Software Engineering 1

Software Architecture

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Kielce, November 24, 2025

Outline

Motto

"A doctor can bury his mistakes but an architect can only advise his clients to plant vines."

-- Frank Lloyd Wright

Software Architecture

There is no agreement among experts on what the software architecture actually is. Here are some definitions:

Definition (Software Architecture by Ralph Johnson)

The Software Architecture is the shared understanding that expert developers have of the system design.

`https://martinfowler.com/architecture/`

Definition (Software Architecture by Len Bass, et al.)

The Software Architecture of a system is the set of structures needed to reason about the system, which comprise software elements, relations among them, and properties of both.

Software Architecture in Practice

Software Architecture

Definition (Software Architecture by Robert C. Martin)

The architecture of a software system is the shape given it by those who build it.

Clean Architecture

Definition (Software Architecture by Software Engineering Institute)

The software architecture of a system represents the design decisions related to overall system structure and behavior.

`https://www.sei.cmu.edu/our-work/software-architecture/`

Software Architecture Designing

Definition (Software Architecture Designing)

Designing of the Software Architecture is an early activity in software designing, when the subsystems, the control flow and the communications paths are defined.

Software Architecture Designing

Explicit designing and documenting of the software architecture has the following advantages:

Communication with stakeholders: the architecture describes high-level features of the software design, and thus it may serve as an entry point for discussion with different stakeholders.

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Features Analysis: the architecture allows the developers to early analyze the software structure and verify if it meets the nonfunctional requirements.

Reusing: the architecture is relatively universal and can be a basis for an entire line of software products.

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Control modelling: the model of control flow in the software system is defined.

Modularization: each subsystem is split into modules.

Subsystems and Modules

Definition (Subsystem)

A subsystem is a part of a software system that provides services independently on other subsystems. The subsystem consists of modules and has an interface that allows it to communicate with other subsystems. A single subsystem can be considered as a standalone system.

Definition (Module)

A Module is a software component offering at least one service. It uses services of other modules, and cannot be considered as a standalone system. A single module usually consists of other modules.

Software Architecture Documentation

The software architecture documentation can describe (graphically or textually) the following models of software:

The structural static model shows the software components that can be developed as independent units.

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The dependencies model defines dependencies such as the data flow between the subsystems.

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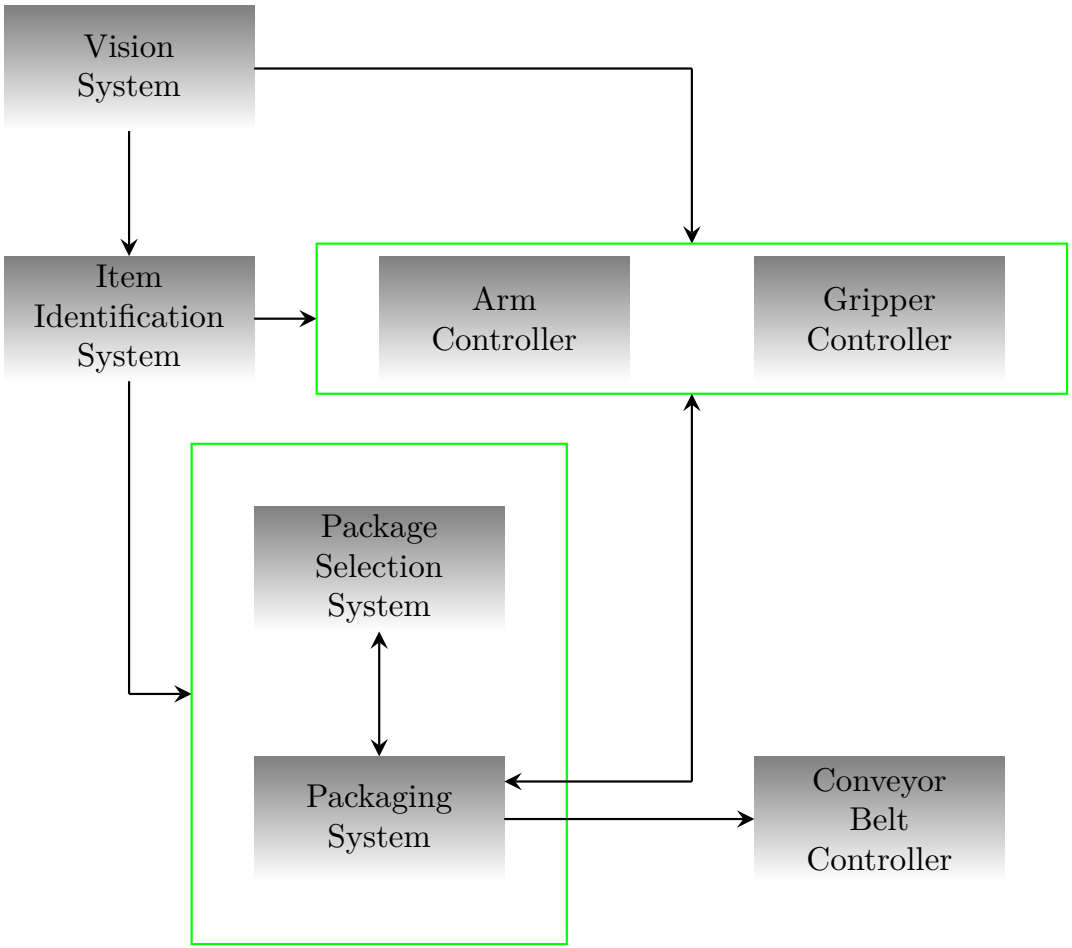
Availability: Redundant components should be used.

Maintenance: A large number of fine-grained, independent, easy to replace components should be used.

Block Diagram Example — Robot Control System



Instability Metric

Robert C. Martin proposed, in his book about the Clean Architecture, an Instability Metric that allows the programmer to estimate how likely is a given component to be changed in the future. To determine the value of such a metric, it is necessary to know the number of fan-in and fan-out (incoming and outgoing) dependencies. The formula for the metric is as follows:

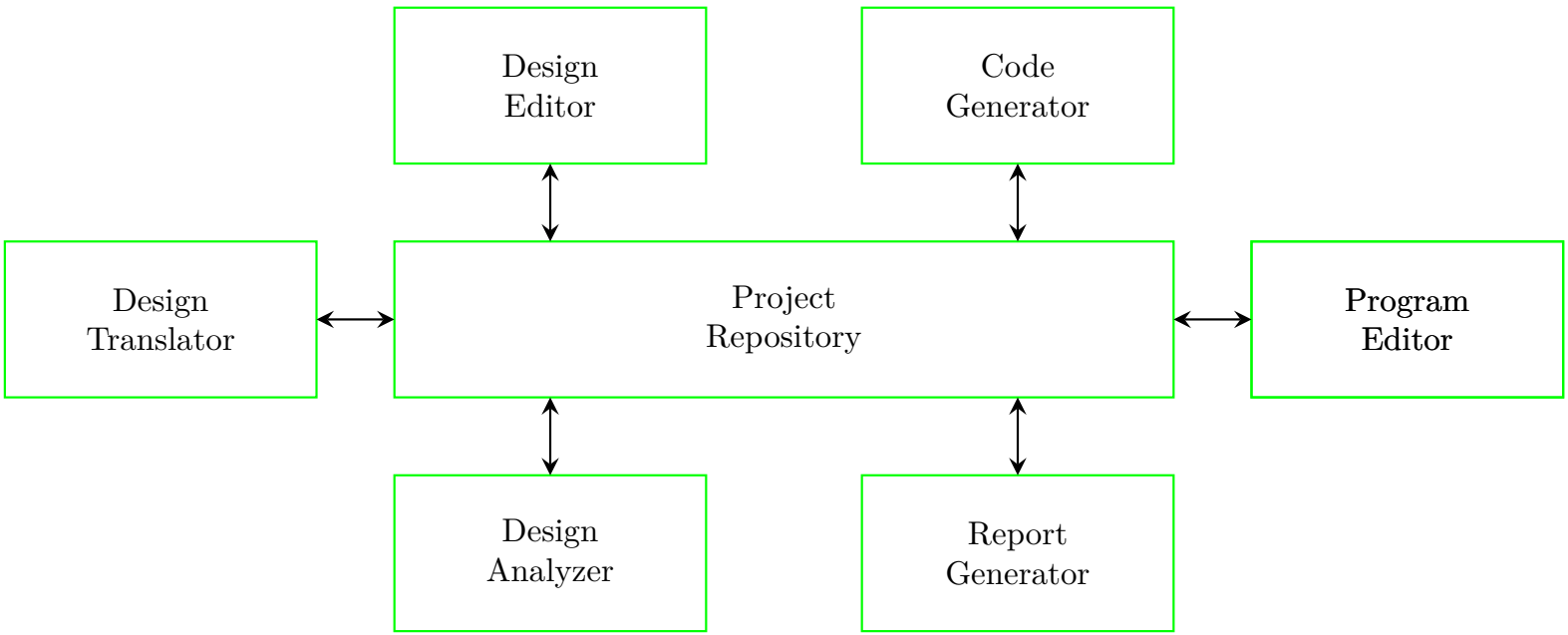
$$I = \frac{\text{Fan-in}}{\text{Fan-in} + \text{Fan-out}}$$

The closer the result is to 1, the more the component is unstable, and the closer is the outcome to 0 the more independent and responsible the component is. For example, the Vision System from the previous slide is maximally independent and responsible ($I = 0$) and the Conveyor Belt Controller is maximally unstable ($I = 1$). The architecture cannot be built from independent and responsible components only, because it could be too rigid. On the other hand, an architecture consisting of only unstable components would be unstable, too. There has to be balance between the number of unstable and independent components.

Repository Model

A central database is the main component of most of systems that process significant amounts of data. This kind of architecture is called a Repository Model. It is specific for systems where data are generated by one of the subsystems and used (processed) by the other.

Repository Model — Example



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- Making a distributed version of the central repository can be difficult.

Client — Server Model

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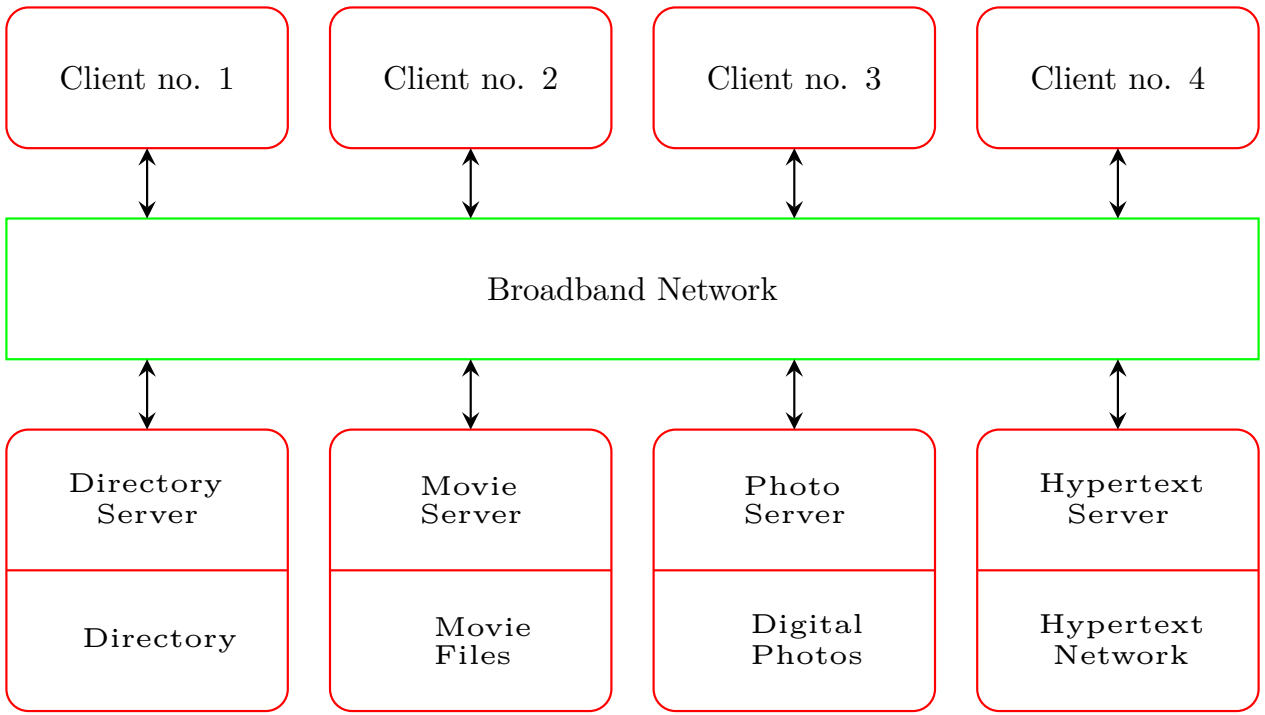
- a network that enables the communication between clients and servers, it's not always necessary.

Example of Client — Server Model



Pros And Cons

+ The client — server model is a distributed architecture.

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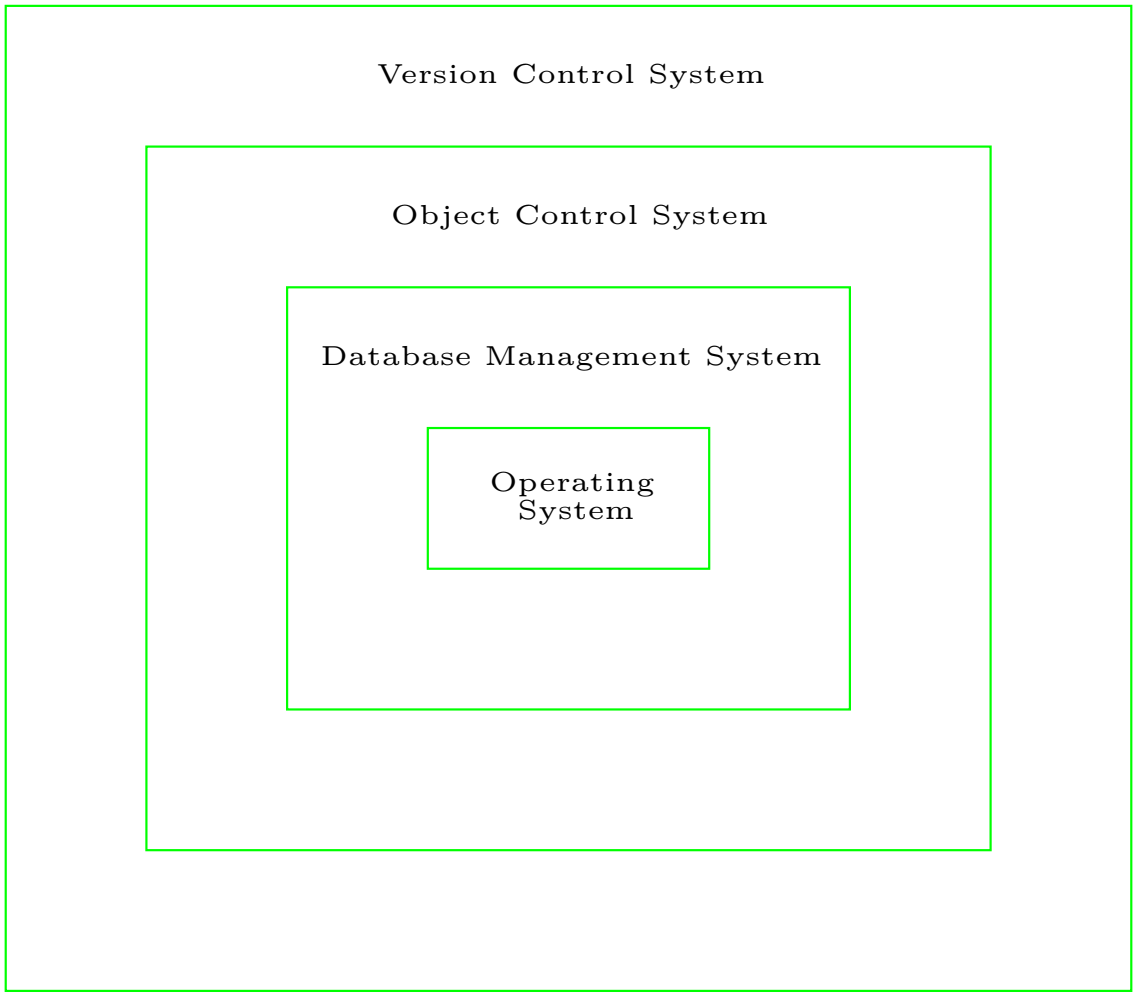
- There is no common data model.

Abstract Machine Model

The Abstract Machine Model (the Layered Model) defines the subsystems relationships (dependencies). The system is organized as a stack of layers offering some services. Each layer is a virtual (abstract) machine, with its own machine language (a set of services), that is used to implement the next level of the abstract machine.

Abstract Machine Model — Example



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- Systems based on a ”pure” layered architecture can be inefficient.

Control Models

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Centralized control: one of the subsystems is responsible for the control.

Event-driven control: the control is not built-in in the system, each of the subsystem can react to external events.

Centralized Control

There are two types of architectures with centralized control, depending on whether the subsystems work concurrently or sequentially:

The Call — Return Model: used only in sequential systems.

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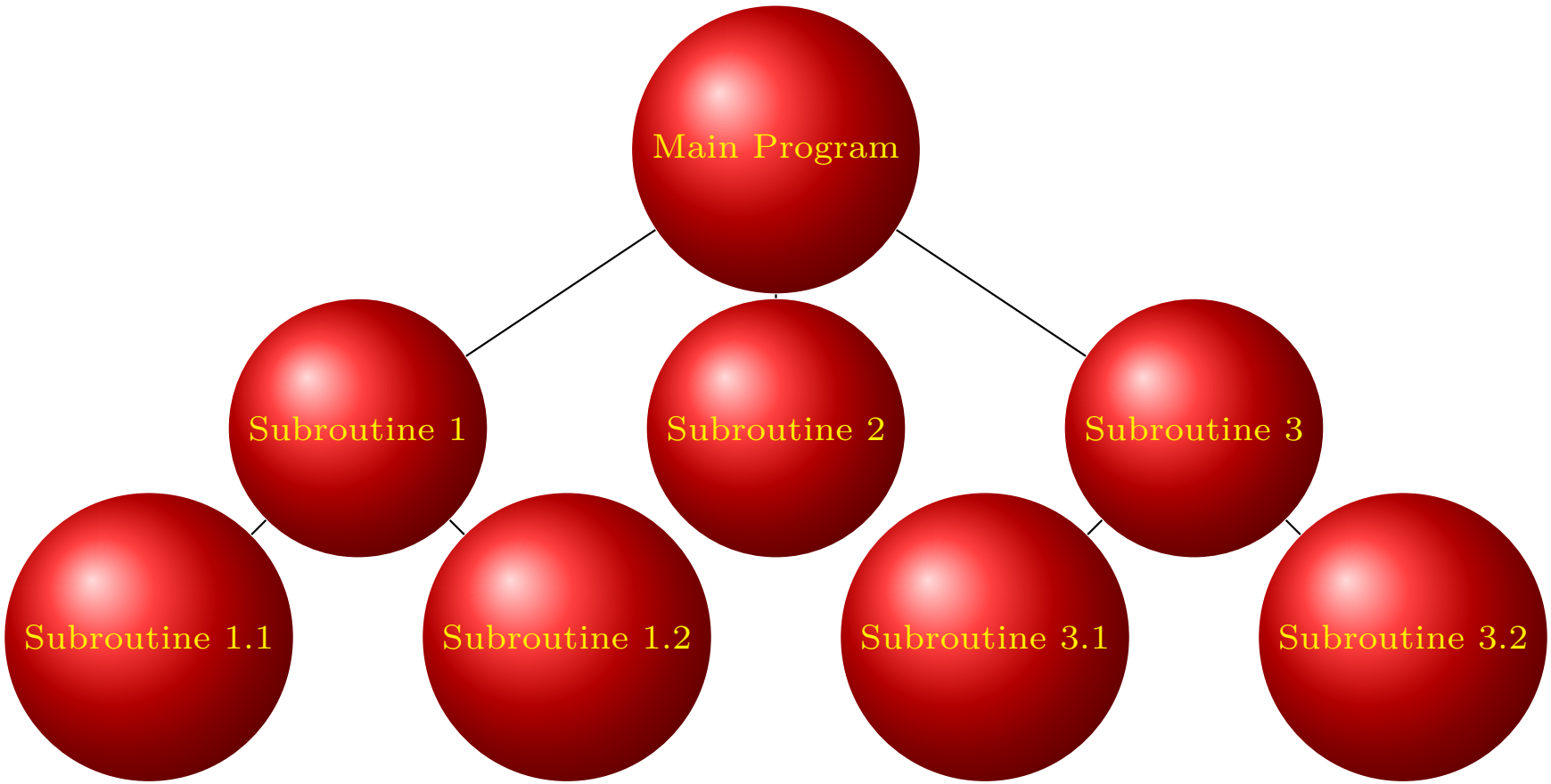
The Call — Return Model: used only in sequential systems.

The Manager Model: may be applied in both sequential and concurrent systems. One of the components is chosen to be a control manager that manages other processes. The model is also called an Event-Loop Model.

The Call — Return Model



Pros And Cons

+ The system is deterministic and the control flow is easy to analyse.

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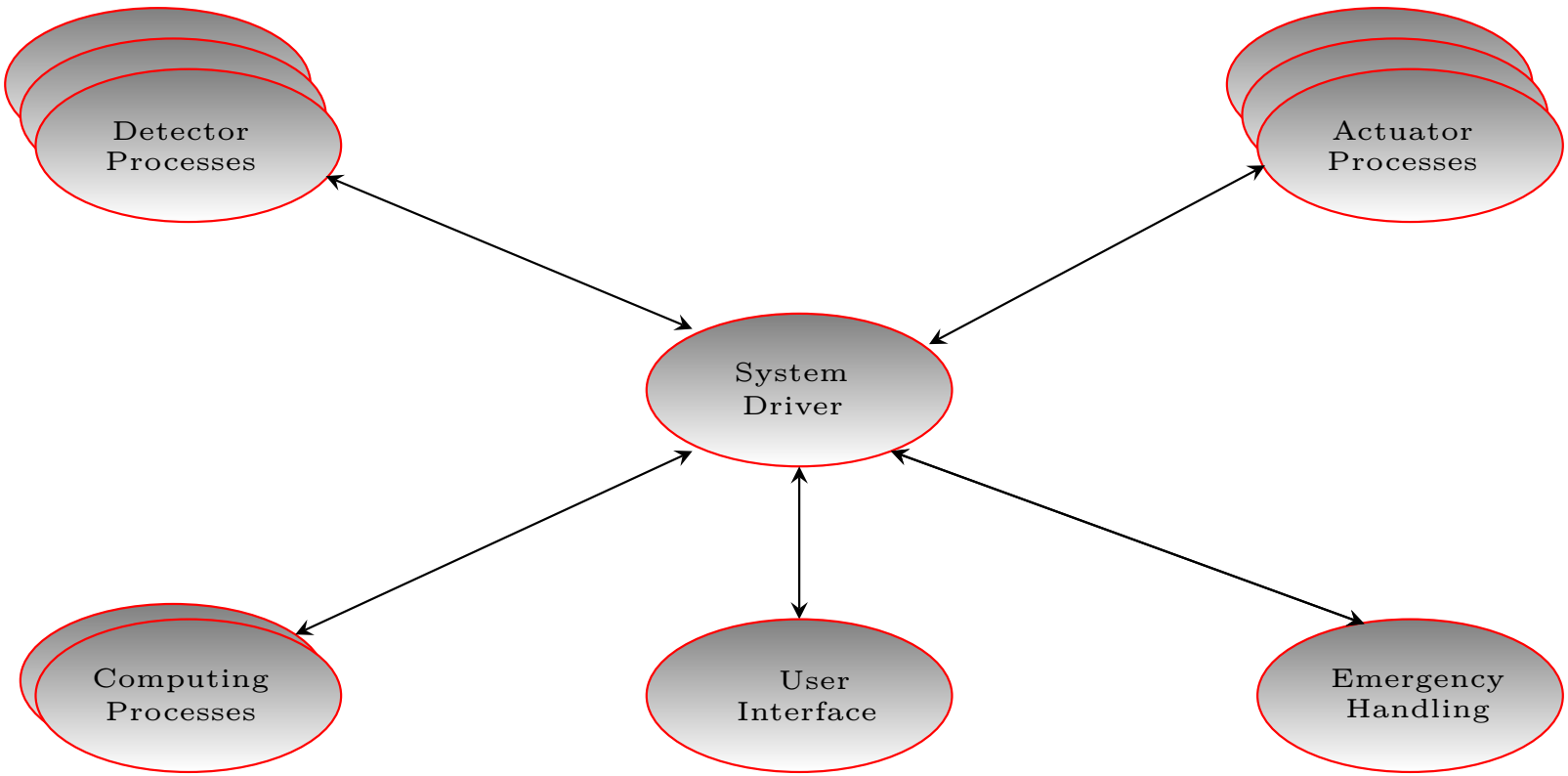
- Exceptions may be difficult to handle.

Centralized Management Model of Control



Event-Driven Control

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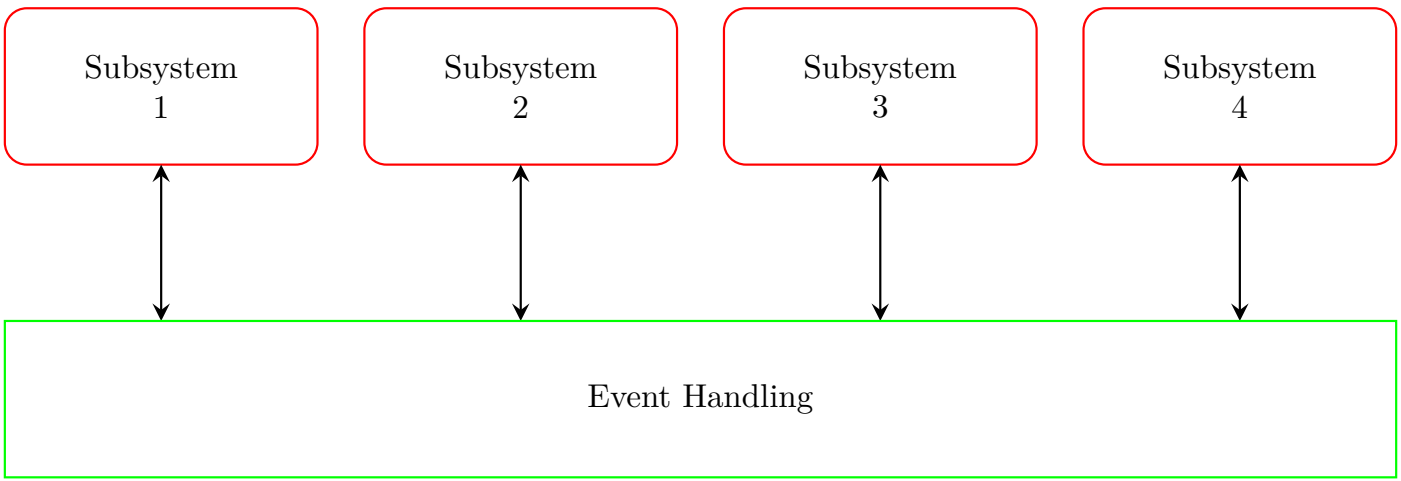
Interrupt-Driven Model: the external interrupts are detected by interrupt handlers and passed to some other components for processing.

Broadcast Model



Pros And Cons

+ Easy evolution.

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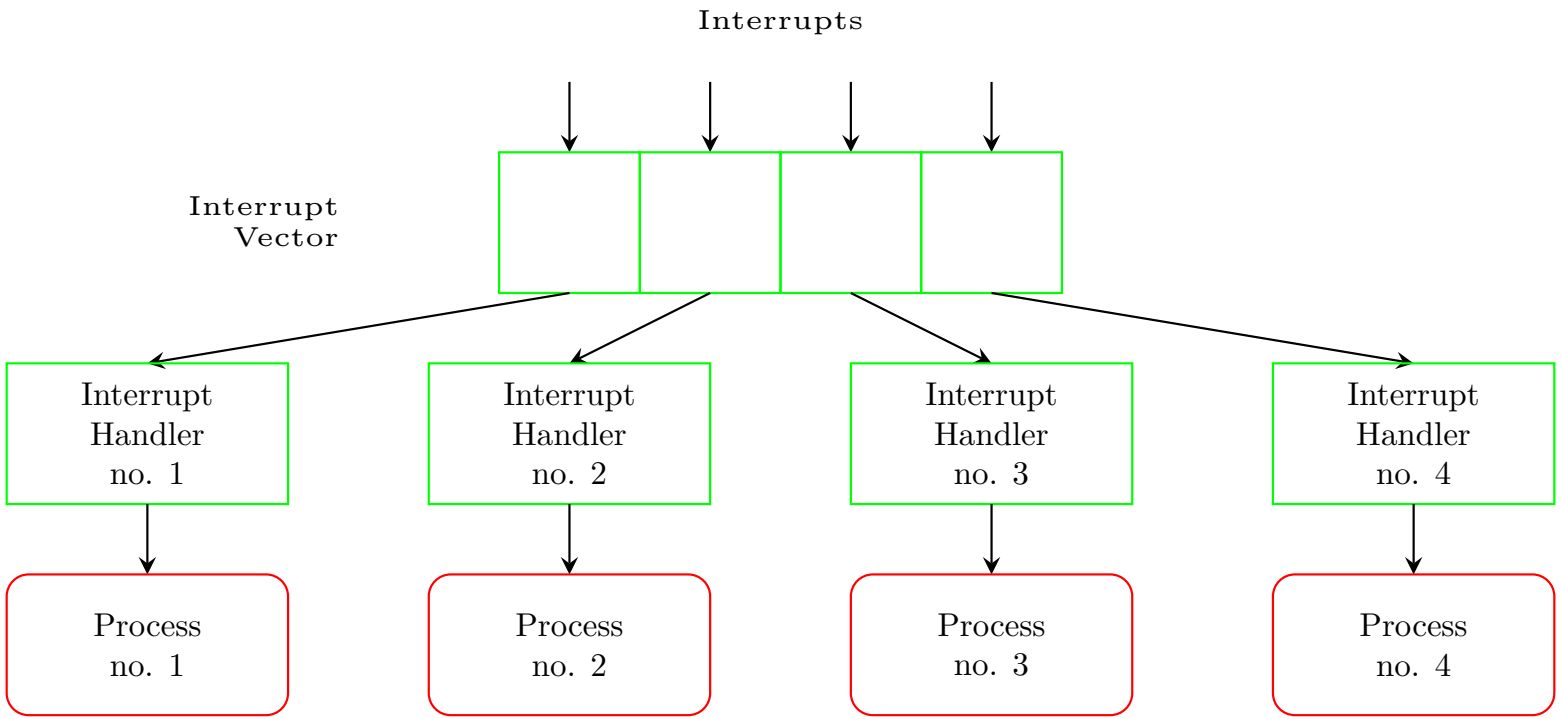
- The event emitter doesn't get the feedback information whether the event was handled.

Interrupt-Driven Control Model



Pros And Cons

+ Fast event responses.

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- Complexity of programming and difficulties with validation.

Modular Decomposition

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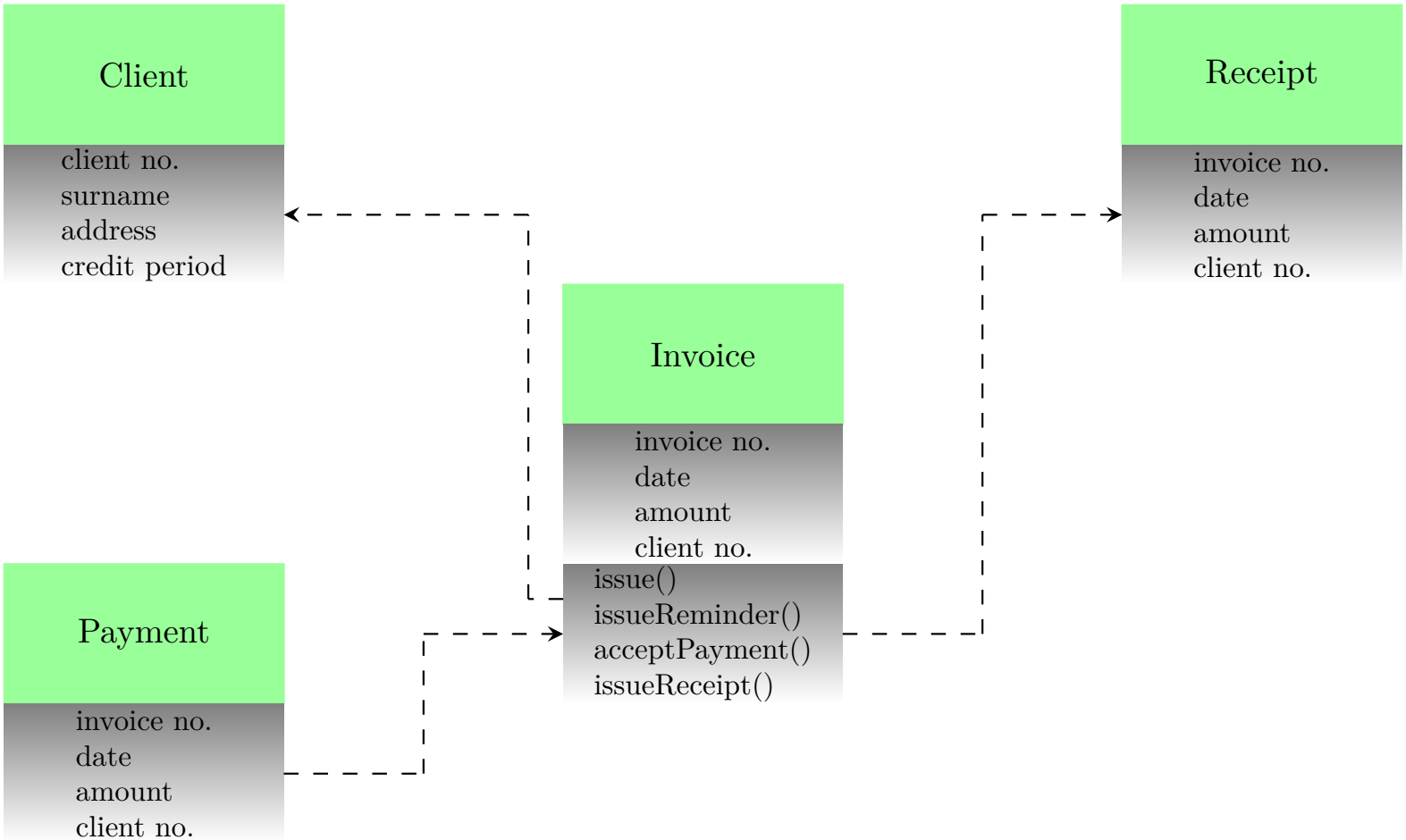
The object-oriented model: the (sub)system is decomposed into a collection of interacting objects.

The data-flow model: the (sub)system is decomposed into functional modules transforming input data into output data. It is also called a Pipeline Model.

The Object-Oriented Model — Example



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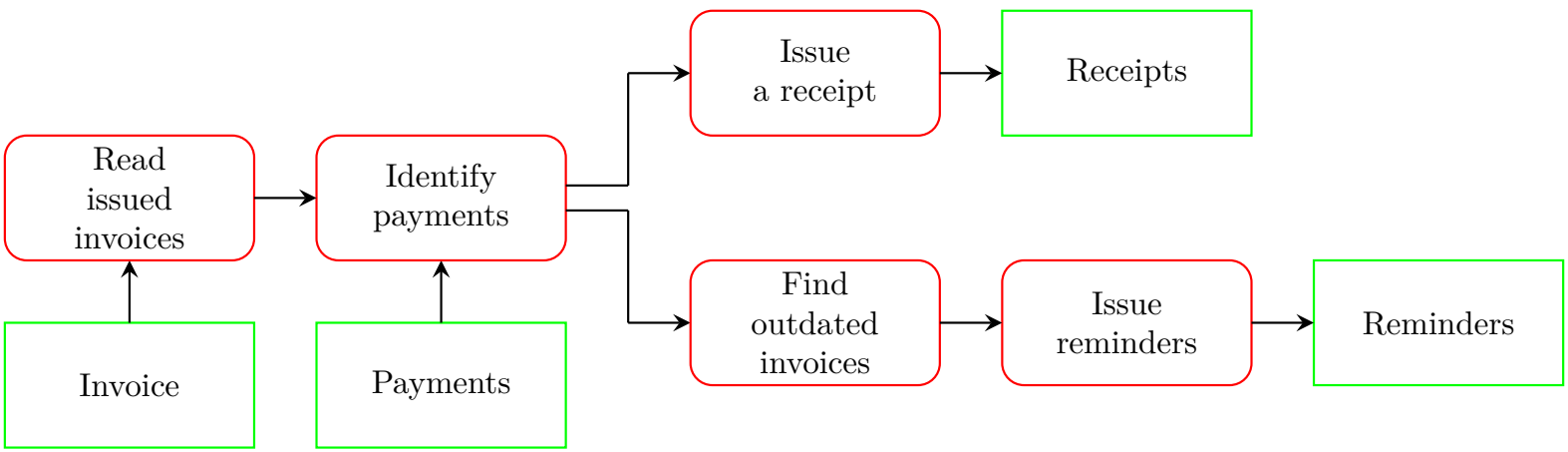
- It can be difficult to represent complex entities as objects.

Data-Flow Model — Example



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- It cannot be applied for building interactive systems.

Domain-Specific Architectures

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Generic Models: are built using the bottom-top method and describe the common features of real-world systems.

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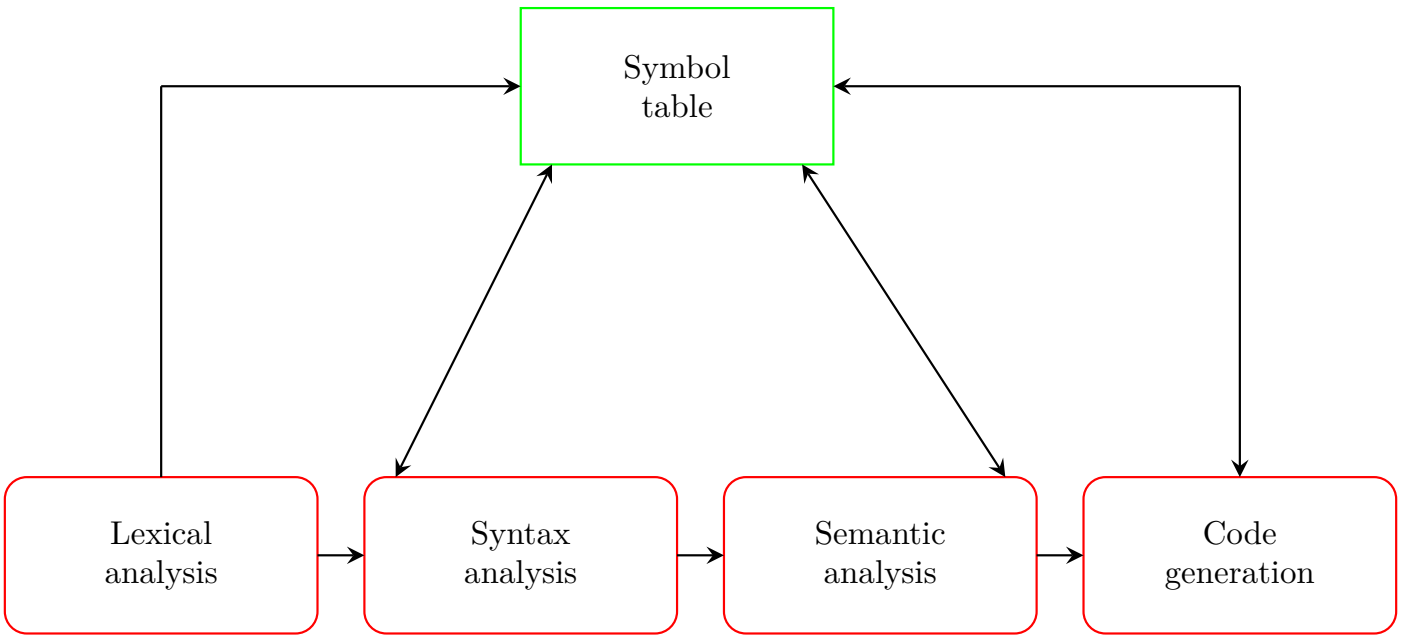
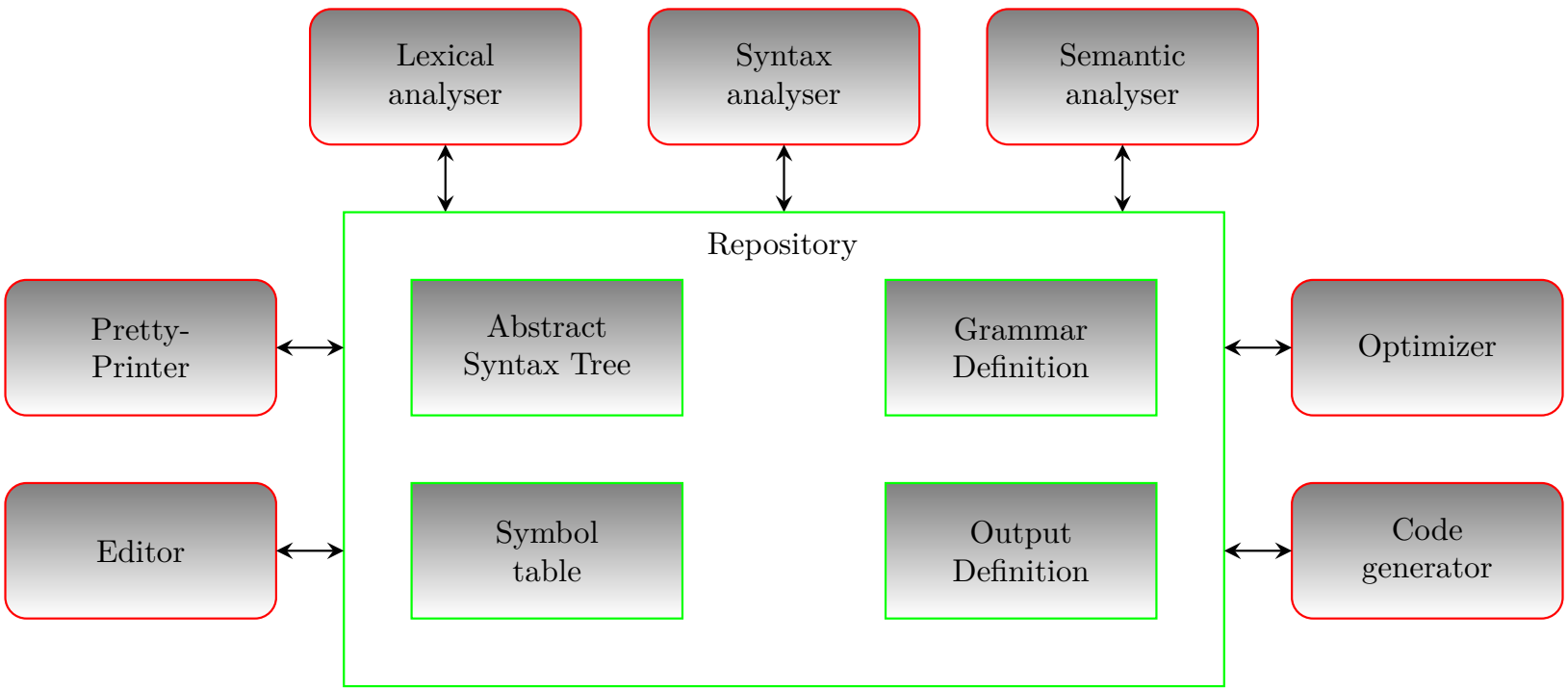
Generic Models: are built using the bottom-top method and describe the common features of real-world systems.

Reference Models: are built using the top-bottom method and are more abstract than the generic models. They introduce a common vocabulary for discussing the design of systems from a specific domain.

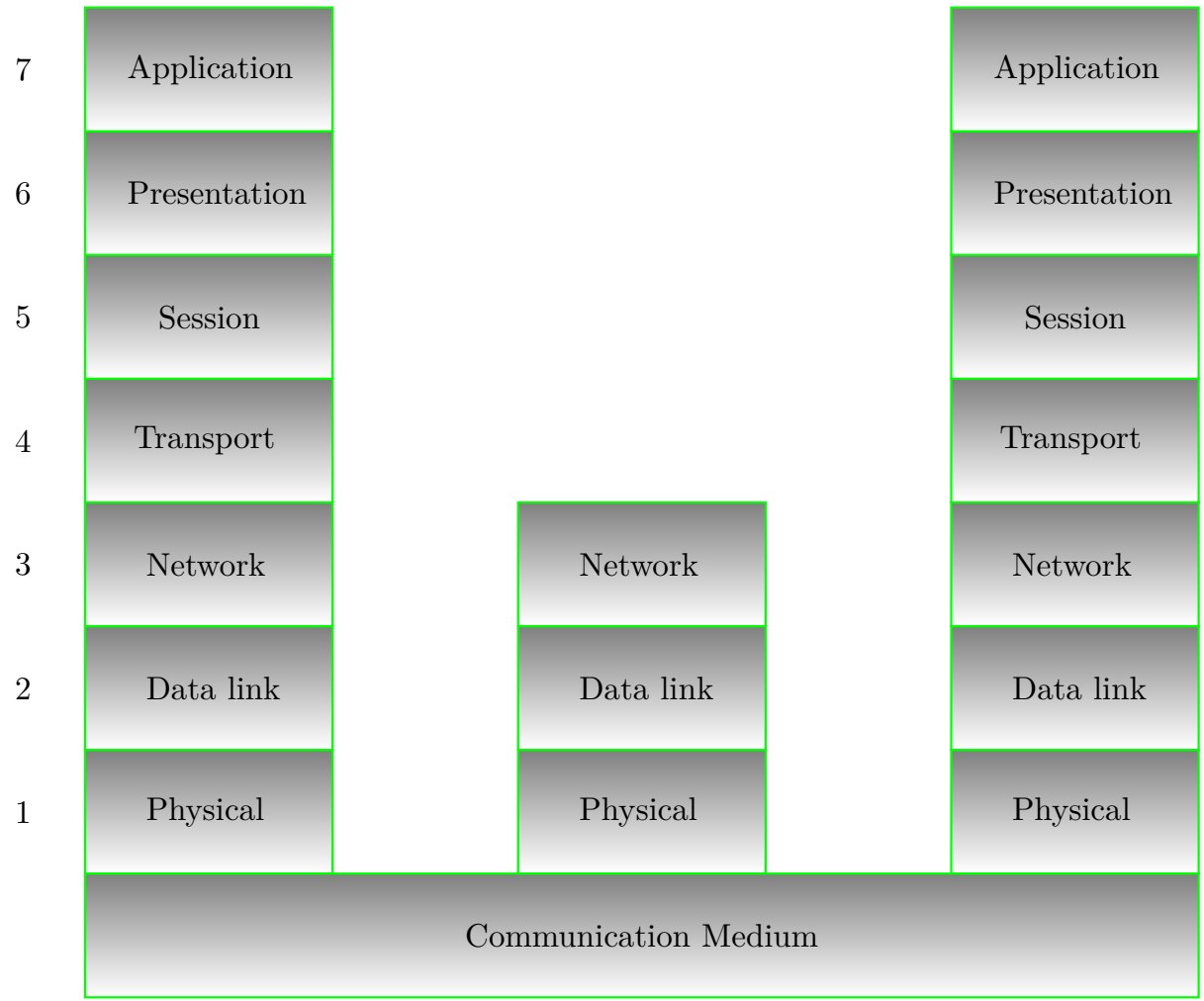
Compiler Generic Model — Data-Flow And Centralized Repository



IDE Generic Model — Centralized Repository



Reference Model — Example



Questions

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The End

Thank You for Your attention!