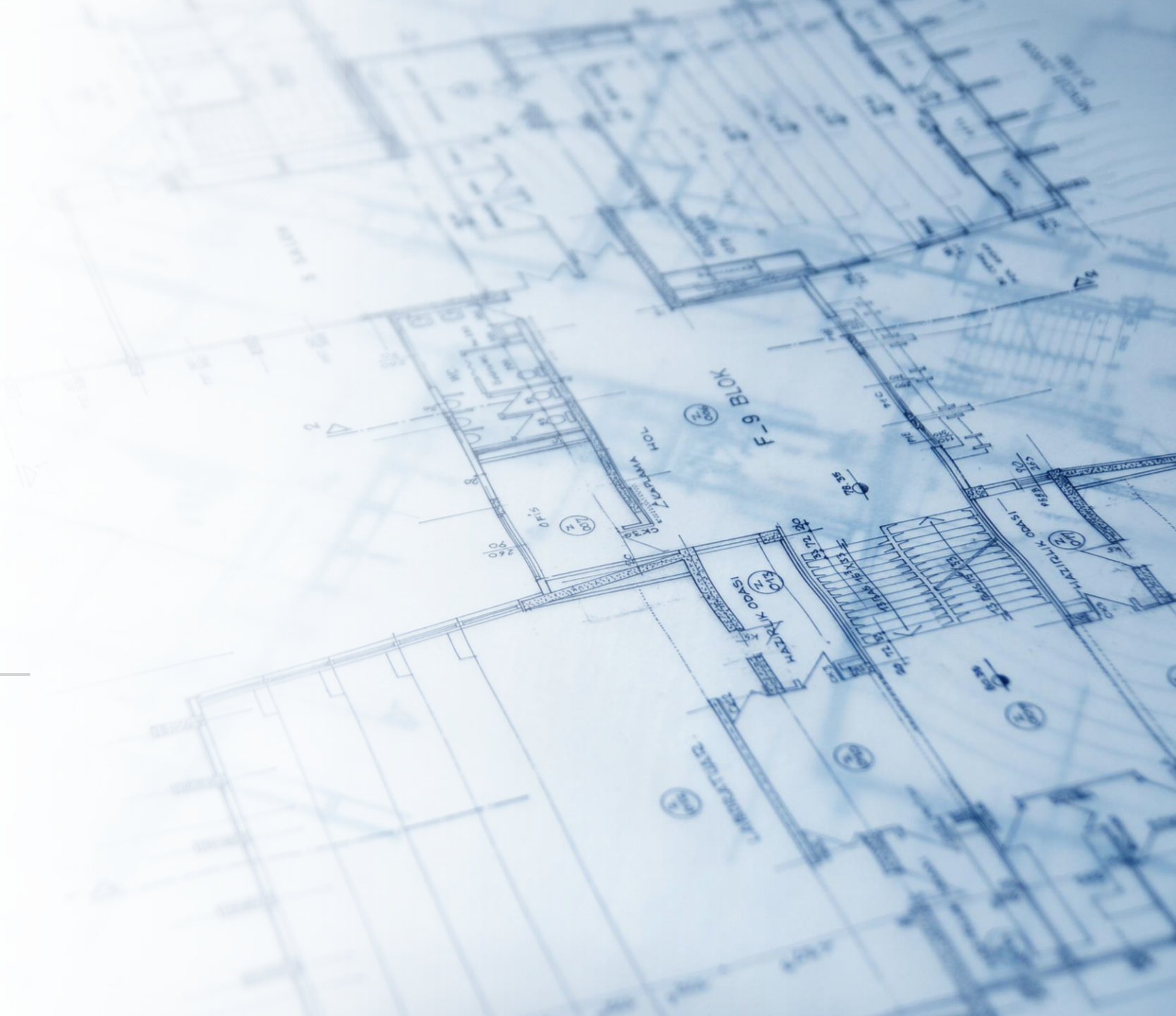
Lecture 11: Architecture II

CS 5150, Spring 2022



Session 2 general feedback

- Need to know deployment infrastructure
  - Have you met with your client?
- Probably need to refine requirements
  - Have you met with your client?
- Remember good meeting strategies
  - Moderator, recorder, agenda (sent ahead of time)
  - Don't just reserve a time – PoC should send an e-mail

Lecture goals

- Identify common architectural styles (continued)
  - Three tier architecture
  - Model-view-controller
- Encapsulate deployments using virtualization

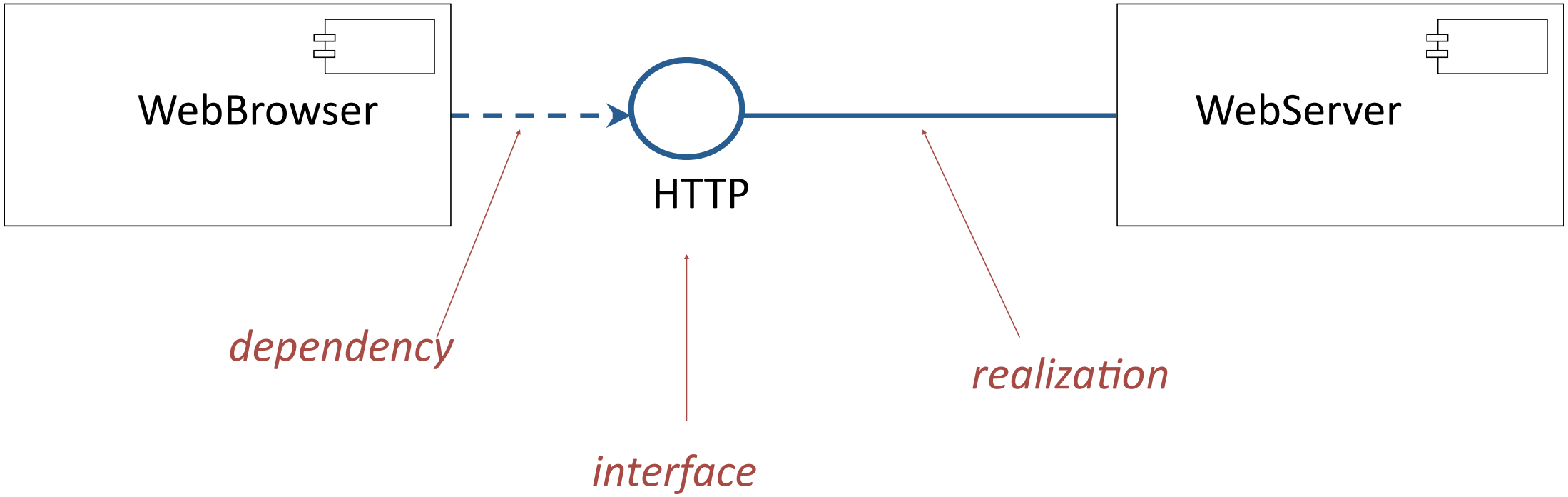
Architectural styles

… continued from Lecture 10

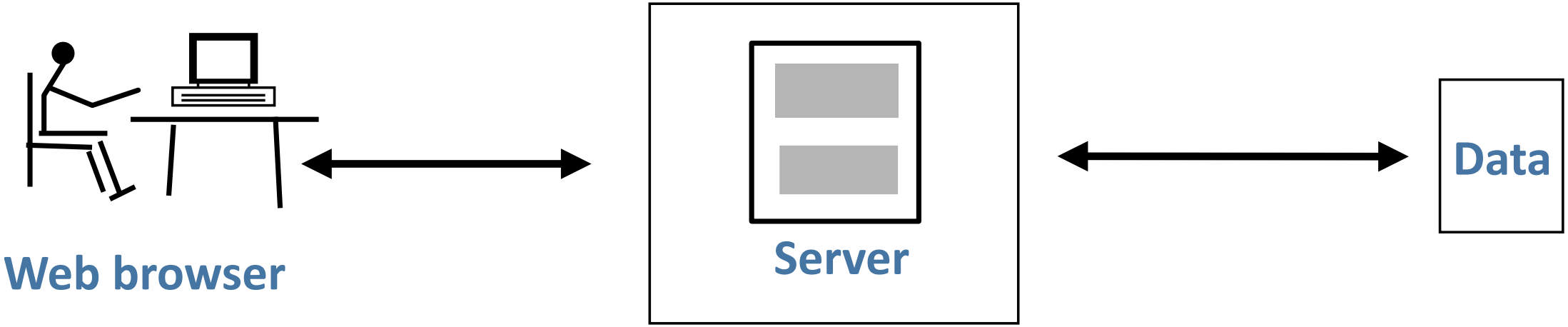
Three tier architecture

- Extension of client/server model
- Commonly used for small-medium web sites
  - Classic example: LAMP stack

Basic website (client/server)



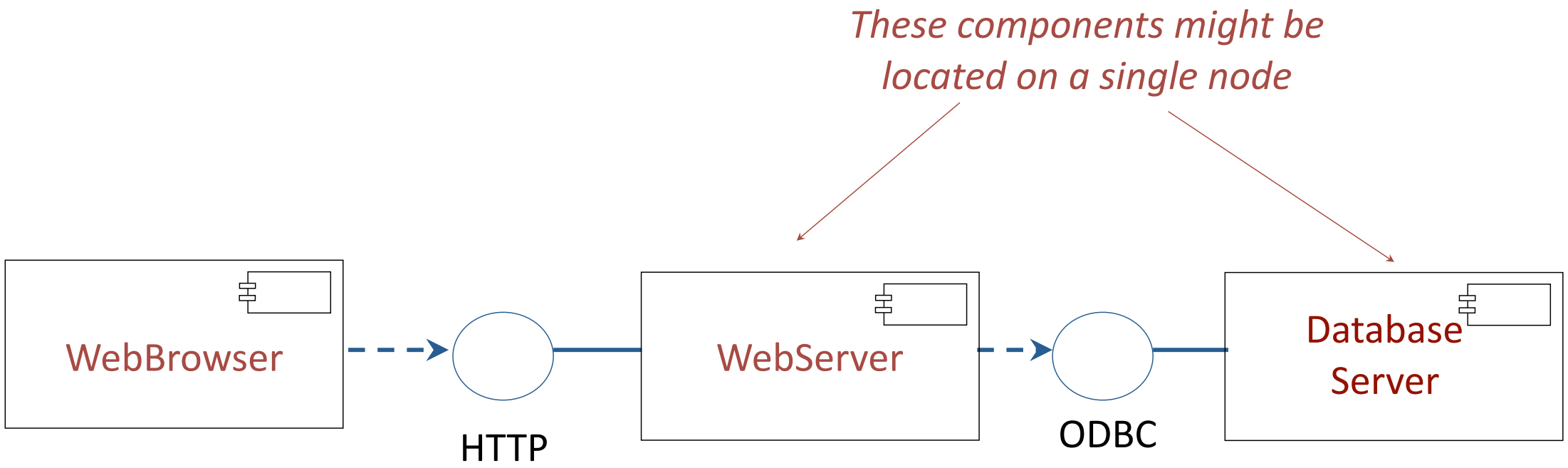
Extension: data store



Review: component & deployment diagrams

PollEv.com/cs5150

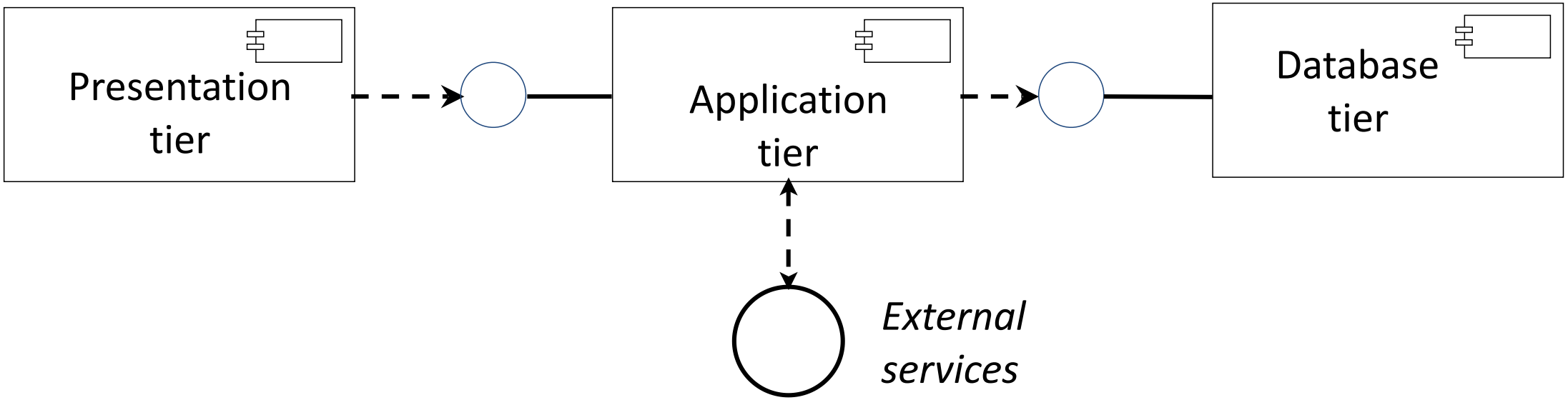
Component diagram



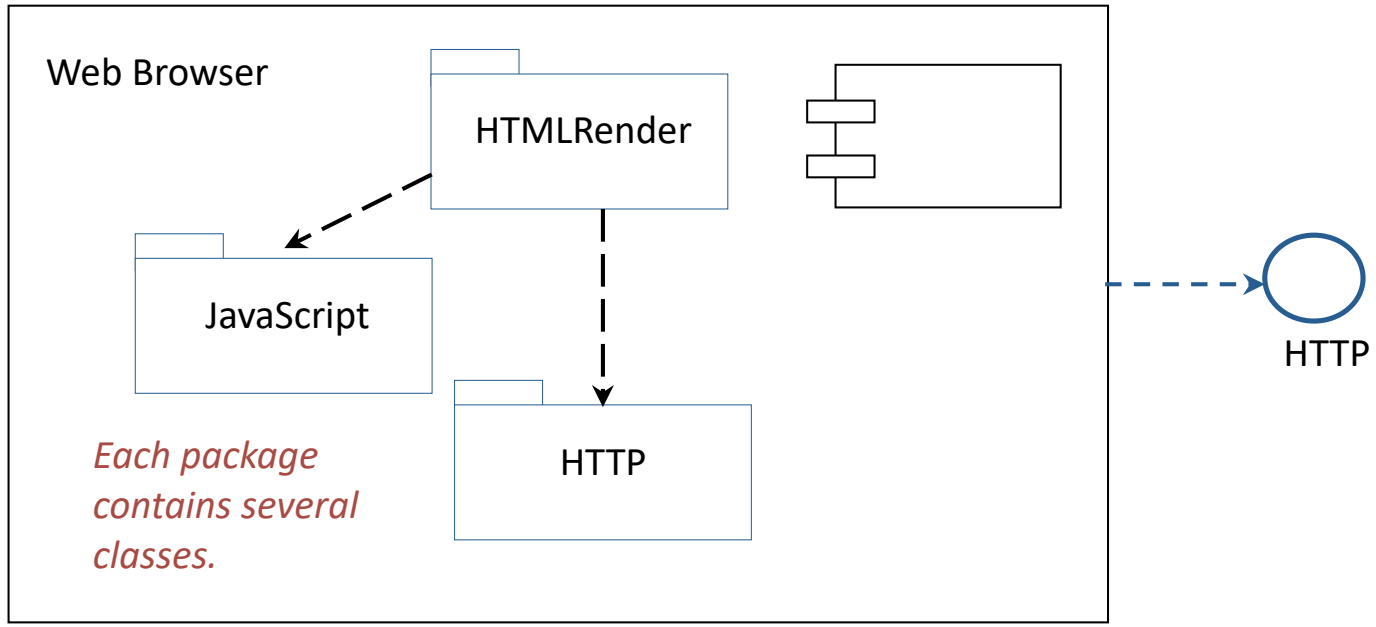
Significance of components (replaceable binary elements):

- Any web browser can access the website
- Database can be replaced by another that supports the same interface

Three tier architectural style



Presentation tier complexity

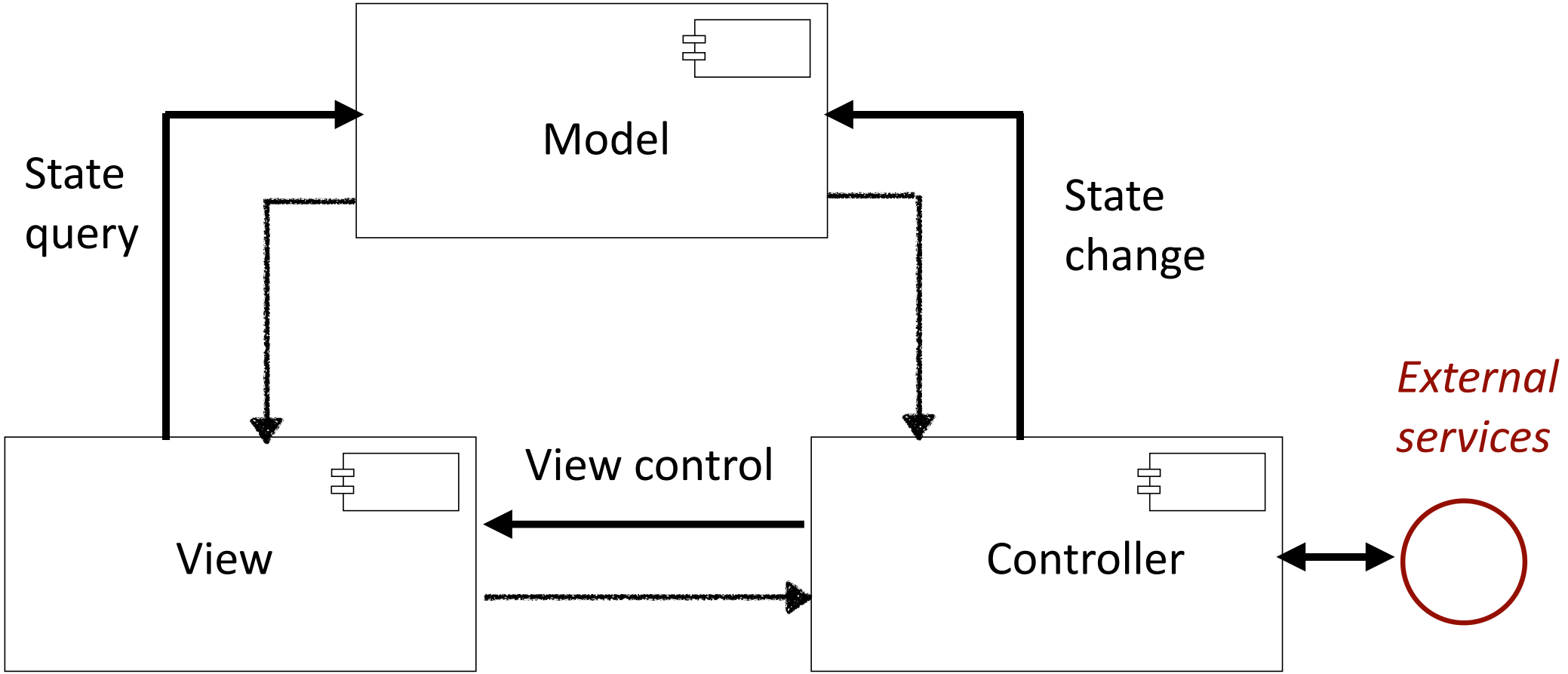


Presentation tier may house internal complexity, but as long as it supports the same interface, it is still a binary-replaceable component

Model-view-controller

- Beware: many variations
  - Some are architectural styles: system-level responsibilities partitioned into different components
    - Example: Play Framework
  - Some are program design patterns: functionality divided between different classes
    - Focus on reusable controls
    - Example: Swing widgets
    - Variation on which logic is widget-level vs. form-level (MVC vs. MVP)
    - Variation on which classes communicate directly (MVC vs. MVA)
    - Variations in model storage (domain objects, DB record sets, immutable store)

Component diagram



Features of MVC

- Separated presentation
  - Decouple model and view (replaceable components)
  - Multiple (possibly simultaneous) views supported

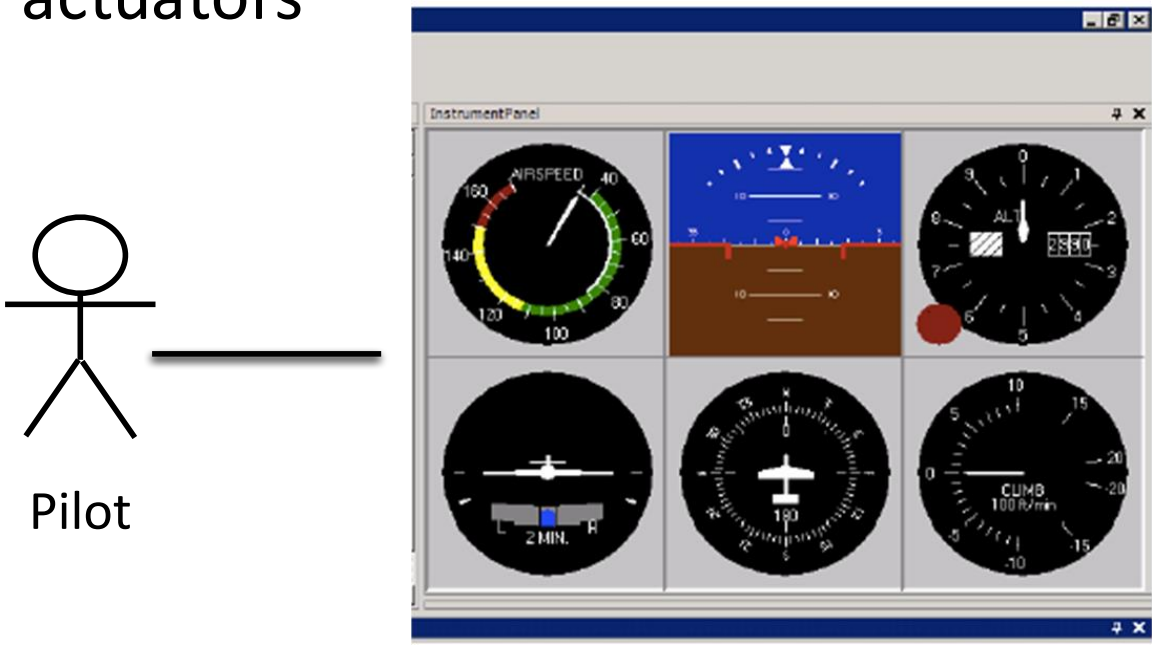
Example: "mission control" terminal

(based on a past CS 5150 project)

- A vehicle (unmanned aircraft) is flown by a pilot interfacing with a computer terminal on the ground
- Vehicle communicates with ground station via radio signals
  - Actuation commands (uplink): change throttle, angle flaps, etc.
  - Sensor measurements (downlink): air speed, GPS position, actuator settings, etc.

Example: View

- Graphical user interface shows model properties (sensor readings, derived state) as instrument dials and provides input widgets for commanding actuators



Example: Model

- Maintains record of state of vehicle (speed, fuel, …)
- Computes derived properties of vehicle (rate of turn, predicted trajectory, …)
- Updates state in response to actions from controller (e.g. new telemetry received)
- Provides view with information to be displayed to user

Different vehicles will need different models but might not require new views or controllers.

Example: Controller

Scenario: Pilot wishes to change flap angle to 20 deg to increase lift and accommodate a slower speed for landing.

1. View sends message to controller: `setFlaps(20)`
2. Controller sends radio command to vehicle: `setFlaps(20)`
3. Vehicle acts on command and replies to controller: `flapsSet(20)`
4. Controller relays telemetry to model: `flapsSet(20)`
5. Model updates state and recomputes stall speed
6. Model notifies view of new state (flap setting, stall speed)
7. View displays new state in user interface

View

- Presents application state and controls to user
- Typically subscribes to model for notifications of state changes
  - "Observer pattern"
- Responsible for rendering to a particular interface
  - Drawing graphics, generating HTML, printing text
- Sends user input to controller
- A single model can support multiple views
  - Example: web app, native app

CS 5150 project: create a new view for pilot. Since this was a separate component, it could replace the old view with no other changes to the system.

Model

- Records state of application and notifies subscribers
  - Responds to instructions to change state (from controller)
- Does not depend on either controller or view
- State may be stored in objects or databases
- May be responsible for some application logic (e.g. input validation)

Controller

- Manages user input and navigation
- Defines application behavior
- Maps user actions to changes in state (model) or view
- May interact with external services via APIs
- May be responsible for some application logic (e.g. input validation)

- Variety in distribution of duties between model and controller

Publish-subscribe

See Sommerville, *Software Engineering, Tenth Edition*, Web sections: Event-driven control

- Event-driven control
  - Application responds to external stimuli and timeouts
  - No centralized orchestration
- Very loose coupling – components communicate via message broker
  - Easy to extend
  - Difficult to analyze (observer pattern)
    - No control over what (if any) code responds to an event
    - Potential for conflicts (multiple components respond in incompatible ways)
    - Potential for silently dropped events
    - Call stacks may not reflect causality

Activity: system decomposition

- What happens when I tap "send" in a mail app on my phone?
  - Draw a hardware block diagram
  - Draw layers of system software

Closing remark

- Beware software architectures that resemble corporate hierarchy
  - Refactoring more disruptive than reorgs
  - Be aware of and accommodate political context, but architecture should serve the application more than the developer

Virtualization

Deployment concerns

- Dependency conflicts
- Configuration, data sprawl
- OS portability
- Unintended interactions
  - Filesystem has same problems as global variables

- Solution: Encapsulation; but...
  - Deploying on separate machines risks under-utilization

Virtual machines

- Multiple OS instances running on one machine
  - Real hardware is managed by host OS or hypervisor
- Improves hardware utilization, reduces cost
  - Avoids energy consumption by redundant hardware
- Stateful – still risks data sprawl
  - Address with automated administration
- High overhead – software redundancy

- Examples: VMware, VirtualBox, Xen, Hyper-V

System configuration management

- Automate deployments
  - Installing dependencies
  - Configuring OS
  - Configuring application
- Combat sprawl

- Examples: Ansible, Puppet, Chef, Vagrant

Containers

- Trade OS heterogeneity for reduced redundancy
- Still isolate filesystem, network without duplicating OS
- Lightweight – new instances start quickly
  - Improves elasticity
- Often encapsulates a single application
- Often treated as stateless (don't write to filesystem)

- Examples: Docker, LXC

"Serverless"

- Computation nodes are stateless, ephemeral, and event-triggered
  - Data store services still persist state, but are application-agnostic
- Application decomposed into event-handler functions
  - Event dispatch, container lifetime managed by platform

- Examples: Amazon Lambda

Three-tier vs. serverless

- See https://martinfowler.com/articles/serverless.html

Microservices

- Components encapsulate services and expose them via standard interfaces. Are ideally binary-replaceable
  - In practice, many frameworks for managing modular applications are language-specific (e.g. OSGi for Java)
  - OOP abstractions like objects, methods are complicated at language boundaries and distributed deployment
- Microservices constrain component definition to reduce coupling
  - Language-agnostic protocols (e.g. RESTful HTTP)
  - Independently deployable

Credits

- Architectural diagrams adapted from work by William Arms