Software Engineering in Industrial Practice (SEIP)

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Architecture Principles

- **FL Factual Locality**: Resources are as spatially and temporarily local-scoped to solution components as possible
- **ES Exclusive Sovereignty**: Exclusive resource sovereignty by the enclosing component
- **CA Contextual Adequacy**: Neither insufficient nor exaggerated solutions for each context
- **SP Solution-oriented Proportionality**: Good expected proportionality in each solution context
- **HC Holistic Consistency**: Full consistency across all aspects of a solution
- **SH Structural Homogeneity**: Maximum homogeneity in the structure of a solution
- **CR Constructional Reusability**: High reuse of proven structural components and partial solutions
- **FS Fulfilled Standards**: Compliancy to standards as much as possible, as long as the benefits predominate the drawbacks
- **FA Functional Abstraction**: Suitable level of abstraction across all functional aspects of a solution
- **FT Functional Traceability**: Suitable traceability across all functional aspects of a solution
- **CI Communicative Interoperability**: Maximum interoperability in communication between solutions
- **EH Environmental Harmony**: Maximum harmony in the integration of the solution with its environment
- **AR Avoided Redundancy**: Minimum total number of copies of a single resource
- **MS Minimum Special-Cases**: Minimum total number of special-cases in a solution
- **LS Logical Separation**: Separation of concerns between the components of a solution
- **SM Structural Modularity**: Splitting of a solution into manageable structural components
- **LC Loose Coupling**: Loose coupling in communication and referencing between solution components
- **SC Strong Cohesion**: Strong relationship between functionalities within a single solution component
- **OE Open Extensibility**: Solution components can be extended by third-parties at fixed interfaces
- **CC Closed Changeability**: Solution components are protected against direct change by third-parties
- **UI Unique Identification**: Unique identification of all components of a solution
- **UA Uniform Addressing**: Uniform addressing of all components of a solution
- **OS Overall Simplicity**: All design aspects of a solution are as simple as possible and only as complicated as necessary
- **EC Encapsulated Complexity**: Complex related aspects of a solution are encapsulated into a single responsible component
- **LA Least Astonishment**: All design aspects of a solution are as little astonishing as possible and only as esoteric as necessary
- **SD Self Documentation**: All design aspects of a solution are preferably self-documenting
- **OD Operational Delight**: The solution provides users true delight even on long-term operation
- **AA Artistic Aesthetics**: The solution has holistic aesthetics and artistic love in details

In IT Architecture, one follows **Architecture Principles**, which summarize basic principles and procedures. One knows 28 principles that can be grouped into 14 pairs since always two principles are very close regarding the content. The architect should follow the principles in general, but he may violate them as long as he has a good reason for it. The best reason would be a particular project-specific requirement.

Note: The principle **Logical Separation** (aka **Separation of Concern**) is one of the most important, since from it several other principles almost automatically follow, including, e.g., **Structural Modularity**.

Note: The principles **Loose Coupling** and **Strong Cohesion** are known in the literature as the combined principle “Loose Coupling, Strong Cohesion.” The principles **Open Extensibility** and **Closed Changeability** are known in the literature as the combined principle “Open-Close.”

Note: The principle **Overall Simplicity** is one of the hardest to implement because nothing in IT is really easy. Everything only looks simple as long as one does not have enough understanding about it. After that, one first has to make it “simple” painstakingly. That’s the art of architecture: simplify difficult things! If something cannot be simplified further and still has a certain complexity, following the principle **Encapsulated Complexity**, one at least can try to shadow it.

Questions

- List at least 4 essential **Architecture Principles**!

ARCHITECTURE FUNDAMENTALS

Component Design

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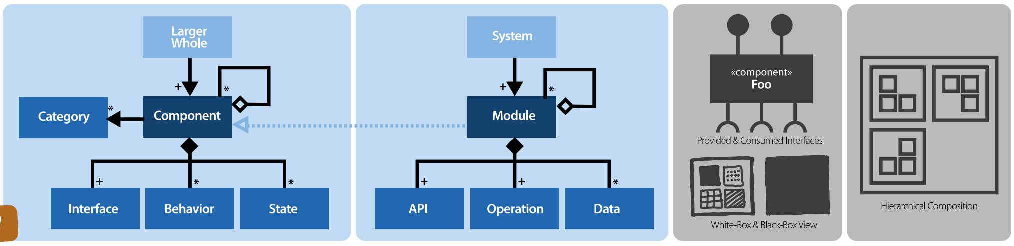
Definition of a Component (of a Larger Whole):
a **know-how encapsulating**, potentially **reusable** and **substitutable unit of hierarchical composition** with **explicit context dependencies**, which **hides the complexity** of its optional **behavior** and **state** realization behind **small contractually specified interfaces**, defines its **added value** in terms of **provided** and **consumed** interfaces and optionally belongs to zero or more **categories** of similar units.

Definition of a Module (of a System):
a know-how encapsulating, potentially reusable and substitutable **source-code** unit of hierarchical composition with explicit context dependencies which hides the complexity of its **operation** and **data implementation** behind small contractually specified **Application Programming Interfaces (API)**, defines its added value in terms of provided and consumed **APIs** and optionally belongs to zero or more categories of similar units.

Example Categories of Components:
- Namespace
- Directory, File
- Configuration, Section, Directive
- Host, Virtual Machine, Container
- Process Group, Process, Thread
- Application, Microservice, Program
- Package, Class, Function
- Database, Schema, Table, Record
- Datamodel, Entity Group, Entity
- User Interface, Dialog, Widget

Any group of anything!



How to find Components (or Modules)?

- **DCA Domain Concept Abstraction** — Model domain concepts as entity components and then group at higher levels.
- **SOC Separation of Concerns** — Build components for clearly distinct concerns.
- **USE Reusability Potential** — Decide on components based on their reusability potential.
- **UCC Use-Case Clustering** — Build domain components for each use-case or each logical use-case cluster.
- **SRP Single Responsibility Principle** — Build components for clearly distinct responsibilities.
- **DCC Divide & Conquer Complexity** — Master overall complexity by splitting larger things into smaller things.
- **DDD Domain-Driven Design** — Model domain "Bounded Contexts" through DDD and derive components from them.
- **CNC Coupling and Cohesion** — Decide on components based on their loose coupling and strong cohesion.
- **CCC Cross-Cutting Concerns** — Build common cross-cutting concerns as cross-cutting components.
- **OOD Object-Oriented Design** — Model Object-Oriented Design entities (and/or OOP constructs) as components.
- **DEP Dependency Encapsulation** — Decide on components based on their encapsulation of dependencies.
- **PAT Architecture Patterns** — Build inner components to comply to outer structure, slicing and clustering architectures.

Software Architecture is all about **Components** and **Interfaces**. Therefore, **Component Design** is a central task of the architect.

A component **encapsulates** a certain **know-how**, is **potentially reusable** and **replaceable**. A component has a **behaviour** and a **state** and hides the internal complexity of both behind "small" **contractual interfaces**. It provides its added value through the difference between provided and consumed interfaces. It can be considered as a **Whitebox** or as a **Blackbox**, depending on whether the internal details can be viewed from outside or not. Components are arranged hierarchically, may belong to specific **categories** and have **explicit dependencies** among each other.

A distinction is made between the more general concept of **Component** ("any group of anything") and the more specific concept of the (via Source code defined) **Module**.

Components can be found in many different ways. Most of them are directly derived from existing methods, principles, or patterns. The two most important ways for a component cut in practice are: **Separation of Concerns** (which unique concern or task has the component?) and **Single Responsibility Principle** (what is the unique responsibility of the component?).

Questions

- List at least 7 properties/aspects which a Component has!
- What are the two most important ways to find a component cut in practice?

ARCHITECTURE FUNDAMENTALS

Interface Design

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Definition of an Interface: well-defined shielding and abstracting **boundary** of a passive, providing **component**, consisting of one or more distinguished, **outside-in** designed, **interaction endpoints**, each accessed and controlled by active, consuming components through the **exchange** of **input/output information** and operating under a certain **syntactical** and **semantical contract**.

Endpoint: Name, Directive, Command, Function, Method, Procedure, Address, Port, URL, Dialog, ...

Exchange: Option, Argument, Parameter, Return Value, Result, Request/Response Message, Error/Exception, Interaction, ...

Contract: Syntax, Pre-Condition, Invariant, Post-Condition, Side-Effect, Idempotence, Determinism, Functionality, ...

Types of Software Interfaces

- **API** — **Application Programming Interface**: Example: `foo("bar", 42)` (call and use)
- **SPI** — **Service Provider Interface**: Example: `register("foo", (x,k) => ...)` (extend and implement)
- **SCI** — **Startup Configuration Interface**: Examples: INI, Java Properties, TOML, YAML, JSON, XML, etc.
- **BPI** — **Batch Processing Interface**: Examples: Unix at(1), Unix ts(1), GNU Batch, Spring Batch, Java Batch, SAP LO-BM, etc.
- **CLI** — **Command-Line Interface**: Example: `foo -x --bar=baz quux`
- **GUI** — **Graphical User Interface**: Examples: Windows/WPF, macOS/Cocoa, KDE/Qt, GNOME/GTK
- **RNI** — **Remote Network Interface**: Examples: GraphQL-IO, HTTP/REST, SOAP, RMI, WebSockets, AMQP, MQTT, etc.

Characteristics of Good Interfaces

- **AP** — **Appropriate & Proportional**: Appropriate to consumer requirements, proportional to provider functionality.
- **SA** — **Shielding & Abstracting**: Shields from direct access, abstracts and hides implementation details.
- **IE** — **Inviting & Expressive**: Invites through "outside – in" design, powerful in expressiveness.
- **IF** — **Intuitive & Foolproof**: Intuitive to grasp and use, hard to misuse.
- **OC** — **Orthogonal & Concise**: Supports combinatorial use-cases, causes minimum boilerplate.
- **TP** — **Tolerant & Predictable**: Tolerant on input, predictable on output.
- **EC** — **Extensible & Compatible**: Easy to extend for providers, backward/forward-compatible for consumers.

Selected Interface Design Patterns

- **IVF** — **Interface Version & Features**: Provide version and feature information for algebraic comparison and feature detection.
- **2LF** — **Leaky Two-Layer Facade**: Provide higher-level convenient use-case and lower-level orthogonal feature interface.
- **EVE** — **Event Emitter**: Emit events to previously registered, interested consumers.
- **CTX** — **Multi-Context**: Use contexts to distinguish between different usage scenarios and to carry common info.
- **CEF** — **Configure-Execute Flow**: Spread use-cases onto a flow of configuration exchanges and a final executional exchange.
- **IOC** — **Inversion Of Control**: Invert control on asynchronous operations via callbacks, promises or async. mechanisms.
- **HMR** — **Human/Machine Responses**: Support humans and machines in outputs through both description and parsing-free info.

An **interface** is a **well-defined**, **shielding**, **abstracting boundary** of a passive providing **component**, which consists of one or more clearly distinguishable **interaction endpoints**.

At each interaction endpoint, an active, consuming component is accessed through the **exchange** of **input/output information** and is operated under a specific **syntactical** and **semantical contract**.

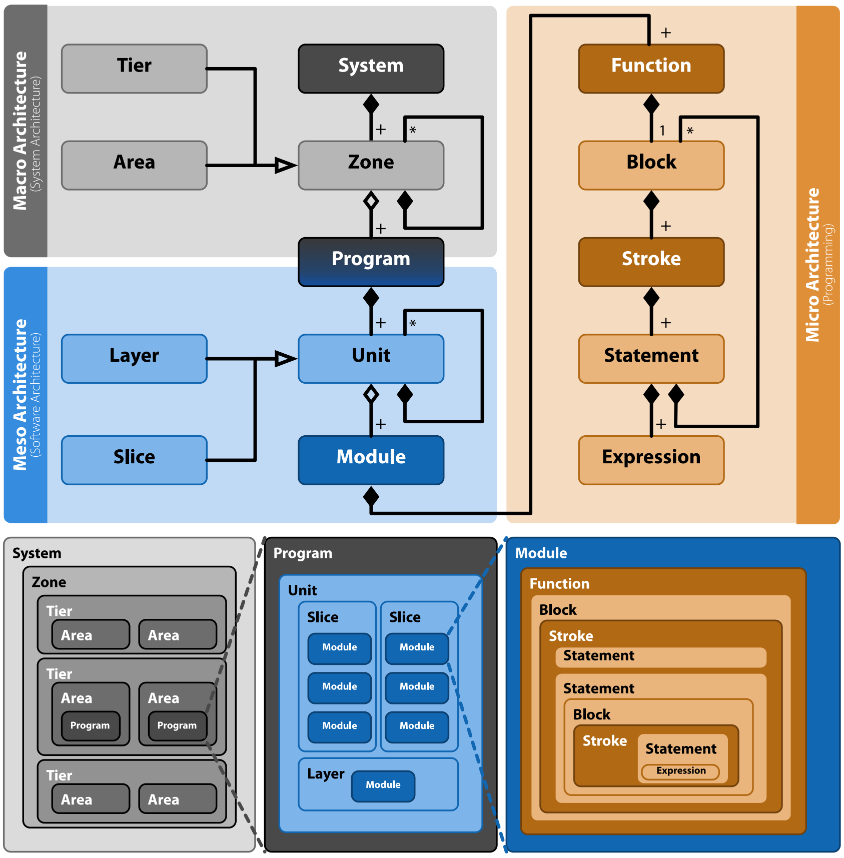
There are numerous kinds of interfaces, all of which meet this definition. In addition, "good" interfaces have specific Properties/Characteristics. The four of the best properties are: **Proportional** (the interface is smaller and in size proportional to the functionality behind it), **Expressive** (the interface provides a powerful programming model), **Orthogonal** (the interface allows combinatorial Use-Cases), and **Concise** (the interface generates little "Boilerplate Code" during use).

There are numerous software patterns for interfaces. An interesting pattern is the **Leaky Two-Layer Facade**, in which a library has two interfaces: an upper, convenient, and Use-Case-related interface and a lower, orthogonal Feature-related interface. The trick is that the upper interface is implemented by the lower interface only and that the lower interface "shines through" ("leaky" or Open Layering).

Questions

- List at least 8 properties/aspects which define an **Interface**!
- List at least 4 properties/characteristics of **good Interfaces**!

Component Hierarchy



Zone: Structuring **Tier** or **Area** within a **System** (or within an outer **Zone**).

Unit: Structuring **Layer** or **Slice** within a **Program** (or within an outer **Unit**).

Tier: Special kind of ranked **Zone** for horizontally grouping (logically or spatially distinct and network-linked) **Programs** or other **Tiers** and **Areas**.

Layer: Special kind of ranked **Unit** for horizontally grouping (logically distinct and memory-linked) **Modules** or other **Slices** and **Layers**.

Area: Special kind of unranked **Zone** for vertically grouping (logically or spatially distinct and network-linked) **Programs** or other **Tiers** and **Areas**.

Slice: Special kind of unranked **Unit** for vertically grouping (logically distinct and memory-linked) **Modules** or other **Slices** and **Layers**.

System: One or more network-linked **Programs**, forming a solution as a whole and the primary unit of thinking at the level of Macro Architecture.

Module: Know-how encapsulating, potentially reusable group of **Functions** and primary unit of thinking at the level of Meso Architecture.

Program: Stand-alone, self-contained, executable piece of software and primary unit of thinking at the level of both Macro and Meso Architecture.

Function: Operation of a **Module**, with a well-defined interface, and one of the two primary units of thinking at the level of Micro Architecture.

Statement: Execution of a single action, specified through one or more **Expressions** and zero or more inner **Blocks**.

Stroke: Logical sequence of **Statements** in a **Block** and one of the two primary units of thinking at the level of Micro Architecture.

Block: Sequence of one or more **Strokes** within a **Function** or an outer **Statement** and scope for variables of inner **Statements**.

Expression: Simple or complex representation of a single data value.

A **Component** is “any group of anything” in Software Architecture. Nevertheless, there are prominent component categories that form an particular, omnipresent **Component Hierarchy** in Software Engineering. This consists of the three levels **Macro Architecture** (aka System Architecture), **Meso Architecture** (aka Software Architecture) and **Micro Architecture** (aka Programming).

In the Macro Architecture level, one has to deal with **Systems** (aka Applications) which consist of hierarchically arranged infrastructural **Zones**, which can be either (horizontal) **Tiers** or (vertical) **Areas**. The **Zones** themselves consist of **Programs**.

These **Programs**, at the level of the Meso Architecture, consist of hierarchically arranged **Units**, which can be either (horizontal) **Layers** or (vertical) **Slices**. The **Units** themselves consist of **Modules**.

The **Modules**, at the level of the Micro Architecture, consist of **Functions** and these consist of hierarchically arranged (lexical) **Blocks**, which in turn consist of **Strokes** (aka “Thoughts”), which in turn consist of **Statements** and these at the end consist of individual **Expressions**.

The five **Primary Units of Thinking** are **Systems**, **Programs**, **Modules**, **Functions** and **Strokes**.

Questions

- Which three component categories are known at the level of Macro Architecture (aka System Architecture)?
- Which three component categories are known at the level of Meso Architecture (aka Software Architecture)?
- Which five component categories are known at the level of Micro Architecture (aka Programming)?

ARCHITECTURE FUNDAMENTALS

Application Composition

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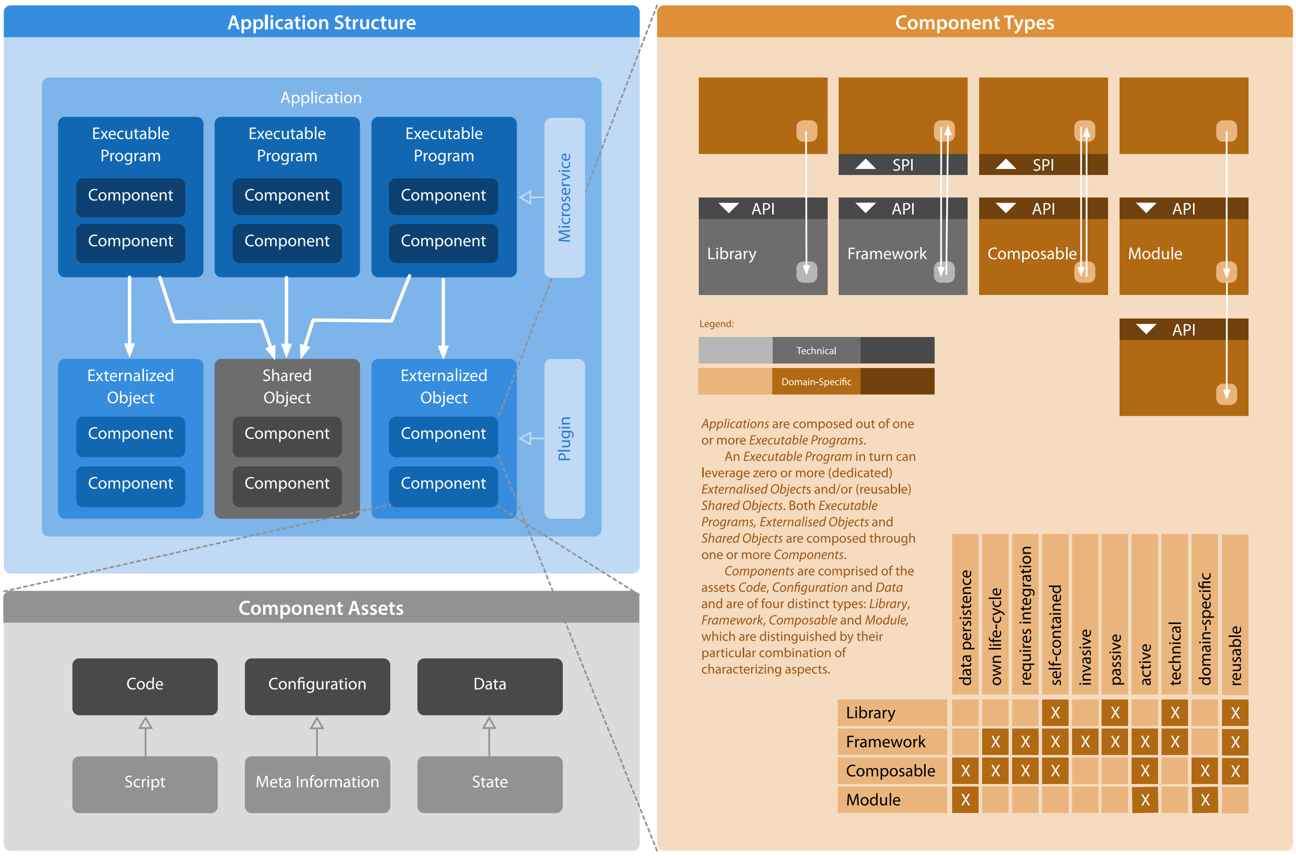

	data persistence	own life-cycle	requires integration	self-contained	invasive	passive	active	technical	domain-specific	reusable
Library				X		X		X		X
Framework		X	X	X	X	X	X	X		X
Composable	X	X	X	X			X		X	X
Module	X						X		X	

Applications are composed out of one or more Executable Programs. An Executable Program in turn can leverage zero or more (dedicated) Externalised Objects and/or (reusable) Shared Objects. Both Executable Programs, Externalised Objects and Shared Objects are composed through one or more Components. In a Microservice Architecture, the Executable Programs are called Microservices. In a Plugin Architecture, the Externalised Objects are called Plugins.

There are four distinct types of Components: Library, Framework, Composable and Module. They can be distinguished by their particular combination of characterizing aspects. Most prominently, whether they provide an Application Programming Interface (API) to the consumer of the Component and/or whether they require the consumer of the Component to fulfill some sort of Service Provider Interface (SPI).

Questions

- What is the main difference between a Library and a Framework?