

Software Paradigms

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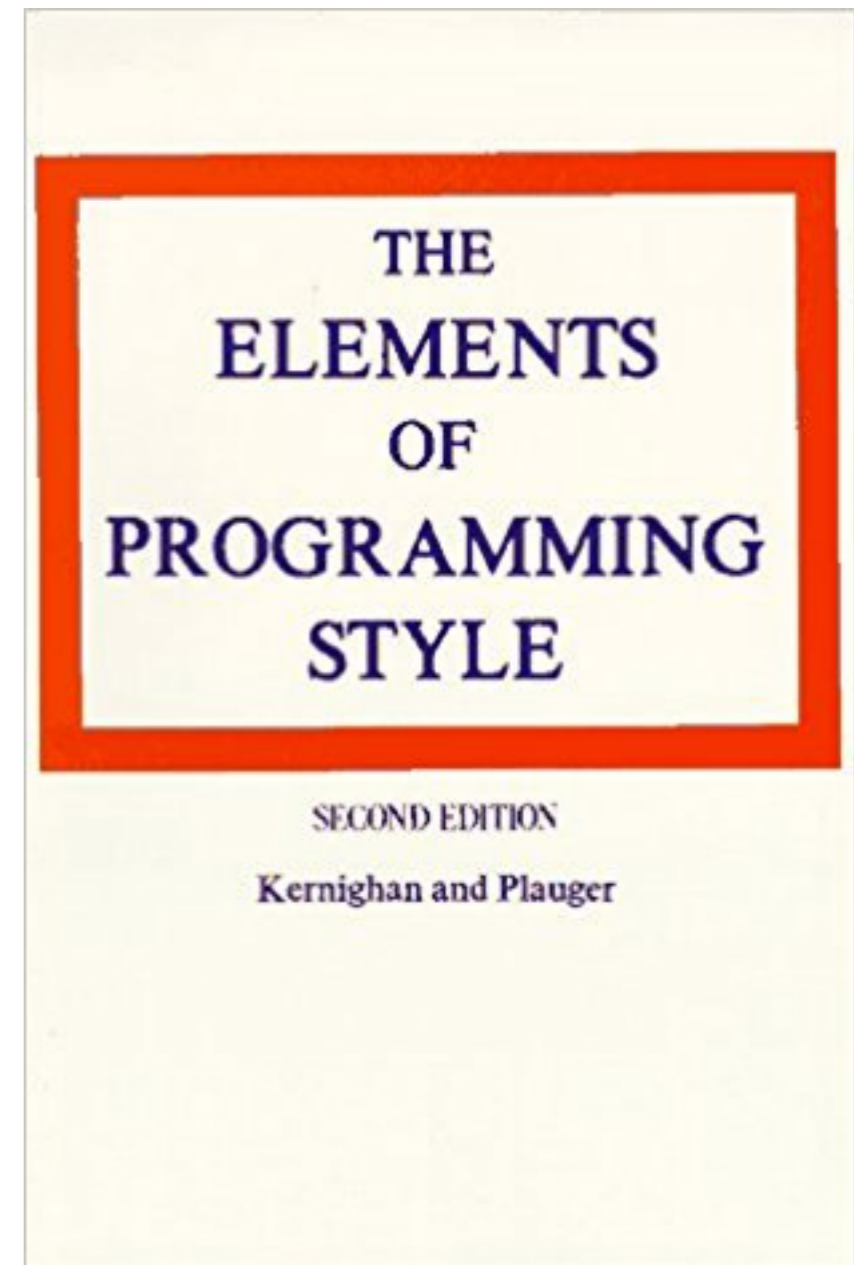
Waterford Institute of Technology
INSTITIÚID TEICNEOLAÍOCHTA PHORT LÁIRGE

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<http://www.wit.ie/>

Literate Programmer...

“Good design and programming is not learned by generalities, but by seeing how significant programs can be made clean, easy to read, easy to maintain and modify, human-engineered, efficient, and reliable, by the application of good design and programming practices. Careful study and imitation of good designs and programs significantly improves development skills.”

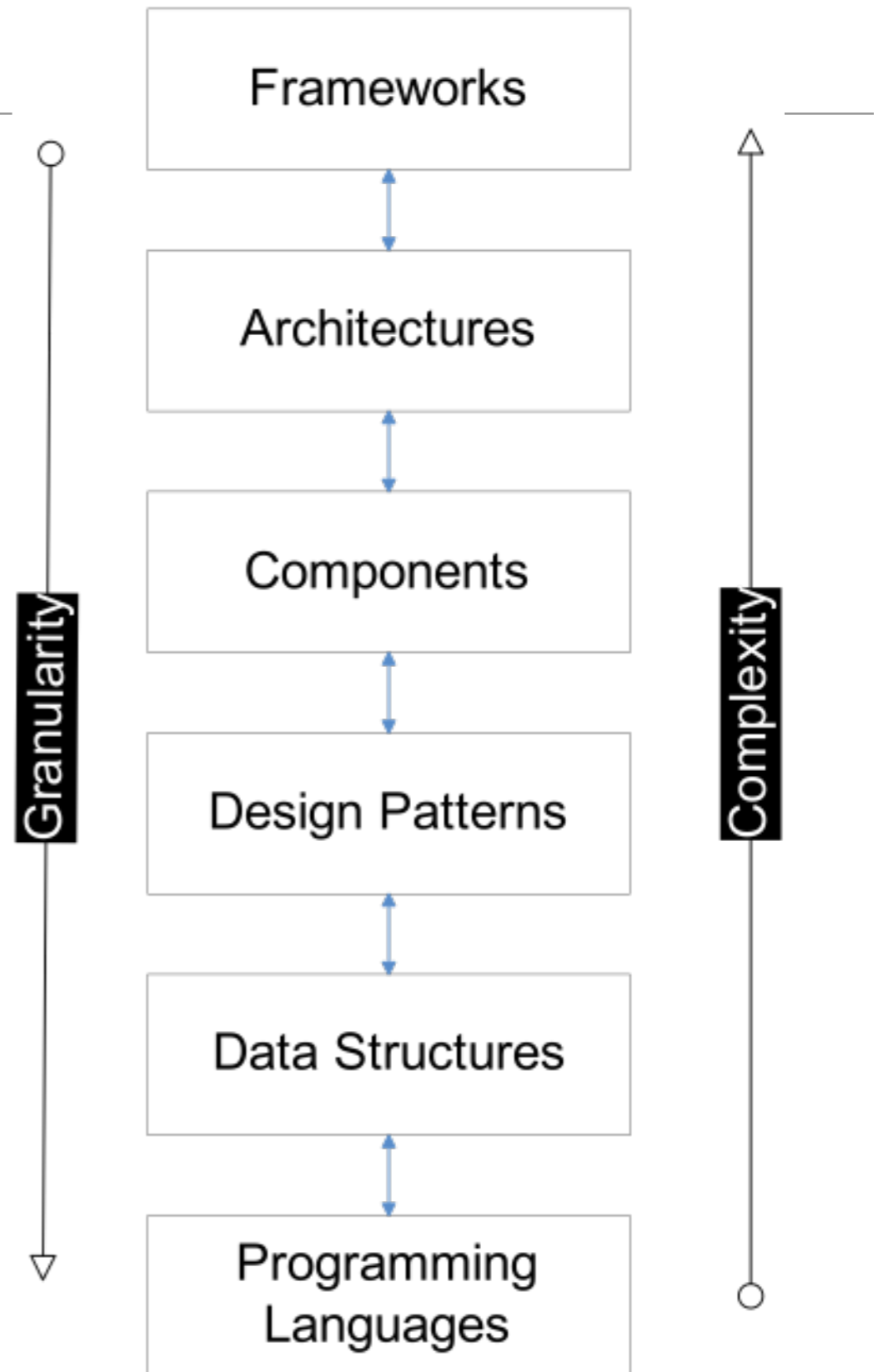
Kernighan & Plauger (1978)



Agenda

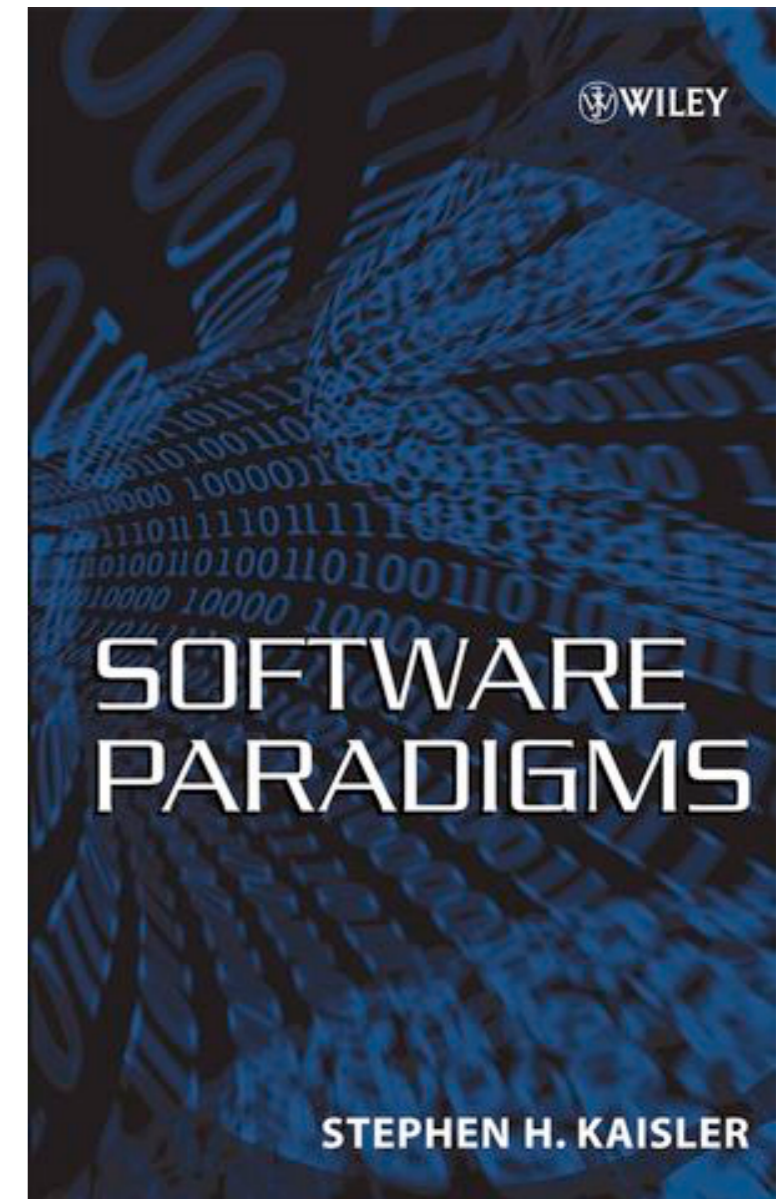
Software & Programming
Paradigms

Software Engineering
Knowledge Stack



Software Paradigms...

- *Paradigm** is commonly used to refer to a category of entities that share a common characteristic.
- Taken to mean a conceptual way of describing something
- The rate of change in the software discipline has seen proliferation of overlapping paradigms.



*from Greek *paradeigma*, 'show side by side',

Software Paradigms (examples..)

- **Imperative programming** – defines computation as statements that change a program state.
- **Procedural programming, structured programming** – specifies the steps a program must take to reach a desired state.
- **Declarative programming** – defines program logic, but not detailed control flow.
- **Functional programming** – treats programs as evaluating mathematical functions and avoids state and mutable data
- **Object-oriented programming (OOP)** – organizes programs as objects: data structures consisting of datafields and methods together with their interactions.
- **Event-driven programming** – program control flow is determined by events, such as sensor inputs or user actions (mouse clicks, key presses) or messages from other programs or threads.
- **Automata-based programming** – a program, or part, is treated as a model of a finite state machine or any other formal automaton.

Paradigm Structure

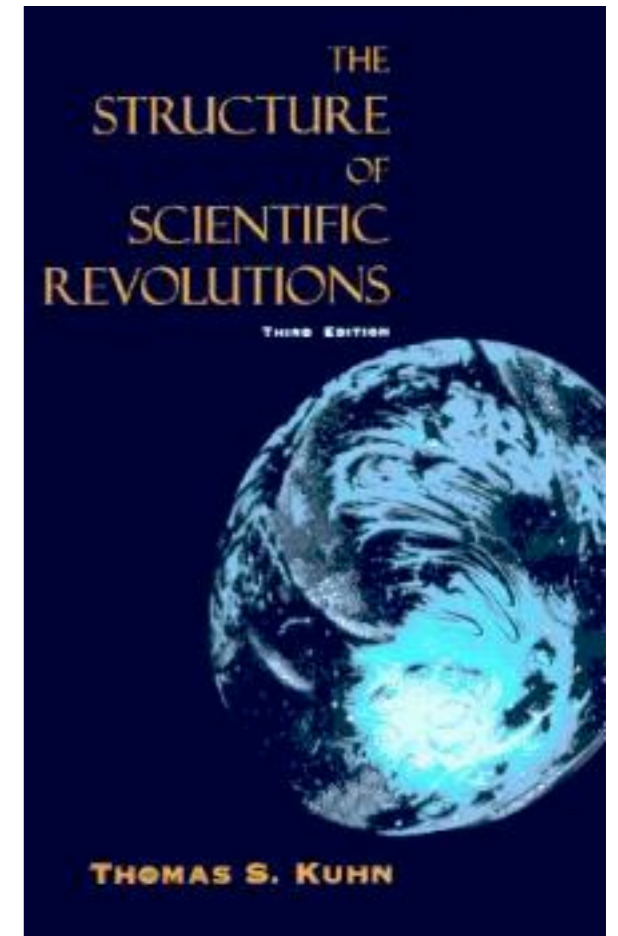
- Two aspects to a paradigm:

1: Principles and techniques:

- Symbolic generalizations: Assertions that are later taken for granted and employed without question
- Model beliefs: a commitment to a belief in a model to which the relevant domain conforms
- Values

2: Exemplars: shared examples that illustrate the properties of the paradigm.

(Kuhn, “The Structure of Scientific Revolutions”)



http://en.wikipedia.org/wiki/The_Structure_of_Scientific_Revolutions



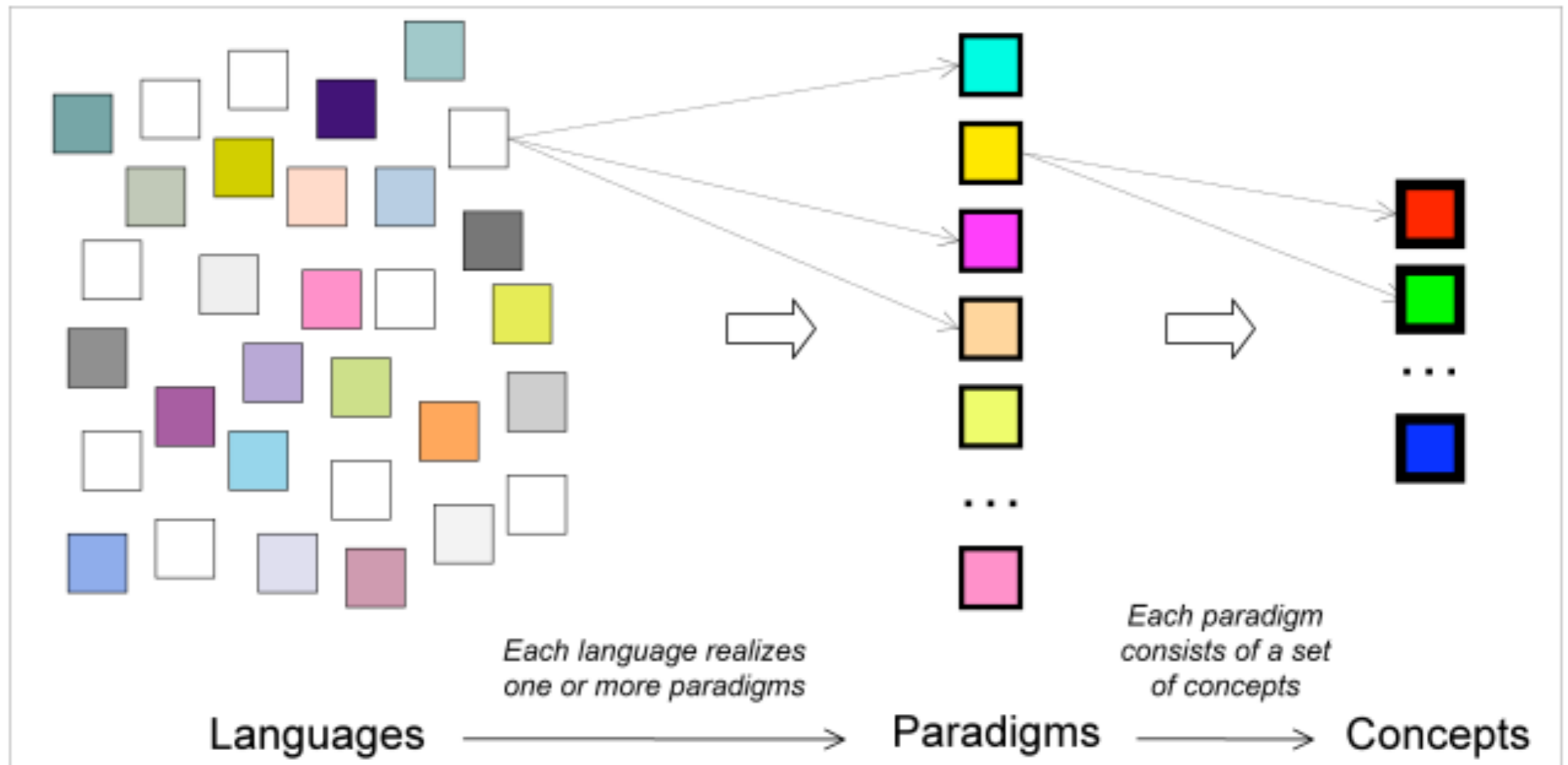
**KEEP
CALM
THERE'S A
PARADIGM
SHIFT
GOING ON**



A fundamental change in the basic concepts and experimental practices of a scientific discipline.



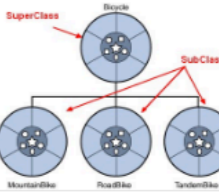
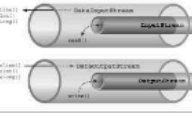

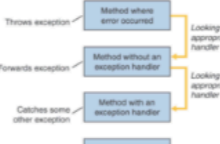
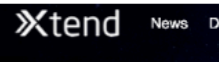



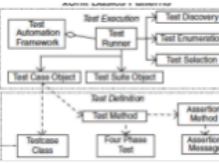
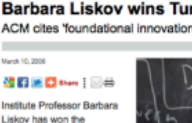
Can be a period of confusion & uncertainty

Software Paradigms

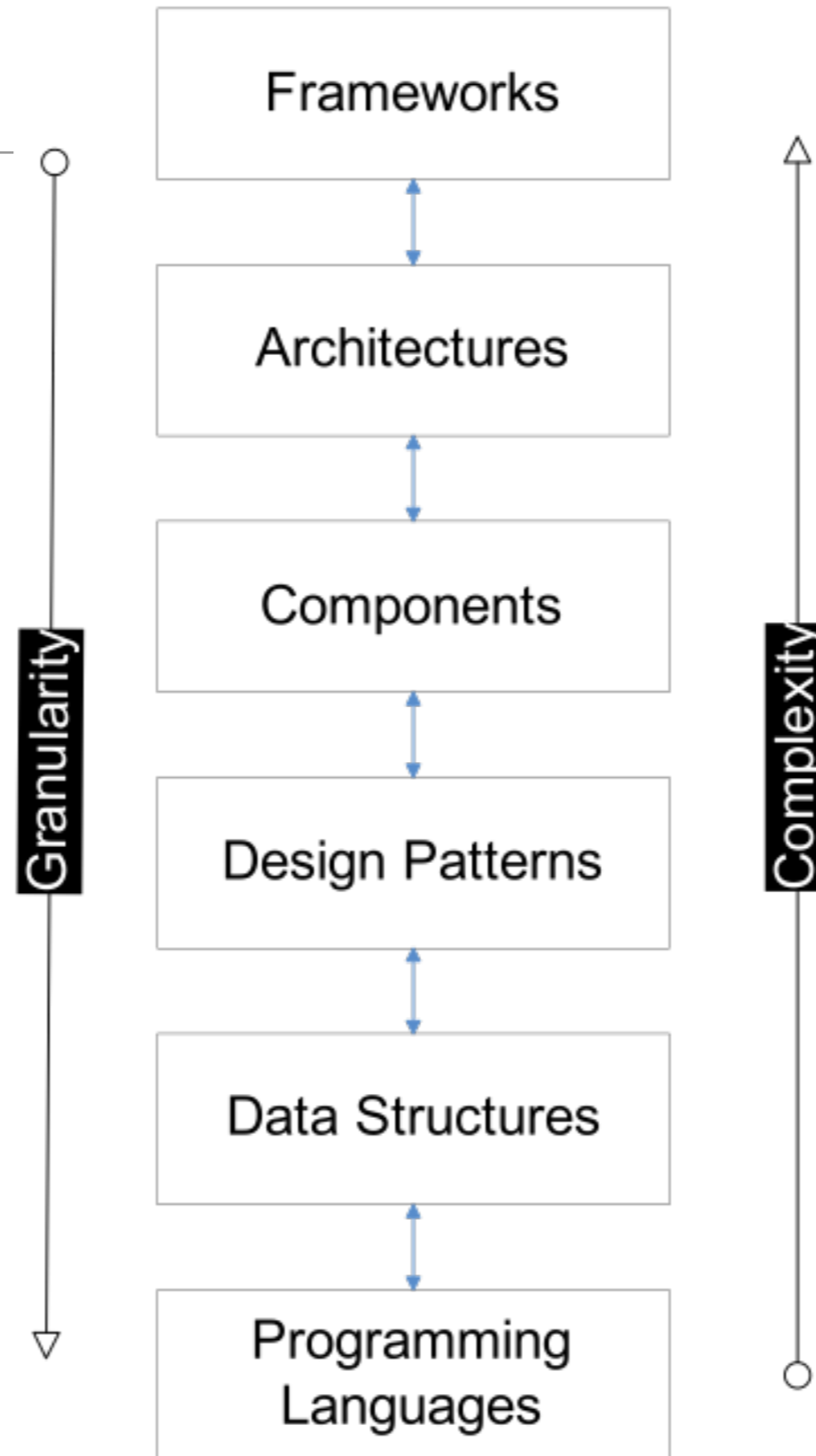


Paradigms for This Module

- **Object Oriented Programming**
 - OO Principles (particularly SOLID principles)
 - Java Programming Language
 - Kotlin Programming Language
- **Agile Methods**
 - Test Driven Development (TDD)
 - Automated Build / Configuration Management
- **Network Programming**
 - Web Services/HTTP/REST

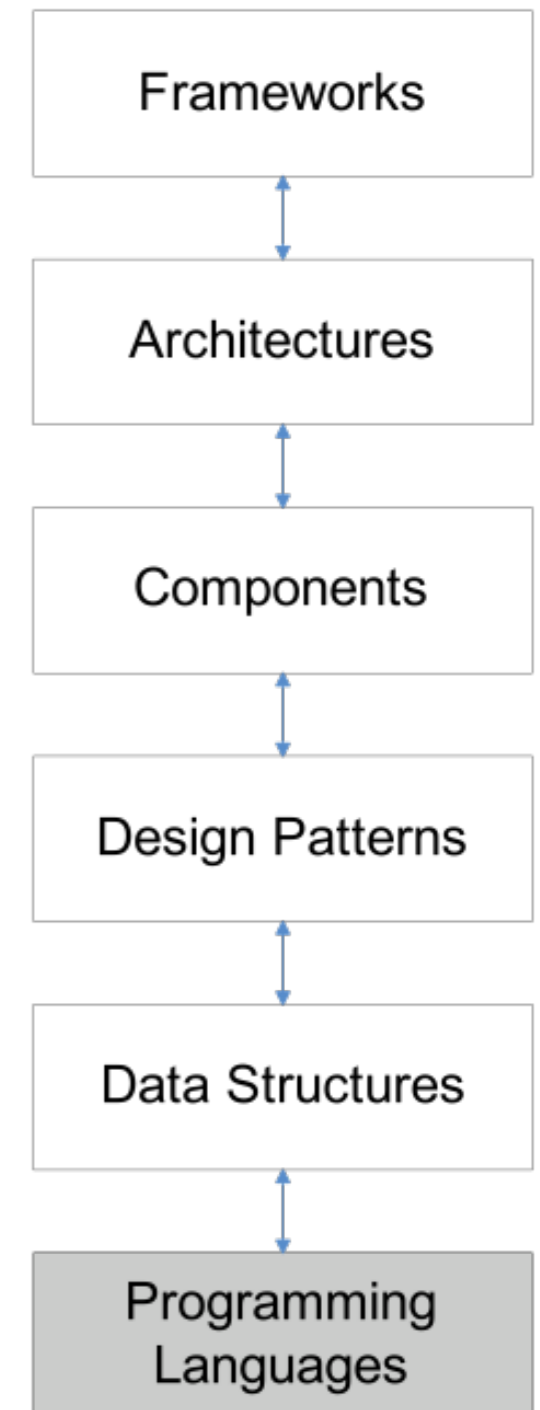
| | | | |
|--|--|---|---|
| <p>Paradigms & Languages</p>  <p>We start by exploring modern software development languages, frameworks and tools. This will include a rapid review of Java and an exploration of the principle features of successors to Java now emerging.</p> | <p>The Java Programming Language</p>  <p>The Java programming language is a mature, well understood language that powers many enterprises and public web applications. Originally design for the consumer electronics market, it was quickly adopted as general purpose, versatile language relatively easy to learn and master.</p> | <p>Inheritance & Collections</p>  <p>Object Oriented thinking has consistently placed the inheritance relationship as a key feature of its approach. We review how this relationship is realized in Java. As you will see it is a complex relationship, and we will return to the difficulties it can cause in a later topic.</p> | <p>Serialization & Test Driven Development I</p>  <p>At the heart of the JDK are object I/O and Serialization capabilities, packaged into a comprehensive library for managing the life cycle of simple objects. Although the approach taken by this particular base library has to some extent been superseded by other approaches, it remains an important and influential technical approach, that can be usefully applied in simpler standalone applications.</p> |
| <p>Test Driven Development II</p>  <p>Test Driven Development has been among the most influential approaches in recent software engineering history. Here we look at its origins, principles and some of the important benefits of the approach.</p> | <p>Exceptions & Maven</p>  <p>Building and deploying Java applications can be a source of considerable complexity and ad-hoc procedures. Maven is a tool than aims to standardize this process, incorporating rigorous dependency management, repository structure and project layout best practices.</p> | <p>Pacemaker 1.0 in Xtend</p>  <p>Xtend is a flexible and expressive compile into readable Java 5 use any existing Java library, a readable and pretty-printed, an equivalent handwritten Java code. Get productive and write beautiful lambdas.</p> | <p>SRP</p>  <p>SRP is a simple yet effective guideline for determining the core features of a class. It is the first of the SOLID principles, a well respected source of effective design practices.</p> |
| <p>Test Driven Development III</p>  <p>Right BICEP: Guidelines for Composing Tests phrased using the acronym: - Right, Boundary, Inverse, Cross-check, Errors & Performance.</p> | <p>OCP</p>  <p>The second of the "SOLID" principles: "Software Entities should be open for extension but closed for modification"</p> | <p>Test Doubles</p>  <p>TDD is a rich and mature field, with its own literature and best practices. Here we review an attempt to capture some of this best practice into a set of higher level patterns.</p> | <p>LSP + Play</p>  <p>Another of the SOLID principles - this time a more subtle take on inheritance, emphasizing the core behaviours expected by the relationship.</p> |

Knowledge Context



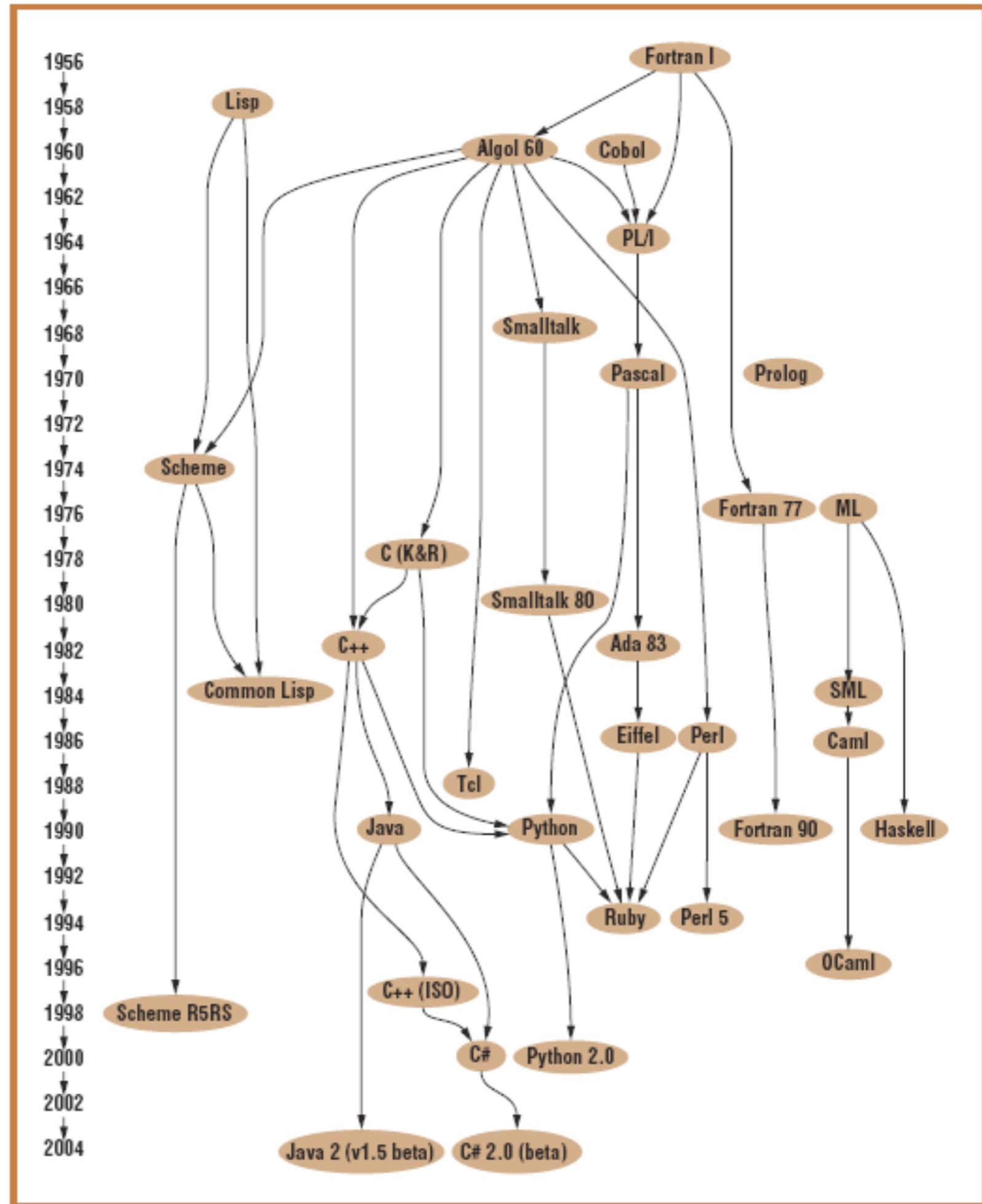
Programming Languages

- A programming language is a system of signs used to communicate a task/algorithm to a computer, causing the task to be performed.
- The task to be performed is called a computation, which follows absolutely precise and unambiguous rules.
- Three components:
 - The **syntax** of the language is a way of specifying what is legal in the phrase structure of the language; (analogous to knowing how to spell and form sentences English)
 - The second component is **semantics**, or meaning, of a program in that language.
 - Certain **idioms** that a programmer needs to know to use the language effectively - are usually acquired through practice and experience.



Family Tree

- Imperative languages: (Fortran, C, and Ada) enable programmers to express algorithms for solving problems.
- Declarative languages, (Lisp, Prolog, Haskell) allow the programmer to specify what has to be computed, but not how the computation is done.
- Object Oriented: can be viewed as a hybrid – of declarative (class structures) & imperative (methods) features.





WEB DEVELOPMENT



GAME DEVELOPMENT



MOBILE APP DEVELOPMENT



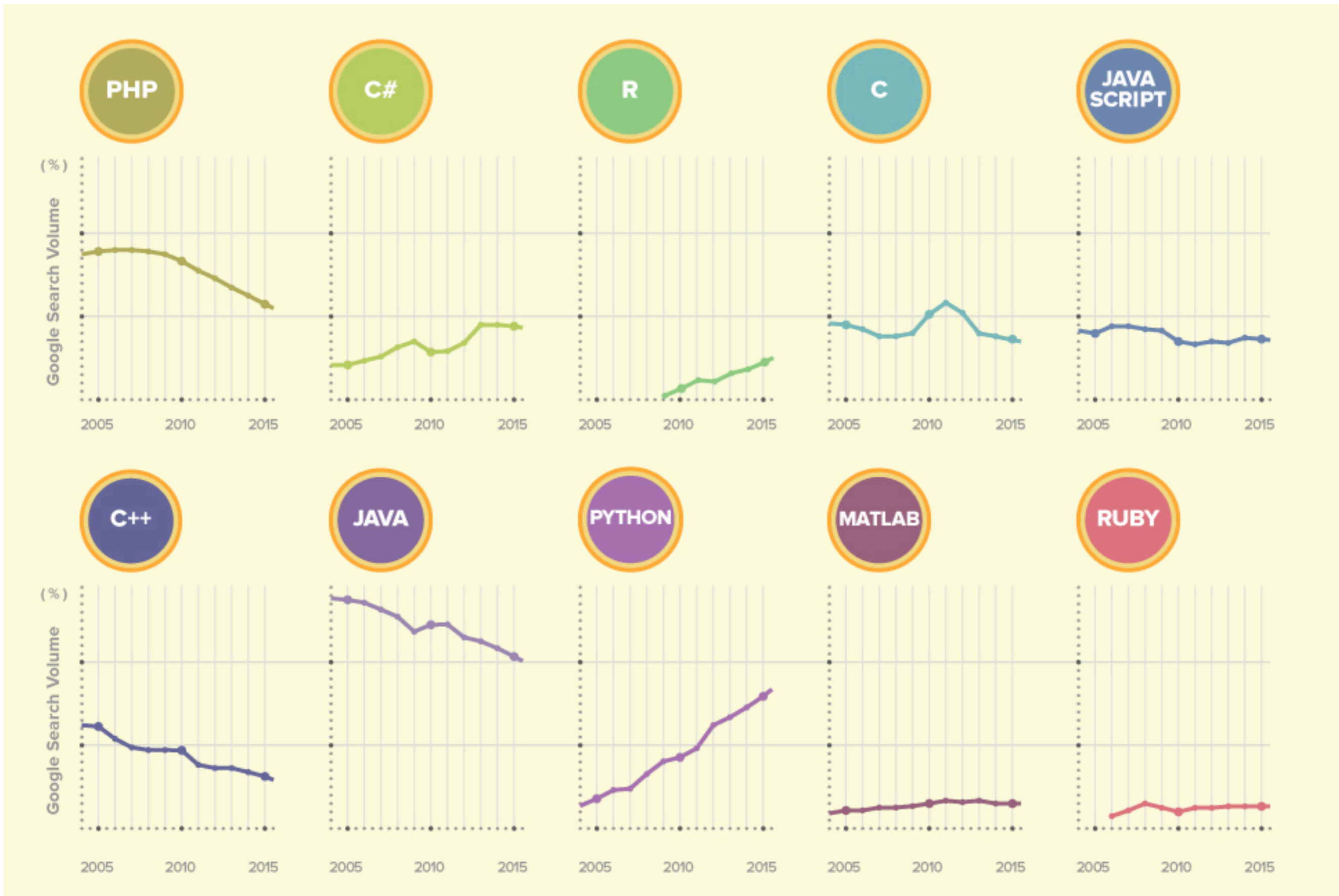
DATA ANALYSIS



EMBEDDED SYSTEM PROGRAMMING

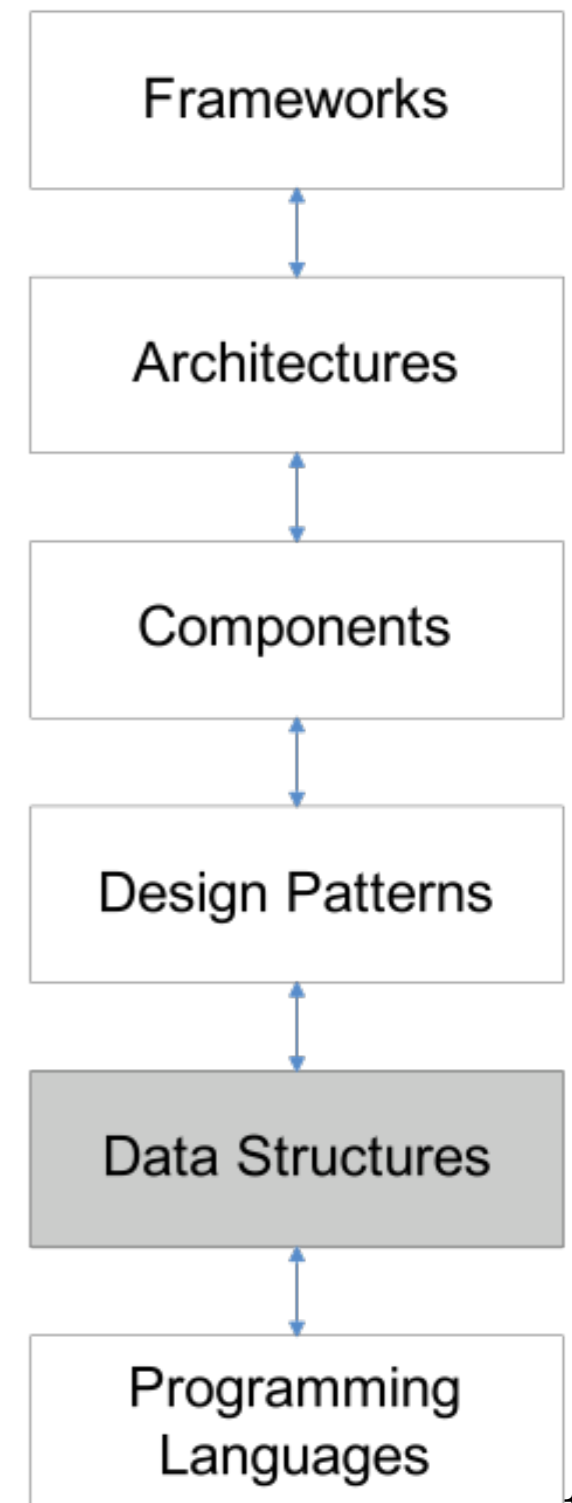


| 2015 Rank | | 2015 | Change% | 2014 | Change% | 2013 | Change% |
|-----------|------------------|--------|---------|--------|---------|--------|---------|
| 1 | Python | 26.67% | -14.64% | 31.24% | 3.10% | 30.30% | 5.21% |
| 2 | Java | 22.58% | 15.37% | 19.57% | -11.85% | 22.20% | -13.95% |
| 3 | C++ | 9.96% | 1.76% | 9.79% | -24.70% | 13.00% | 3.17% |
| 4 | C# | 9.39% | 27.37% | 7.37% | 47.37% | 5.00% | 100.00% |
| 5 | C | 7.37% | 21.37% | 6.07% | 48.14% | 4.10% | -16.33% |
| 6 | JavaScript | 6.88% | 6.09% | 6.48% | 24.66% | 5.20% | 33.33% |
| 7 | Ruby | 5.88% | -17.27% | 7.11% | -32.90% | 10.60% | 10.42% |
| 8 | PHP | 3.82% | 5.45% | 3.62% | 9.84% | 3.30% | -54.79% |
| 9 | Haskell | 1.77% | 17.24% | 1.51% | 25.83% | 1.20% | |
| 10 | Go | 1.27% | -44.00% | 2.26% | 50.67% | 1.50% | -25.00% |
| 11 | Scala | 1.04% | -17.80% | 1.27% | 27.00% | 1.00% | 66.67% |
| 12 | Perl | 0.95% | -37.33% | 1.52% | -6.17% | 1.62% | |
| 13 | Objective-C | 0.82% | -17.62% | 1.00% | 265.76% | 0.27% | 173.40% |
| 14 | Bash | 0.46% | 7.21% | 0.43% | 290.91% | 0.11% | |
| 15 | R | 0.37% | 165.71% | 0.14% | -30.00% | 0.20% | |
| 16 | Visual Basic,NET | 0.37% | 825.50% | 0.04% | | | |
| 17 | Lua | 0.19% | -44.51% | 0.35% | 337.50% | 0.08% | |
| 18 | Clojure | 0.14% | -8.53% | 0.15% | -48.28% | 0.29% | -63.75% |
| 19 | Tcl | 0.06% | -8.57% | 0.07% | 133.33% | 0.03% | 50.00% |



Data Structures & Problems

- Typical Data Structures:
 - Lists, Maps, Stacks, Queues, Trees, etc.
 - Static and Dynamic implementations
- Typical Problem Categories:
 - Search
 - Sorting
 - Traversal
 - Inserting / Deleting
 - Merging
 - Clustering
 - Classification



Exploring a Data Structure

```
public class Contact
{
    private String name;

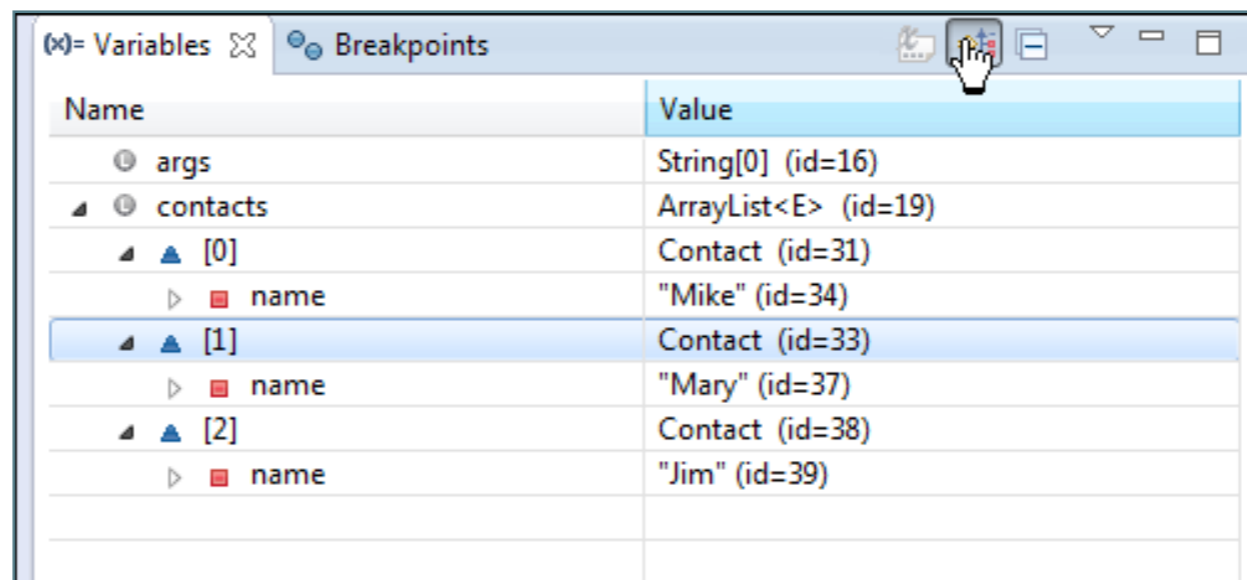
    public Contact(String name)
    {
        this.name = name;
    }

    public String toString()
    {
        return name;
    }
}
```

```
public class Main
{
    public static void main(String[] args)
    {
        List<Contact> contacts
            = new ArrayList<Contact>();

        contacts.add(new Contact("Mike"));
        contacts.add(new Contact("Mary"));
        contacts.add(new Contact("Jim"));

        System.out.println(contacts);
    }
}
```

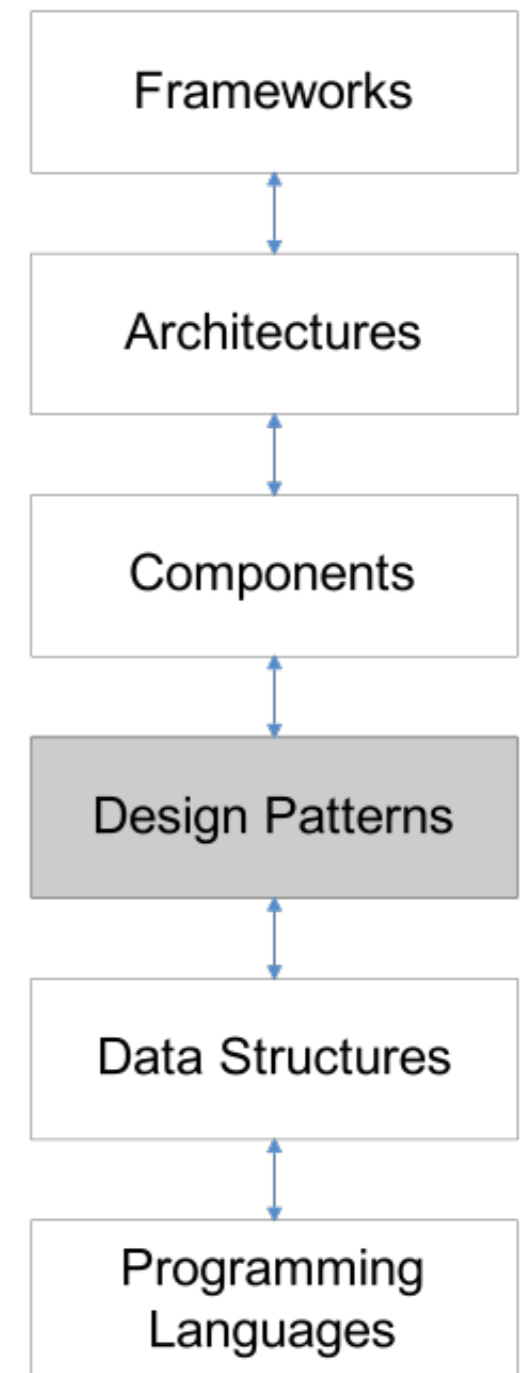


The screenshot shows the 'Variables' window in an IDE. The window title is '(x) Variables' and it has a 'Breakpoints' tab. The table below shows the current state of the program's variables.

| Name | Value |
|----------|----------------------|
| args | String[0] (id=16) |
| contacts | ArrayList<E> (id=19) |
| [0] | Contact (id=31) |
| name | "Mike" (id=34) |
| [1] | Contact (id=33) |
| name | "Mary" (id=37) |
| [2] | Contact (id=38) |
| name | "Jim" (id=39) |

Design Patterns

- A design pattern is a **proven** solution for a general design problem.
- It consists of communicating ‘objects’ that are customised to solve the problem in a particular context.
- Patterns have their origin in object-oriented programming; they are pre-packaged Object-oriented design knowledge that allows you to create more flexible and maintainable code.
- There isn't any fundamental relationship between patterns and objects; it just happens they began there.
- Patterns may have arisen because objects seem so elemental, but the problems we were trying to solve with them were so complex.



Why the need for Design Patterns?

- Change is a constant in software design e.g. bugs, new features, changes to design, new regulations, etc. All software changes, so your designs should be ready for it.
- They allow you to typically anticipate common ways that systems grow and change over time.
- The primary goal of any design pattern is to help you structure your code so it is flexible and resilient.
- All patterns let some part of the code vary independently of the other parts.

Pattern Levels

Architectural Patterns:

- Expresses a fundamental structural organization or schema for software systems. It provides a set of predefined subsystems, specifies their responsibilities, and includes rules and guidelines for organizing the relationships between them.

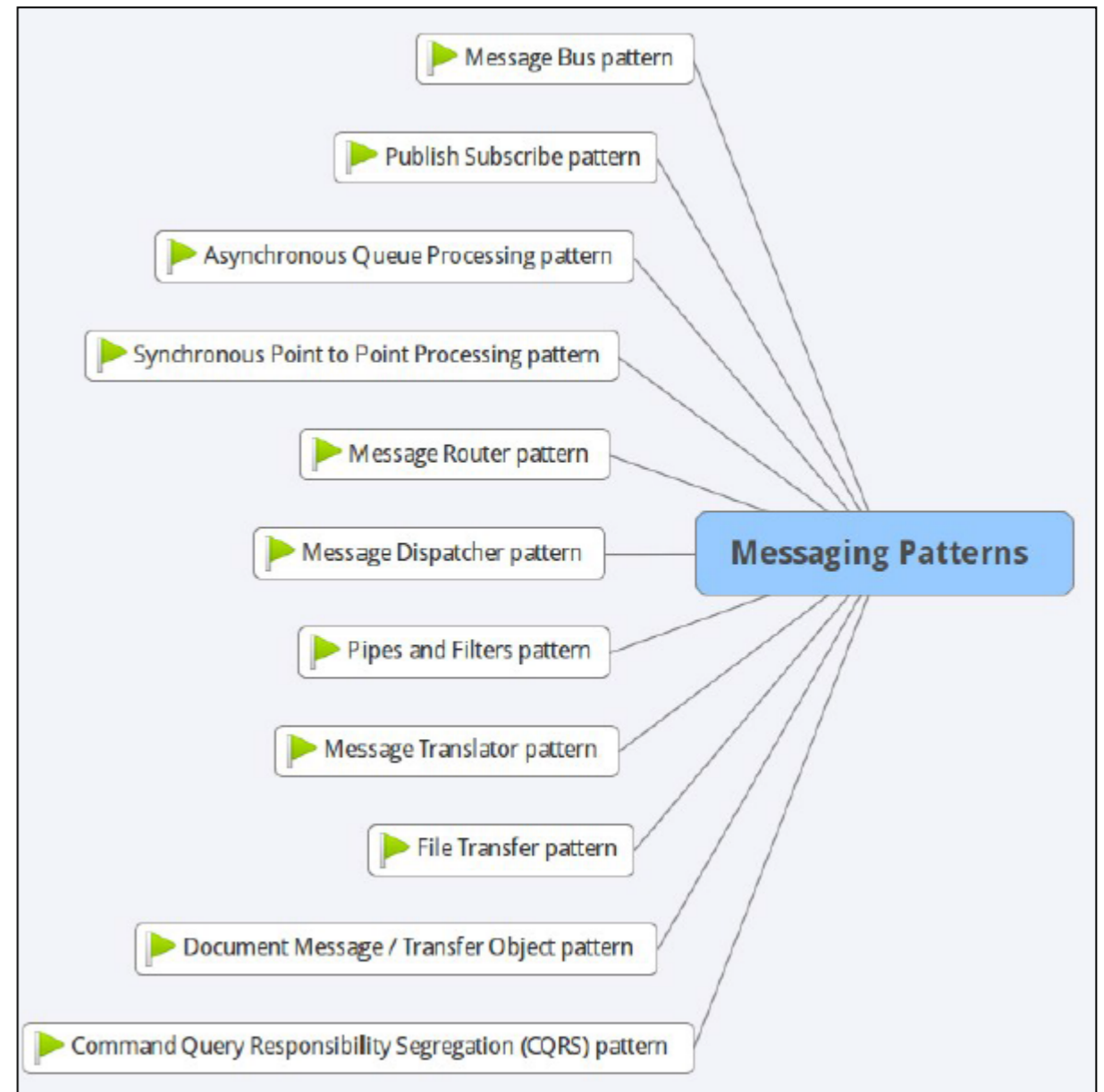
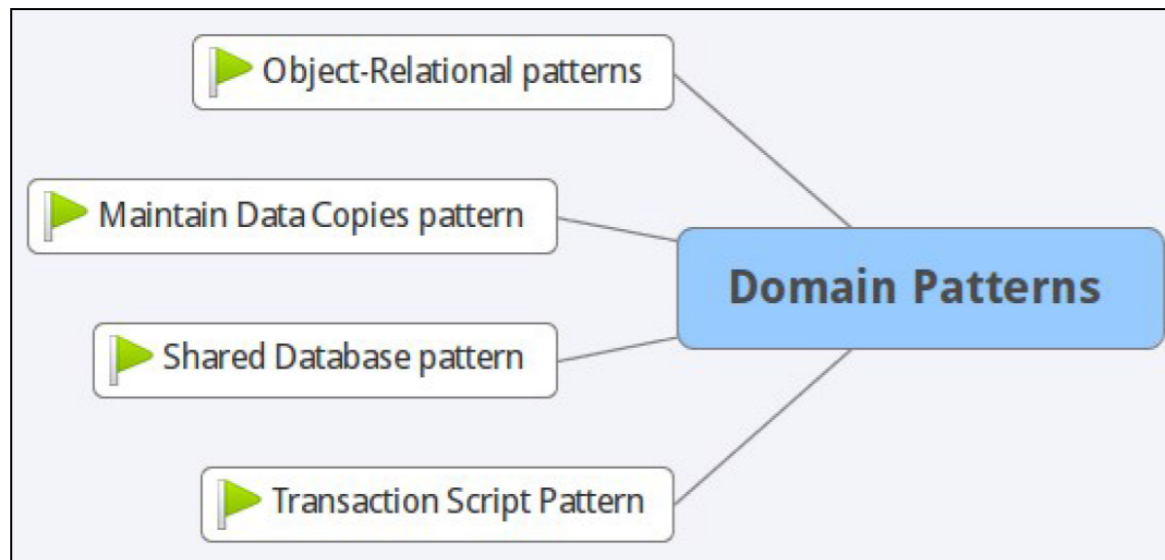
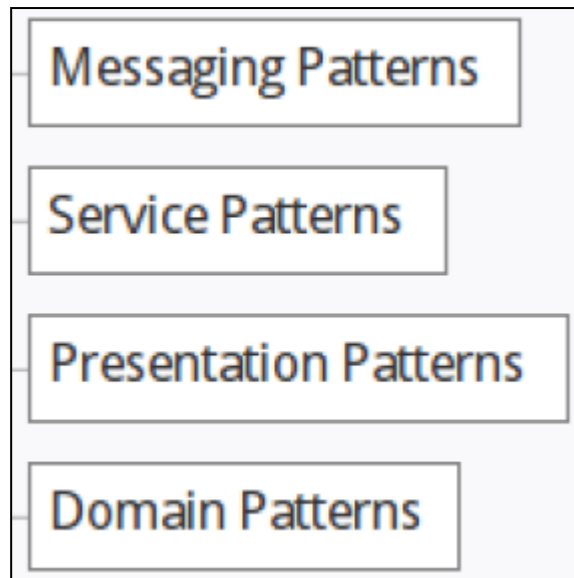
Design Patterns:

- Provides a scheme for refining the subsystems or components of a software system, or the relationships between them. It describes commonly recurring structure of communicating components that solves a general design problem within a particular context.

Idioms:

- A low-level pattern specific to a programming language. An idiom describes how to implement particular aspects of components or the relationships between them using the features of the given language.

Architectural Patterns Examples





Note: this area is covered in detail in the Design Patterns Module.


Singleton Pattern

```
public class FileLogger{  
    private static FileLogger logger;  
  
    private FileLogger(){  
    }  
  
    public static FileLogger getLogger(){  
        if (logger == null){  
            logger = new FileLogger();  
        }  
        return logger;  
    }  
  
    public boolean log(String msg){  
        try{  
            PrintWriter writer = new PrintWriter(new FileWriter("log.txt", true));  
            writer.println(msg);  
            writer.close();  
        }  
        catch (FileNotFoundException ex){  
            return (false);  
        }  
        catch (IOException ex){  
            return (false);  
        }  
        return (true);  
    }  
}
```

Design Patterns Examples
























 **Creational Patterns:** Used to construct objects such that they can be decoupled from their implementing system.

 **Structural Patterns:** Used to form large object structures between many disparate objects.

 **Behavioral Patterns:** Used to manage algorithms, relationships, and responsibilities between objects.

Object Scope: Deals with object relationships that can be changed at runtime.

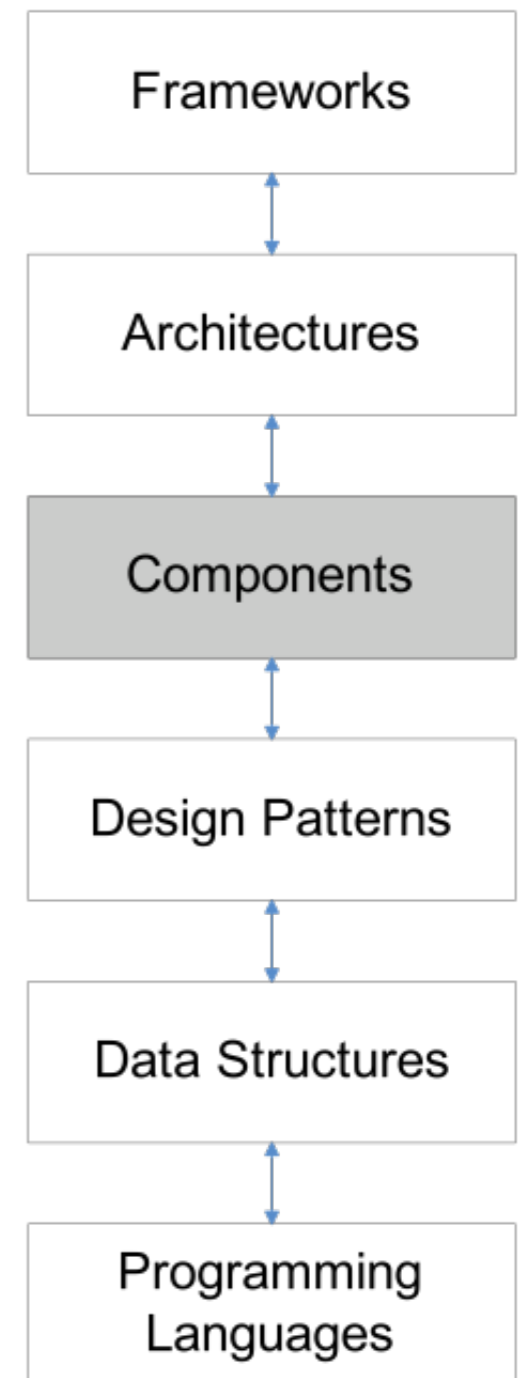
Class Scope: Deals with class relationships that can be changed at compile time.

| | | | | | |
|---|----------------------------|---|----------------|---|-----------------|
|  C | Abstract Factory |  S | Decorator |  C | Prototype |
|  S | Adapter |  S | Facade |  S | Proxy |
|  S | Bridge |  C | Factory Method |  B | Observer |
|  C | Builder |  S | Flyweight |  C | Singleton |
|  B | Chain of Responsibility |  B | Interpreter |  B | State |
|  B | Command |  B | Iterator |  B | Strategy |
|  S | Composite |  B | Mediator |  B | Template Method |
| | |  B | Memento |  B | Visitor |

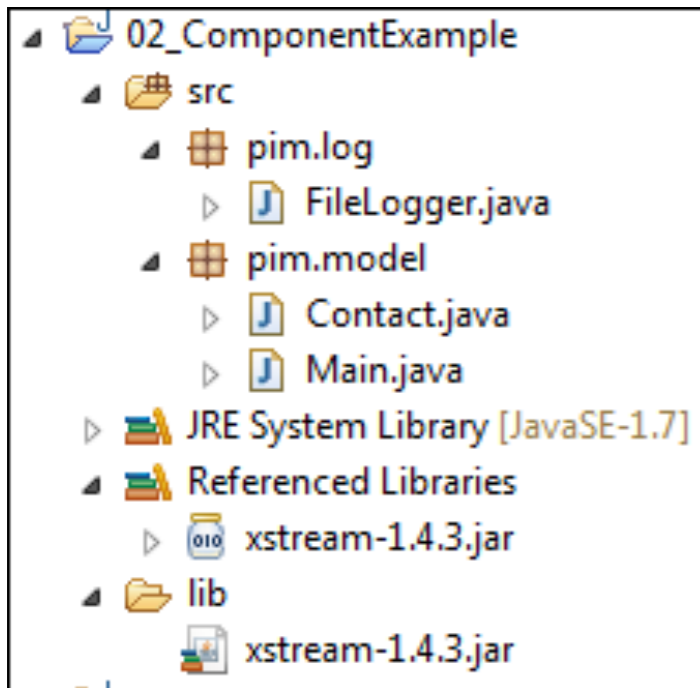
Note: this area is covered in detail in the Design Patterns Module.

Components

- Software components are binary units of:
 - independent production,
 - acquisition,
 - deployment
- that interact to form a functioning program.
(Szyperski, 1998)
- Emphasis on reusable units.
- A component must be compatible and interoperate with a whole range of other components.
- Two main issues arise with respect to interoperability information:
 - How to express interoperability information
 - How to publish this information



Exploring a Component (xstream-1-4-3.jar)



```
public class Main{
    public static void main(String[] args) throws IOException{
        FileLogger logger = FileLogger.getLogger();

        logger.log("Creating contact list");

        List<Contact> contacts = new ArrayList<Contact>();
        logger.log("Adding contacts");
        contacts.add(new Contact("Mike"));
        contacts.add(new Contact("Mary"));
        contacts.add(new Contact("Jim"));
        System.out.println(contacts);

        logger.log("Serializing contacts to XML");
        XStream xstream = new XStream(new DomDriver());
        ObjectOutputStream out =
            xstream.createObjectOutputStream
                (new FileWriter("contacts.xml"));
        out.writeObject(contacts);
        out.close();

        logger.log("Finished - shutting down");
    }
}
```

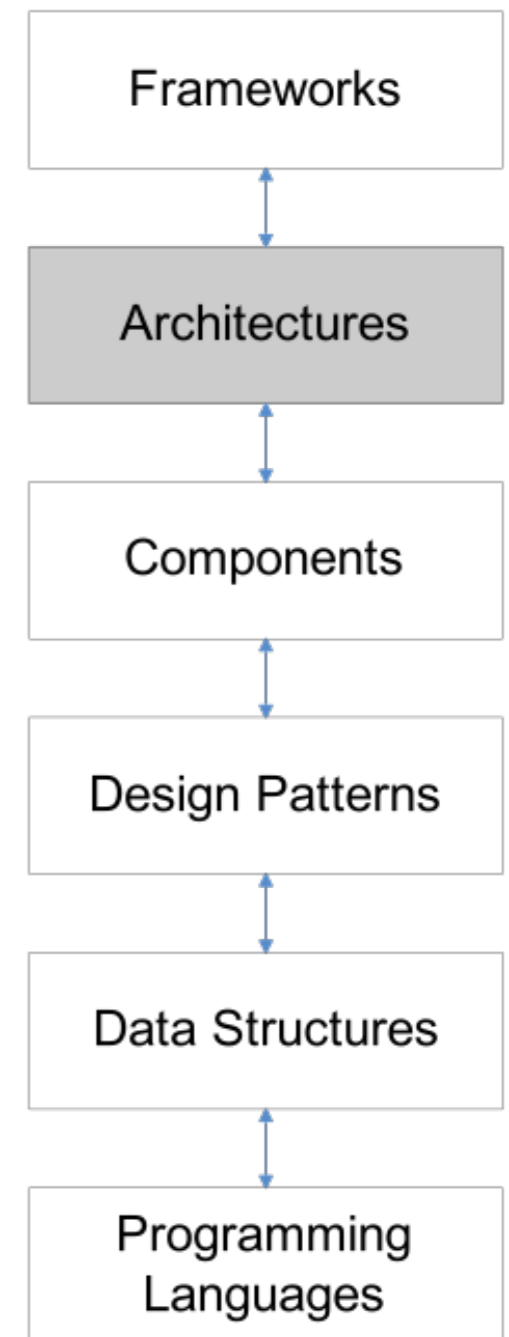
```
<object-stream>
  <list>
    <pim.model.Contact>
      <name>Mike</name>
    </pim.model.Contact>
    <pim.model.Contact>
      <name>Mary</name>
    </pim.model.Contact>
    <pim.model.Contact>
      <name>Jim</name>
    </pim.model.Contact>
  </list>
</object-stream>
```

More Component Definitions

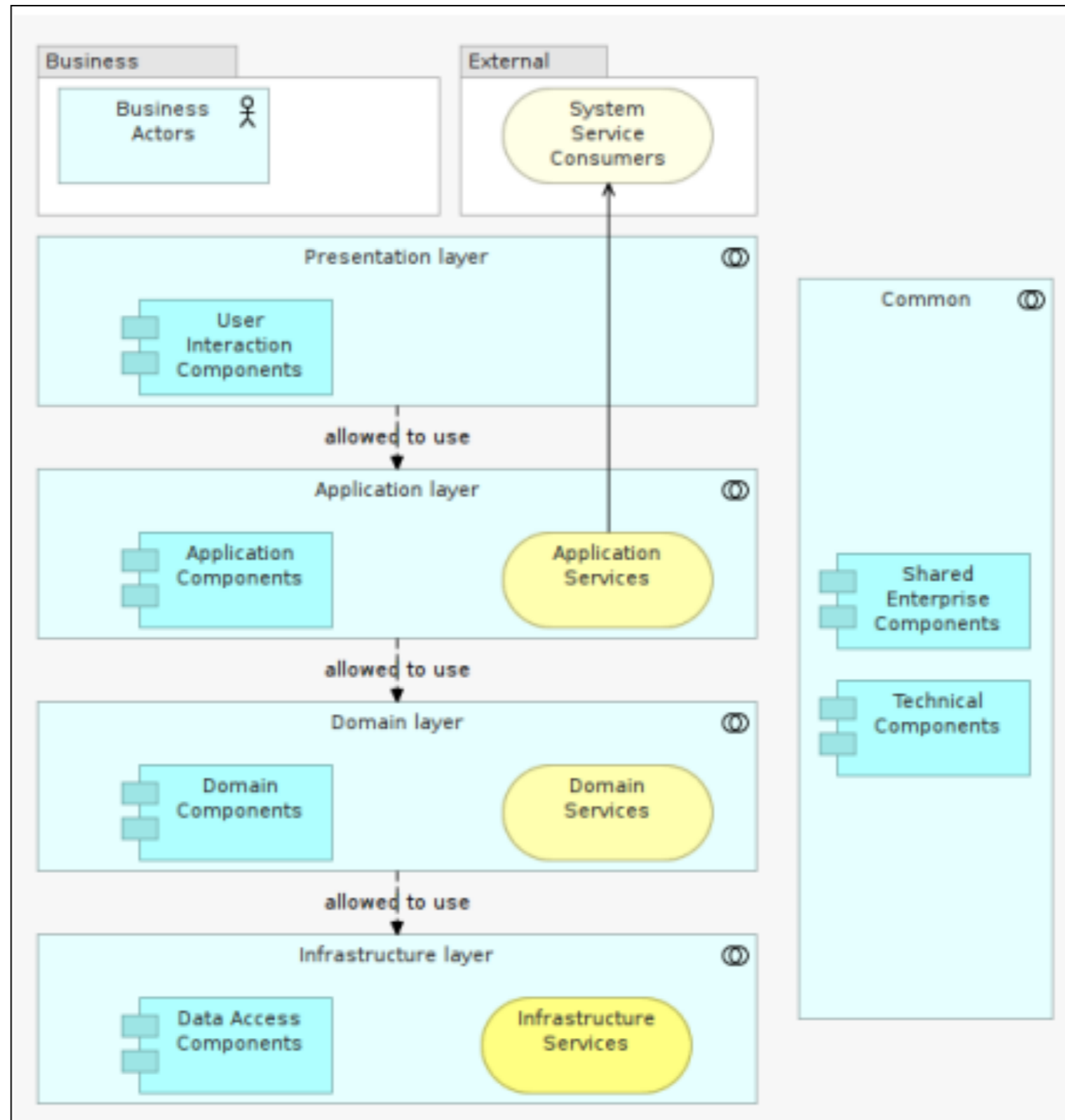
- "A component is a nontrivial, nearly independent, and replaceable part of a system that fulfills a clear function in the context of a well-defined architecture. A component conforms to and provides the physical realization of a set of interfaces." (Philippe Krutchen, Rational Software)
- "A runtime software component is a dynamically bindable package of one or more programs managed as a unit and accessed through documented interfaces that can be discovered at runtime." (Gartner Group)
- "A component is a physical and replaceable part of a system that conforms to and provides the realization of a set of interfaces...typically represents the physical packaging of otherwise logical elements, such as classes, interfaces, and collaborations." (Grady Booch, Jim Rumbaugh, Ivar Jacobson, The UML User Guide, p. 343)

Architecture

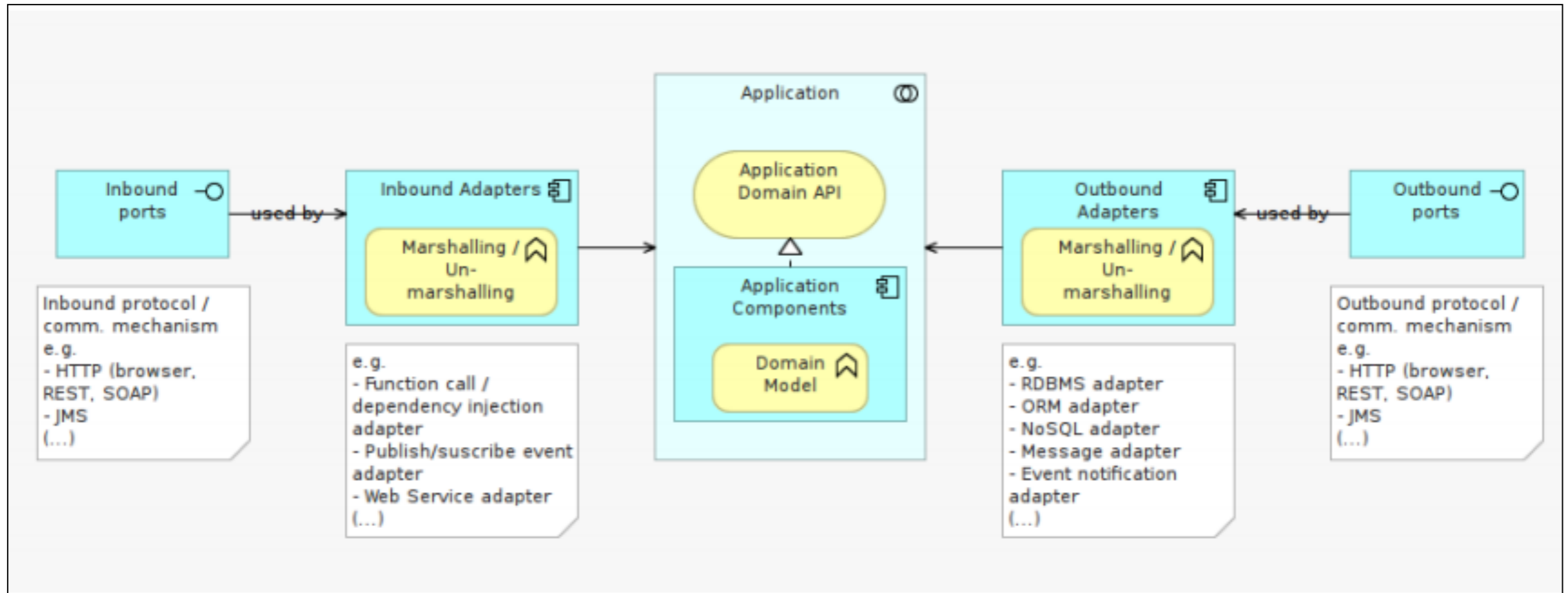
- The software architecture of a program or computing system is:
 - the structure or structures of the system, which comprise software components,
 - the externally visible properties of those components, and
 - the a set of rules that govern relationships among them.
- An architectural style is a family of software architectures, defining types of components and types of connections, and rules describing how to combine them.
- A software architecture is an instantiation of an architectural style for a certain system. The components and connections may be decomposed into architectures themselves.



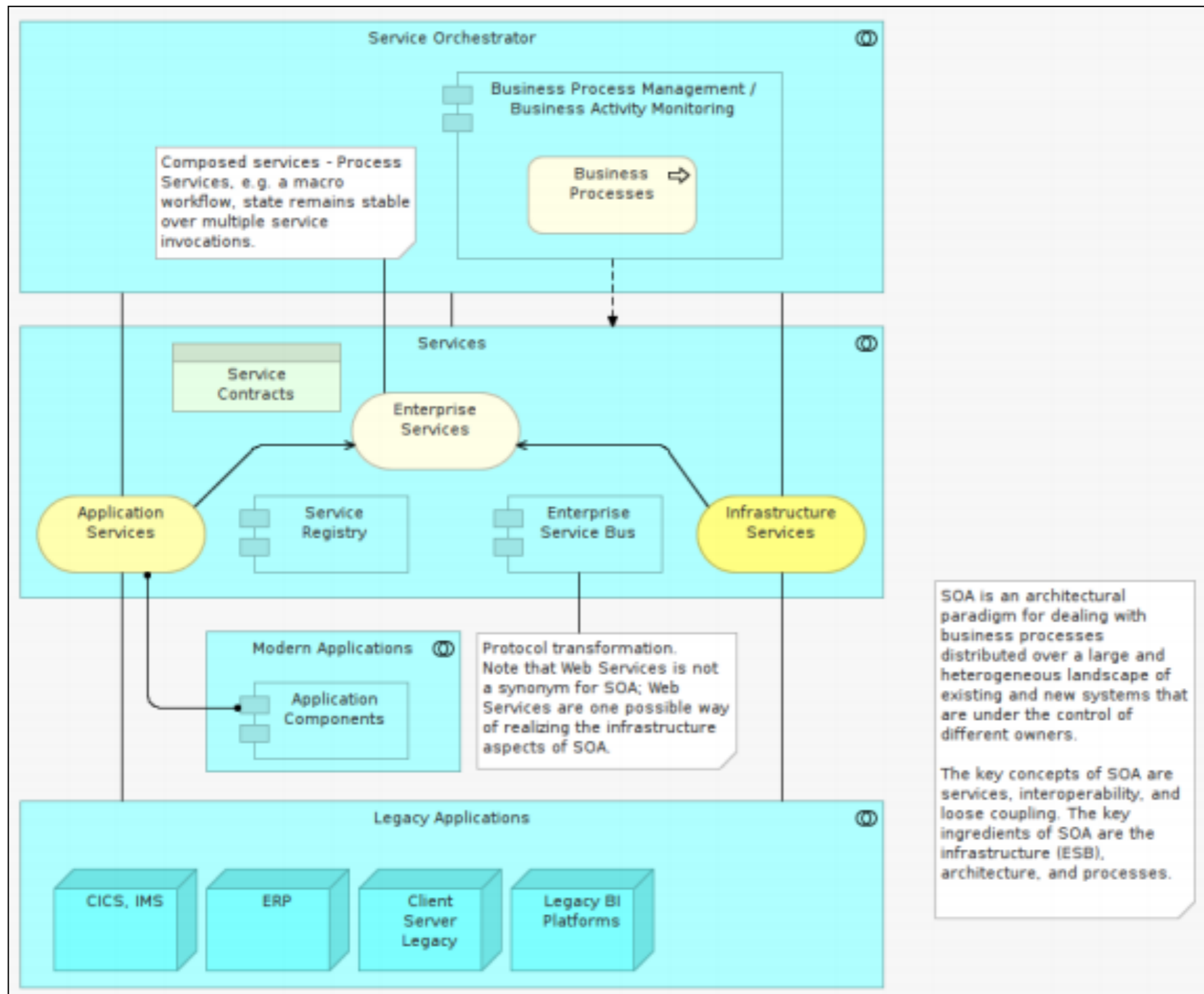
Architecture Example: Layered



Architecture Example: Ports and Adaptors



Architecture Example: Service Oriented

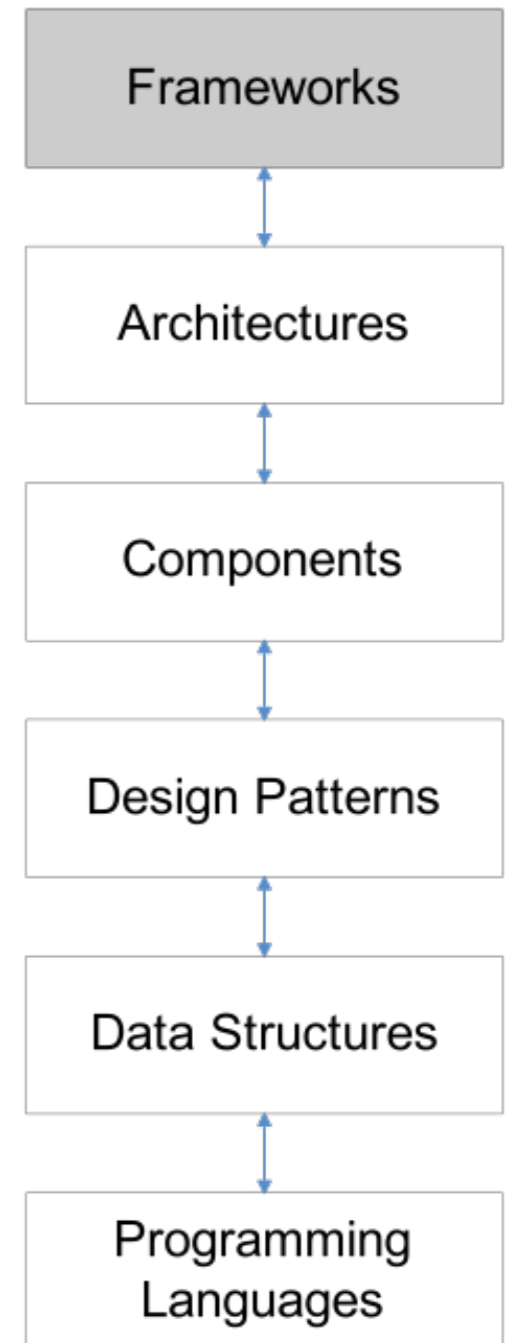


SOA is an architectural paradigm for dealing with business processes distributed over a large and heterogeneous landscape of existing and new systems that are under the control of different owners.

The key concepts of SOA are services, interoperability, and loose coupling. The key ingredients of SOA are the infrastructure (ESB), architecture, and processes.

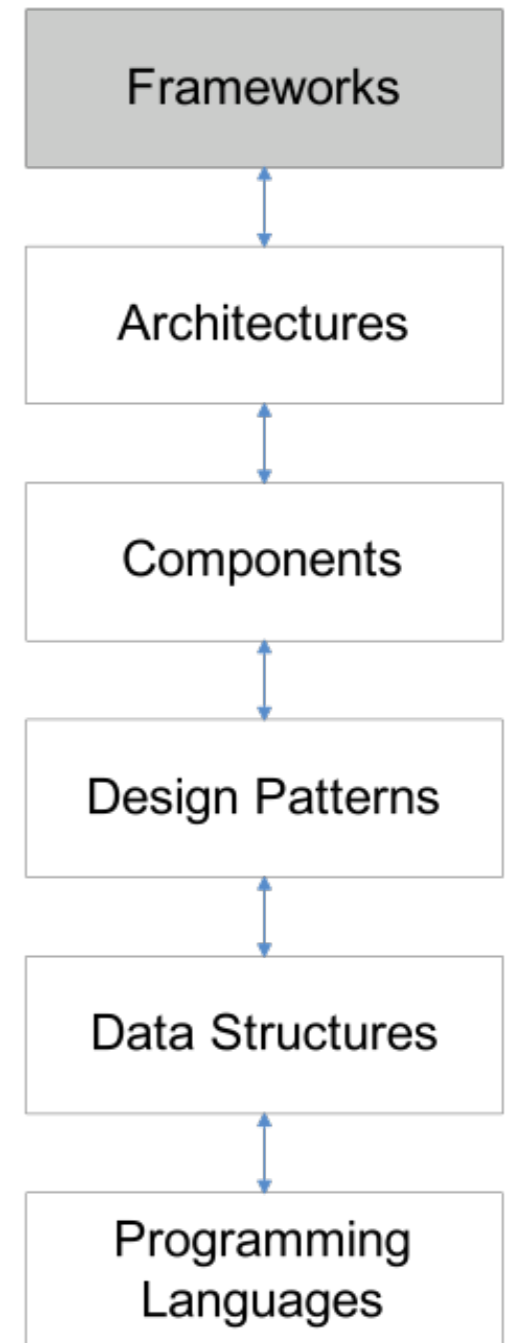
Frameworks

- A framework is a set of related components which you:
 - Specialize
 - Integrate and/or
 - Instantiate
- to implement an application or subsystem.
- A framework is usually a semi complete application containing dynamic and static components that can be customized to produce applications.

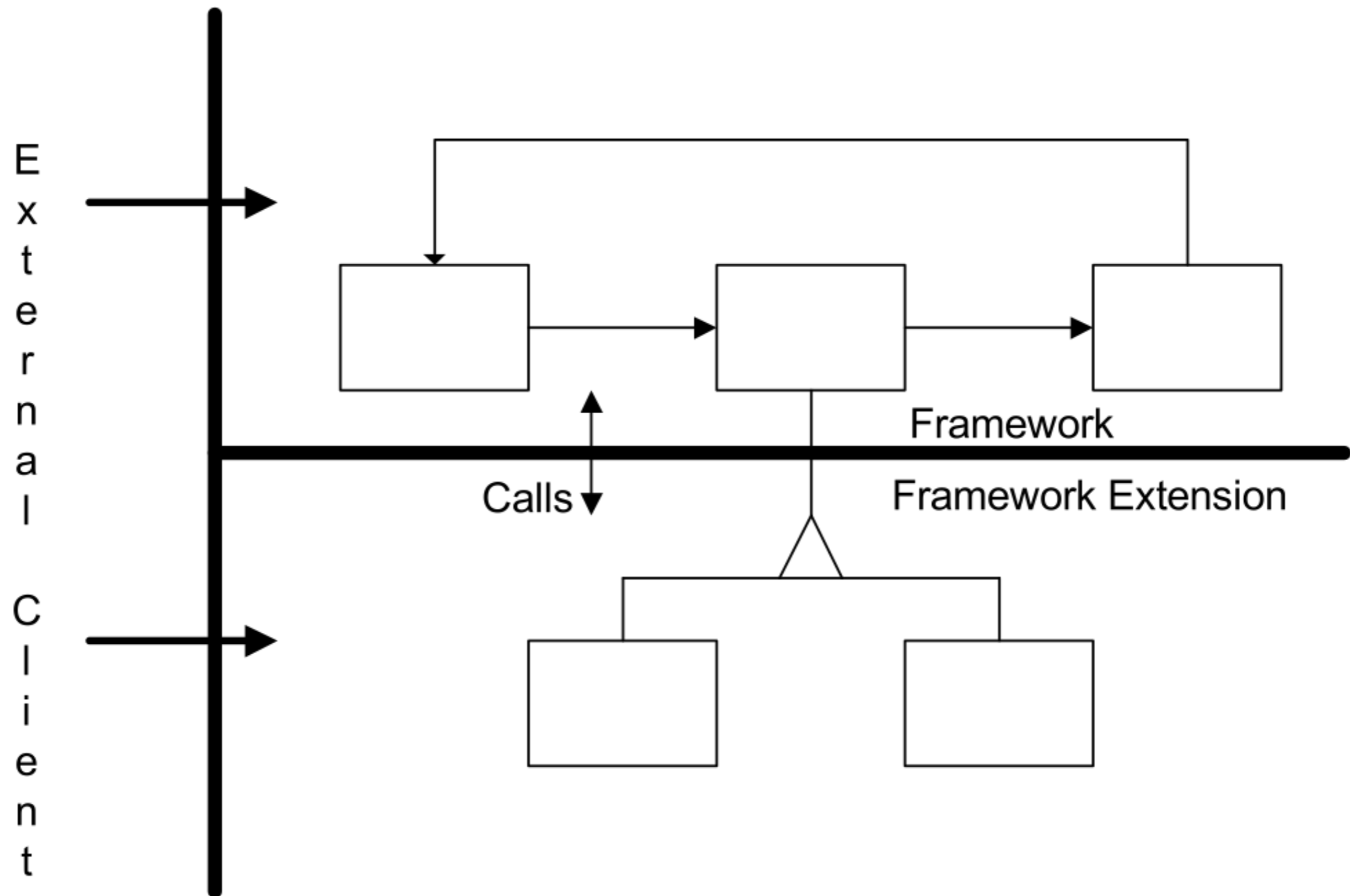


Frameworks

- Frameworks are targeted for a particular application domain & consists of a set of classes (abstract & concrete), whose instances:
 - collaborate
 - are intended to be extended, i.e. reused (abstract design)
 - do not have to address a complete application domain (allowing for composition of frameworks)
- Emphasize stable parts of the domain and their relationships and interactions.



Framework Structure



Framework Example

- ▼ > spacebook-p2 [spacebook-p2 master]
 - ▼ app
 - ▶ (default package)
 - ▶ controllers
 - ▶ models
 - ▶ views
 - ▶ views.nav
 - ▼ test
 - ▼ (default package)
 - ▶ ApplicationTest.java
 - ▶ FriendsTest.java
 - ▶ IntegrationTest.java
 - ▶ MessagesTest.java
 - ▶ UsersTest.java
 - ▶ Referenced Libraries
 - ▶ JRE System Library [Java SE 7 [1.7.0_21]]
 - ▶ > conf
 - ▶ logs
 - ▶ > project
 - ▶ public
 - ▶ target
 - ▶ README



The screenshot shows the Play Framework website homepage. At the top left is the 'play' logo. To its right are navigation links for 'Download', 'Documentation', and 'Get Involved'. Below the navigation is a green banner with the text 'The High Velocity Web Framework For Java and Scala' and a play button icon. A video player is embedded in the center, titled 'Introduction to Play Framework for Java developers'. Below the video player are two call-to-action buttons: 'Download 2.1.4' and 'GETTING STARTED WITH Java & Scala'. At the bottom, there is a main heading 'Play Framework makes it easy to build web applications with Java & Scala.' followed by two paragraphs of text describing the framework's architecture and resource consumption.

play

Download Documentation Get Involved

The High Velocity Web Framework For Java and Scala

Introduction to Play Framework for Java developers

GET THE LATEST PACKAGE

Download 2.1.4

or [browse all versions](#)

GETTING STARTED WITH

Java & Scala

or [read full documentation](#)

Play Framework makes it easy to build web applications with Java & Scala.

Play is based on a lightweight, stateless, web-friendly architecture.

Built on Akka, Play provides predictable and minimal resource consumption (CPU, memory, threads) for highly-scalable applications.

Agile Software Development Module

- Assumptions:
 - General Programming Ability (not necessarily java)
- Focus for this course:
 - SOLID Principles within OO Programming
 - Test Driven Software Development in Java
 - Effective Build Processes
 - Network Programming
 - Beyond Java (Kotlin)