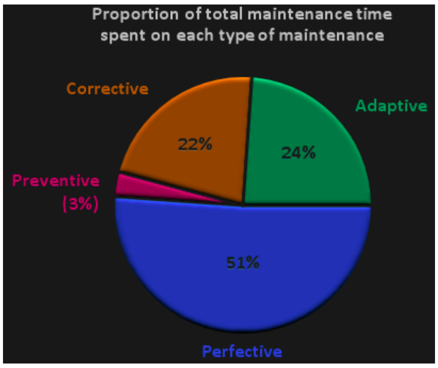


Figure 2: `http://clarityincode.com/software-maintenance`, from Lientz, Swanson (1980)

Why should we think about architecture/design?

Documentation Developers tend to change jobs often. Newcomers need to get up to speed quickly.

Efficiency Clean code is usually more efficient than messy code.

Error prevention Clean code is less prone to bugs.

Modern Application Development

small decompose to testable small pieces that can speed-up delivery

developer-oriented architecture and design easier to undestand, devops

networked applications communicate over network rather than in memory, SOA, distributed teams, easier deployment

2 Software Architecture

What is a software architecture?

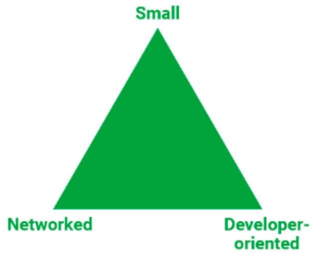


Figure 3: `https://www.nginx.com/blog/principles-of-modern-application-developmen`

> The software architecture of a program or computing system is the structure or structures of the system, which comprise software elements, the externally visible properties of those elements, and the relationships among them. Architecture is concerned with the public side of interfaces; private details of elements—details having to do solely with internal implementation– are not architectural.

- Bass, Clements, and Kazman *Software Architecture in Practice (2nd edition)*

Software architecture

Architecture describes the overall structure of a software system. Good architecture enables smooth evolution of the system, taking into account

- Deployment environment
- Platform and technology specifics
- Expected system scope

Architecture design principles

Standard design principles also apply to system-wide architecture

- *Separation of concerns*
- *Single responsibility principle*
- *Law of Demeter*
- *Don't repeat yourself*

Before you design the system architecture, you need to

- Determine application type
- Determine deployment strategy and environment

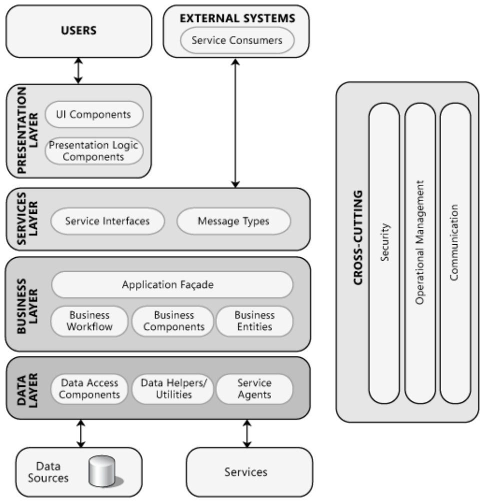


Figure 4: System architecture example. Source: `https://msdn.microsoft.com/en-us/library/ee658124.aspx`

- Determine technologies to use
- Determine quality attributes
- Determine cross-cutting concerns

Architecture example

System architecture

- Usually consists of multiple architectural styles
- Should be well understood by the team
- Should be documented (diagrams, pictures, notes)
- Should clearly expose system structure, while hiding implementation details
  - I.e. show where stuff happens, but not how
- Should address all user scenarios (eventually)
- Should handle both functional and non-functional requirements
- Evolves as the software grows

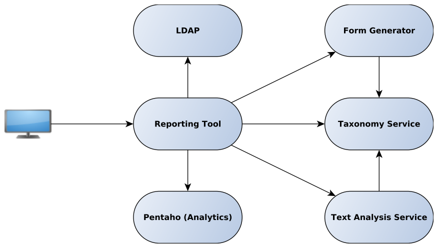


Figure 5: SOA system example.

3 Architectural Styles

Architectural styles

Architecture Style (AS)

- is a proven best practice solutions
- is a means of communication (Documentation, Communication between developers)
- improves code structure

- There exist plenty of architectural styles
- They are usually combined in an application
- Different styles are suitable for different scenarios
- Various ways of architectural style classification

AS – Communication

Service-Oriented Architecture

- Distributed applications provide services for each other
- Using standard protocols and data formats (REST – HTTP and JSON/XML)
- Loose coupling, easy implementation switch
- *Microservices*

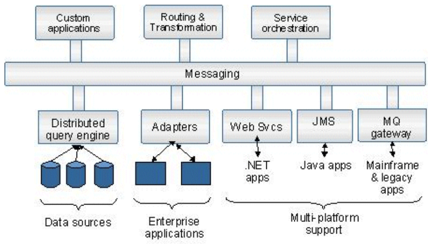


Figure 6: ESB architecture. Source: `https://docs.oracle.com/cd/E23943_01/doc.1111/e15020/img/esb_architecture.gif`

AS – Communication II

Message Bus

- Central message queue handles message distribution
- Asynchronous messages between clients
- Loose coupling, scalability
- *Enterprise Service Bus* – provided by Oracle, IBM etc.

AS – Deployment

Client/Server

- Client sends requests, server responds
- Web applications use this pattern
- Server – possible single point of failures and scalability issues

N(3)-tier

- Independent tiers providing functionality
- Easier scaling
- E.g. load balancing, company firewall

AS – Domain

Domain-driven Design

- Business components represent domain entities
- Suitable for modelling complex domains
- Common language and model for developers and domain experts

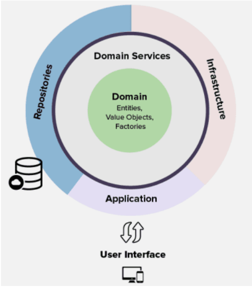


Figure 7: https://dev.to/microtica/the-concept-of-domain-driven-design-explained-1ccn

AS - Structure

Object-oriented

- Objects consist of both behaviour and data
- Natural representation of the real world
- Encapsulation of implementation details

Layered

More on layers later...

AS - Structure II

Component-based

- System decomposed into logical or functional components
- Components provide public interfaces
- Supports separation of concerns and encapsulation
- Components can be managed by architecture provider
  - *Dependency injection* and *Service locator* used to managed dependencies
- Components can be distributed
- Higher level than OOP

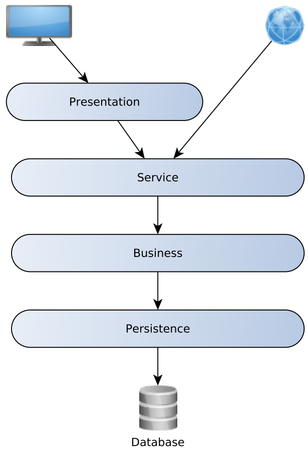


Figure 8: Layered system architecture.

3.1 Layered Architecture

Layered architecture

- Layers of related functionality
- Typical for web applications
- Behaviour encapsulation, clear separation of concerns, high cohesion, loose coupling
- Testability

Layered architecture II

- In contrast to *N-tier architecture*, the layers are usually in one process (e.g. application server)
- Each component communicates only with other components within the same layer or in the layer(s) below it

  Strict interaction Layer communicates only with the layer directly below

  Loose interaction Layer can communicate also with layers deeper below

- Cross-cutting concerns stem across all layers (e.g. security, logging)

4 Design Patterns

Design patterns

Design patterns represent generally applicable solutions to commonly occurring problems.

Patterns mostly consist of (this was cemented by the GoF):

Pattern name Simple identification useful in communication

Problem Description of the problem and its *context*

Solution Solution of the problem (good practice)

Consequences Possible trade-offs of applying the pattern

4.1 GoF Design Patterns

Gang of Four Patterns

Based on the book *Design Patterns: Elements of Reusable Object-Oriented Software.*

- Bible of design patterns
- Patterns applicable to all kinds of object-oriented software
  - creational
  - structural
  - behavioural

Creational Patterns

Abstract Factory Interface for creating families of related objects

Builder Instance construction process in a separate object

Factory Method Subclasses decide which class to instantiate

Prototype Build instances based on a prototype

Singleton Only one instance of the class

Structural Patterns

Adapter Convert the interface of one class to a different interface (e.g. for legacy classes)

Bridge Decouple abstraction from implementation

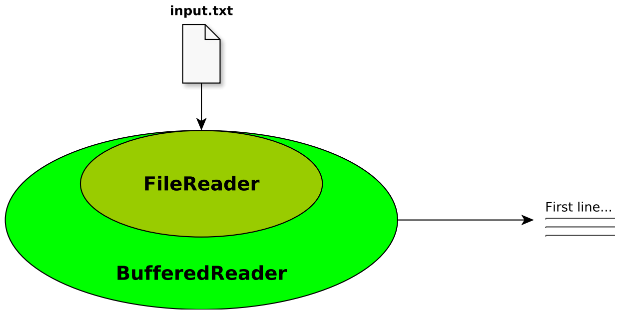
Composite Build a tree-like structure of objects

Decorator Add or alter behaviour of another object by wrapping it in a class with the same interface (e.g., Java I/O streams)

Facade Provide a unified interface to a set of interfaces

Flyweight Use sharing to support a large number of fine-grained objects

Proxy Provide a placeholder for another object to control access to it (e.g. Spring bean proxies)



Decorator

Decorator in Java I/O

```
BufferedReader in = new BufferedReader(new FileReader(new File("input.txt")));
```

Behavioral Patterns

Chain of Responsibility Multiple objects in a chain can handle a request (e.g., request filters)

Command Encapsulate a request in an object (e.g., *undo* functionality)

Interpreter Interpreter for a language and its grammar

Iterator Provide a way to access elements of an aggregate object (e.g., Java collections)

```
Iterator<String> it = set.iterator();
```

Mediator An object that encapsulates how a set of objects interact

Memento Capture an object's state so that it can be restored to this state later

Behavioral Patterns II

Observer Decoupled notification of changes of object's state

State Allows object's behaviour to change based on its internal state

Strategy A family of algorithms which can be interchanged independently of the client

Template method Define a skeleton of an algorithm and let subclasses fill in the details

Visitor Represent an operation to be performed on the elements of an object structure

4.2 Enterprise Design Patterns

Enterprise Design Patterns

Mostly based on the book *Patterns of Enterprise Application Architecture*.

- Design patterns used especially in enterprise software
- Similarly to GoF design patterns, they originate from best practice solutions to common problems, but this time in enterprise application development
- Many are implemented by frameworks and tools we will use (e.g., JPA, Spring)

PEAA

Data Transfer Object (DTO)

- Object that carries data between processes in order to reduce the number of calls
- Useful, e.g., when JPA entities are not the best way of carrying data between REST interfaces

Lazy Load

- Object does not contain all of its data initially, but knows how to load it
- Useful for objects holding large amounts of data (e.g., binary data)
- Often overused as a way of premature optimization

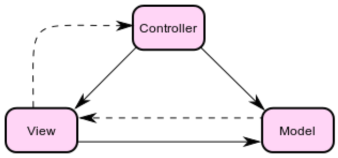
Lazy Load Antipattern

```
public final class Singleton {

   private static singleton = null;

   private Singleton () {}

   public static Singleton getInstance() {
      if(singleton == null) {
         singleton = new Singleton();
      }
      return singleton;
   }
}
```



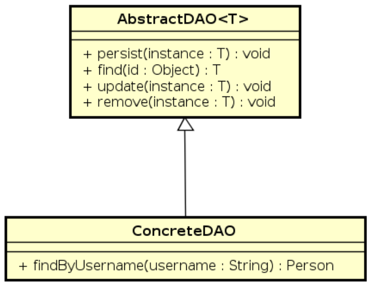


Figure 9: Common Data access object hierarchy.

PEAA II

Model View Controller (MVC)

- Splits user interface interaction into three distinct roles
- Decouples UI rendering from data and UI logic
- UI implementation interchangeable

Unit Of Work

- Maintains objects affected by a business transaction and coordinates the writing out of changes and the resolution of concurrency problems
- Common in JPA implementations (e.g., Eclipselink)

4.3 Other Useful Patterns

Data Access Object (DAO)

- Data access object encapsulates all access to the data source
- Abstract interface hides all the details of data source access (data source can be a RDBMS, an external service, a linked data repository)

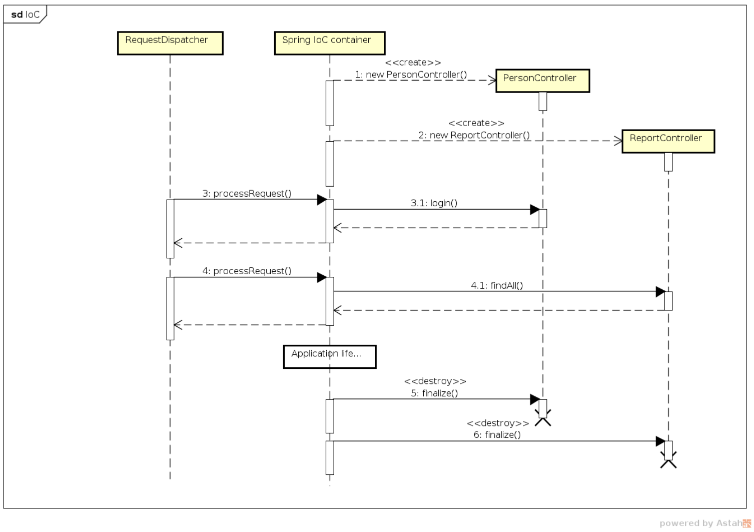


Figure 10: Inversion of Control in a Spring application.

Inversion of Control (IoC)

- Most common when working with frameworks
- The framework takes control of what and when gets instantiated and called
- The framework embodies some abstract design and we provide behaviour in various places
- Especially important in applications which react to client actions
  - Where the client can be a different application
  - Or a person using your application's UI
- aka *The Hollywood Principle* – "Don't call us. We'll call you."

IoC II

Dependency Injection

- An assembler takes care of populating a field in a class with an appropriate implementation for the target interface
- Enables the application to use loosely coupled components with interchangeable implementations

Dependency Injection II

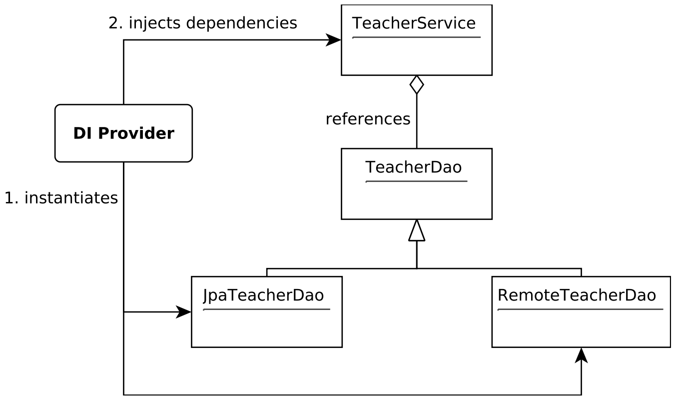


Figure 11: Dependency injection principle.

4.4 Microservices patterns

Microservices patterns

- Aggregator
- API Gateway
- Chained or Chain of Responsibility
- Asynchronous Messaging
- Database or Shared Data
- Event Sourcing
- Branch
- Command Query Responsibility Segregator
- Circuit Breaker
- Decomposition

Circuit Breaker

for accessing unreliable services. Taken from `https://martinfowler.com/bliki/CircuitBreaker.html`

5 Conclusions

Conclusions

- Application design **does** matter

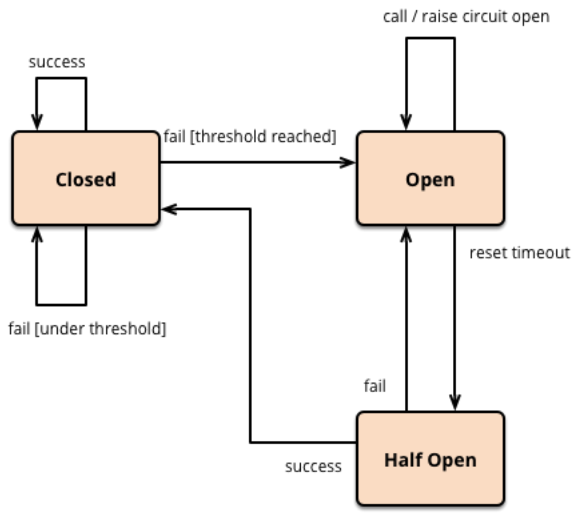


Figure 12: Circuit Breaker states.

- Architecture consists of multiple architectural styles
- Design patterns are more fine grained than architectural styles
- Web applications usually follow the layered style

The End

Thank You

Resources

- E. Gamma, R. Johnson, R. Helm, J. Vlissides: Design Patterns: Elements of Reusable Object-Oriented Software
- M. Fowler: Patterns of Enterprise Application Architecture
- E. Evans: Domain Driven Design: Tackling Complexity in the Heart of Software
- Lectures of Tomáš Černý – A7B36ASS
- `https://msdn.microsoft.com/en-us/library/ee658098.aspx`
- `https://www.petrikainulainen.net/software-development/design/understanding-spring-web-app`
- `https://sv.wikipedia.org/wiki/Model-View-Controller\#/media/Fil:ModelViewControllerDiagra svg`
- B. P. Lientz, E.B. Swanson. (1980). Software maintenance management : a study of the maintenance of computer application software in 487 data processing organizations. Addison-Wesley.