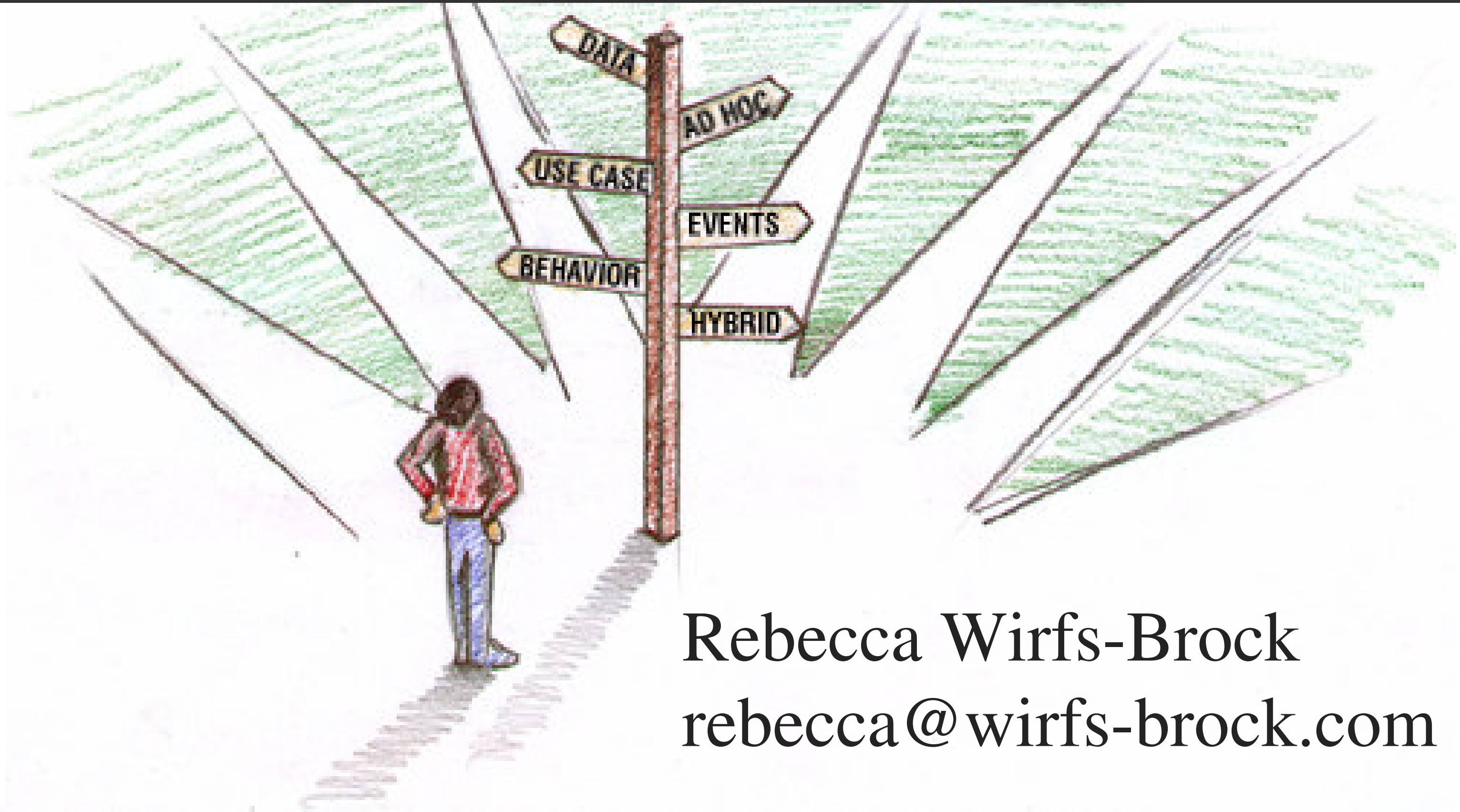
A Brief Tour of Responsibility-Driven Design in 2004



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What Is Responsibility-Driven Design?

A way to design software that…

–emphasizes behavioral modeling of objects' roles, responsibilities, and collaborations

–uses informal tools and techniques

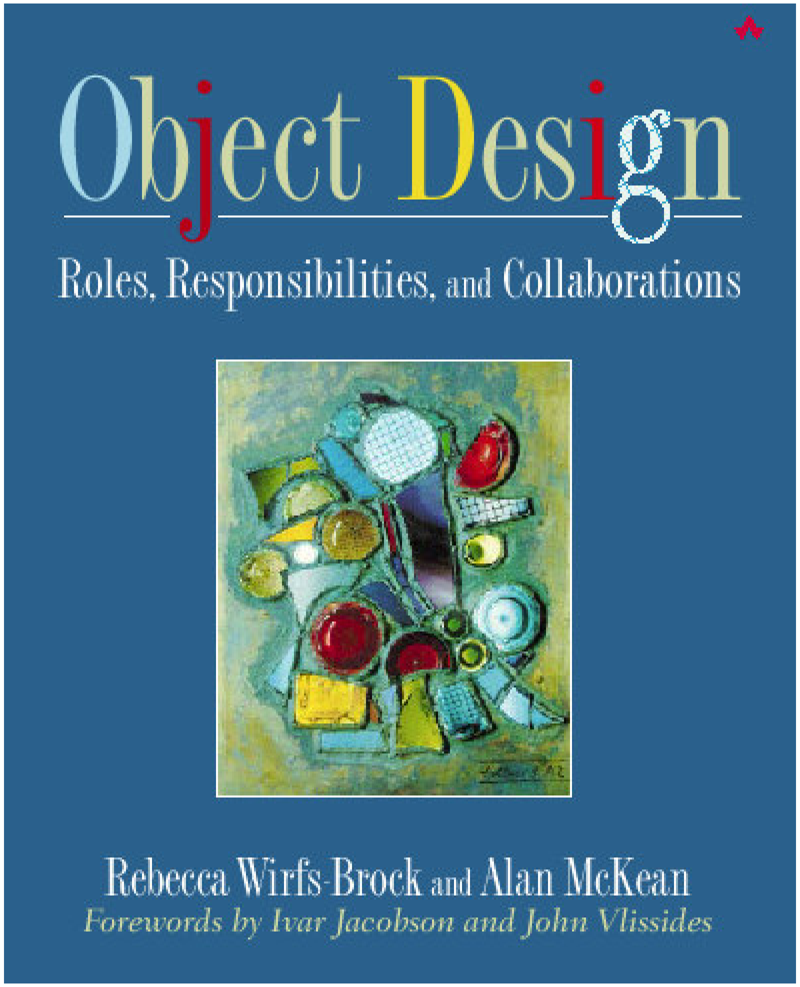
–enhances development processes from

XP (eXtreme Programming) to

RUP (Rational Unified Process)

…with responsibility concepts and thinking

Responsibility-Driven Design Resources


Object Design
Roles, Responsibilities, and Collaborations
Rebecca Wirfs-Brock and Alan McKean
Forewords by Ivar Jacobson and John Vlissides

Designing Object-Oriented Software by Rebecca Wirfs-Brock, Brian Wilkerson and Lauren Wiener, Prentice-Hall, 1990

Our new book has more techniques and practices. *Object Design: Roles, Responsibilities and Collaborations,* Rebecca Wirfs-Brock and Alan McKean, Addison-Wesley, 2003

www.wirfs-brock.com for articles & presentations

Responsibility-Driven Design Principles

Maximize Abstraction

Hide the distinction between data and behavior. Think of objects responsibilities for “knowing”, “doing”, and “deciding”

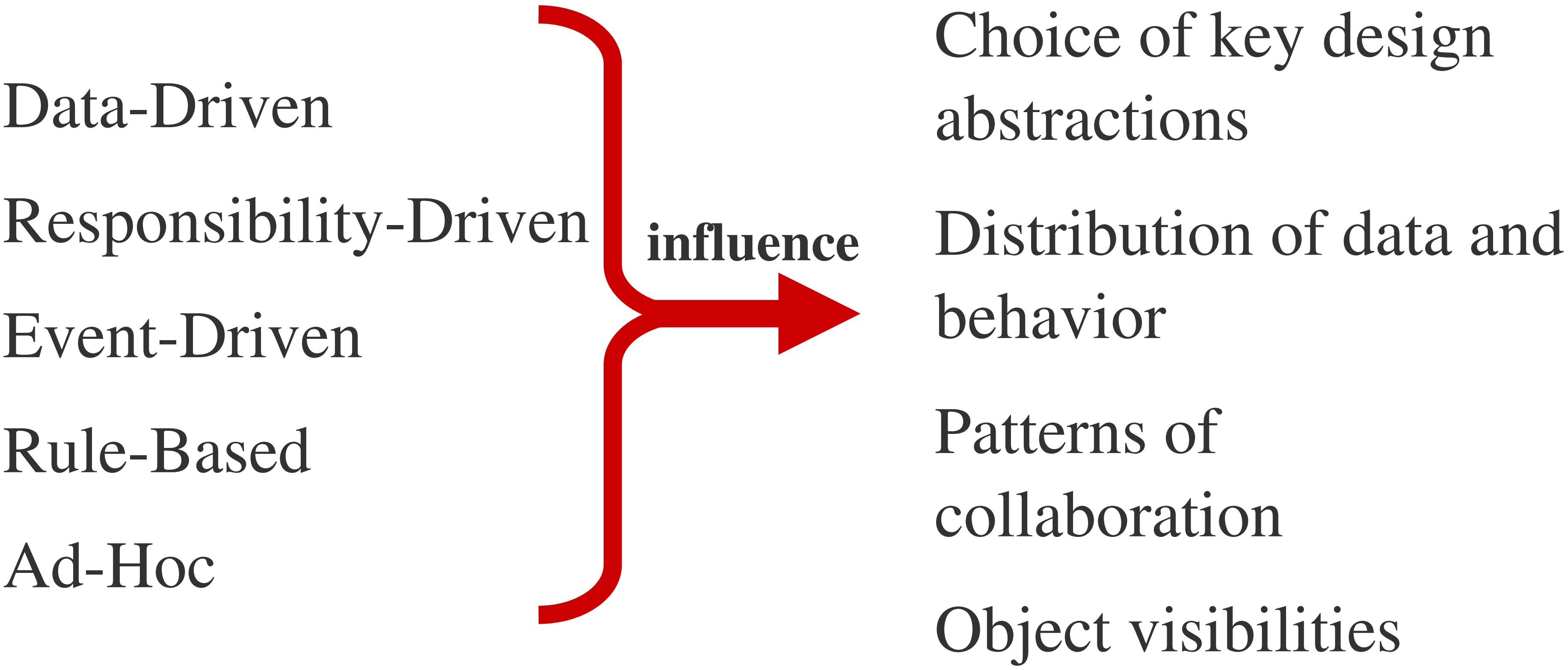
Distribute Behavior

Make objects smart— have them behave intelligently, not just hold bundles of data

Preserve Flexibility

Design objects so they can be readily changed

Different Points-of-View: Different Results



Data-Driven

Responsibility-Driven

Event-Driven

Rule-Based

Ad-Hoc

influence

Choice of key design abstractions

Distribution of data and behavior

Patterns of collaboration

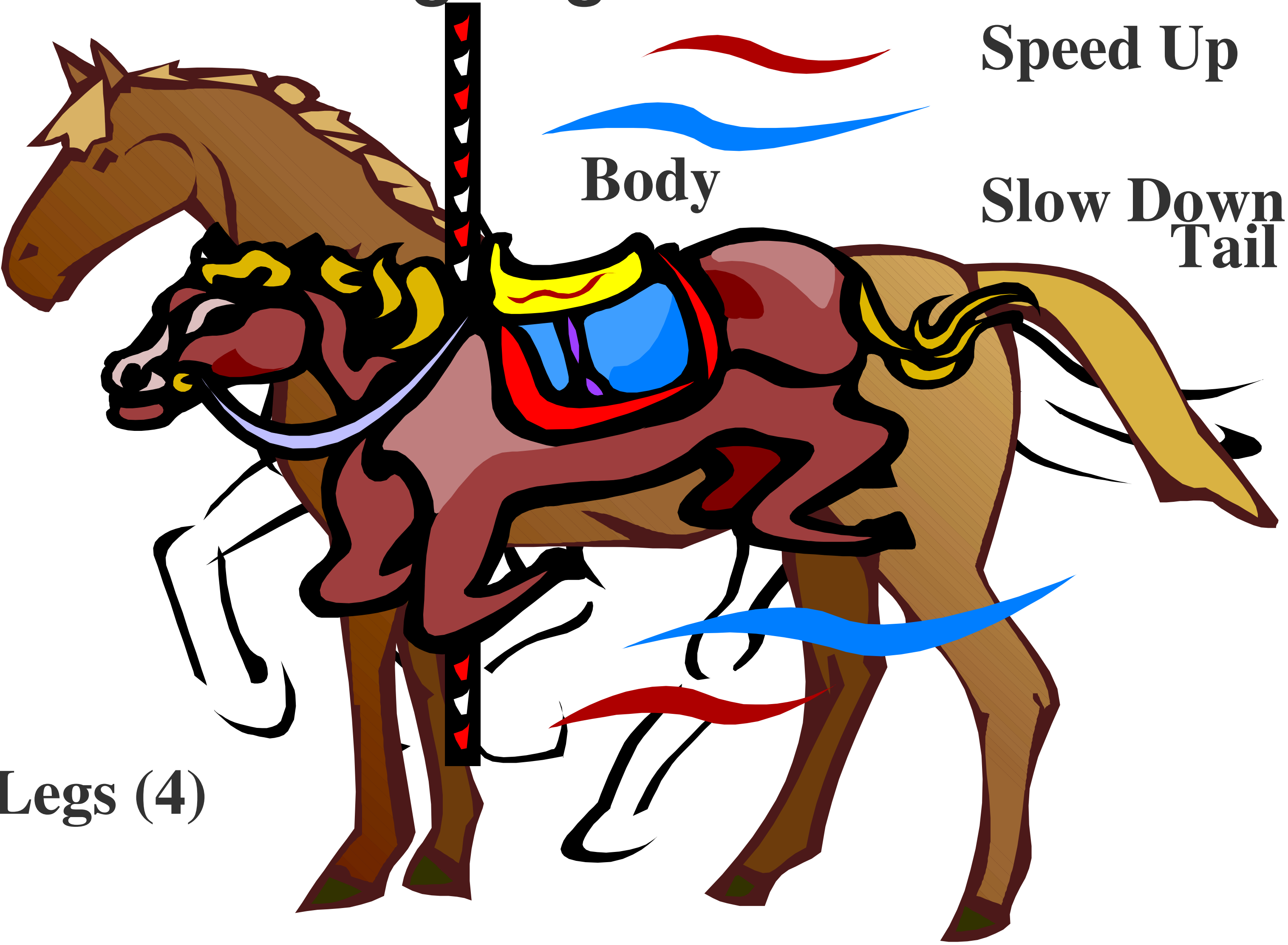
Object visibilities

Designing a Horse

Head

Start

Stop



Speed Up

Body

Slow Down

Tail

Legs (4)

Designing a Horse Responsibly

Responsibility-Driven Design Constructs

an application = a set of interacting objects

an object = an implementation of one or more roles

a role = a set of related responsibilities

a responsibility = an obligation to perform a task or know information

a collaboration = an interaction of objects or roles (or both)

a contract = an agreement outlining the terms of a collaboration

Roles and Responsibilities

Role Stereotypes

Stereotypes are simplified views that help you understand an object or component’s purpose

> “Something conforming to a fixed or general pattern; especially a standardized mental picture held in common by members of a group and representing an oversimplified opinion.”—Webster’s Seventh New Collegiate Dictionary

Each object fits at least one stereotype. They can fit more than one. Common blends:

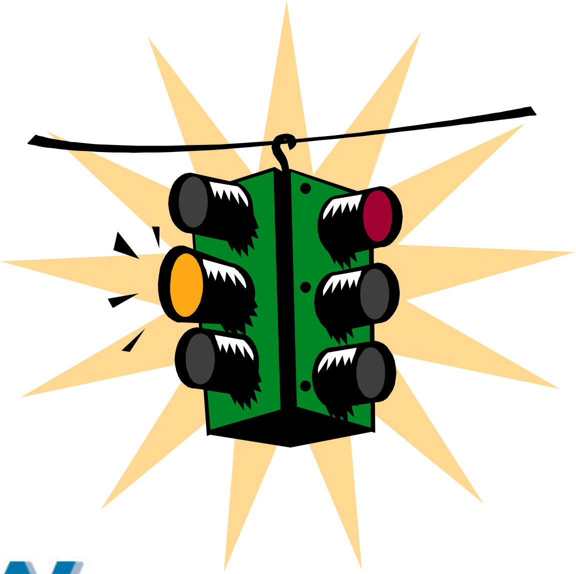
service provider and information holder, interfacer and service provider, structurer and information holder

Stereotypes
simplified views of roles

Controller—Controls application execution

Characterized by decisions it makes

Example: TransactionController

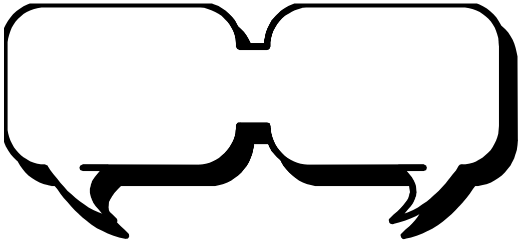


Coordinator—Coordinates actions

Characterized by actions it delegates

Example: ViewCoordinator

Stereotypes
simplified views of roles



Interfacer—Communicates actions and intentions between our system and others, or between layers of a system

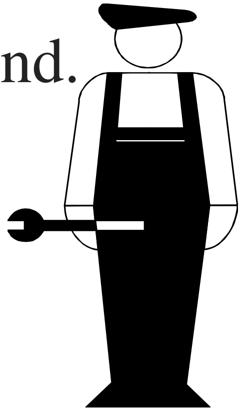
Characterized by what it communicates with and how well it "hides" their details

Examples: UI objects, an object that "wraps" an interface to another application

Service Provider—Performs specific operations on demand.

Characterized by what it does (computation, calculation, transformation)

Example: CreditChecker

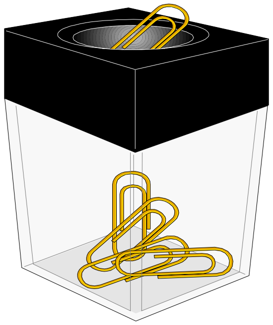


Stereotypes
simplified views of roles

Information Holder—Holds facts.

Characterized by what it knows

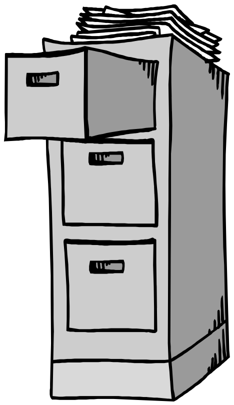
Example: TransactionRecord, Account



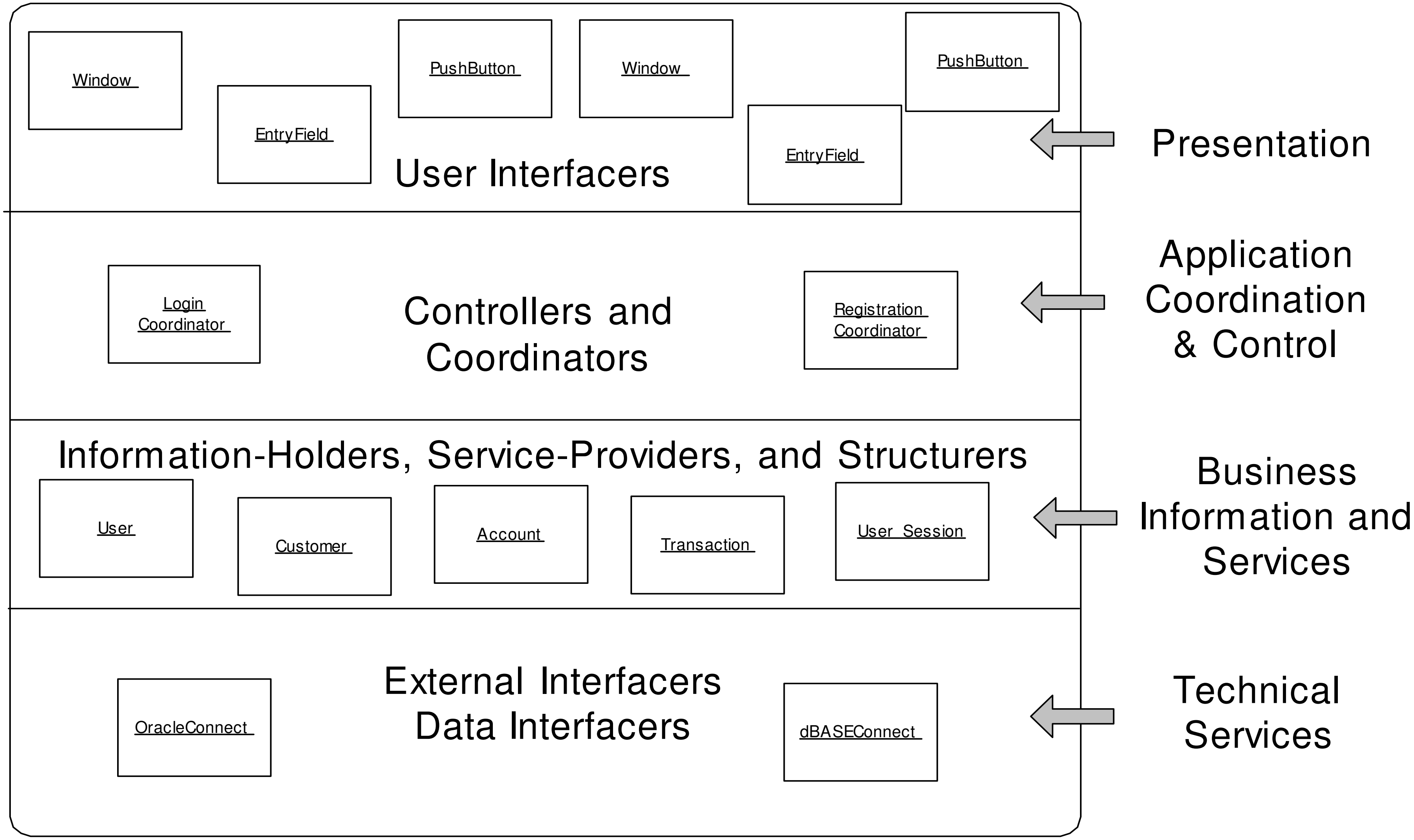
Structurer—Maintains relationships between others.

Characterized by who it knows and what it knows about them

Example: Order



Layered Architecture



Three Uses for Object Role Stereotypes

1. In early modeling, stereotypes help you think about the different kinds of objects that you need

2. You consciously blend stereotypes with a goal of making objects more responsible and intelligent

   –information holders that compute with their information

   –service providers that maintain information they need

   –structurers that interface to persistent stores, and derive new relationships

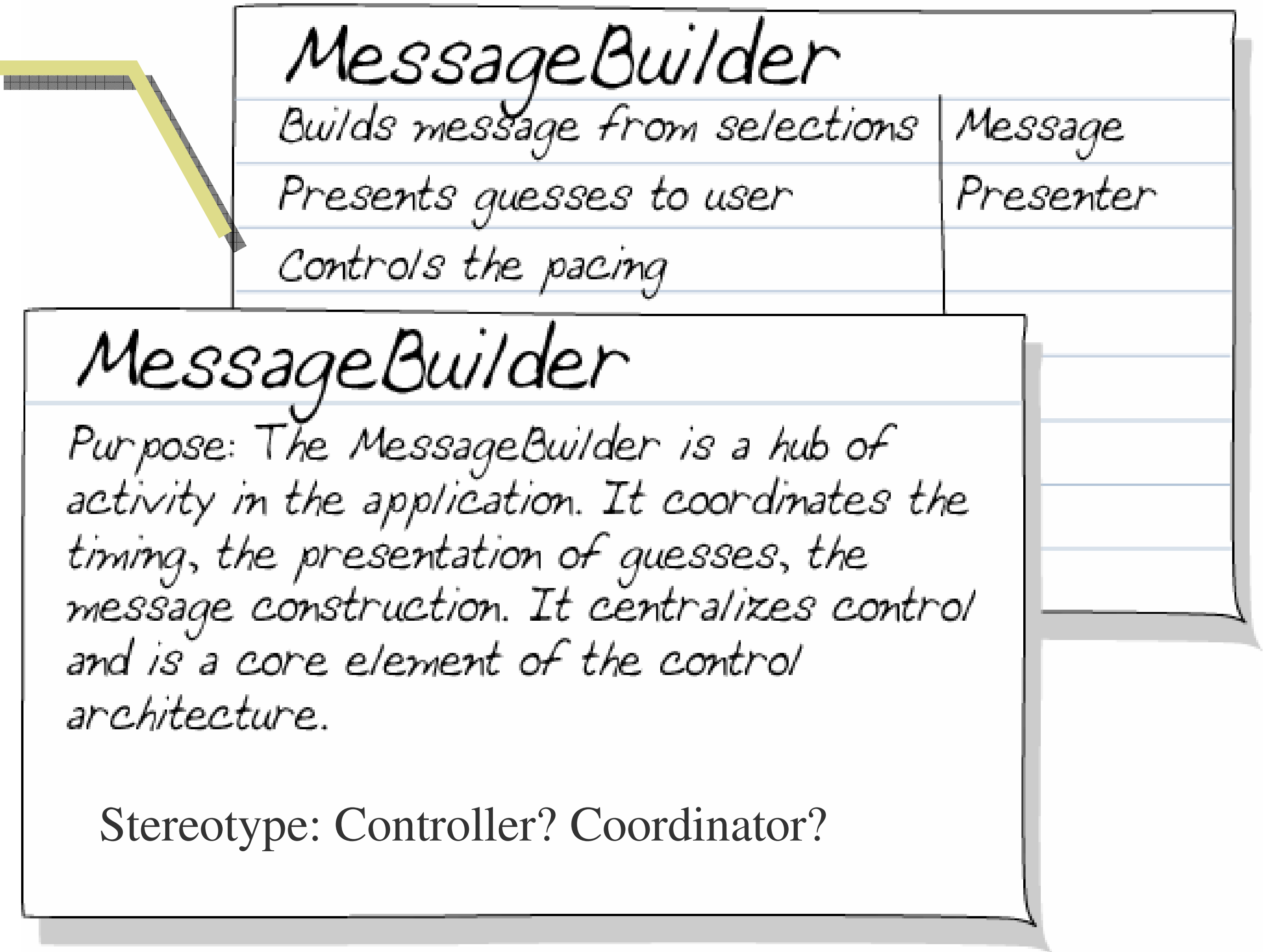
   –interfacers that transform information and hide many low-level details

3. Study a design to learn what types of roles predominate and how they interact

Informal Technique: CRC Cards

Candidate, Responsibilities, Collaborators

CRC cards are an informal way to record early design ideas about candidates



MessageBuilder

Builds message from selections	Message
Presents guesses to user	Presenter
Controls the pacing	

MessageBuilder

Purpose: The MessageBuilder is a hub of activity in the application. It coordinates the timing, the presentation of guesses, the message construction. It centralizes control and is a core element of the control architecture.

Stereotype: Controller? Coordinator?

Purpose: Describing Candidate Roles

An object does and knows certain things for a reason. Briefly, say why it exists and an overview of its responsibilities. Mention one or more interesting facts about the object or a detail about what it does or knows or who it works with.

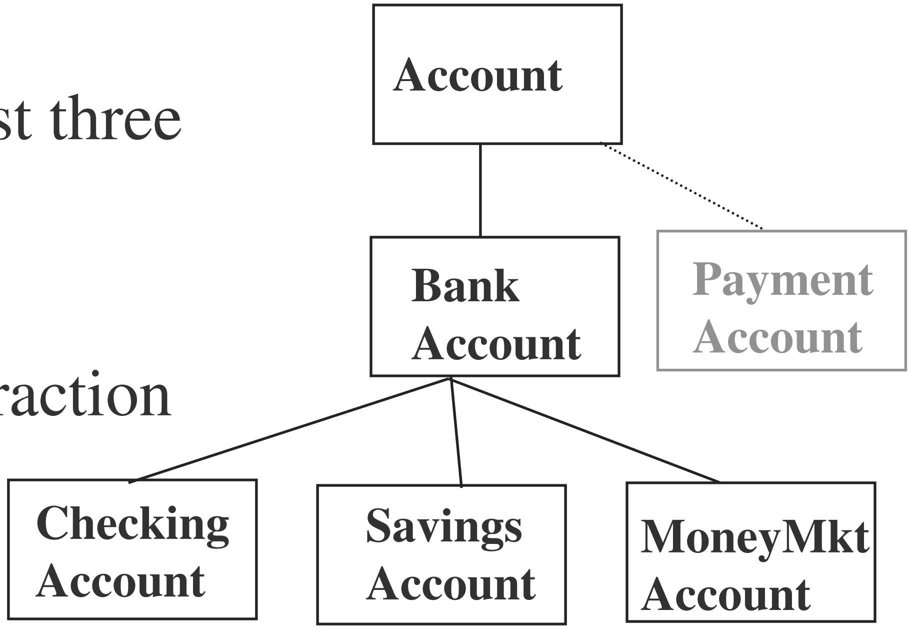
> A compiler is a program that translates source code into machine language.
>
> A FinancialTransaction controls a single accounting transaction performed by our online banking application. Successful transactions result in updates to a customer's accounts.

Look for Appropriate Abstractions

Model an abstraction if it defines responsibilities common to at least three subclasses

Do not include a lower level abstraction if it adds no significant value

Objects can always behave differently by checking and making decisions based on encapsulated state!



What are Responsibilities?

Behavior for

- knowing
- doing
- deciding

Stated at a high level

Assigned to appropriate objects

How Do You State Responsibilities?

They are larger than individual attributes or operations. A single responsibility is often realized by several methods

Example: A Customer object has a name which may be comprised of a first name, surname, middle name, and there may be titles or nicknames.

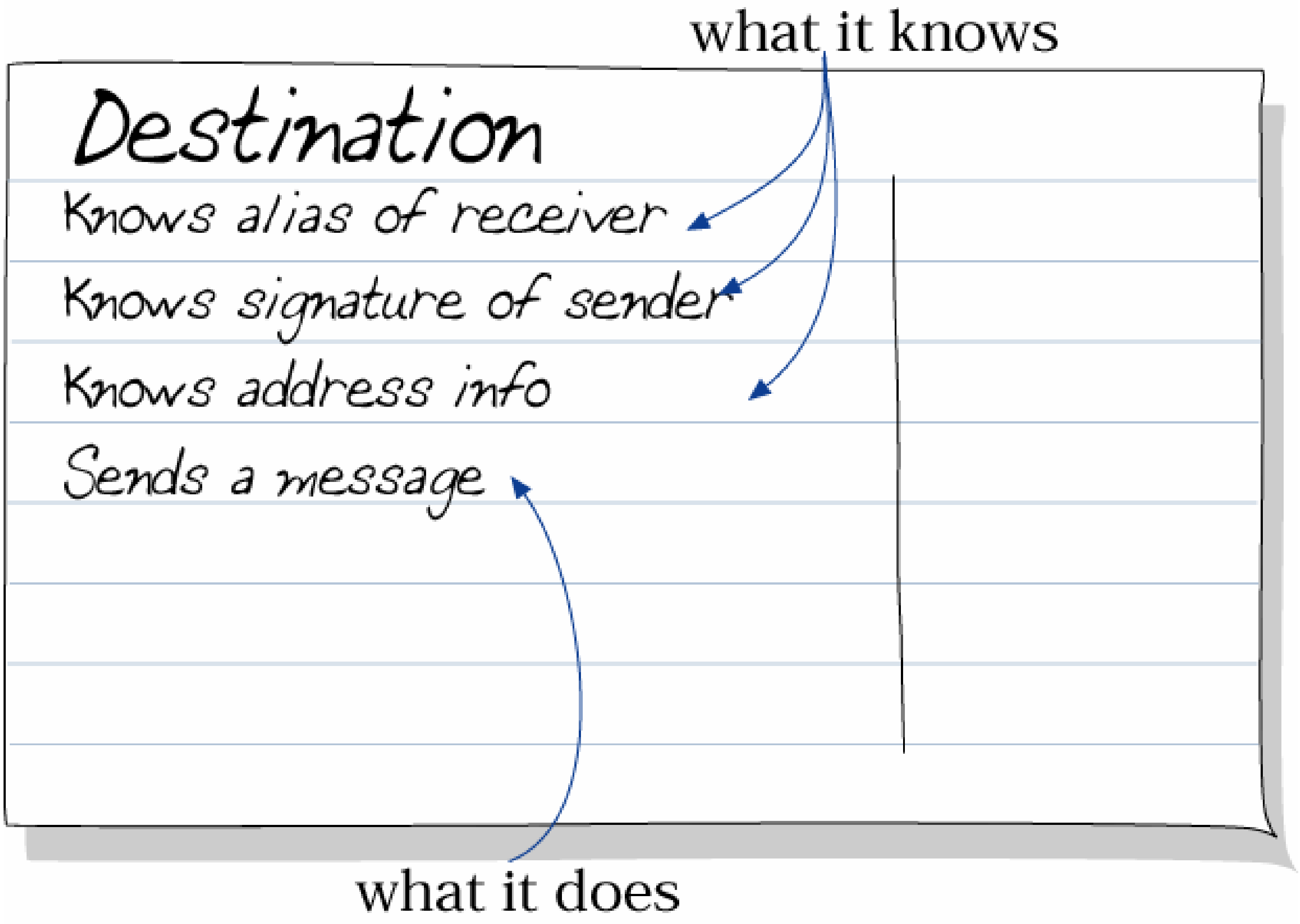
A good statement of its responsibility: A customer “knows its name and preferred ways of being addressed.”

Use strong descriptions. The more explicit the action, the stronger the statement.

Stronger verbs: remove, merge, calculate, credit, activate

Weaker verbs: organize, record, process, maintain, accept

CRC - the Responsibilities



Guidelines for Assigning Responsibilities

Keep behavior with related information. This makes objects efficient

Don’t make any one role too big. This makes objects understandable

Distribute intelligence. This makes objects smart

Keep information about one thing in one place. This reduces complexity

Options for Fulfilling a Responsibility

An object can always do the work itself:

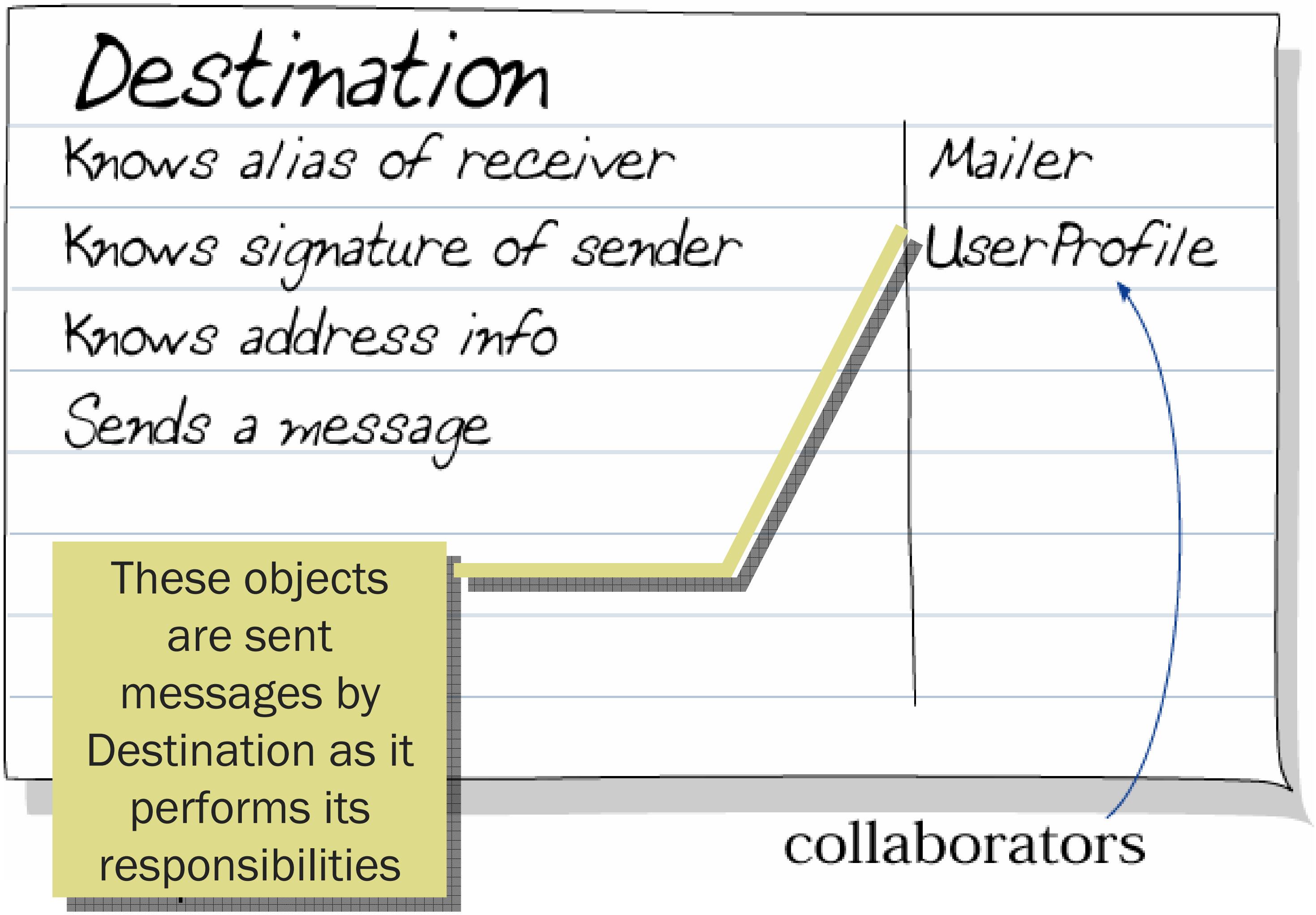
- A single responsibility can be implemented by one or more methods
- Divide any complex behavior into two parts
    - One part that defines the sequence of major steps + helper parts that implement the steps
- Send messages to invoke these finer-grained helper methods

Delegate part of a responsibility to one or more helper objects:

- Ask them to do part of the work: make a decision or perform a service
- Ask them relevant questions

Collaborations and Trust Regions

CRC - the Collaborators



These objects are sent messages by Destination as it performs its responsibilities

collaborators

Guidelines for Collaborating

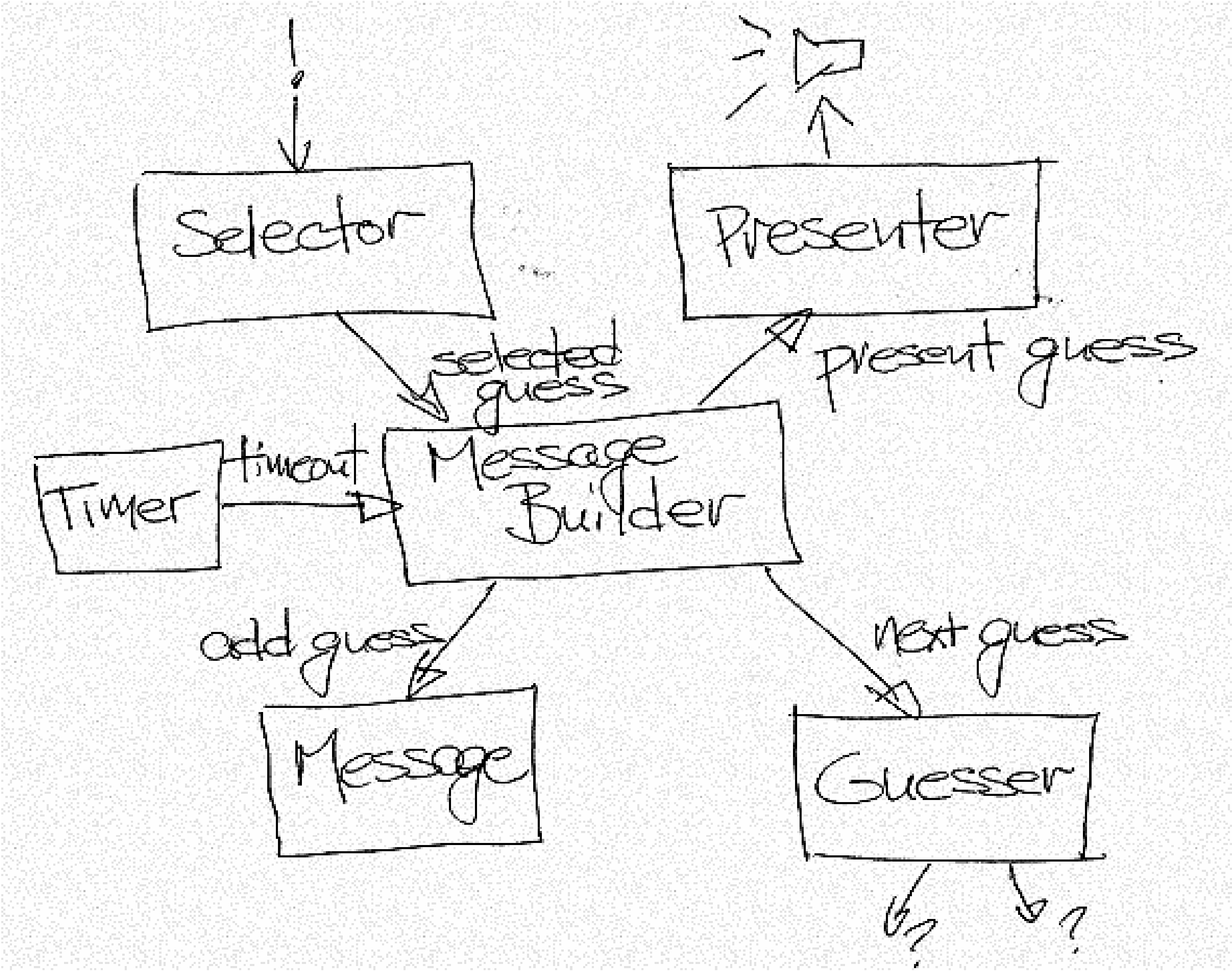
Delegate control if possible. Let collaborators be responsible

Look for opportunities to ask for services or direct others' actions more intelligently

Give objects the ability to both do and know things

Look for ways to make similar things work consistently

Start with rough sketches…

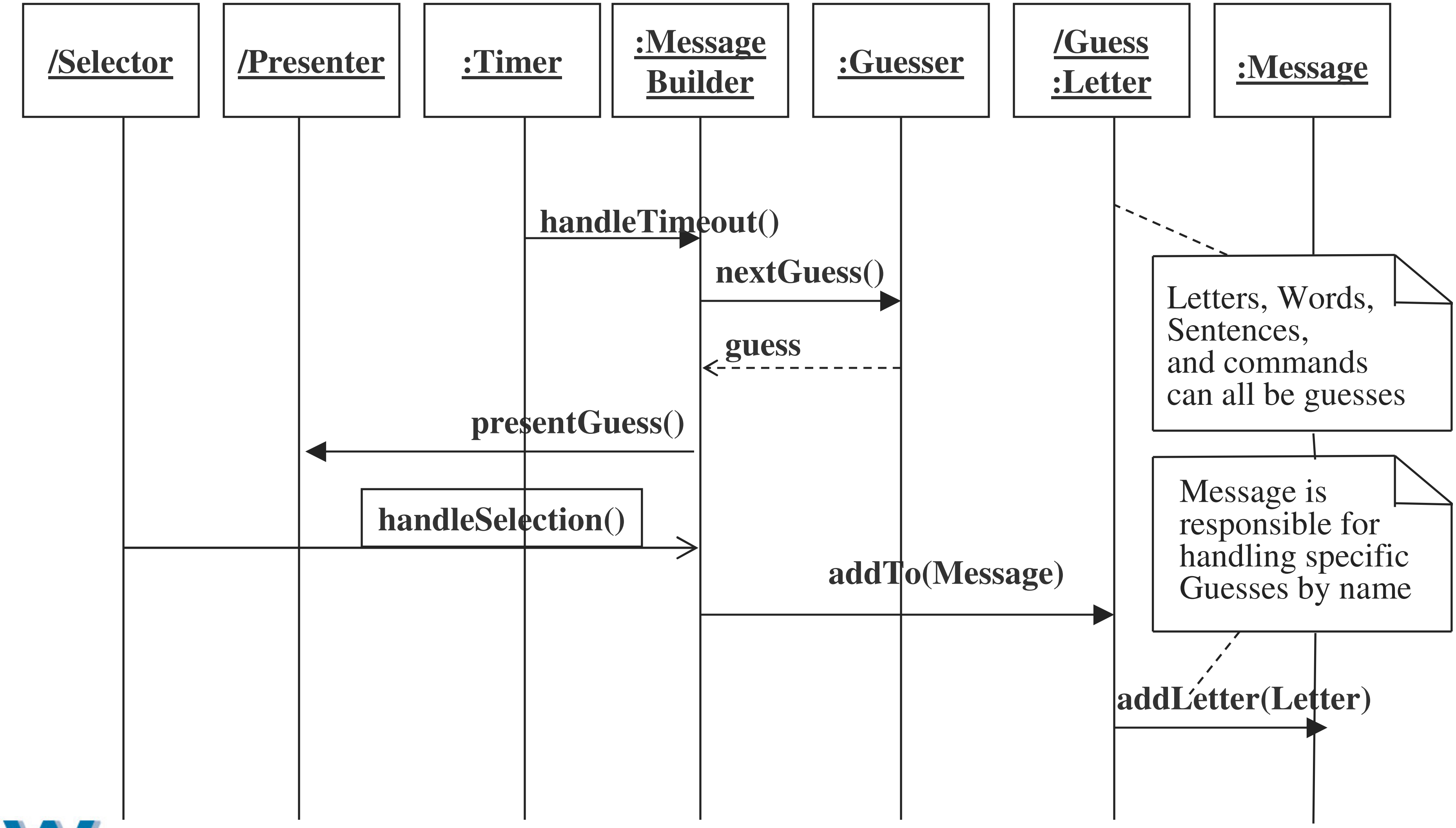


…then get more precise

Show a sequence of messages between these objects

- Label message arrows with names of requests
- Show arguments passed along with requests when it is important to understanding what information (objects) pass between collaborators
- Show return values when it is important that information is returned from a request

Sequence Diagram: Adding a Guess To A Message



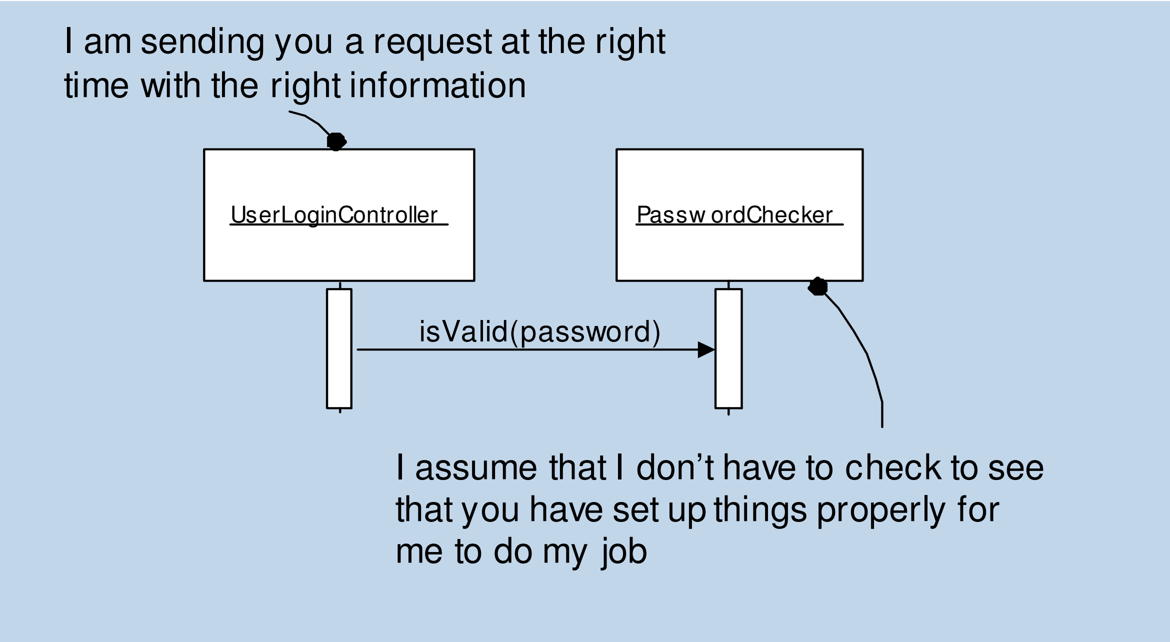
Letters, Words, Sentences, and commands can all be guesses

Message is responsible for handling specific Guesses by name

Definition: Collaborate

To work together, especially in a joint intellectual effort

This definition is collegial: Objects working together toward a common goal. Both client and service provider can be designed to assume that if any conditions or values are to be validated, they need be done only once



I am sending you a request at the right time with the right information

I assume that I don't have to check to see that you have set up things properly for me to do my job

But Can Collaborators Always Be Trusted to Behave Responsibly?

Consider collaborations between objects…

- that interface to the user and the rest of the system
- inside your system and objects that interface to external systems
- in different layers or subsystems
- you design and objects designed by someone else

Informal Tool: Technique Trust Regions

Divide your software into regions where trusted communications occur. Objects in the same trust region communicate collegially

Give objects at the edges responsibilities for verifying correctly formed requests

Assign objects that have control and coordination responsibilities added responsibilities for recovering from exceptions and errors

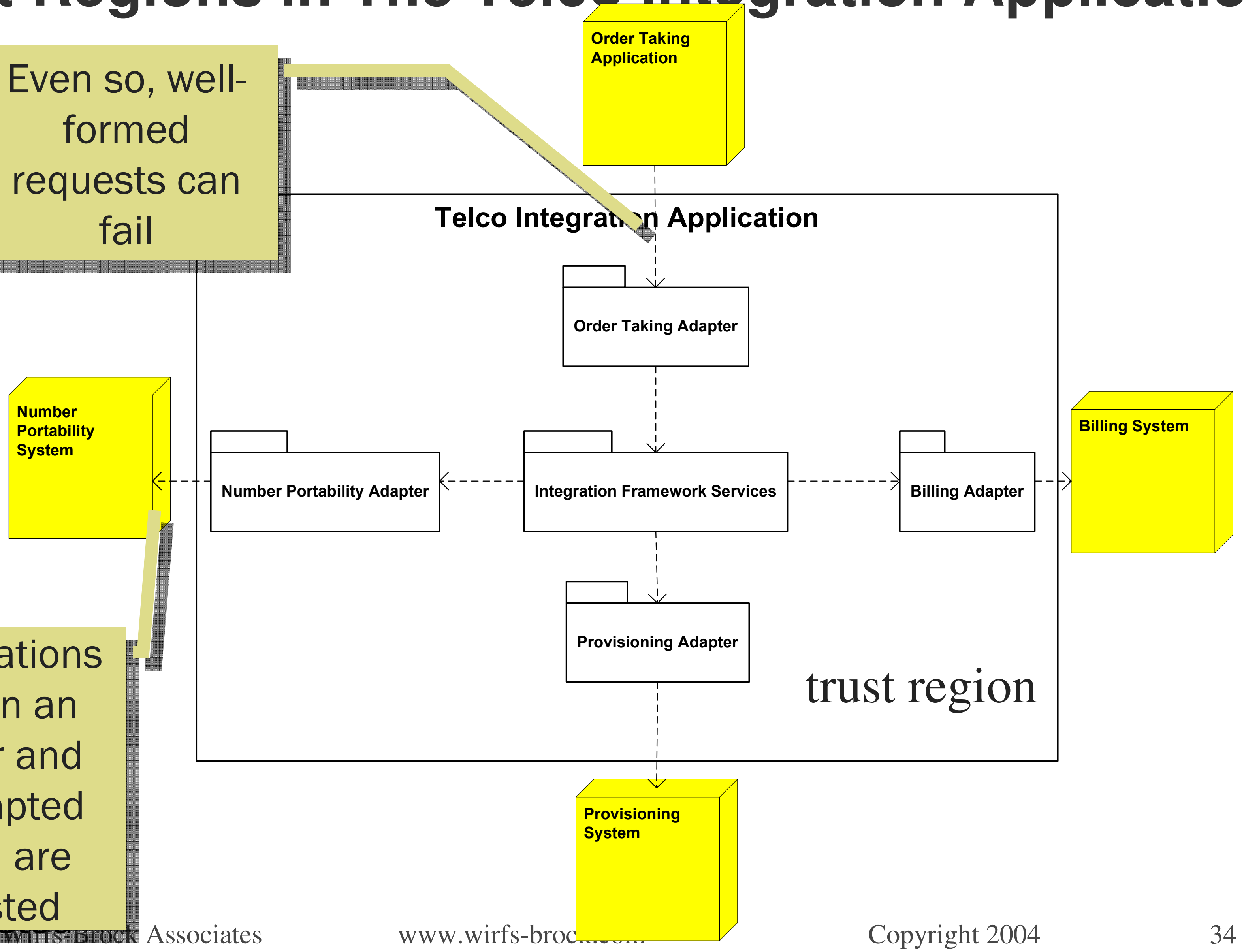
Implications of Trust

In a large system, distinguish whether collaborations among components can be trusted

Identify the guarantees, obligations, and responsibilities of each component

Use contracts to specify the details

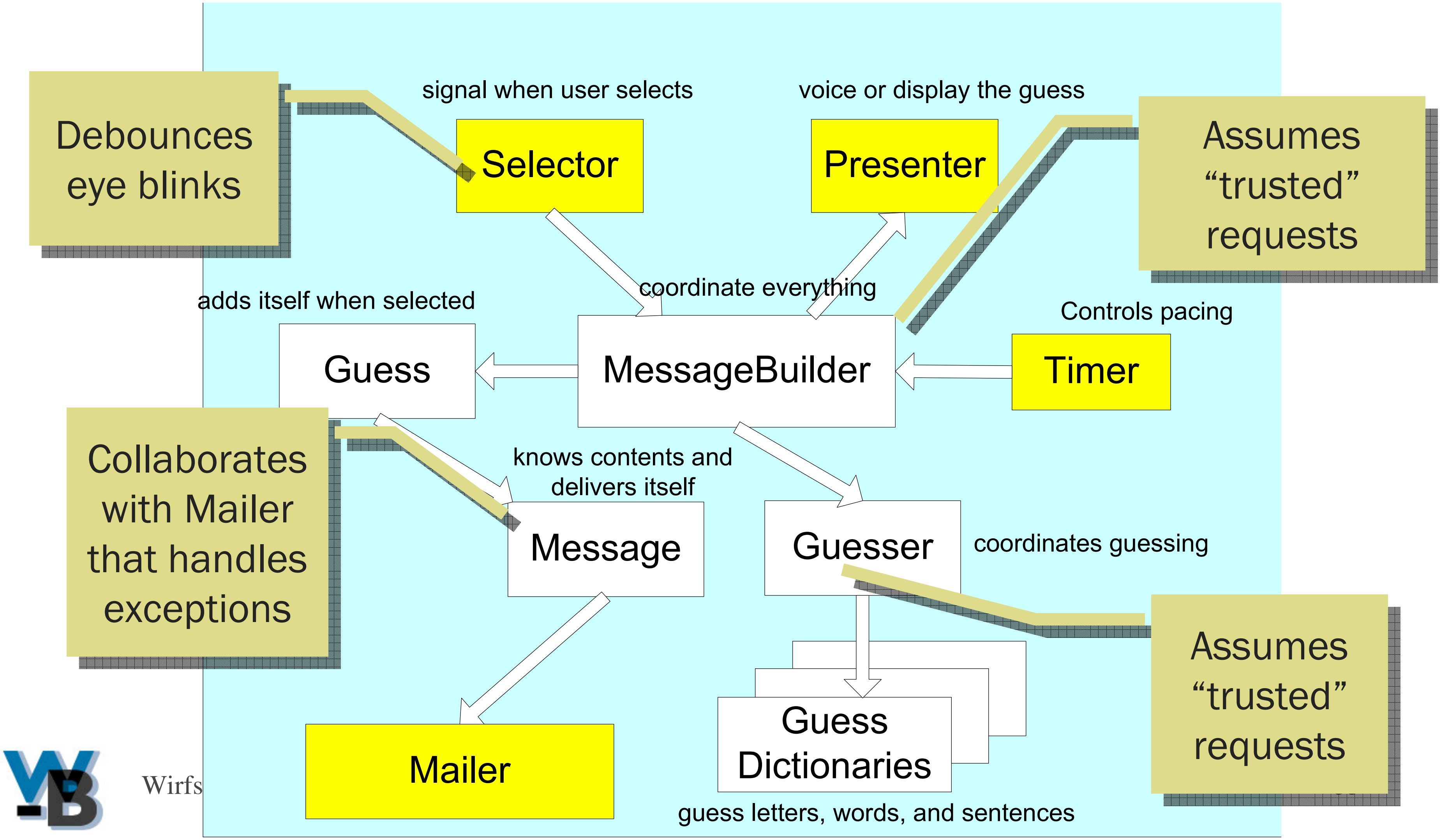
Trust Regions in The Telco Integration Application



Even so, well-formed requests can fail

Collaborations between an adapter and any adapted system are untrusted

Objects At The “Edges” Take On Added Responsibilities



Debounces eye blinks

signal when user selects

Selector

voice or display the guess

Presenter

Assumes “trusted” requests

coordinate everything

adds itself when selected

Guess

MessageBuilder

Controls pacing

Timer

Collaborates with Mailer that handles exceptions

knows contents and delivers itself

Message

Guesser

coordinates guessing

Mailer

Guess Dictionaries

Assumes “trusted” requests

guess letters, words, and sentences

Collaborations Among Trusted Colleagues

For collaborations among objects within the same trust region, there is little need to check on the state of things before and after each request

If an object cannot fulfill its responsibilities and it is not designed to recover from exceptional conditions, it could raise an exception or return an error, enabling its client (or someone else in the collaboration chain) to handle the problem

When Receiving Requests From Untrusted Sources

When receiving requests untrusted sources, you are likely check for timeliness, relevance, and correctly formed data

But don’t design every object to collaborate defensively

- It leads to poor performance
- Redundant checks are hard to keep consistent and lead to brittle code

When Using An Untrusted Collaborator

If a collaborator can’t be trusted, it doesn’t mean it is inherently more unreliable. It may require extra precautions to use:

- Pass along a copy of data instead of sharing it
- Check on conditions after the request completes
- Employ alternate strategies when a request fails

Control Styles and Control Center Design

Control Design

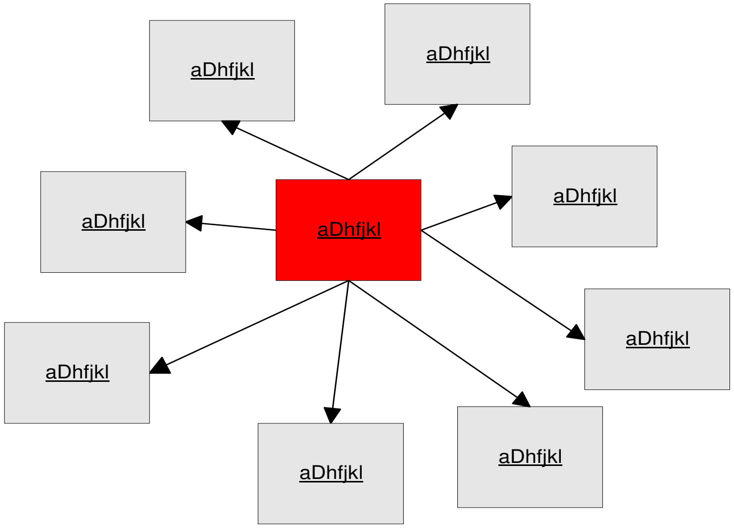
Involves decisions about

- how to control and coordinate application tasks (use case control design),
- where to place responsibilities for making domain-specific decisions (rules), and
- how to manage unusual conditions (the design of exception detection and recovery)

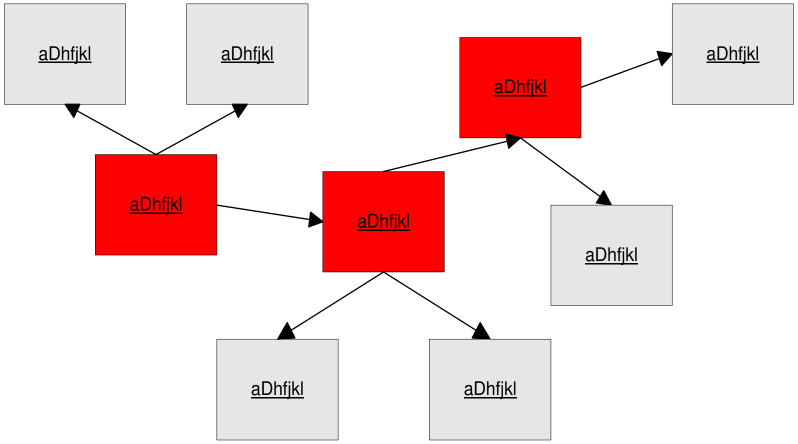
Goal: develop a dominant pattern for distributing the flow of control and sequencing of actions among collaborating objects

Control Styles

Centralized

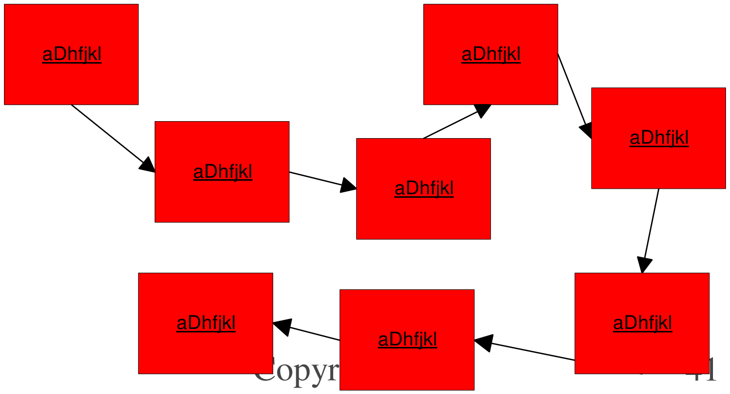


Delegated



Control styles range from centralized to fully dispersed

Dispersed



Characteristics of Centralized Control

Generally, one object (the controller) makes most of the important decisions. Decisions may be delegated, but most often the controller figures out what to do next. Tendencies with this strategy:

- Control logic can get overly complex
- Controllers surrounded by simple information holders and service providers
- These simple objects tend to have low-level, non-abstract interfaces

Drawback:

Changes can ripple among controlling and controlled objects

Characteristics of Delegated Control

A delegated control style passes some decision making and much of the work off one objects surrounding a control center. Each object has a more significant role to play:

- Coordinators know about fewer objects than dominating controllers
- Objects both know and do things—blends of stereotypes
- Higher-level communications between objects

Benefits:

- Changes typically localized and simpler
- Easier to divide detailed design work

Characteristics of Dispersed Control

A dispersed control style spreads decision making and action among objects who do very little, but collectively their work adds up. This can result in:

- Little or no value-added by those receiving a message and merely "delegating" request to next in chain

Drawback:

- Hardwired dependencies between objects in call chain
- May break encapsulation

Control Center Design

A control center is a place in an application where a consistent pattern of collaboration needs to exist.

In all but the simplest application, you will have multiple control centers

Control center design is important to consider when:

- Handling user-initiated events (typically described by use cases)
- Managing complex software processes
- Designing how objects work together within a subsystem
- Controlling external devices and/or external applications under your software's control

Control Style Development Guidelines

Don’t adopt the same control style everywhere. Develop a control style suited to each situation:

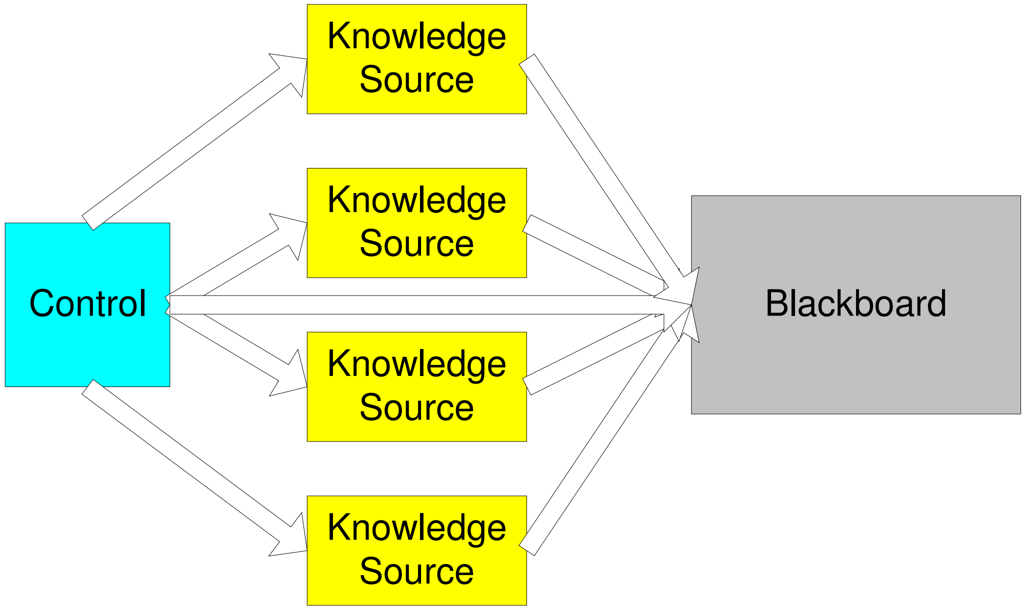
- Adopt centralized control when you want to localize decisions in a single controller
- Develop a delegated style when work can be assigned to specialized objects

Several styles can co-exist in a single application

- Similar use cases often have a similar control style
- Control styles within subsystems can vary widely

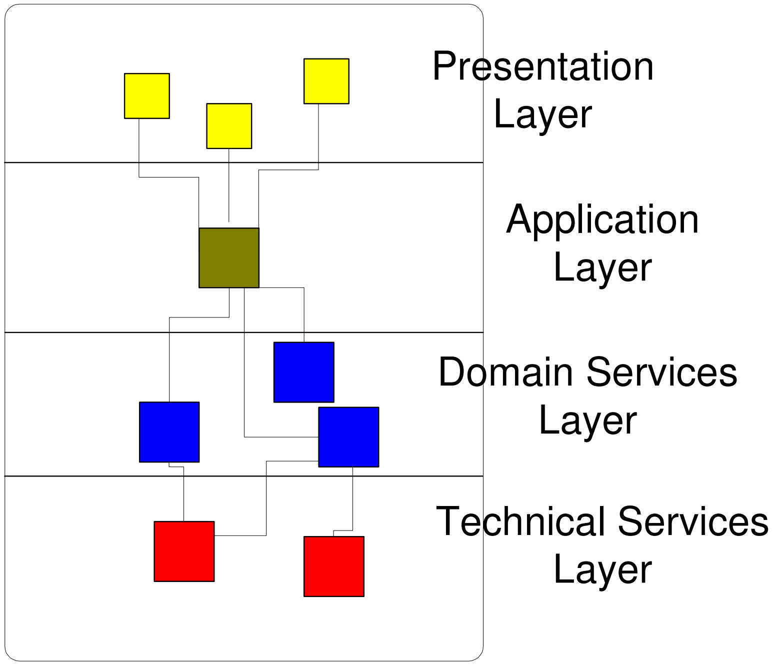
General design rule: Make analogous parts of your design be predictable and understandable by making them work in similar ways

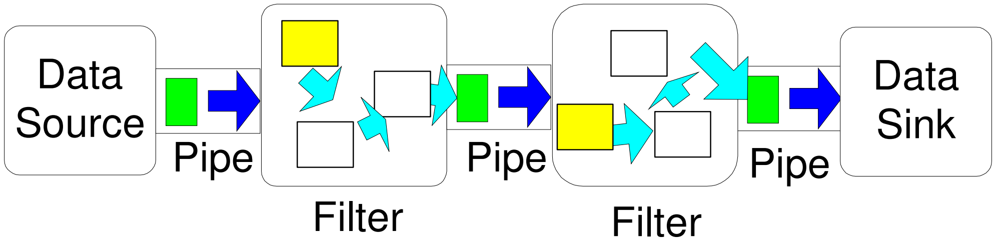
Different Application Architectures



Blackboard

Layers

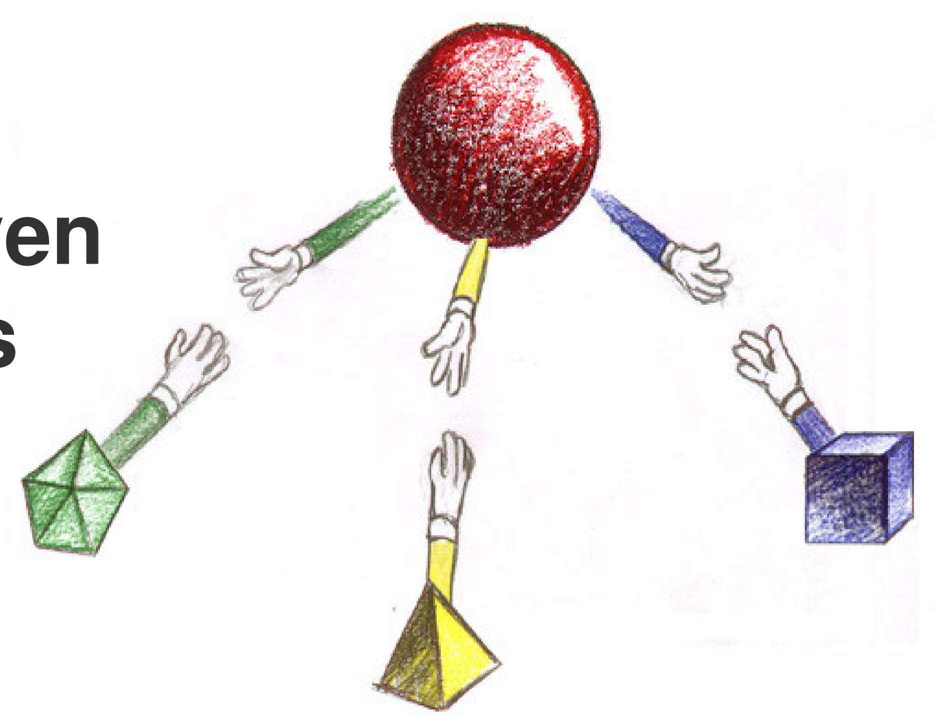




Pipes and Filters

Contracts

Responsibility-Driven Design Contracts



"The ways in which a given client can interact with a given server are described by a contract. A contract is the list of requests that a client can make of a server. Both must fulfill the contract: the client by making only those requests the contract specifies, and the server by responding appropriately to those requests. …For each such request, a set of signatures serves as the formal specification of the contract."

—Wirfs-Brock, Wilkerson & Wiener

Finding and Preserving Contracts

A class that is viewed by all its clients identically, offers a single contract

A class that inherits a contract should support it in its entirety. It should not cancel out any behavior

A subclass may extend a superclass by adding new responsibilities and defining new contracts

A class that is viewed differently by clients can offer multiple contracts. Organize responsibilities into contracts according to how they are used:

Example: Specify four BankAccount contracts

1. Balance Adjustment
2. Balance Inquiry
3. Managing Challenge Data
4. Maintaining Transaction History

Specifying Detailed Contracts

"Defining a precondition and a postcondition for a routine is a way to define a contract that binds the routine and its callers…."

—Bertrand Meyer, *Object-Oriented Software Construction*

Meyer's contracts add even more details. They specify:

- Obligations required of the client
  - Conditions that must be true before the service will be requested
- Obligations required of the service provider
  - Conditions that must be true during and after the execution of the service
- Guarantees of service

Defined for each method or service call

Example: A Contract For A Request That Spans A Trust Boundary

Request: Funds Transfer	Obligations	Benefits
Client: Online banking app	(precondition) User has two accounts	Funds are transferred; balances adjusted
Service provider: backend banking system	(preconditions) Sufficient funds in the first account Honor requests only if both accounts active (postcondition) Both balances are adjusted	Only needs to check for sufficient funds and active accounts, need not check that user is authorized to access accounts

A Unified View of Contracts

A design can be viewed at different levels of abstraction

- Responsibility-Driven Design Contract
  - name and description
  - list of clients and suppliers
  - list of responsibilities defined by the contract
    - method signatures
- Meyer’s contracts add precision where we stopped:
    - method signature
      - client obligations
      - supplier benefits
      - preconditions, postconditions, invariants

When To Use Contracts

Use them as a point of discussion when you are assigning responsibilities among collaborators

But writing detailed contracts is a lot of work. Use them when you want to be formal and precise

Detailed contracts are especially useful for defining collaborations between your software and external systems

Designing Responsibly

Use the best tool for the job

- Tools for thinking, abstracting, modeling
- Tools for analyzing
- Tools for making your application flexible

Learn your tool set, and practice, practice, practice

The best designers never give up, they just know when to call it a day!