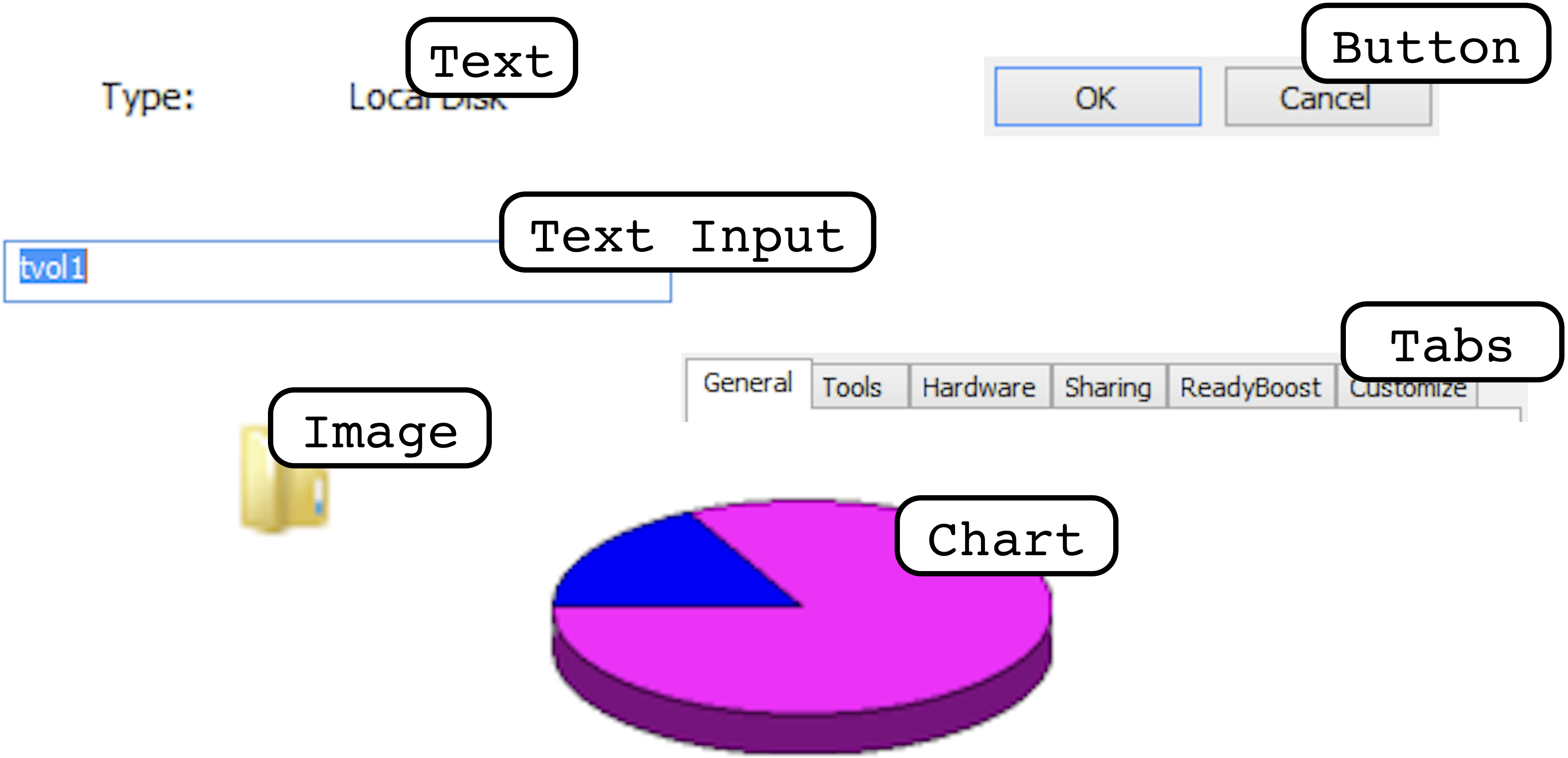
PV252 Lecture 1

Part 1: Element hierarchy

Basic building blocks of user interfaces:

`Elements`, `Views`, `Widgets`, ...



Each `Element` is responsible for how a specific piece of information is rendered.

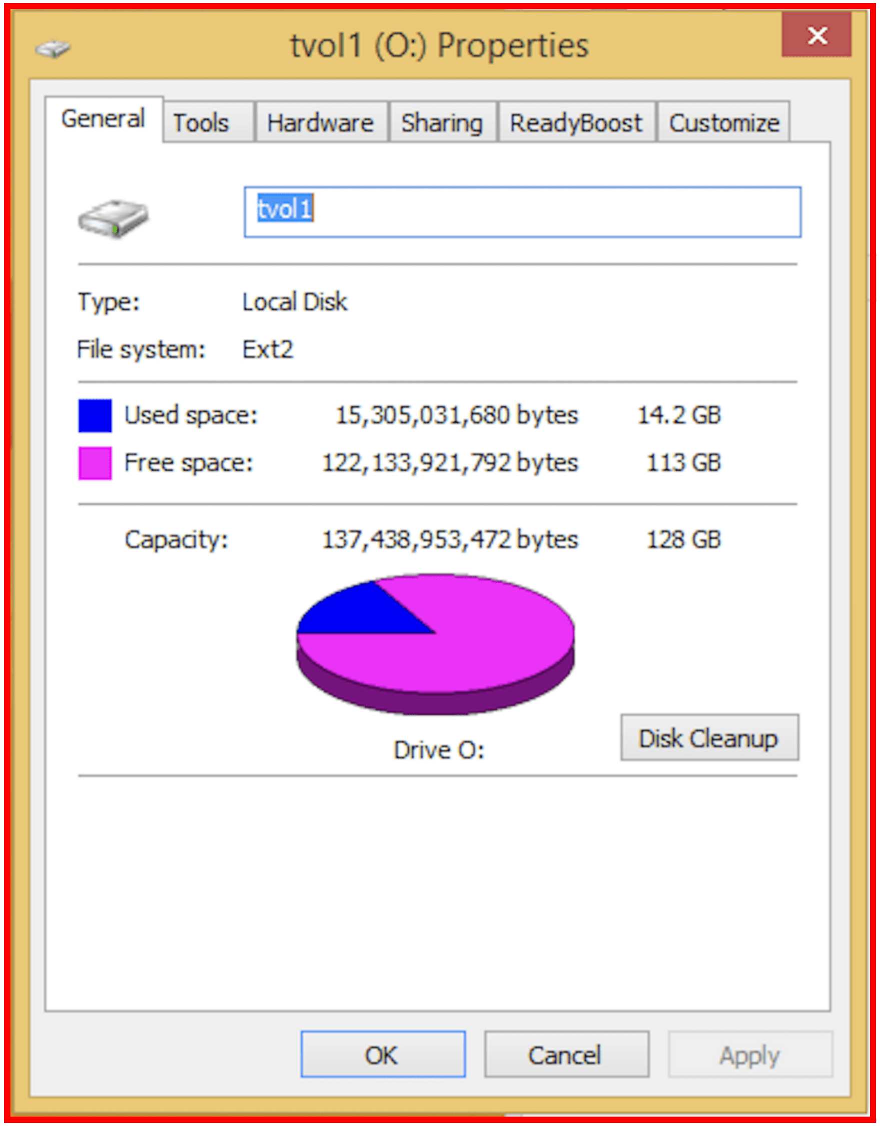
```
// A gross oversimplification...
class Button {

    draw(canvas) {
        canvas.drawRectangle(self.bounds, self.backgroundColor)
        canvas.drawText(self.text, self.centerPoint(), self.fontStyle)
        canvas.drawBitmap(self.icon, self.iconPoint())
    }

}
```

UI Elements are structured as a tree

Dialog Window



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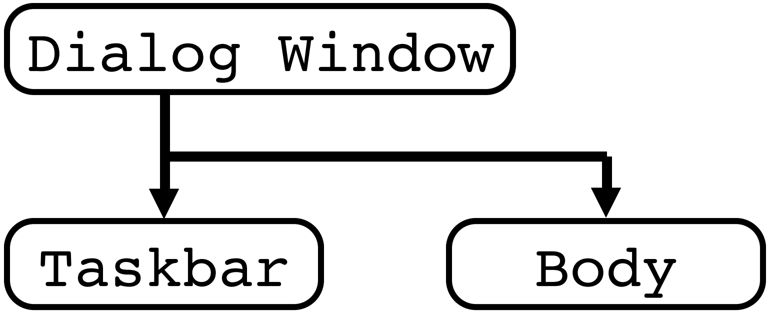

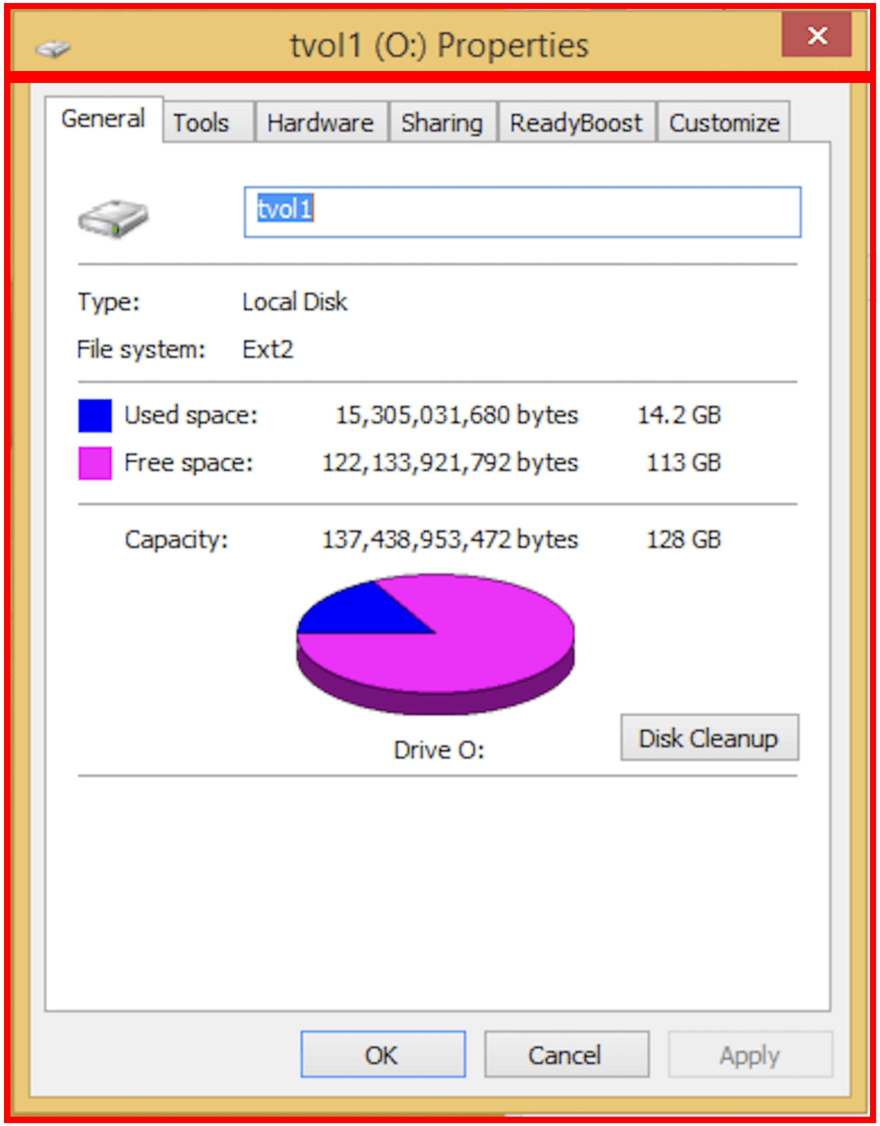

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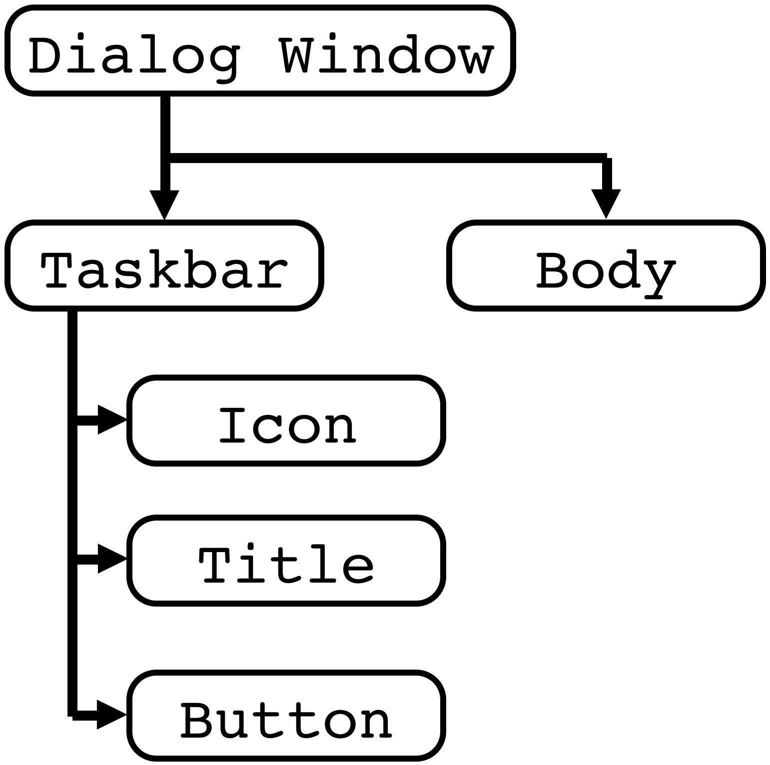

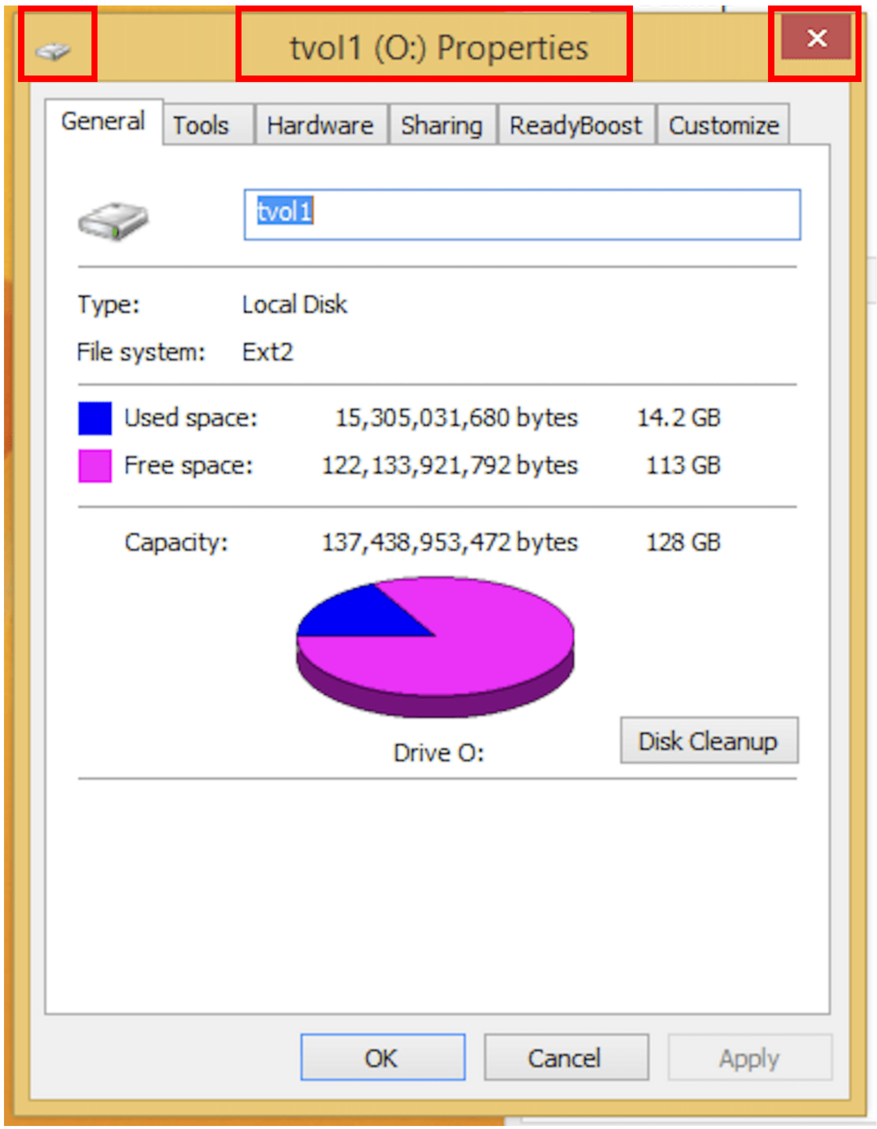

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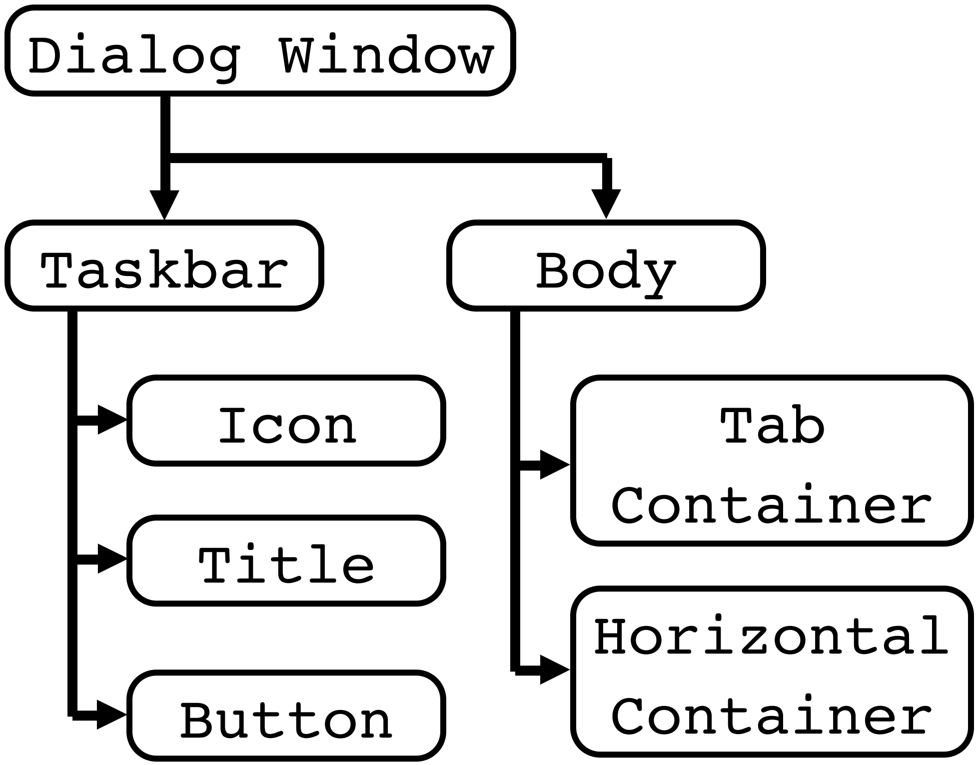

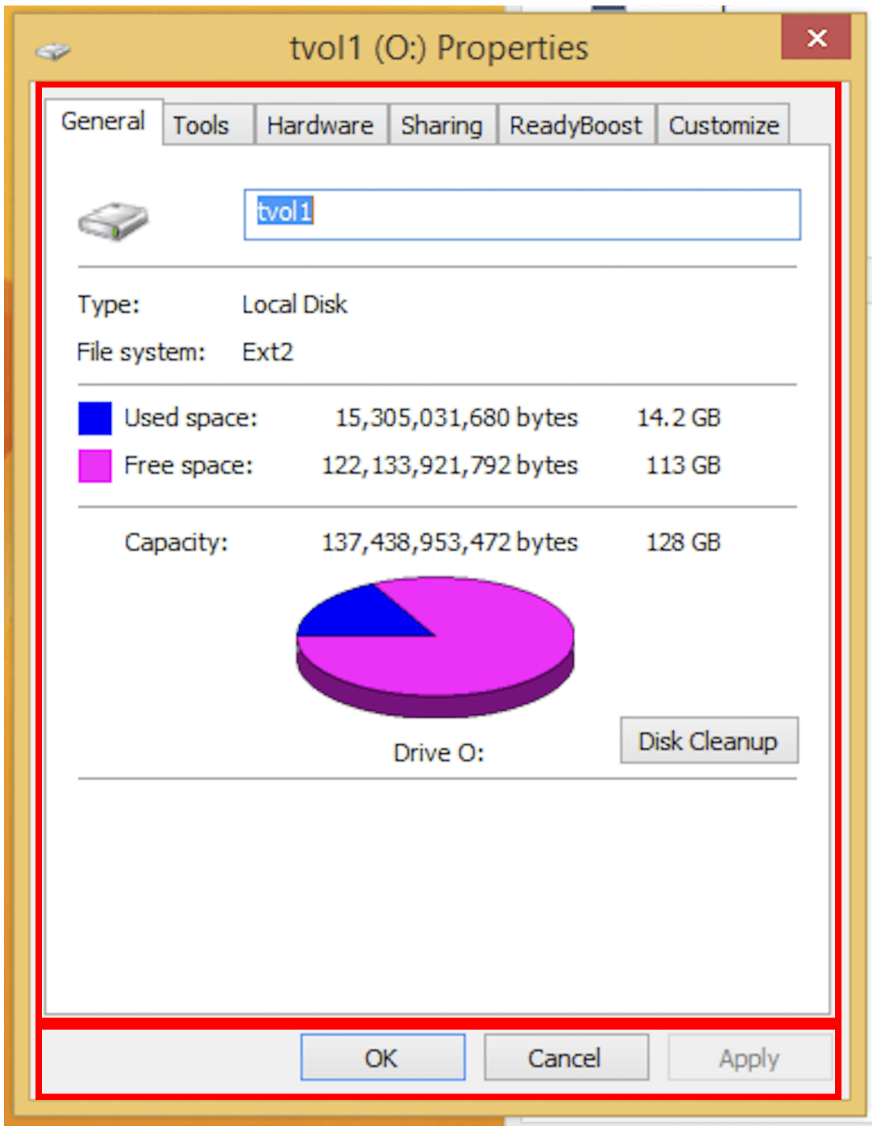

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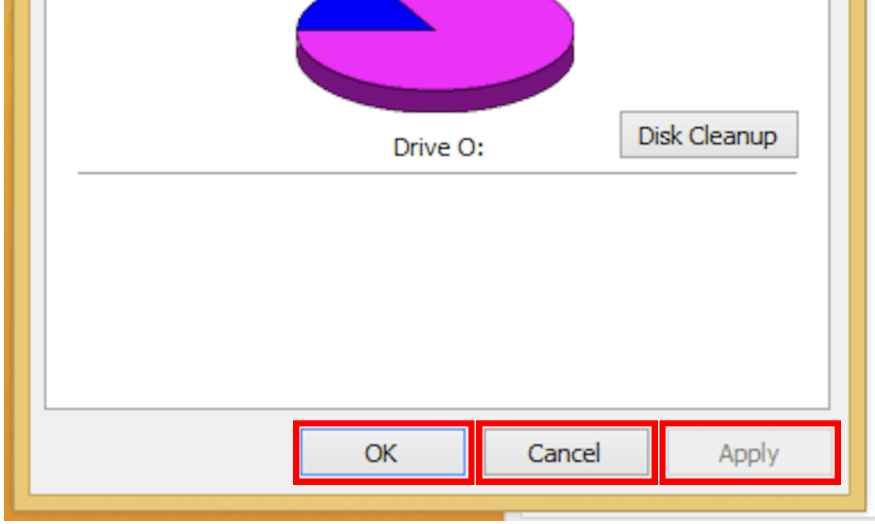

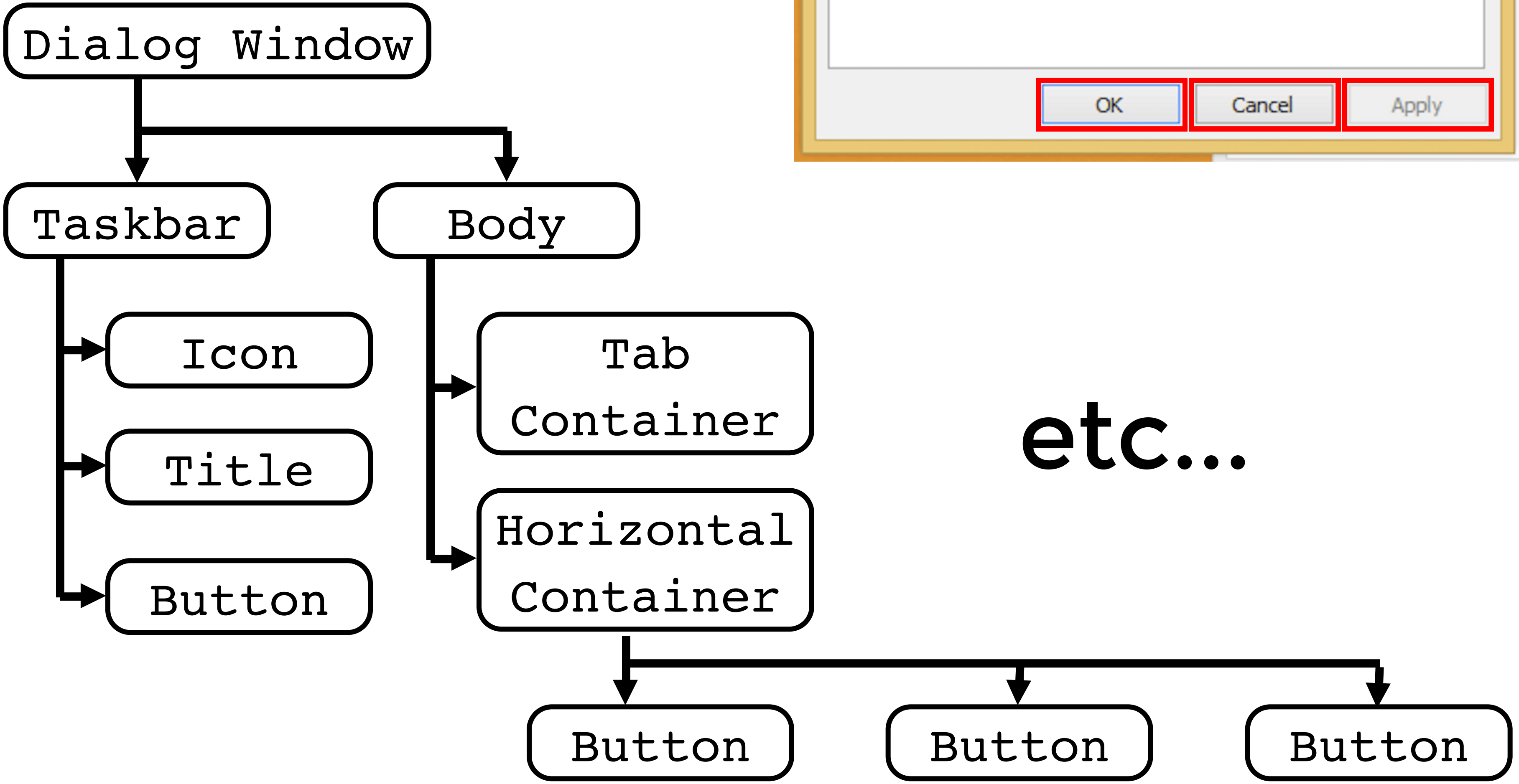

etc...

Part 2: Basis of interactivity

So far, the Element hierarchy is completely *static*… how does user interaction come into play?

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`Event`

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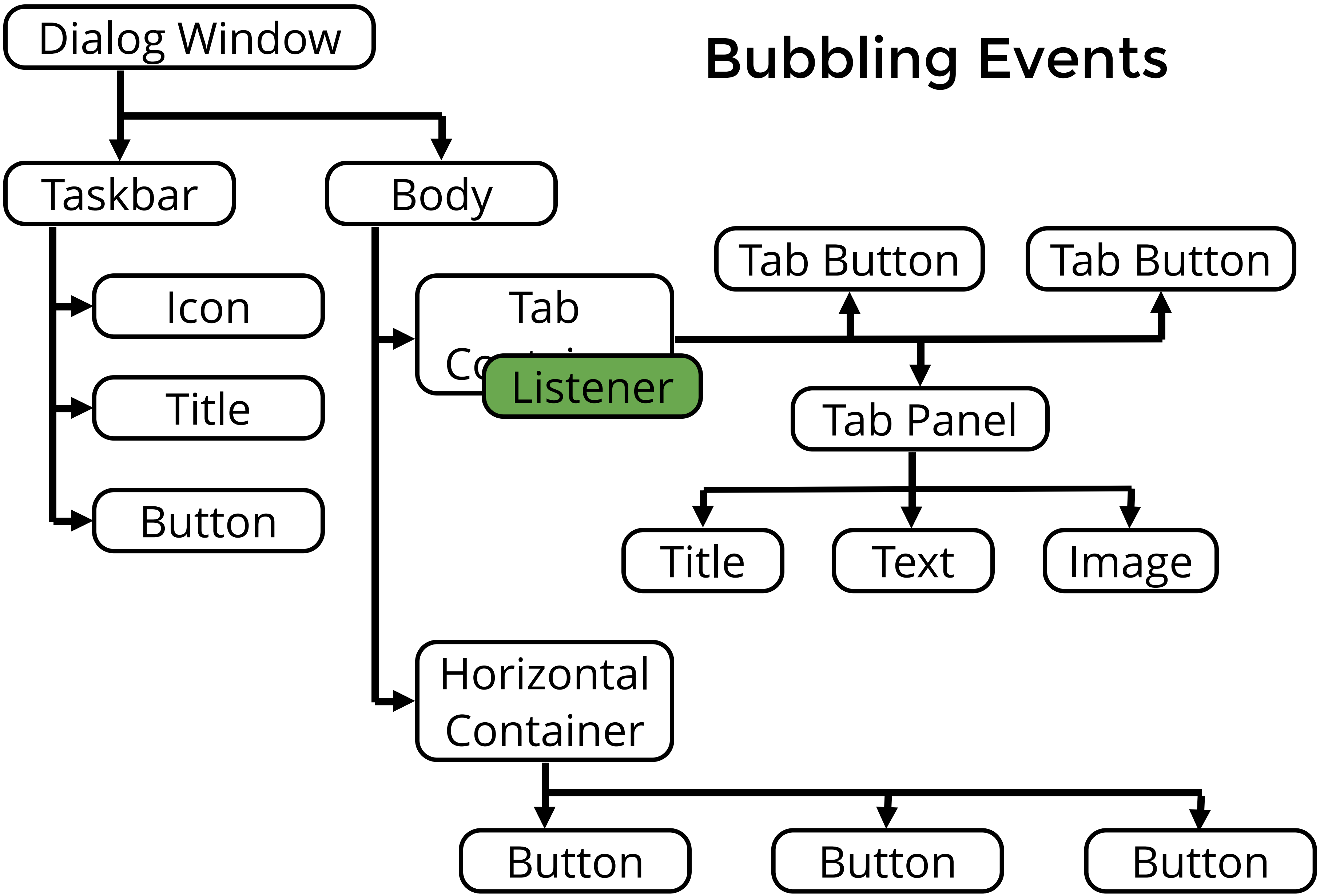
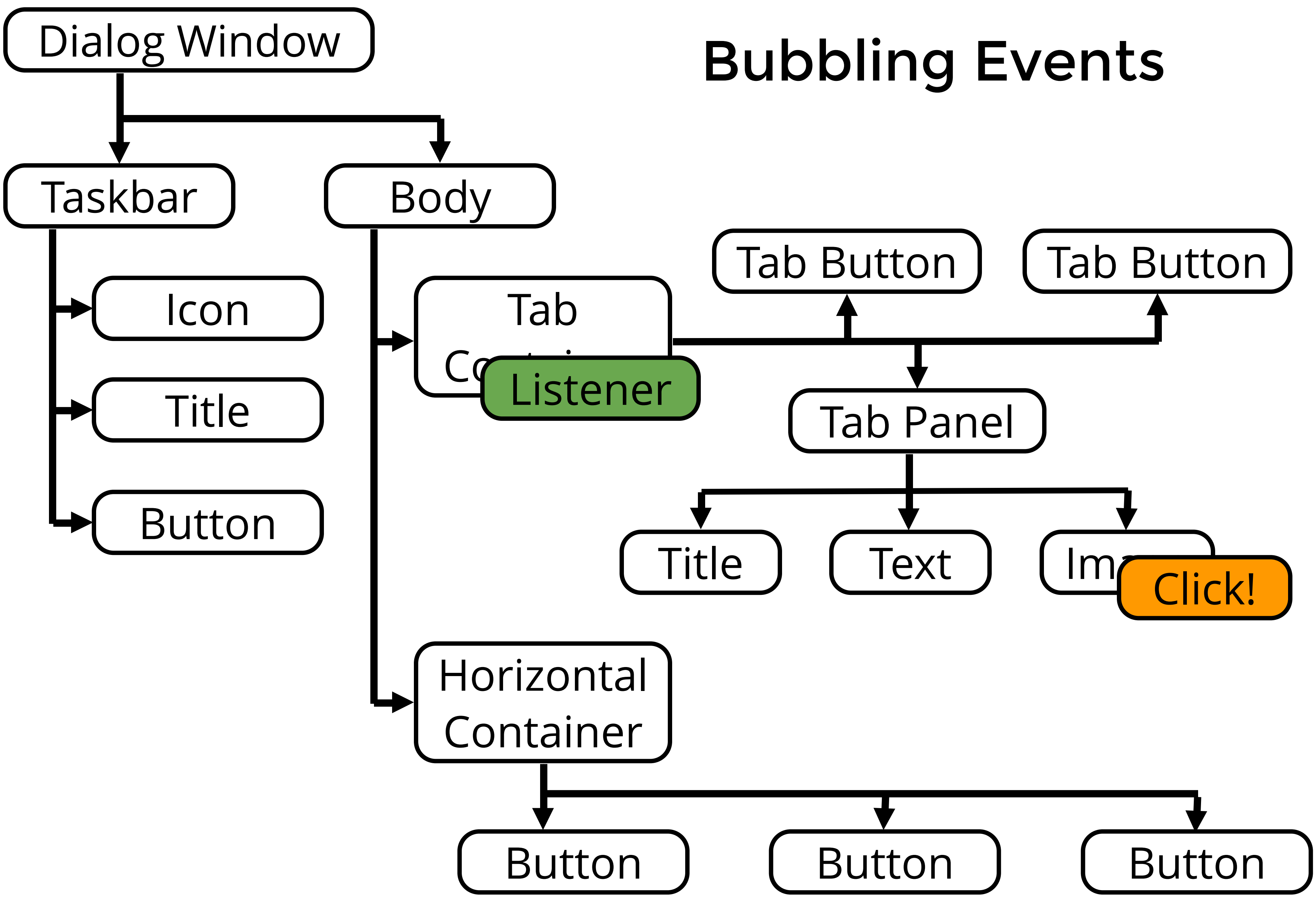
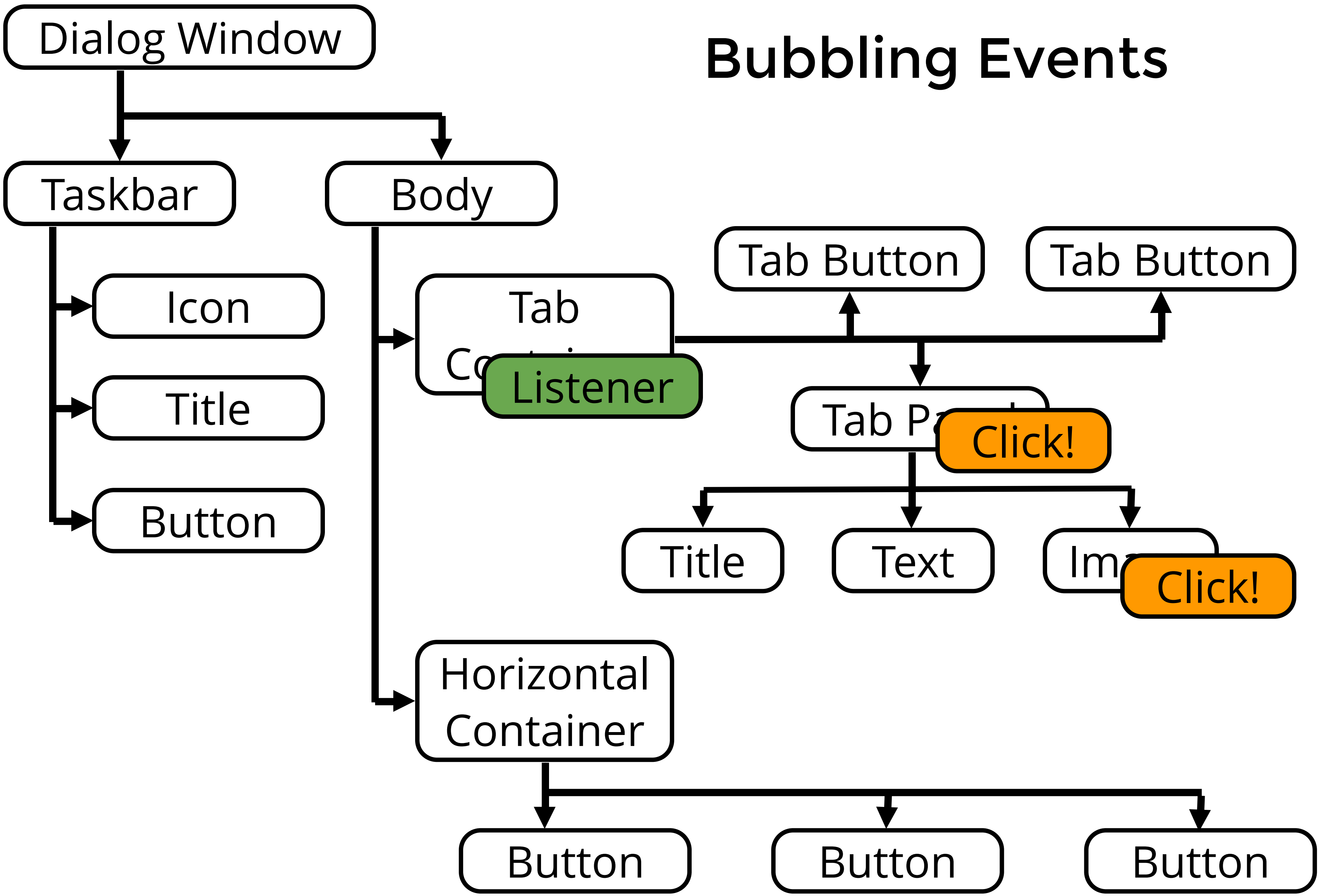
- A *capturing* `Event` is delivered to an `Element` and that `Element` either consumes the `Event` it or not.
- A *bubbling* `Event` is delivered to an `Element` and if it is not consumed by that `Element`, it is propagated upwards in the Element tree.

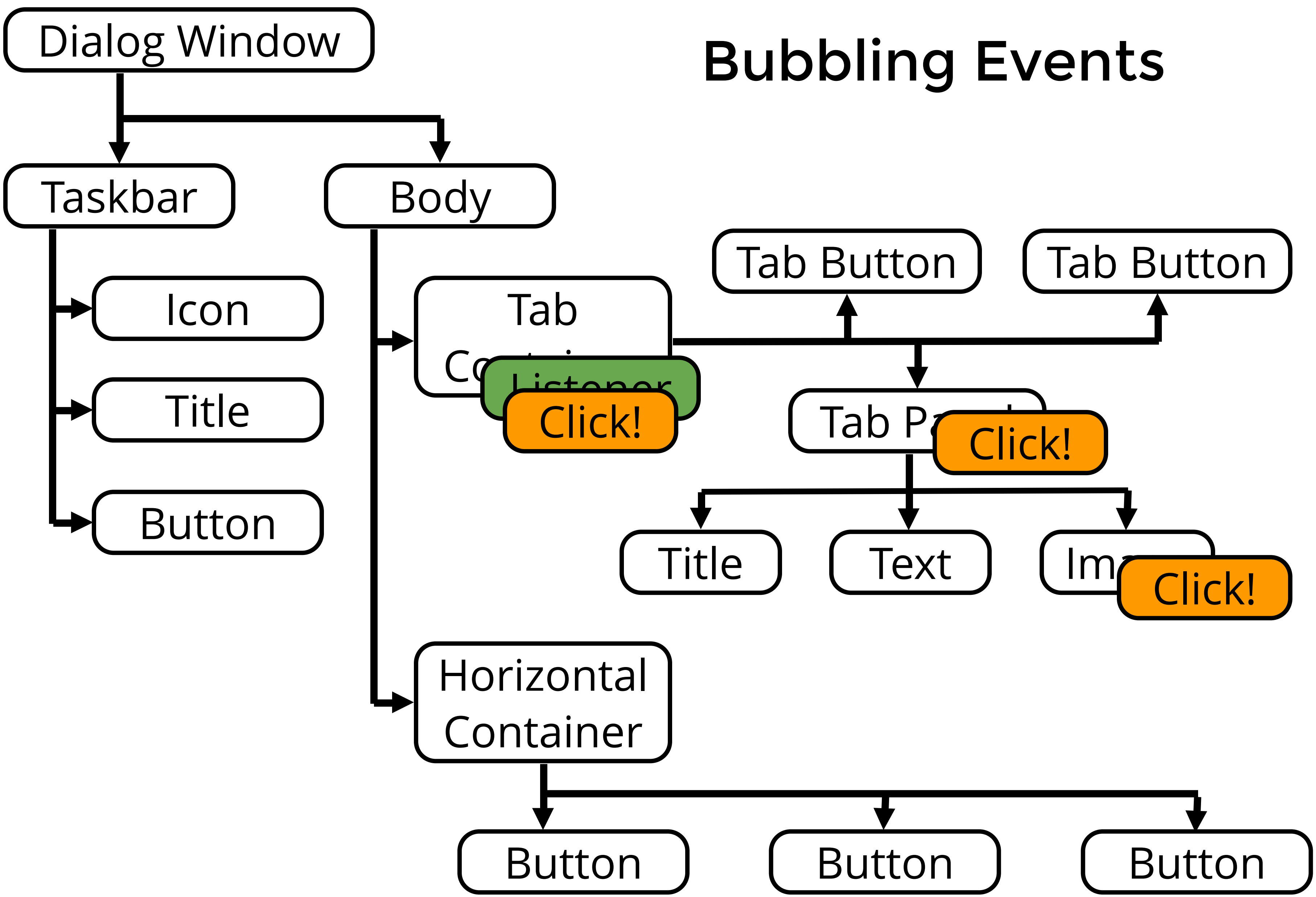
Bubbling Events

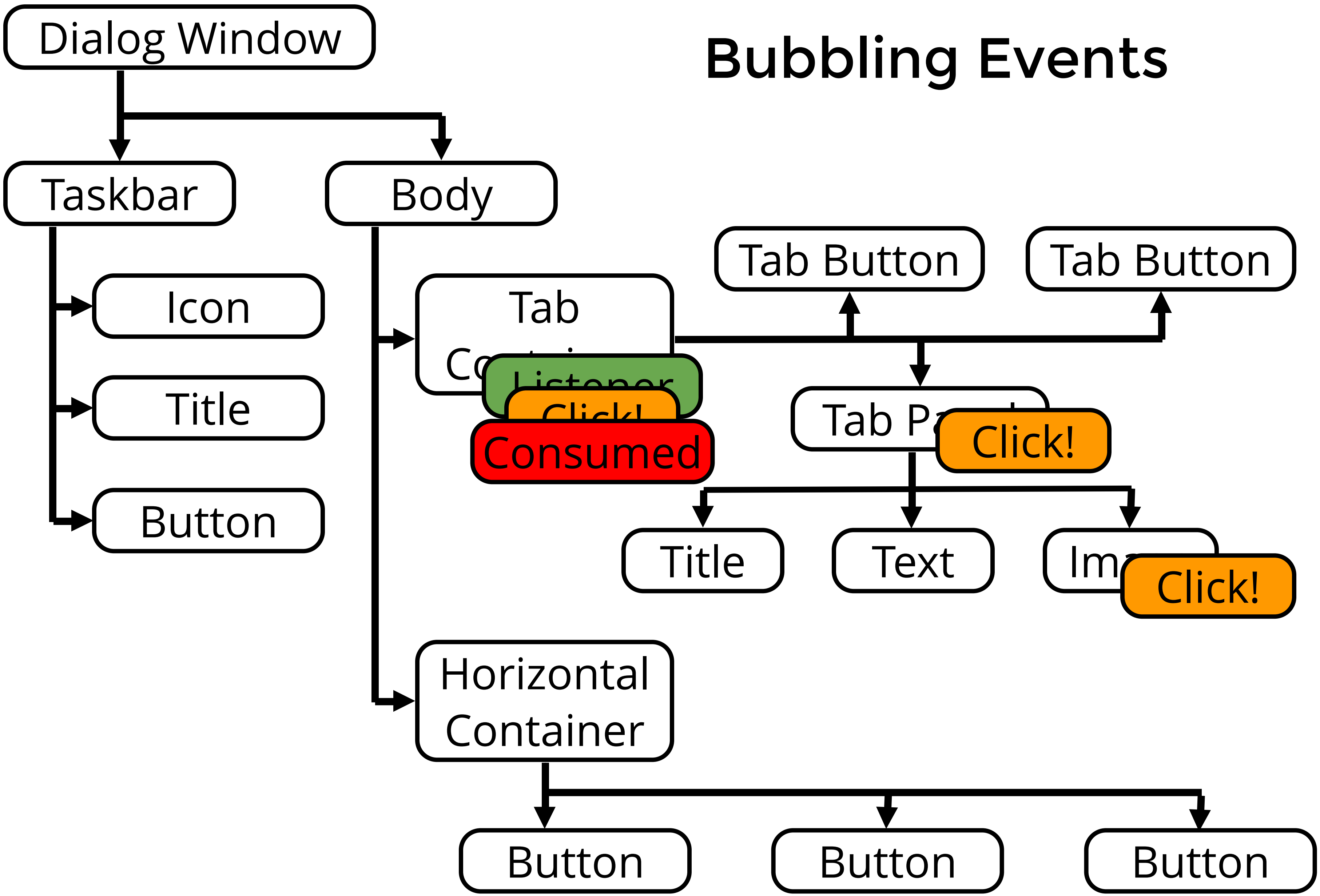



Bubbling Events
Dialog Window
Taskbar
Body
Icon
Title
Button
Tab Container
Listener
Tab Button
Tab Button
Tab Panel
Title
Text
Image
Click!
Horizontal Container
Button
Button
Button

Bubbling Events




Dialog Window
Bubbling Events
Taskbar
Body
Icon
Title
Button
Tab Button
Tab Button
Tab
Click!
Tab Pa
Click!
Title
Text
Im
Click!
Horizontal Container
Button
Button
Button


Bubbling Events
Dialog Window
Taskbar
Body
Icon
Title
Button
Tab Button
Tab Button
Tab
Consumed
Click!
Title
Text
Click!
Horizontal Container
Button
Button
Button

Events [edit]

HTML events [edit]

Common events [edit]

There is a huge collection of events that can be generated by most element nodes:

- Mouse events.[3][4]
- Keyboard events.
- HTML frame/object events.
- HTML form events.
- User interface events.
- Mutation events (notification of any changes to the structure of a document).
- Progress events[5] (used by XMLHttpRequest and File API[6]).

Note that the event classification above is not exactly the same as W3C's classification.

Category	Type	Attribute	Description	Bubbles	Cancelable
	click	onclick	Fires when the pointing device button is clicked over an element. A click is defined as a mousedown and mouseup over the same screen location. The sequence of these events is: • mousedown • mouseup • click	Yes	Yes
	dblclick	ondblclick	Fires when the pointing device button is double-clicked over an element	Yes	Yes
	mousedown	onmousedown	Fires when the pointing device button is pressed over an element	Yes	Yes
	mouseup	onmouseup	Fires when the pointing device button is released over an element	Yes	Yes
	mouseover	onmouseover	Fires when the pointing device is moved onto an element	Yes	Yes
	mousemove[7]	onmousemove	Fires when the pointing device is moved while it is over an element	Yes	Yes

Part 3: State hierarchy

So what happens if an `Event` is consumed?

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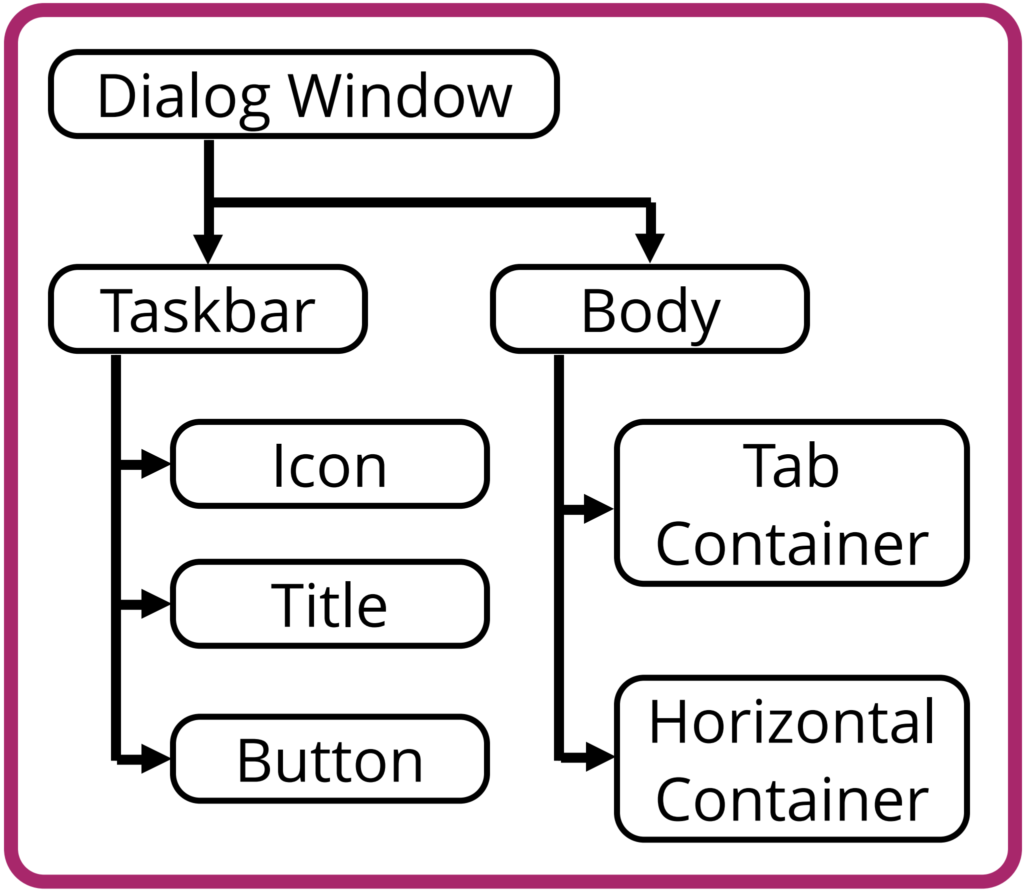
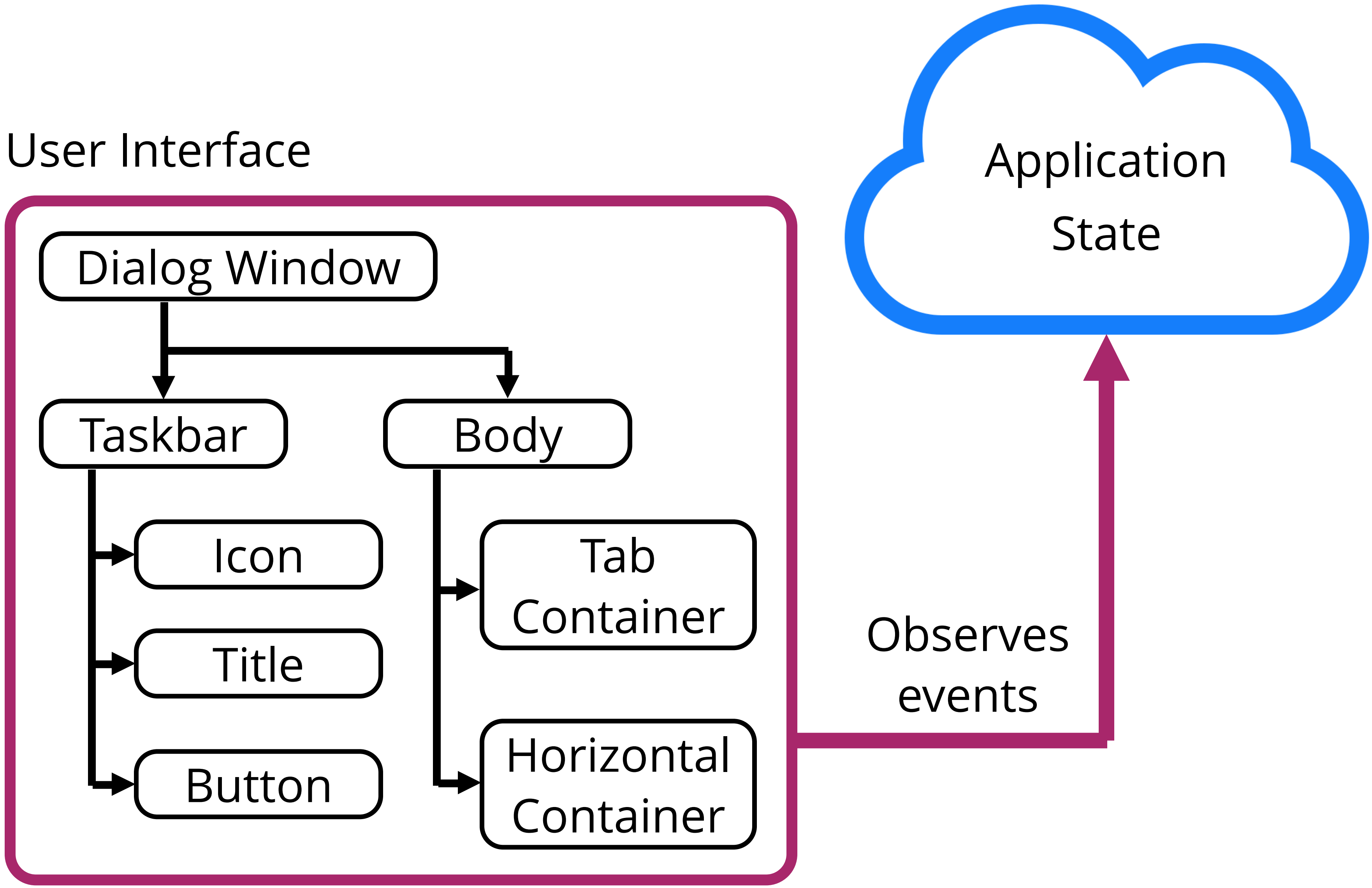
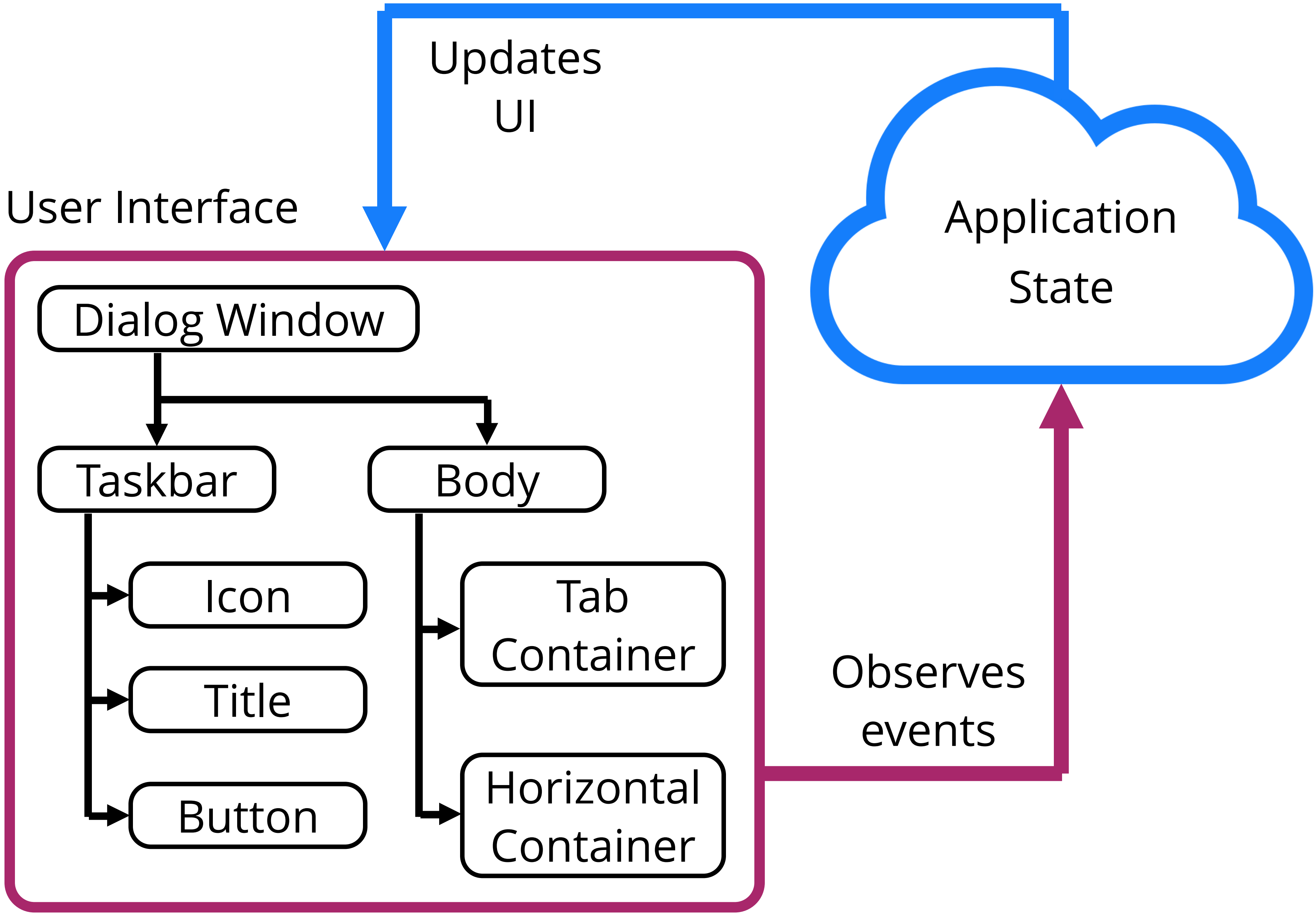
Until this point, the vast majority of UI systems agree on this architecture, even if they sometimes have abstractions to hide it from the programmer...

User Interface




User Interface
Dialog Window
Taskbar
Body
Icon
Title
Button
Tab Container
Horizontal Container
Application State
Observes events


Updates
UI
User Interface
Application
State
Dialog Window
Taskbar
Body
Icon
Title
Button
Tab
Container
Horizontal
Container
Observes
events

These are the most fundamental questions that
UI frameworks/architectures are trying to answer:

- Where is application state stored?
- How is application state updated?
- How is state change propagated to the user interface?

A useful framework for thinking about state...

(what goes into each category depends on the application)

Element state

- "Stuff that you lose if you remove an element."
- Position, scroll location, input field values, ...
- Stored by the individual UI `Elements`.

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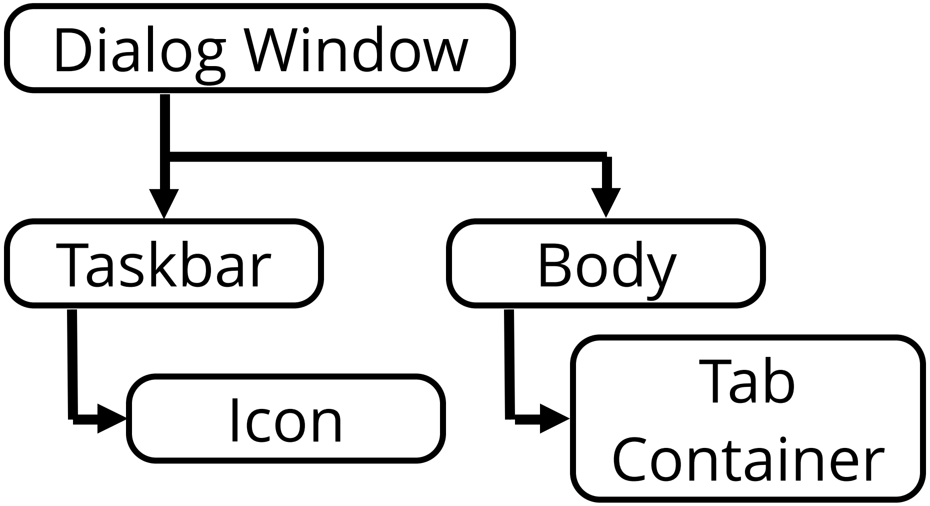

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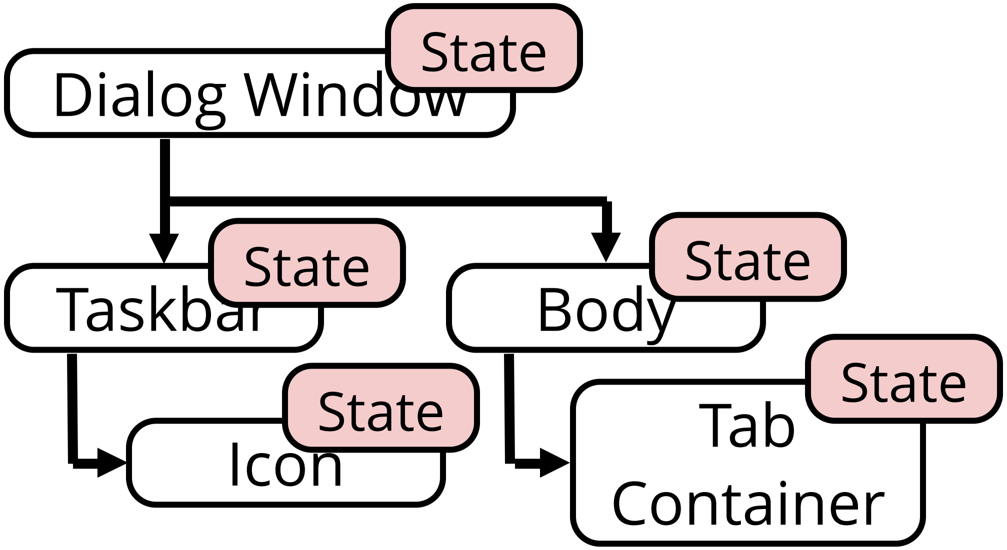

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Session state

- "Stuff that you lose if you close the window."
- E-shop cart, login credentials, navigation...
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Browser

`[session state]`

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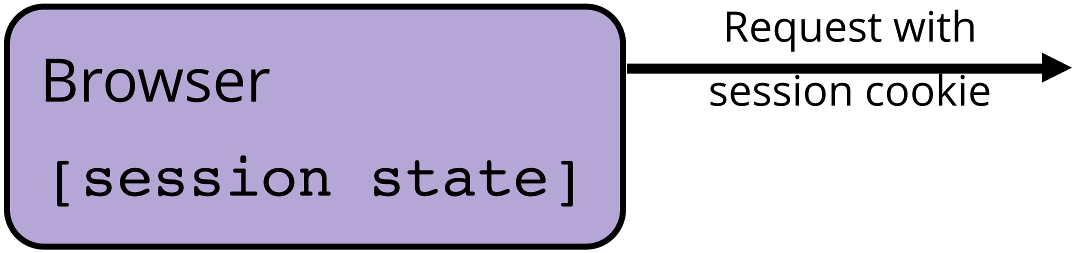

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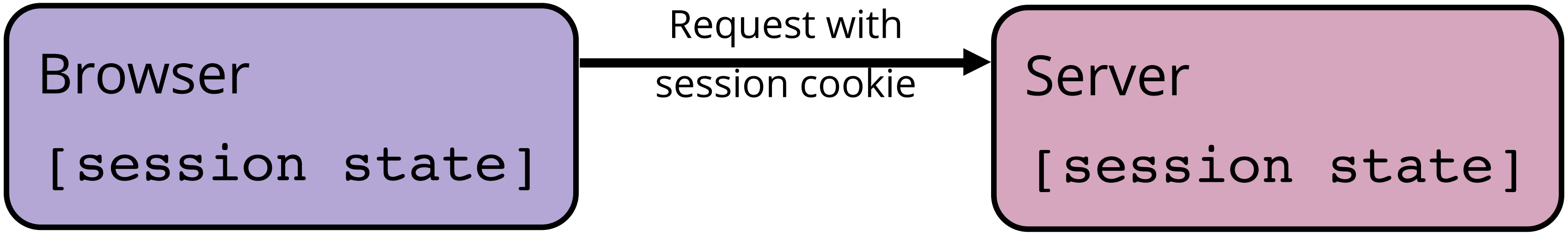

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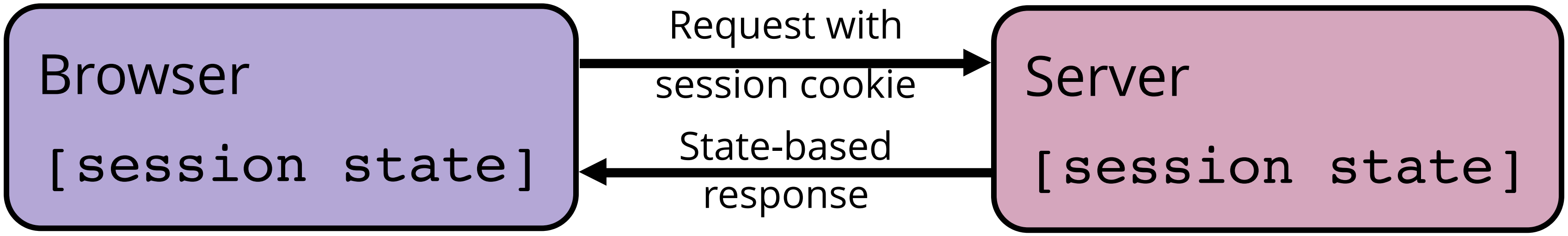

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Persistent state

- "Stuff that you lose if the hard drive breaks down."
- Account information, settings, "content", ...
- Stored in files or databases, both within the browser (locally) or on a server (remotely).

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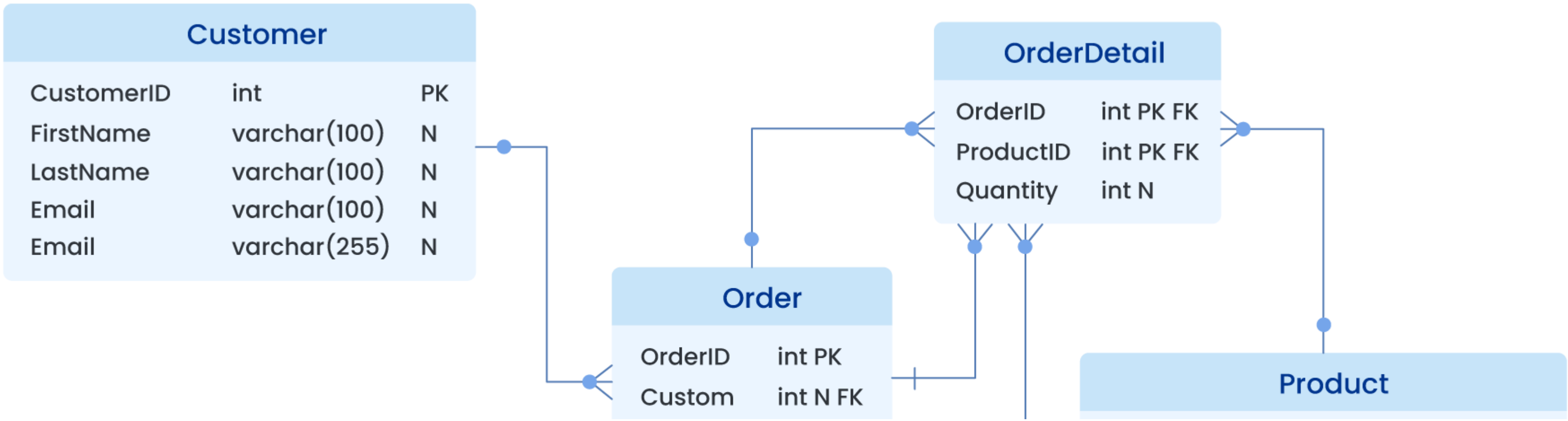


Element state

"what the UI looks like right now"

Session state

"what the user is doing"

Persistent state

"what the user has saved"

Part 4: Client vs. Server

Client-side rendering

Server-side rendering

Not rendering in the GPU sense, but
"where is state turned into HTML".

Client-side rendering

Server-s

We started here

rendering

Not rendering in the GPU sense, but
"where is state turned into HTML".

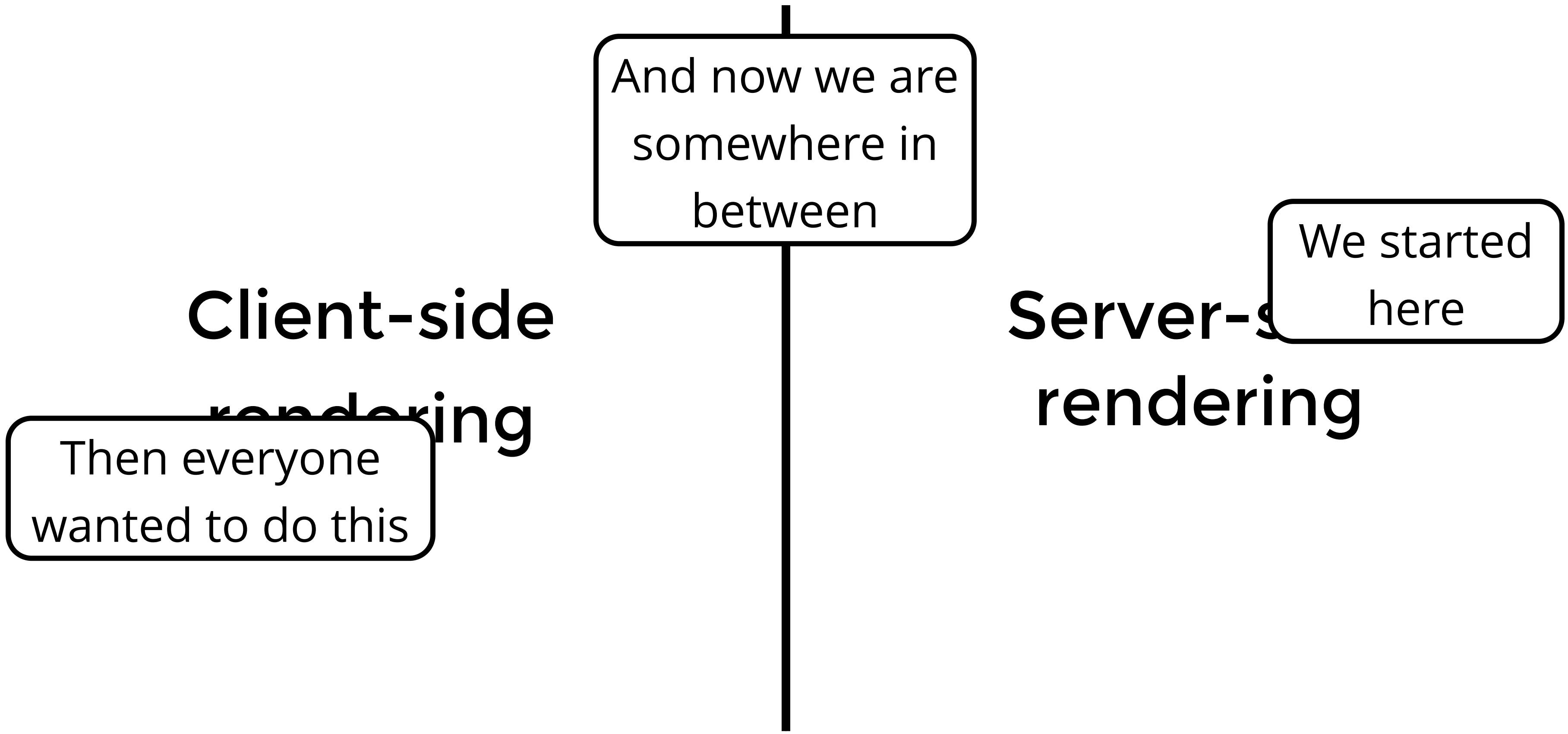
Client-side rendering

Then everyone wanted to do this

Server-s rendering

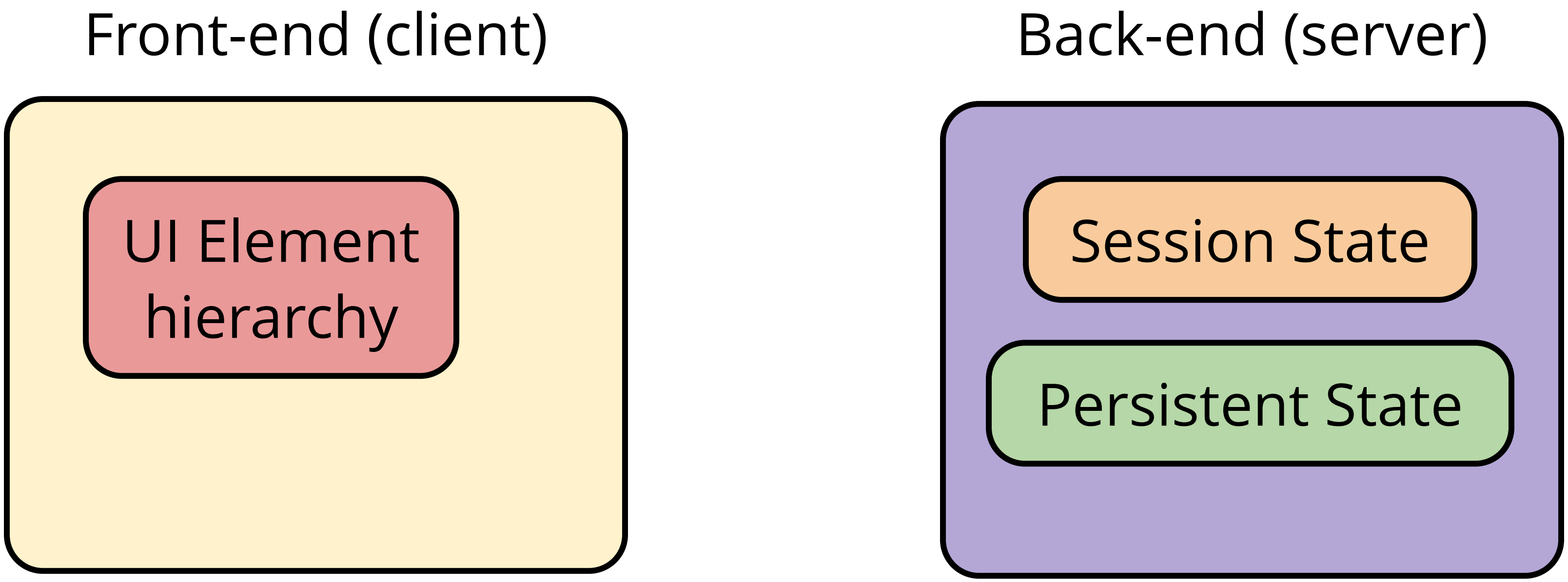
We started here

Not rendering in the GPU sense, but *"where is state turned into HTML"*.

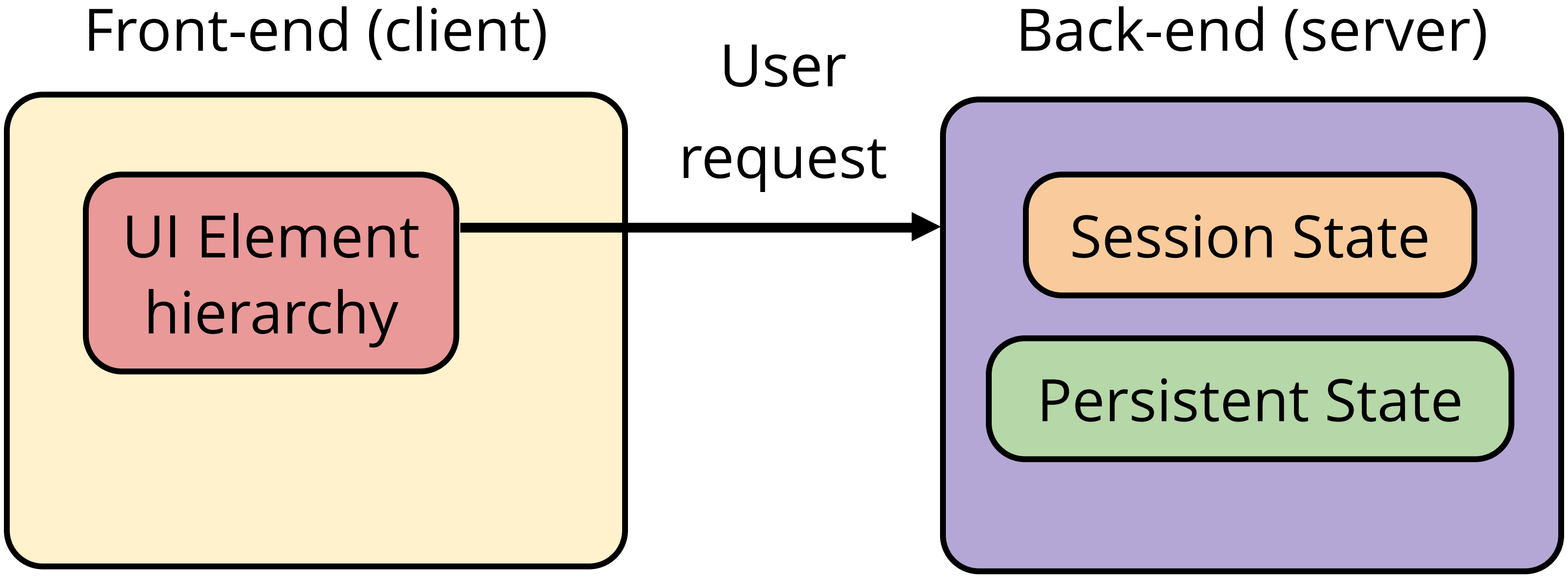


Not rendering in the GPU sense, but *"where is state turned into HTML"*.

Server-side rendering



Server-side rendering



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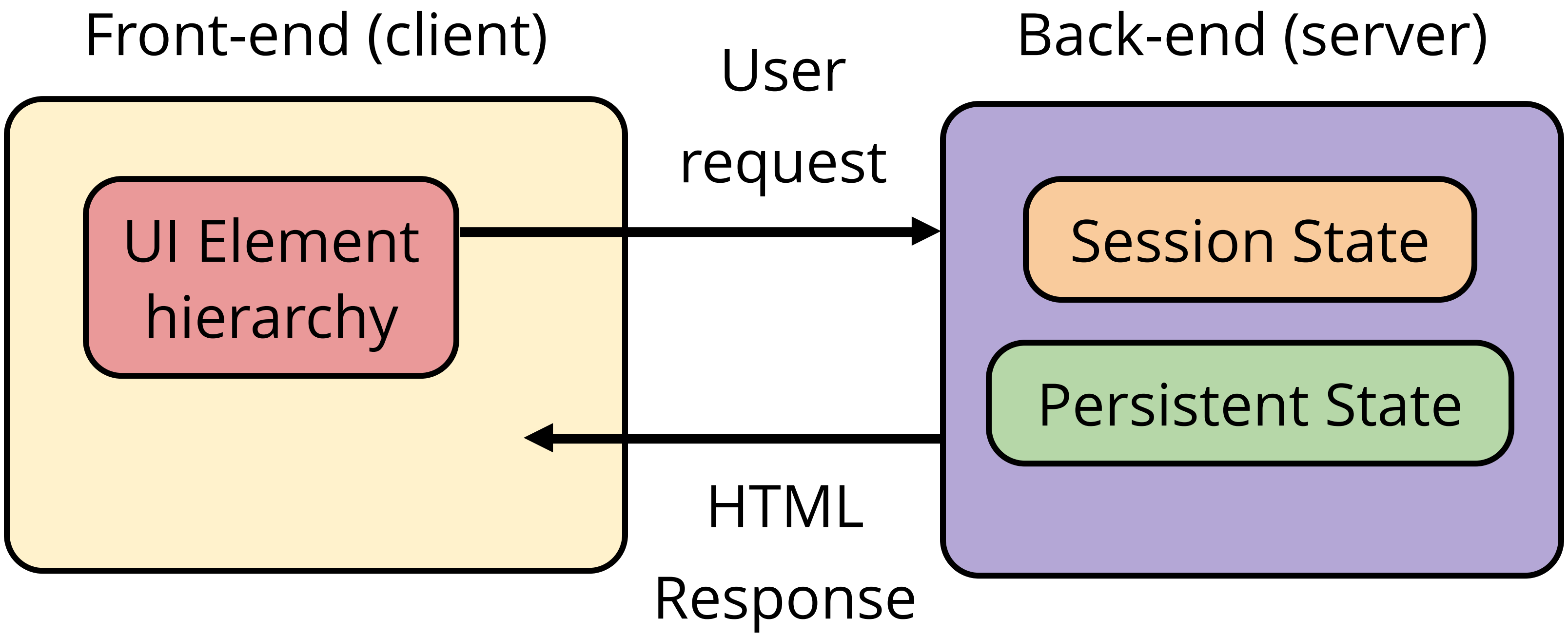

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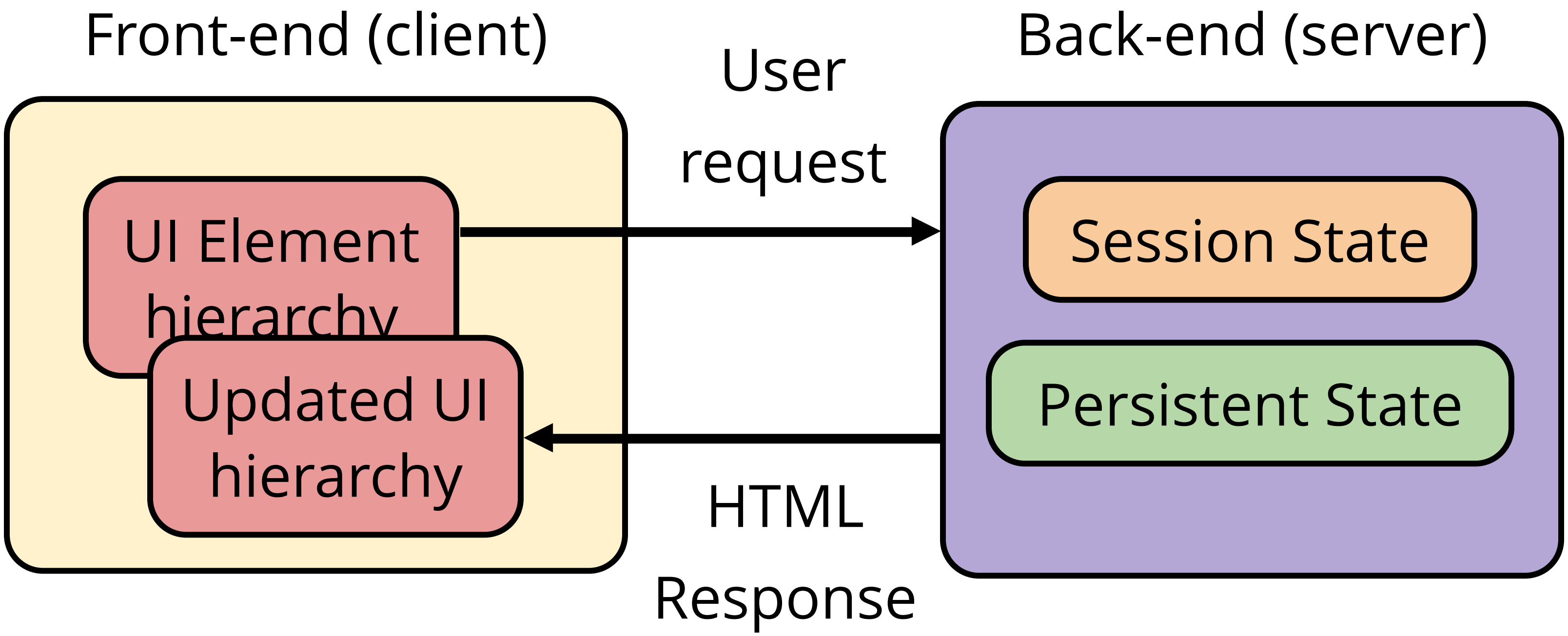

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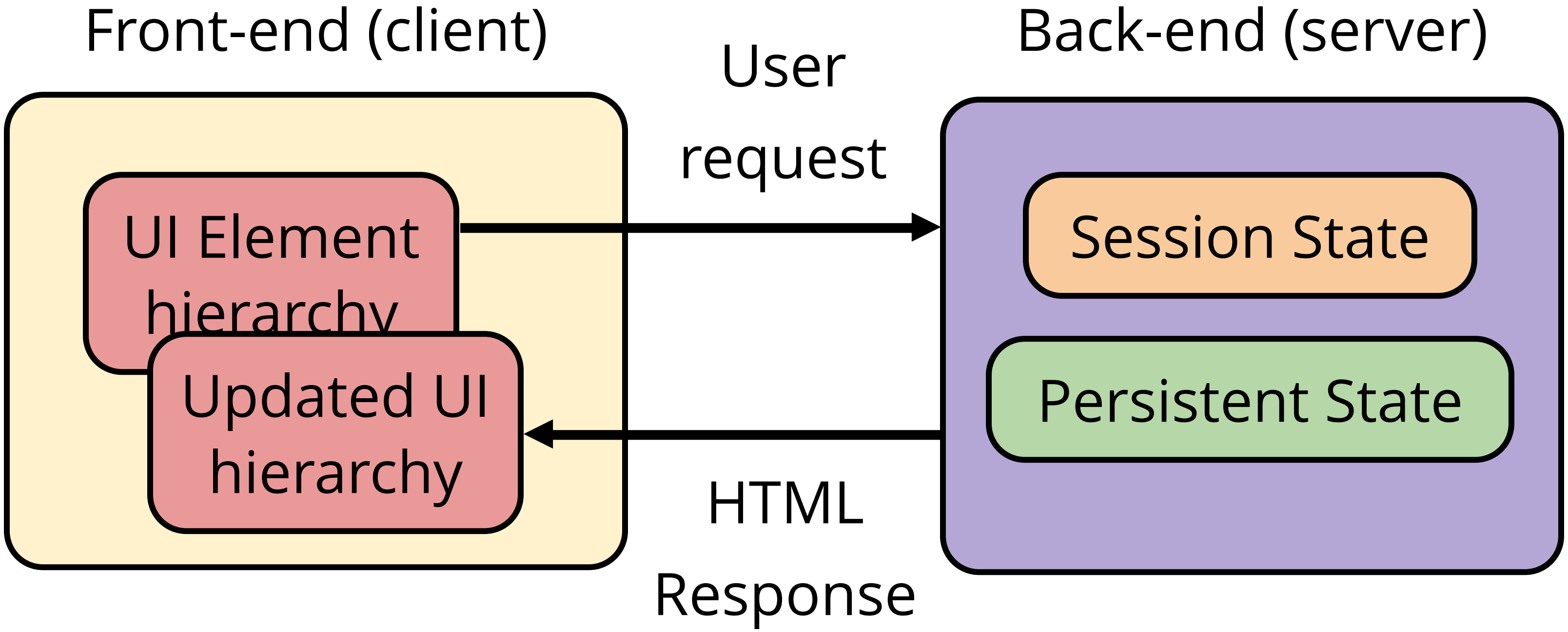

Element state is still managed by the client and can be non-trivial, so the client is not entirely state-less. But for the most part, client is not meaningfully changing the UI hierarchy.

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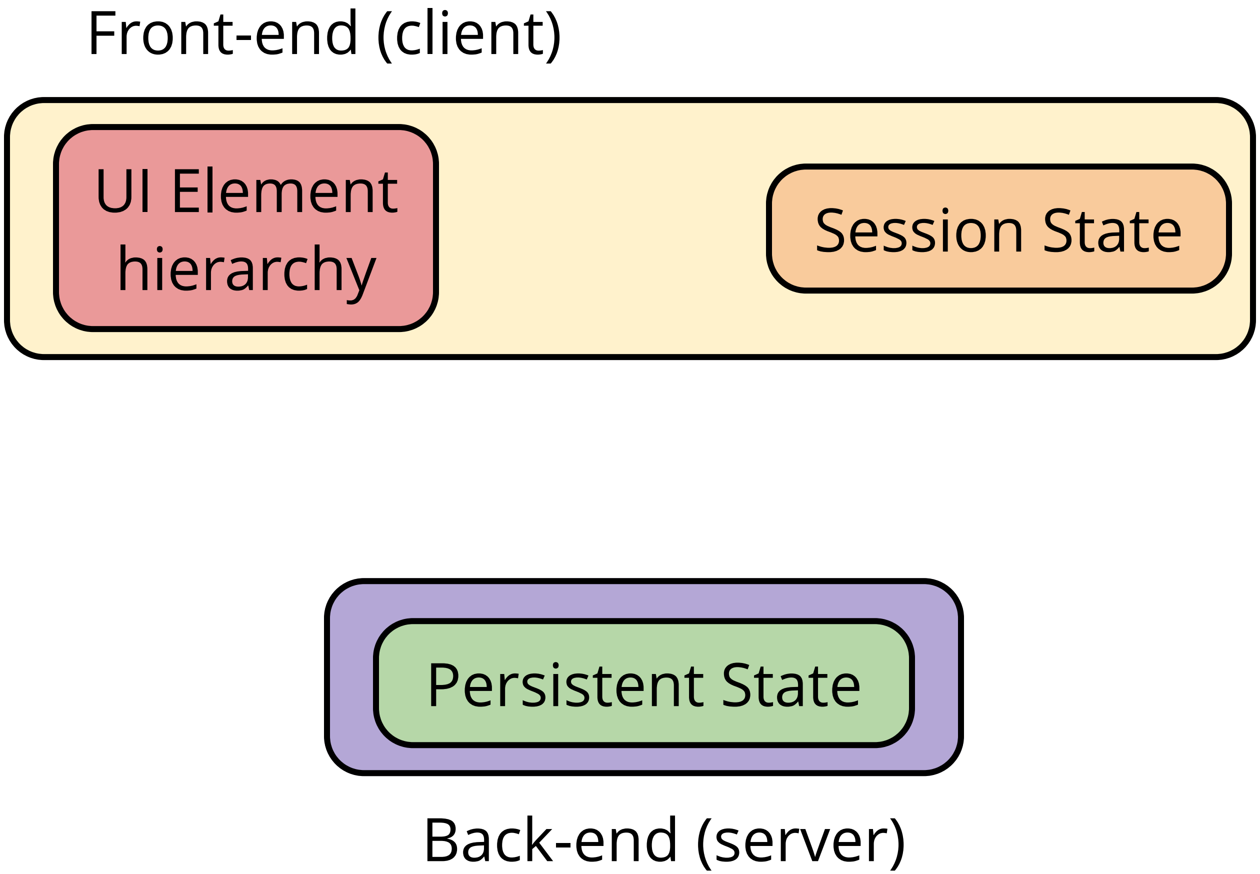

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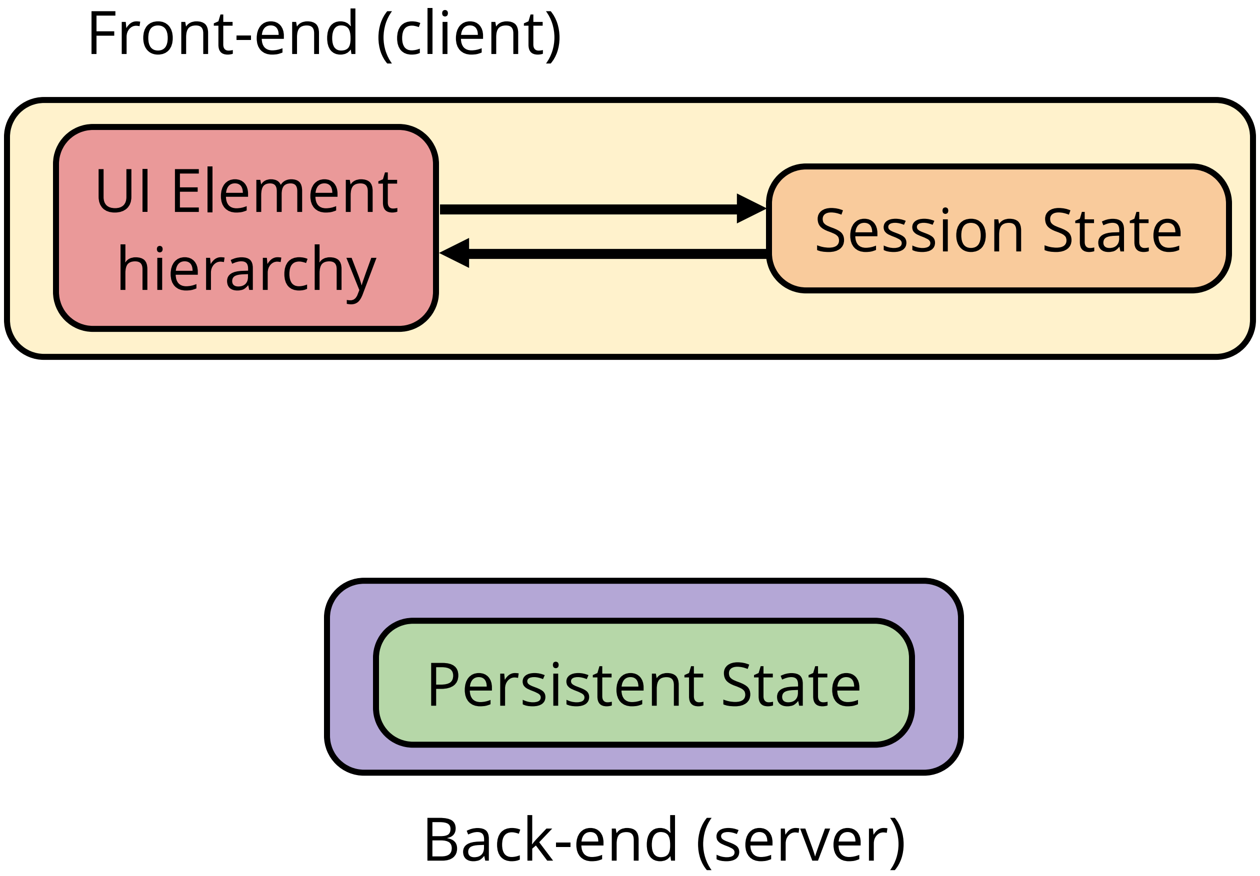

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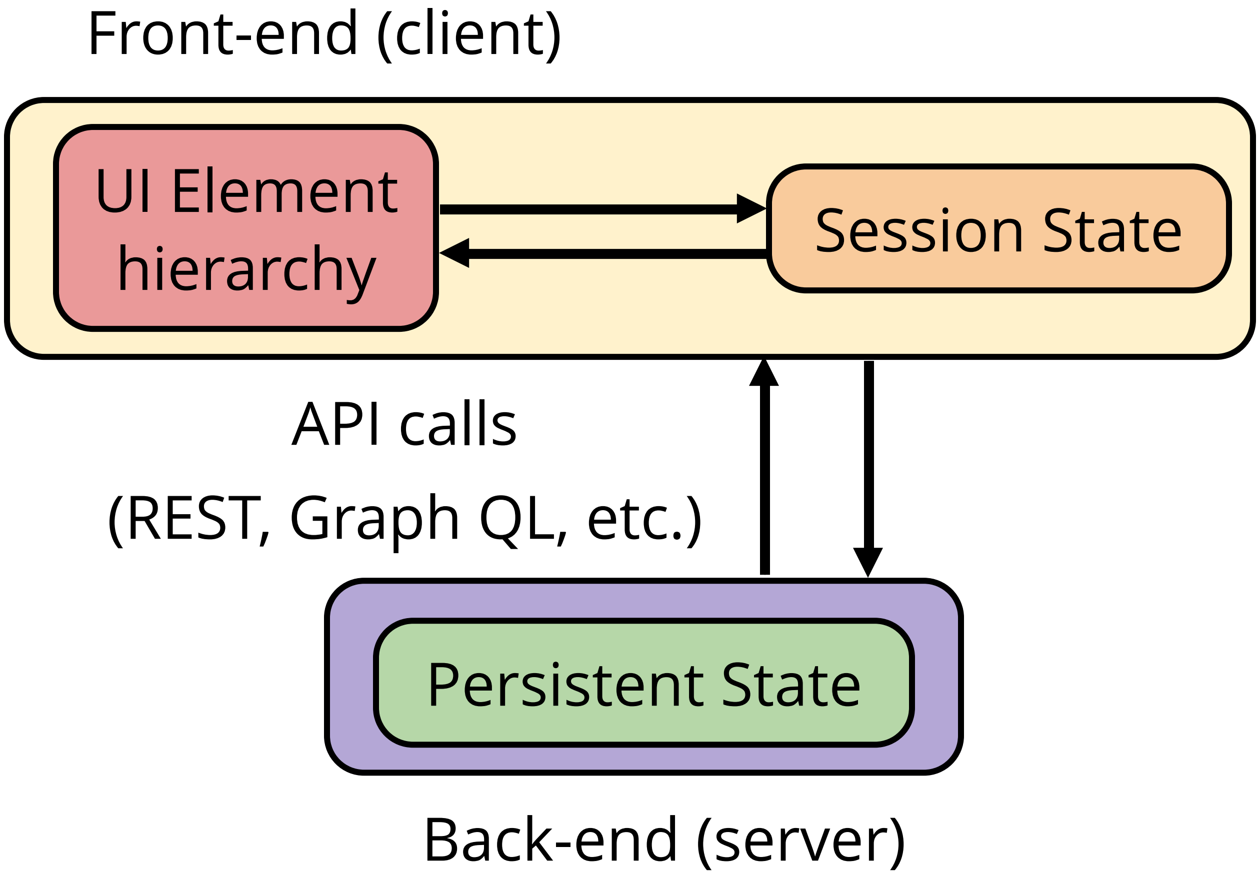

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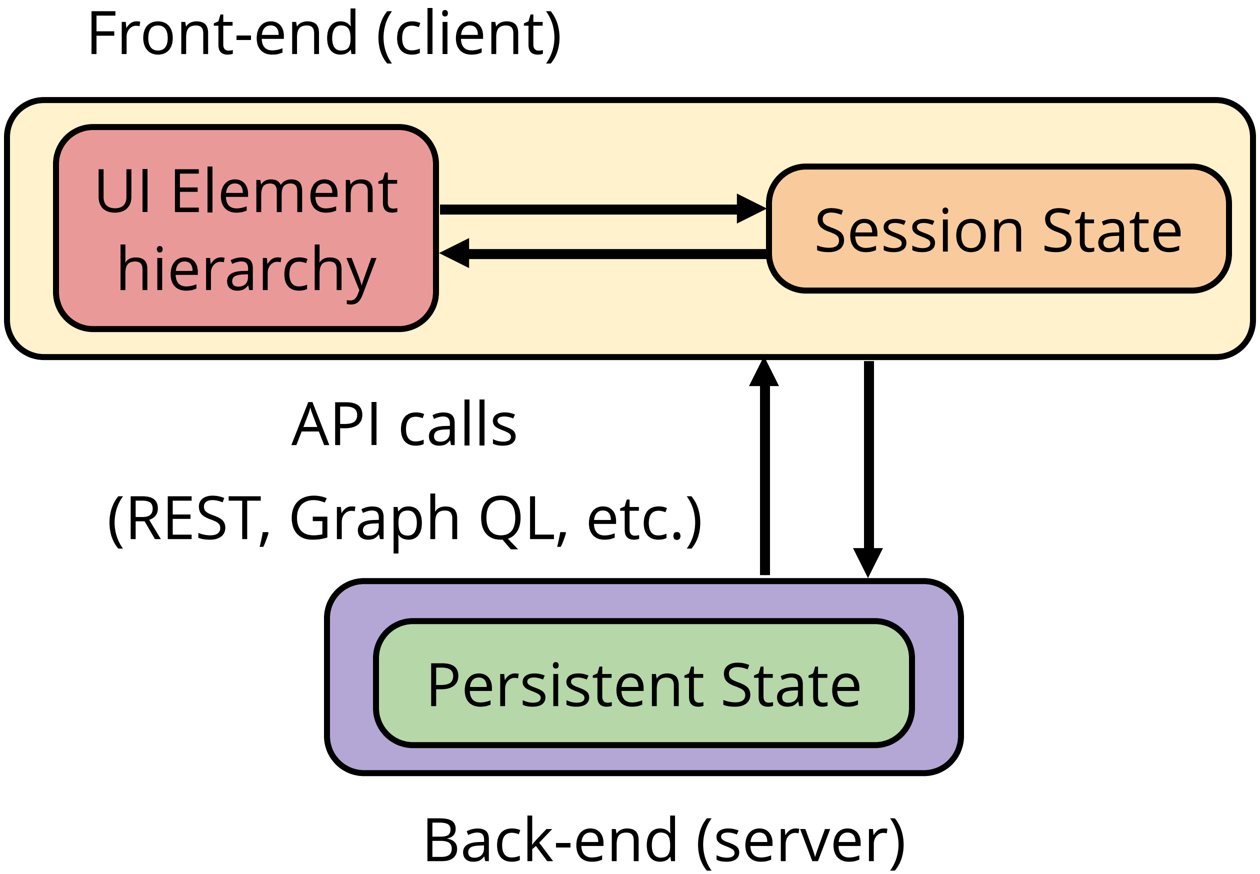

Client is responsible for updating the UI hierarchy based on both the local state and the data received from the server. Server's only responsibility is serving and storing data. (Less common, but client can also store some of the persistent state)

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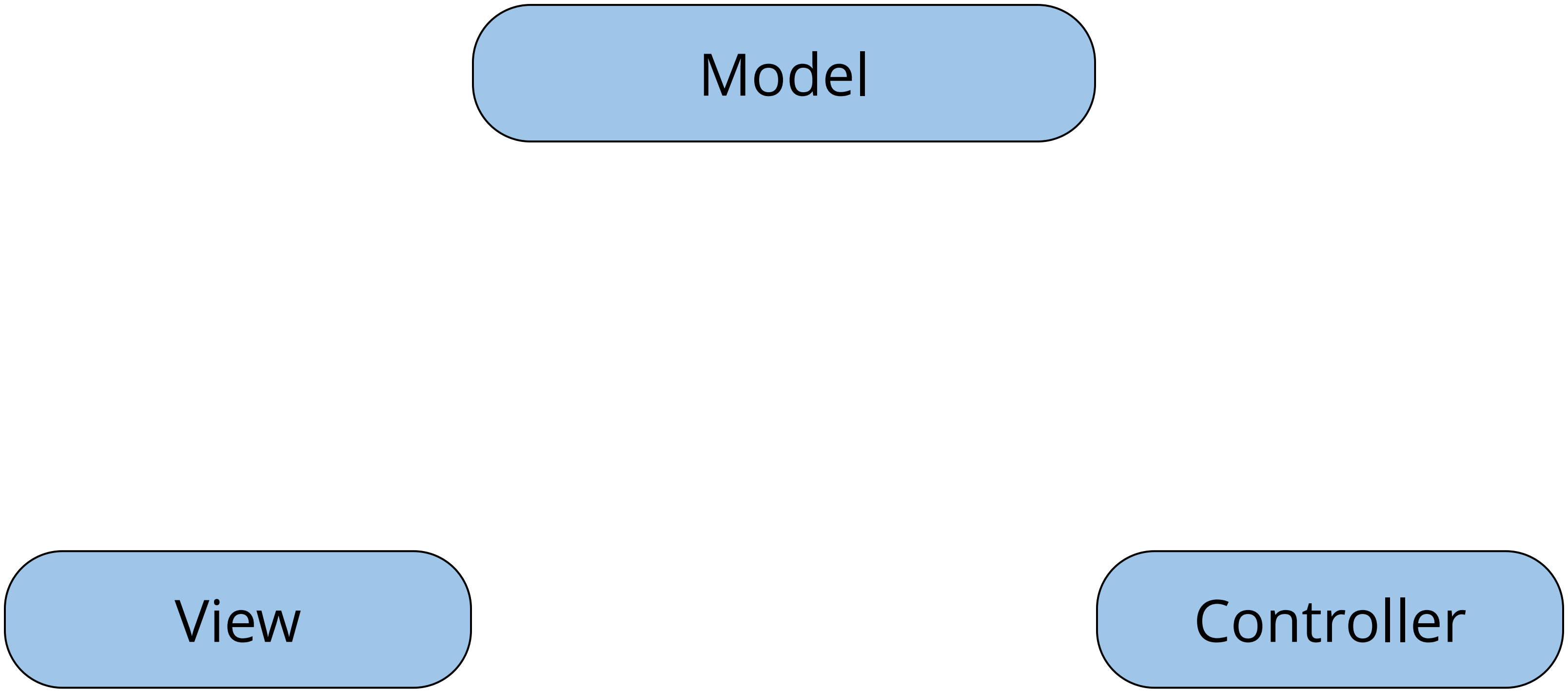
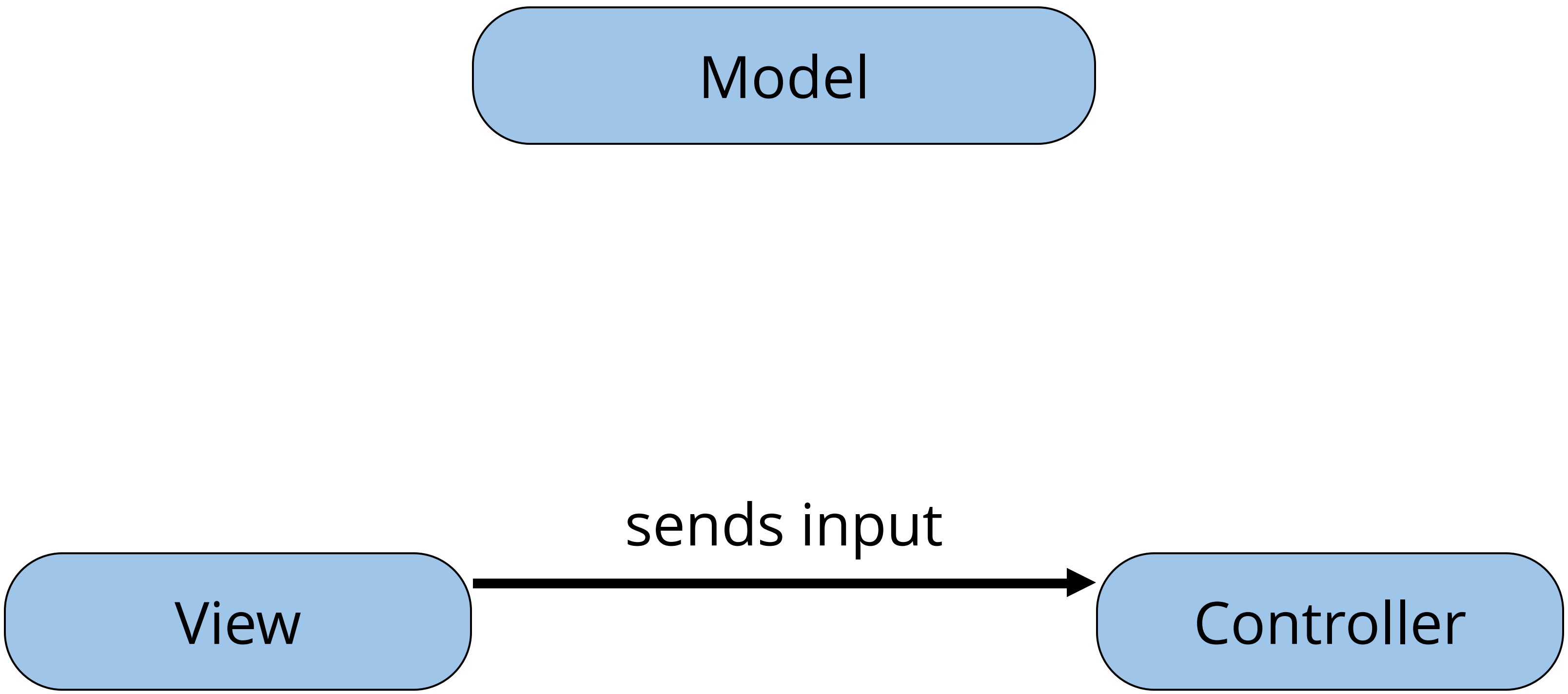
- Client first: More complex and responsive interaction patterns, reduced server costs, modular (multiple clients, one API)...
  - Can have offline or other "native" features.
  - More logic (generally more complex UIs, but also logic for retrieving and sending data, caching, etc.).

Part 5: Managing state

Model View Controller



Model View Controller



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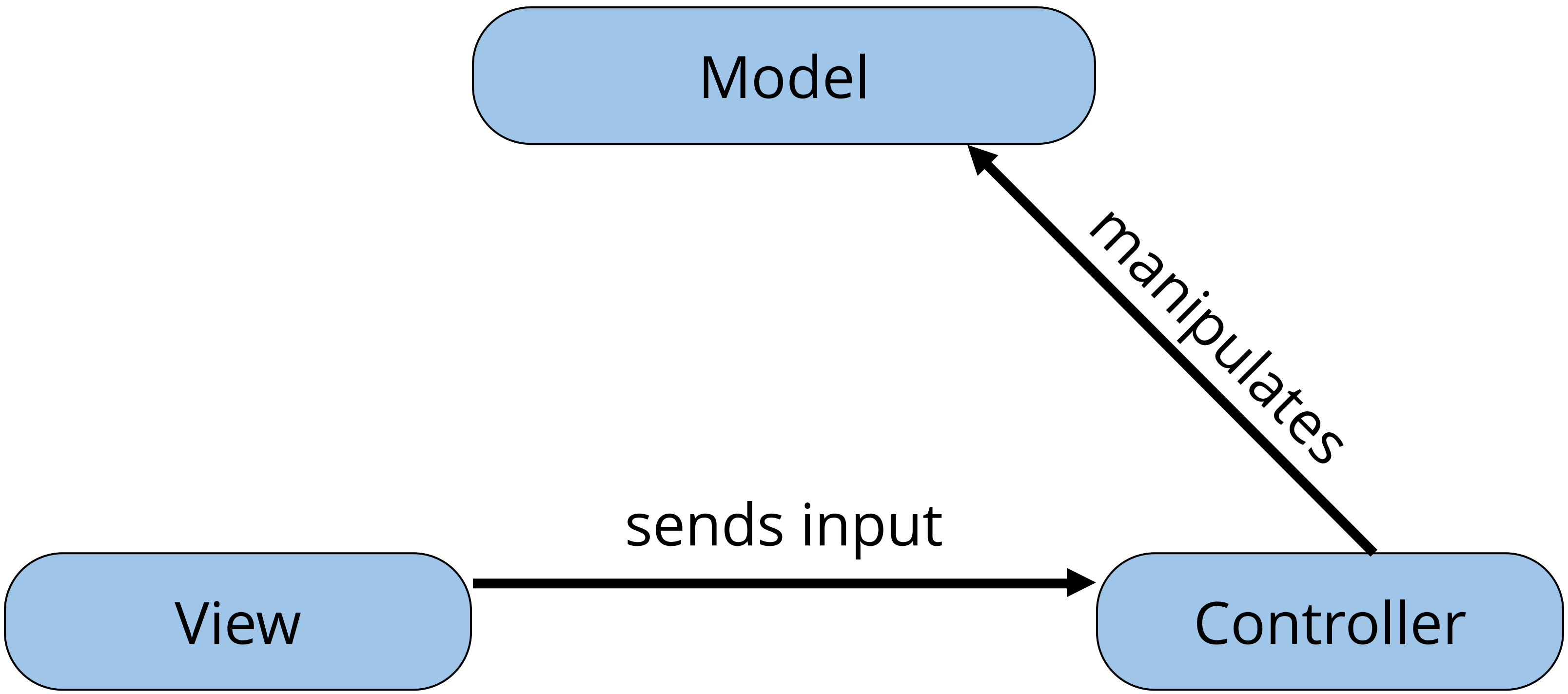

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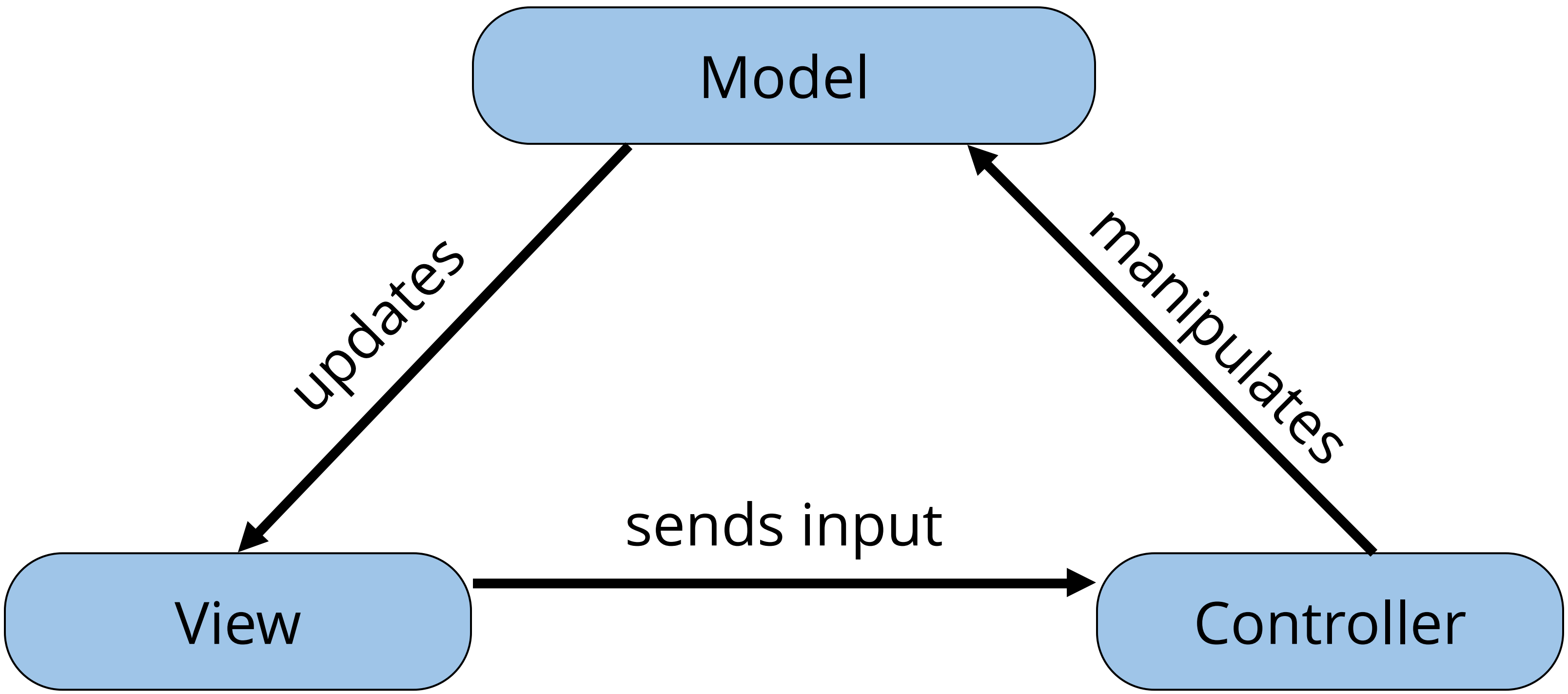

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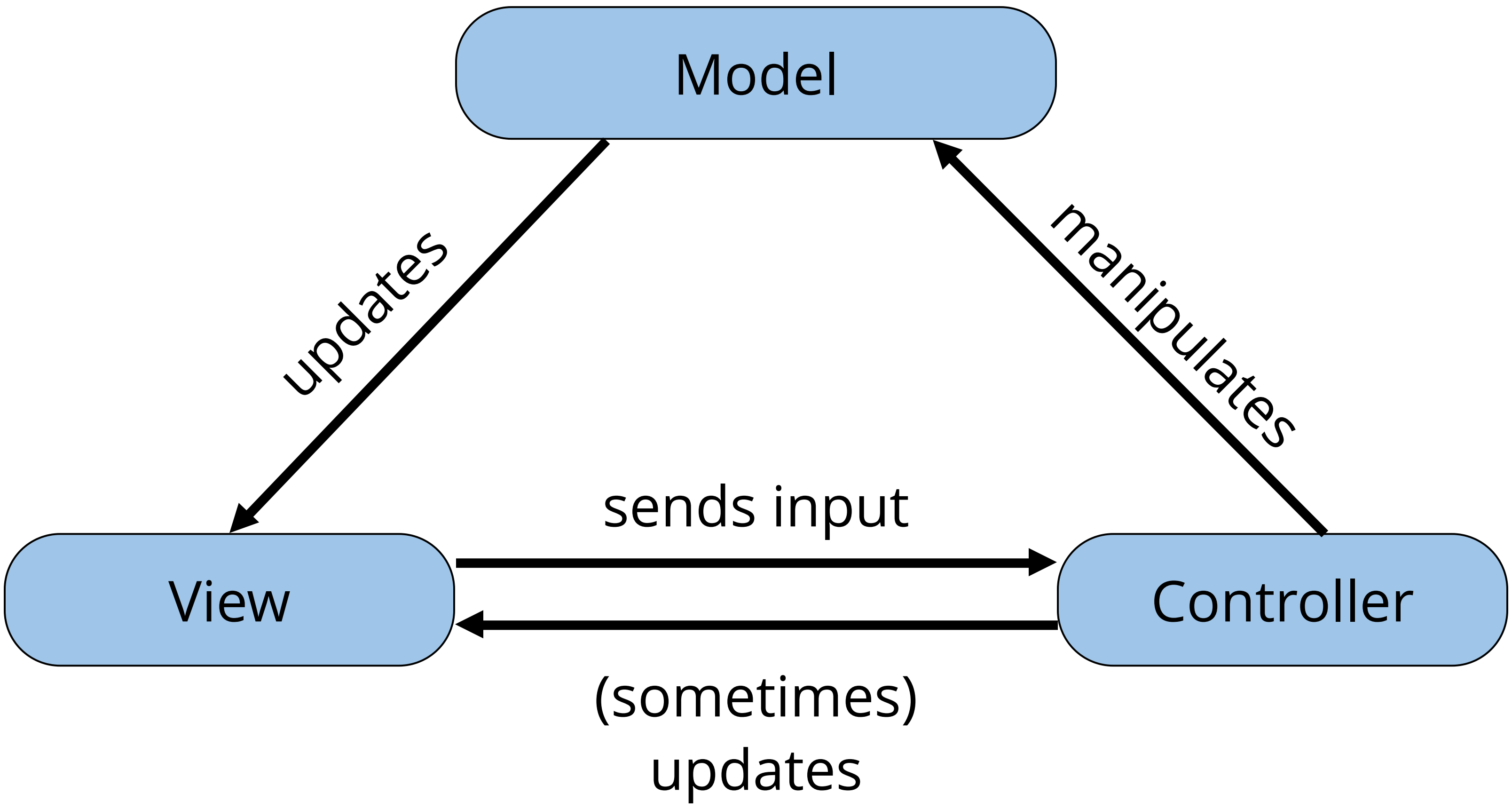

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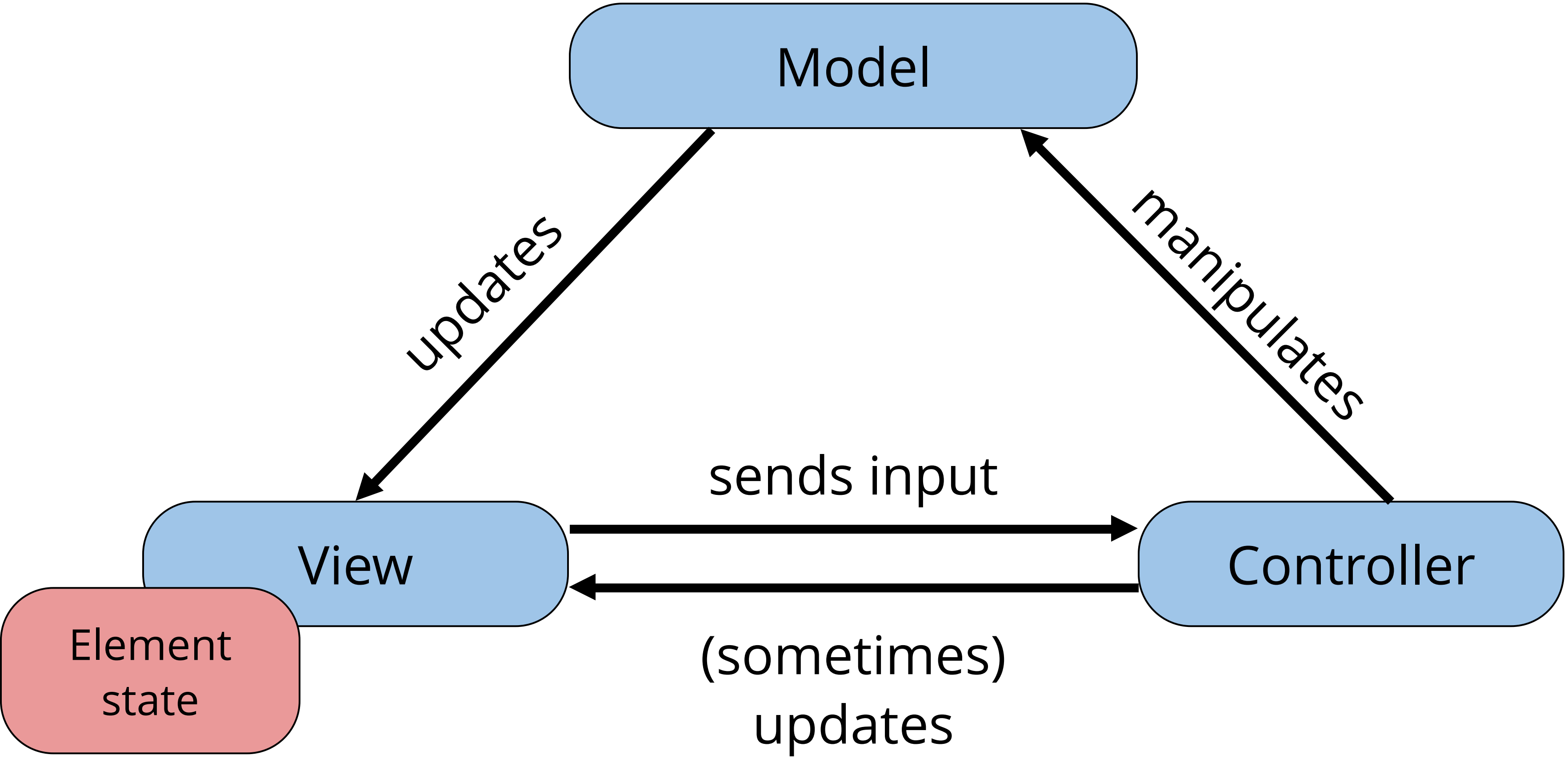

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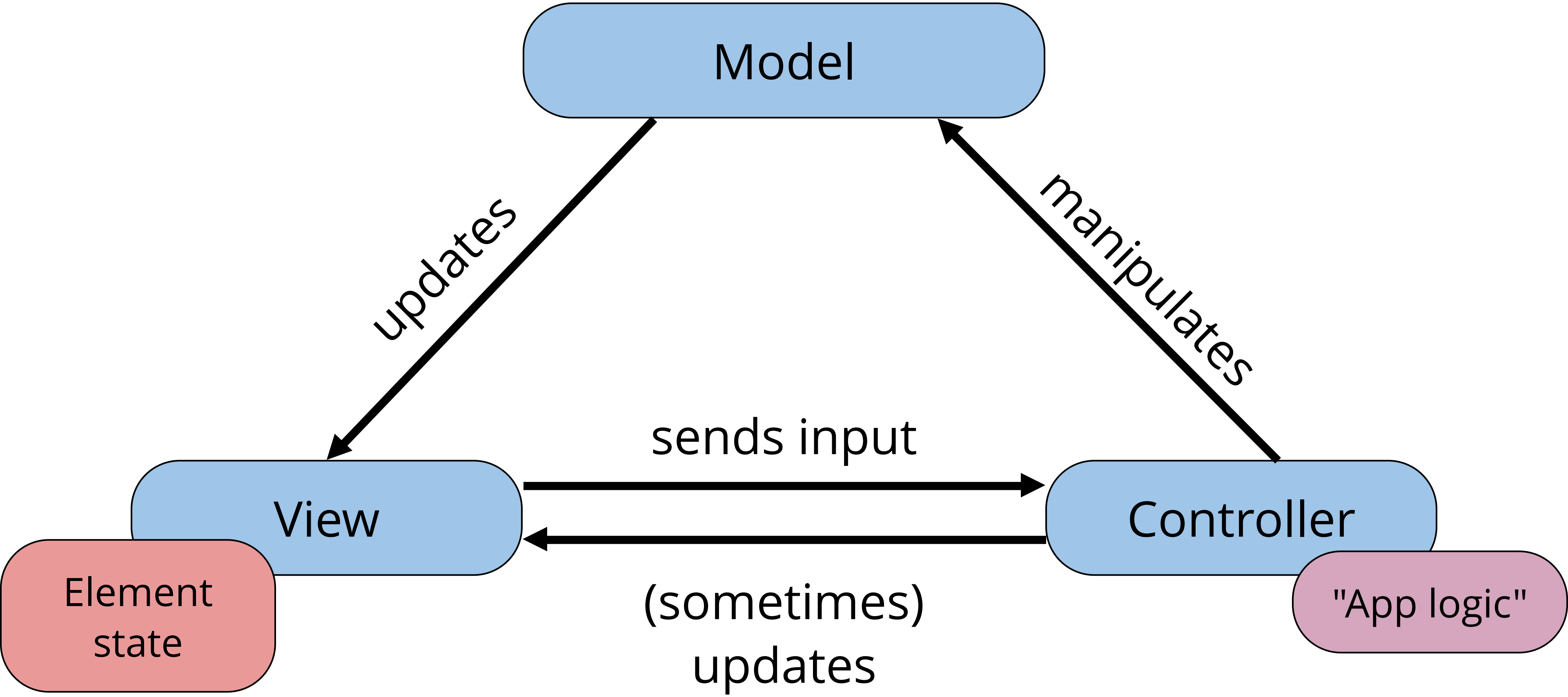

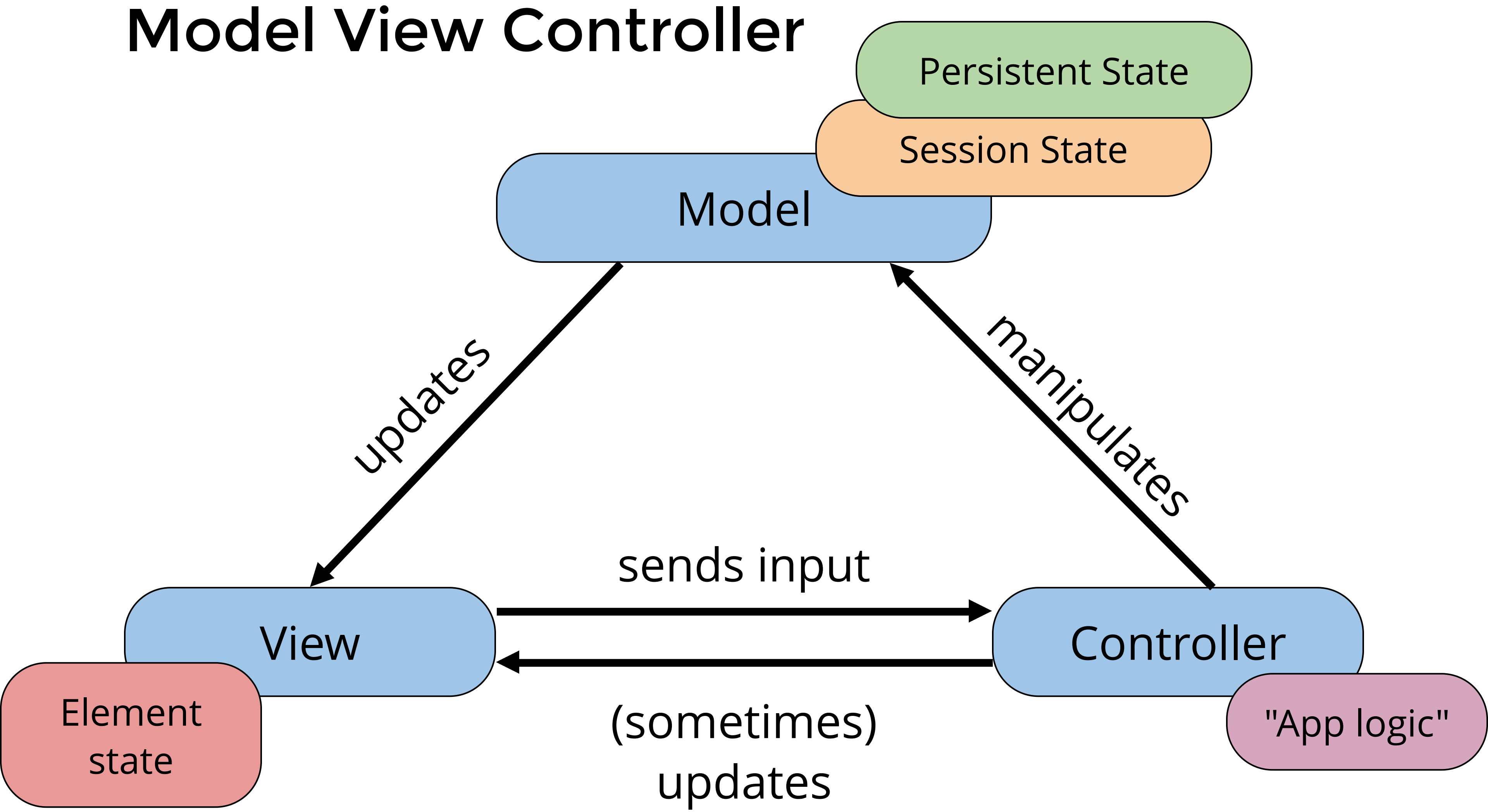

Model View Controller
Persistent State
Session State
Model
updates
manipulates
sends input
View
Controller
Element state
(sometimes) updates
"App logic"

Model View Controller

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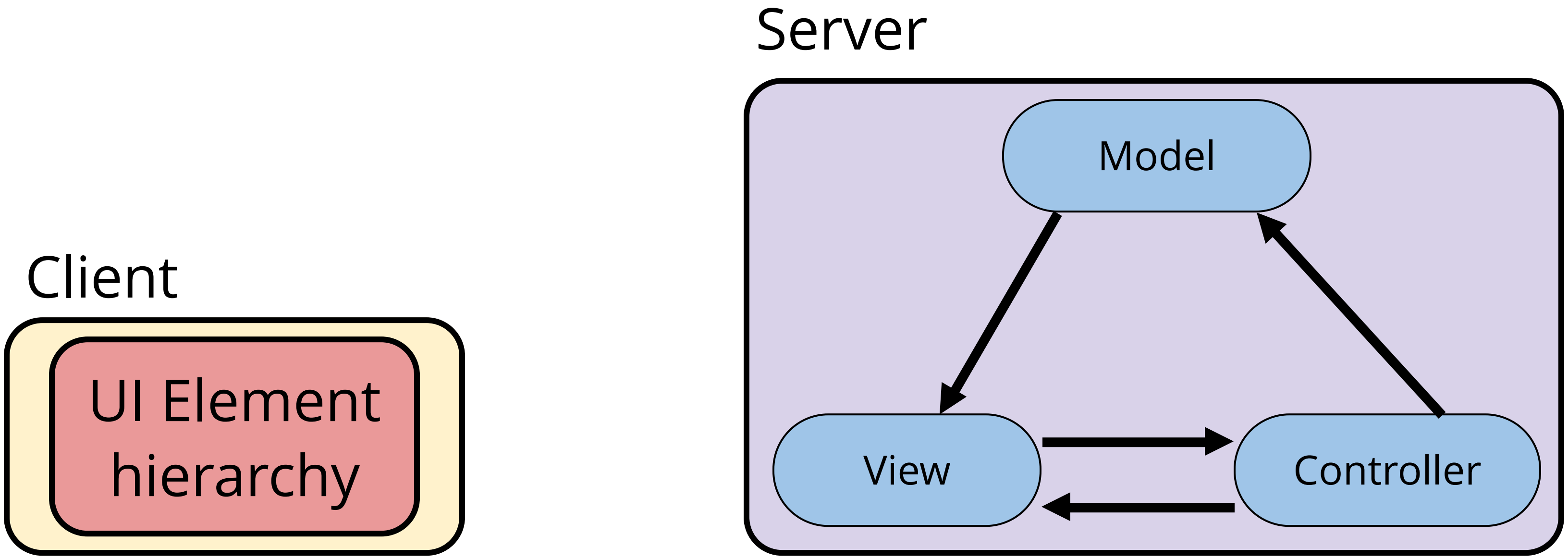
But where does this "live" in a Web app?

MVC, server-side rendering



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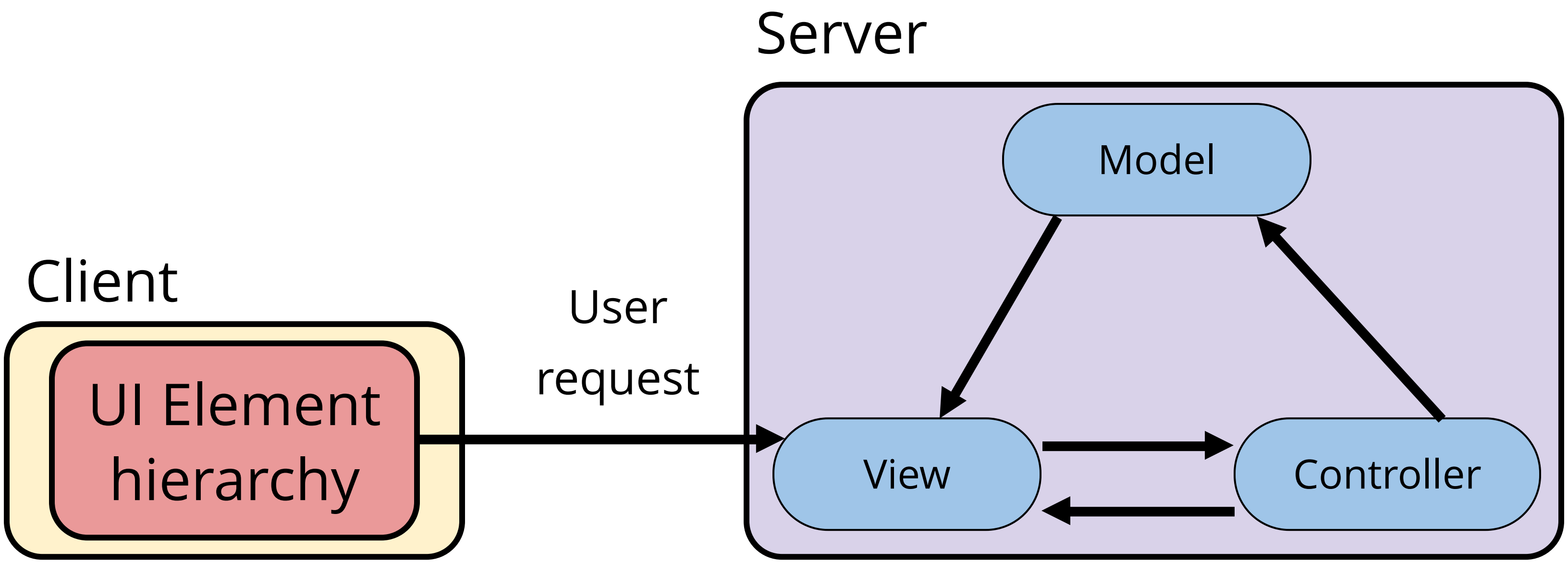
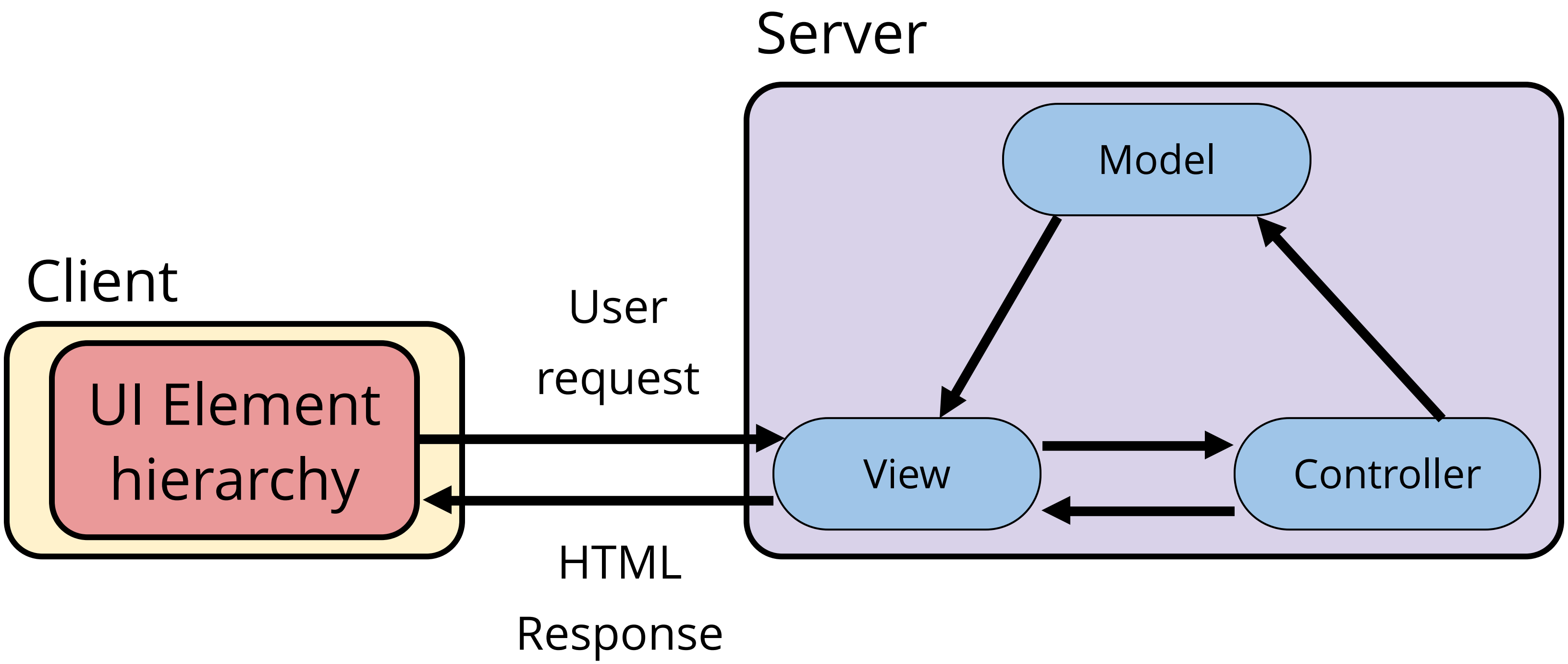


MVC, server-side rendering



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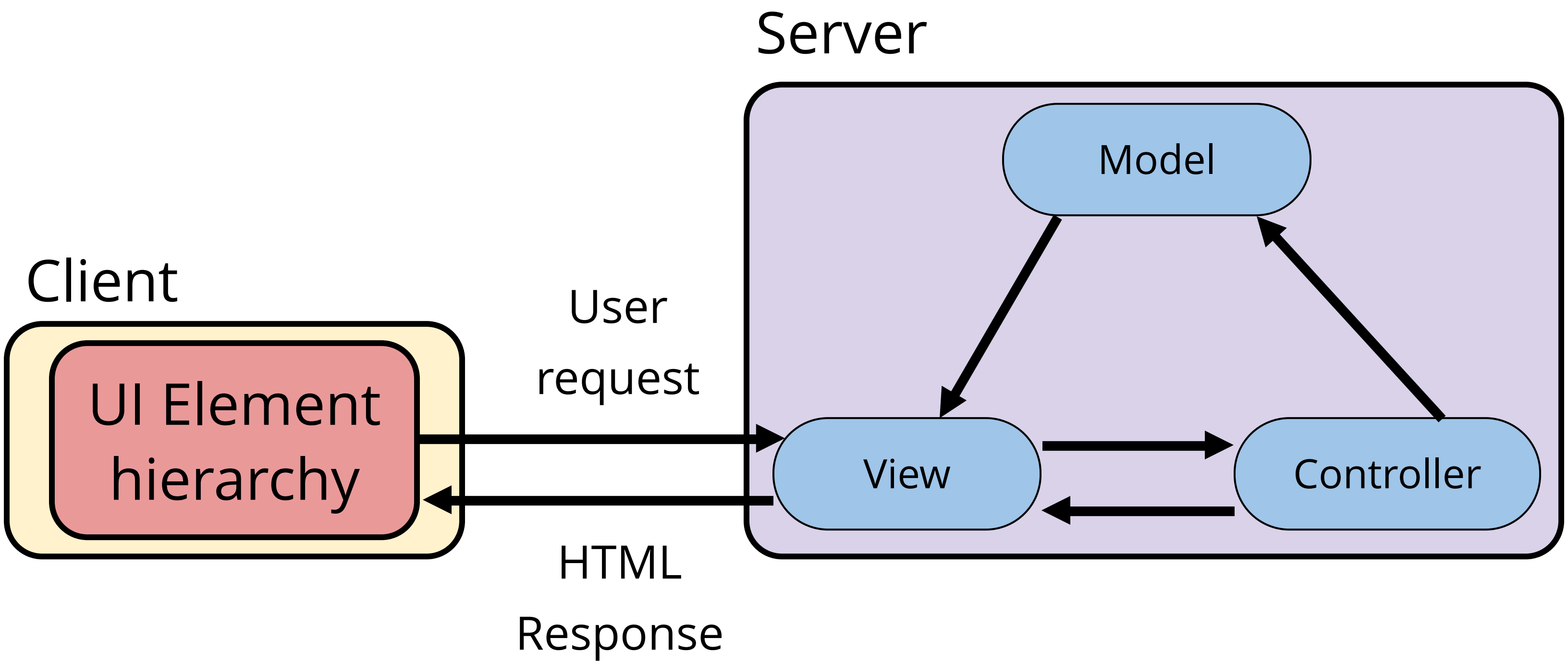
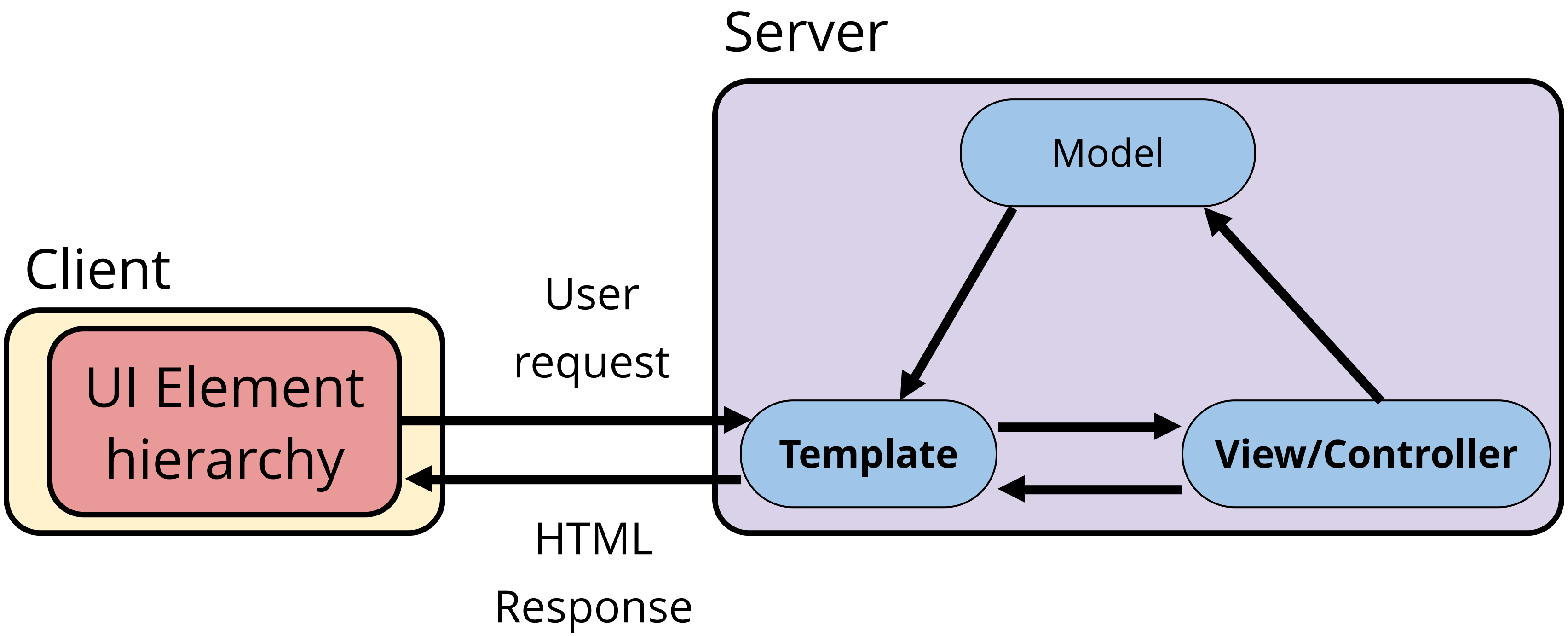


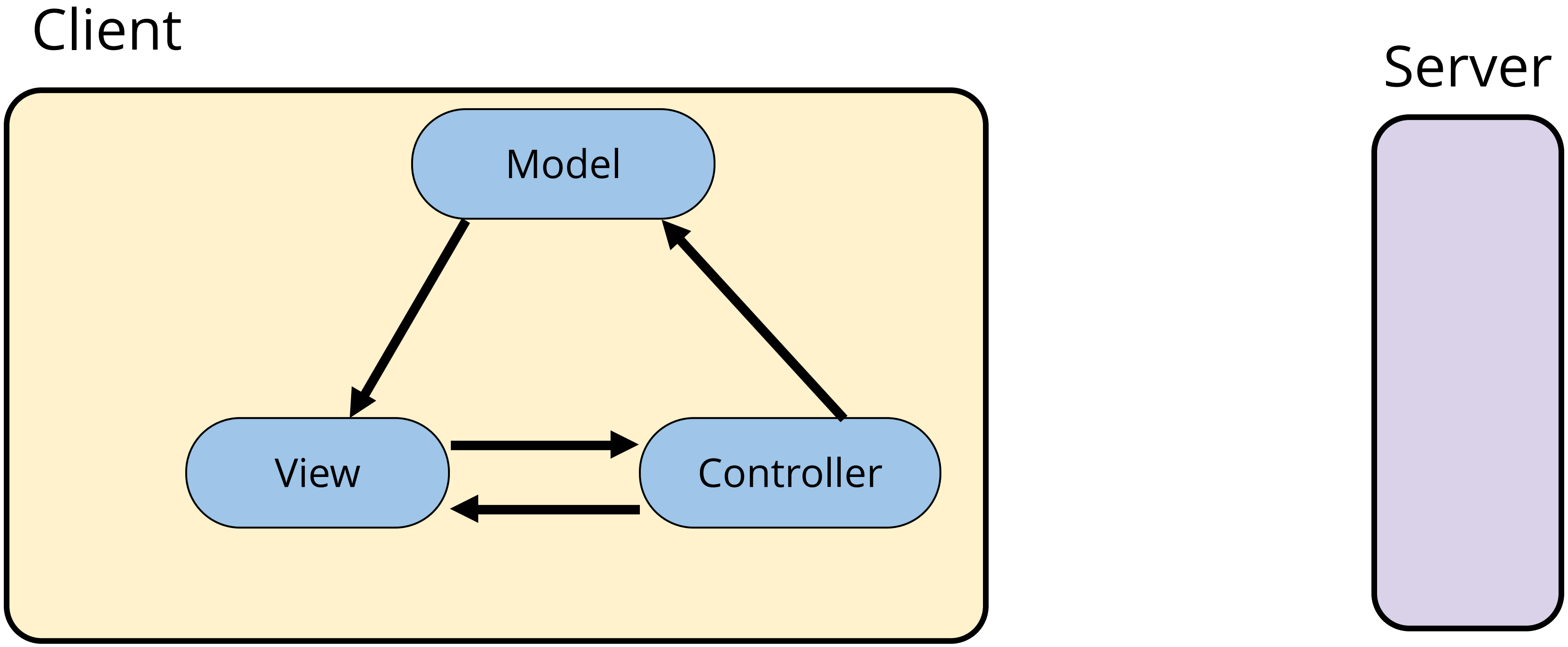
Server-first frameworks like ASP.NET (C#), Spring (Java), Django (Python), Rails (Ruby), Laravel (PHP) are usually "MVC-like".

Model-View-Template?



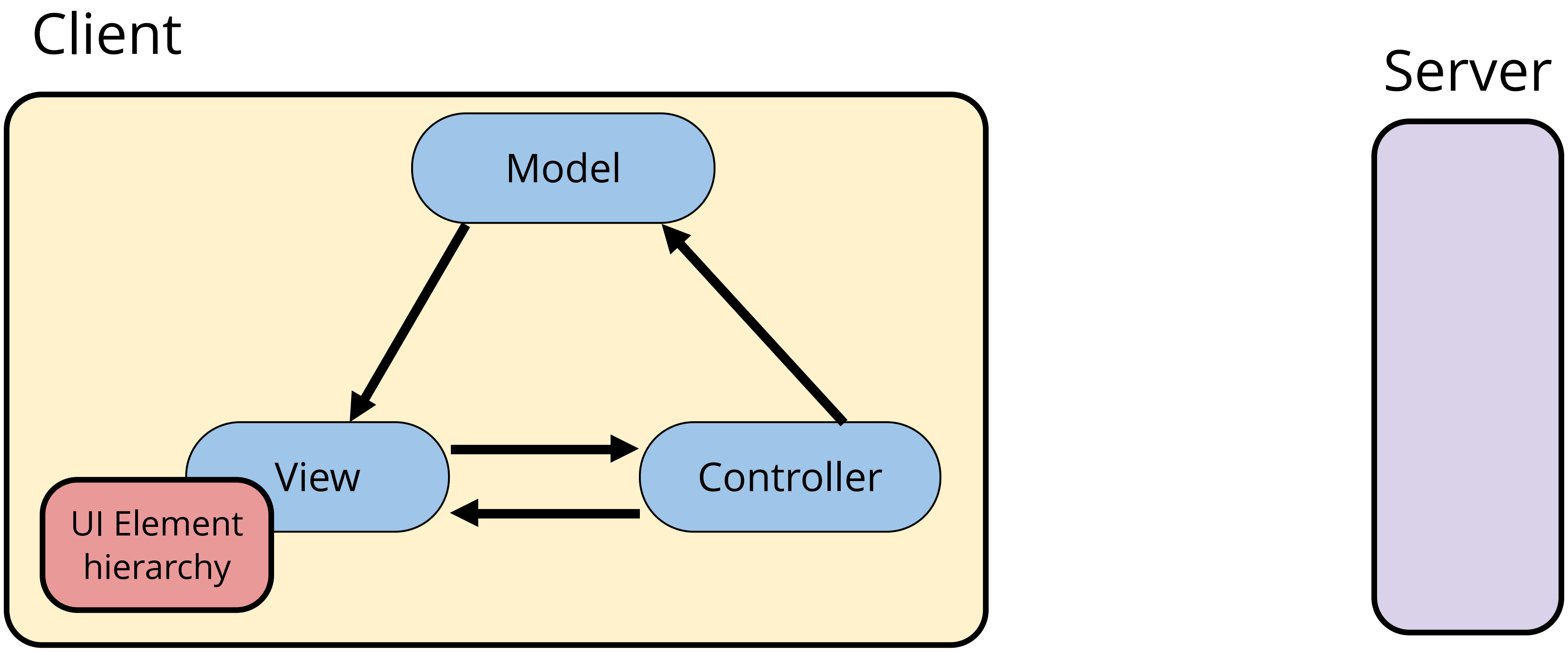
"MVC-like": Other minor interpretations of what `View` and `Controller` stand for.

MVC, client-side rendering



Not that common... Angluar (JavaScript; mostly older versions).

MVC, client-side rendering



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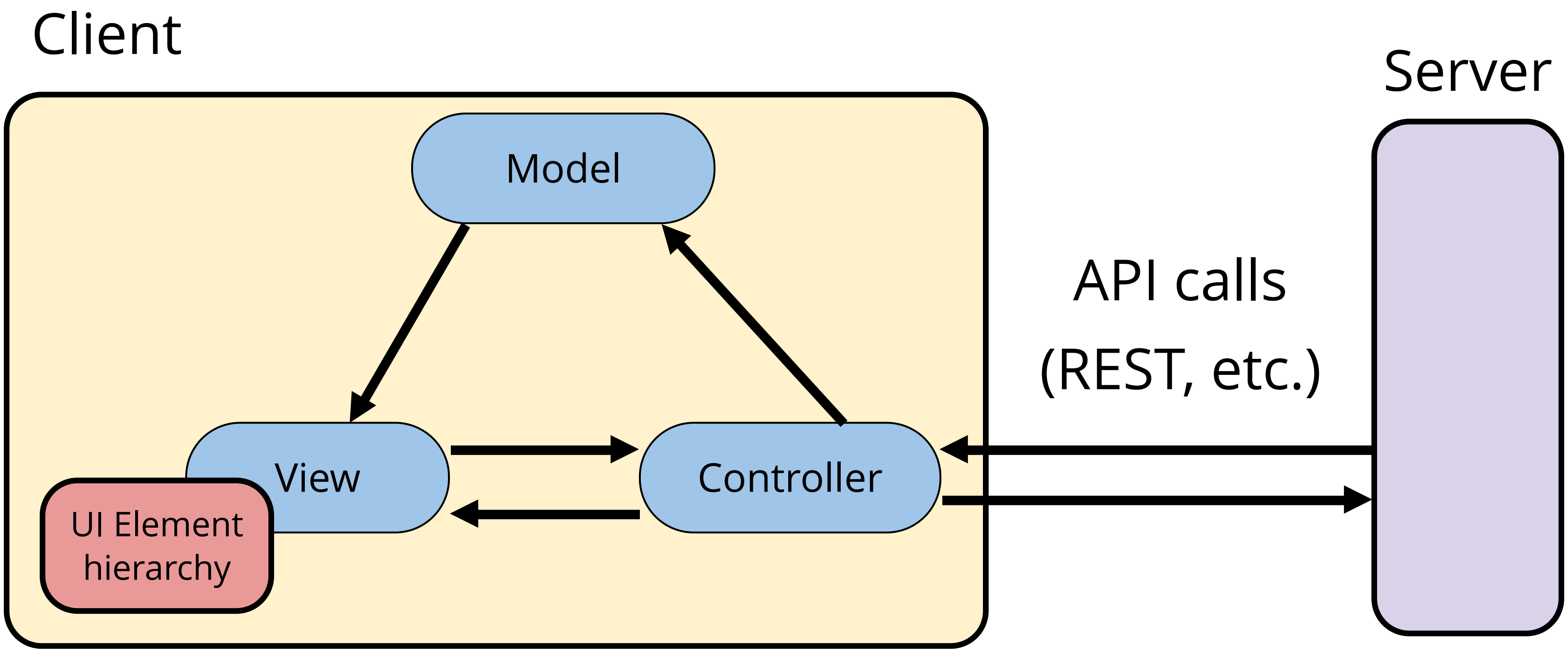

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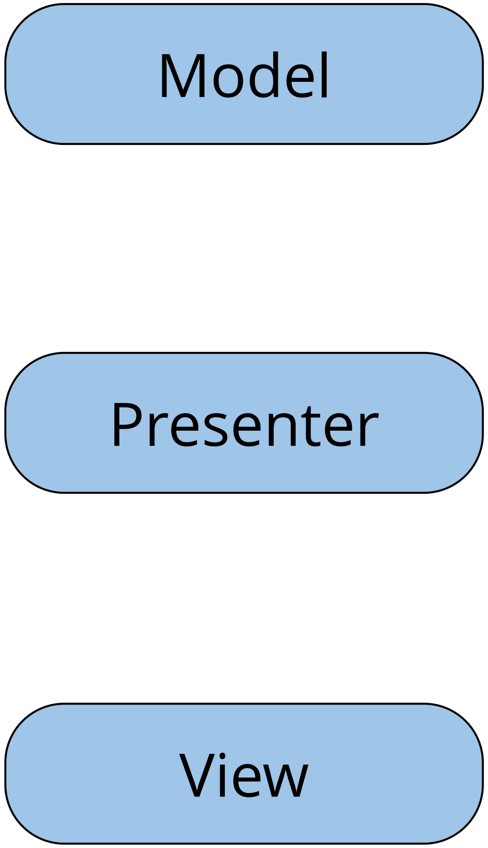
Model View Presenter



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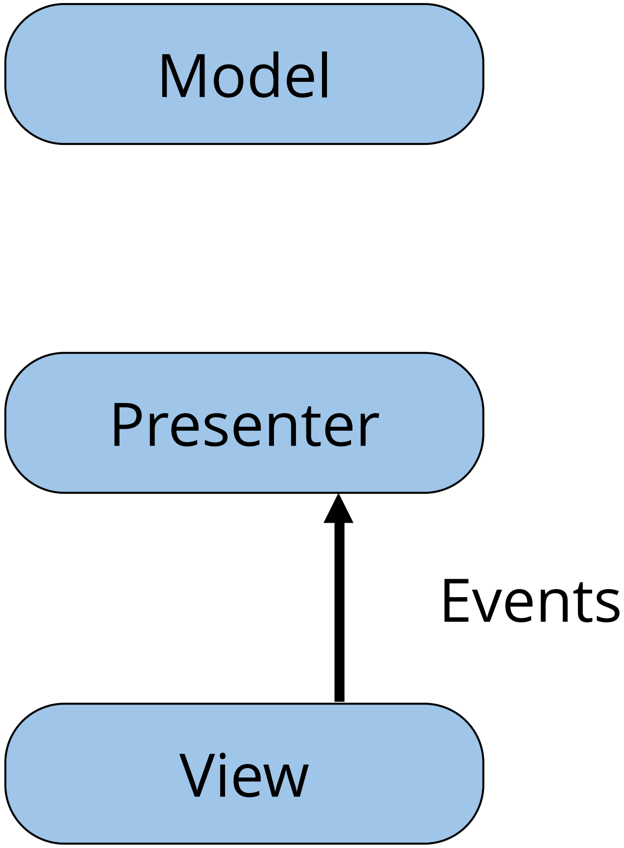

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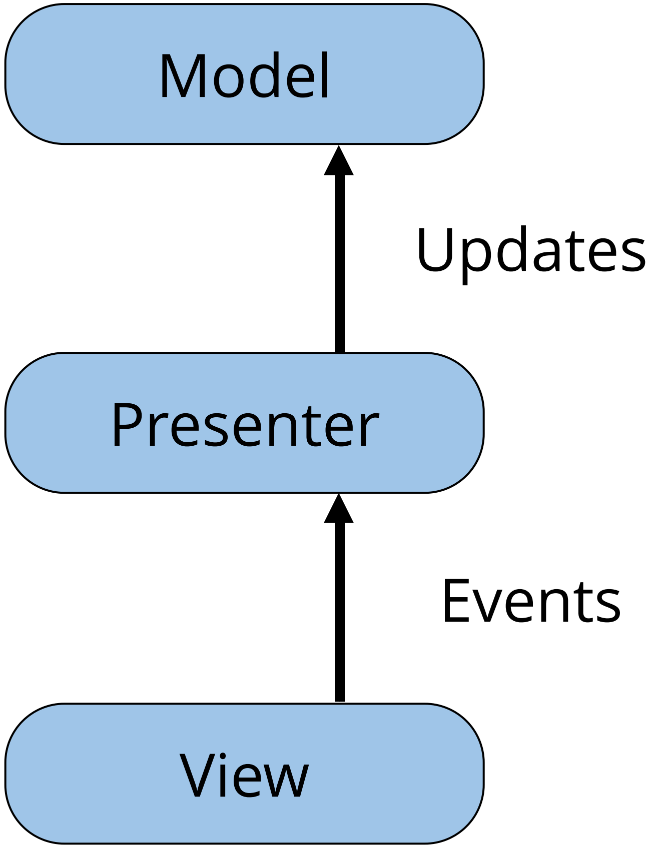

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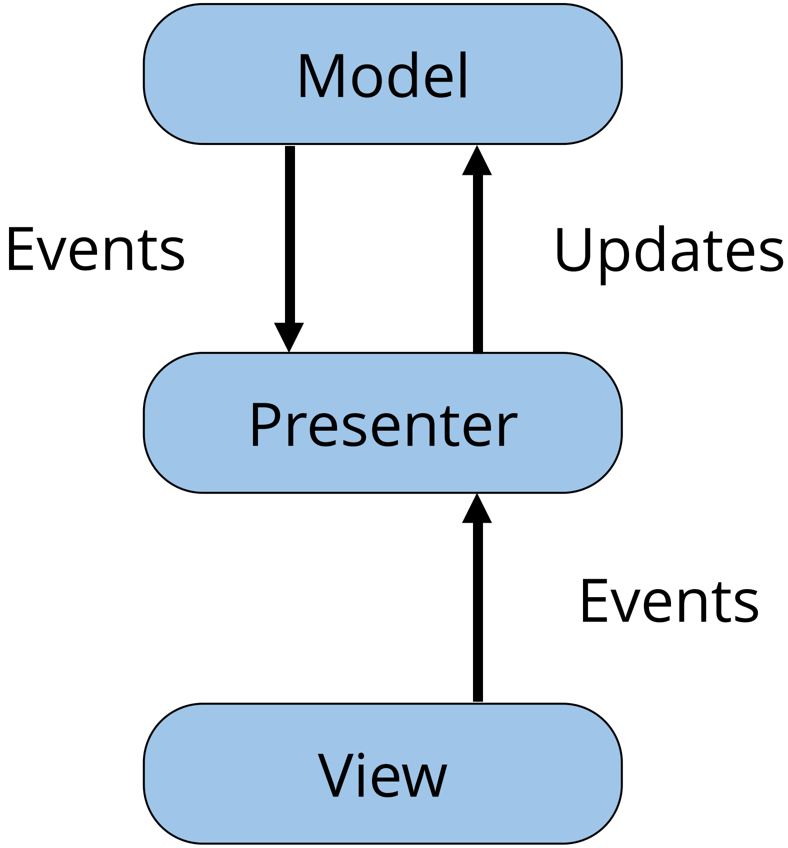

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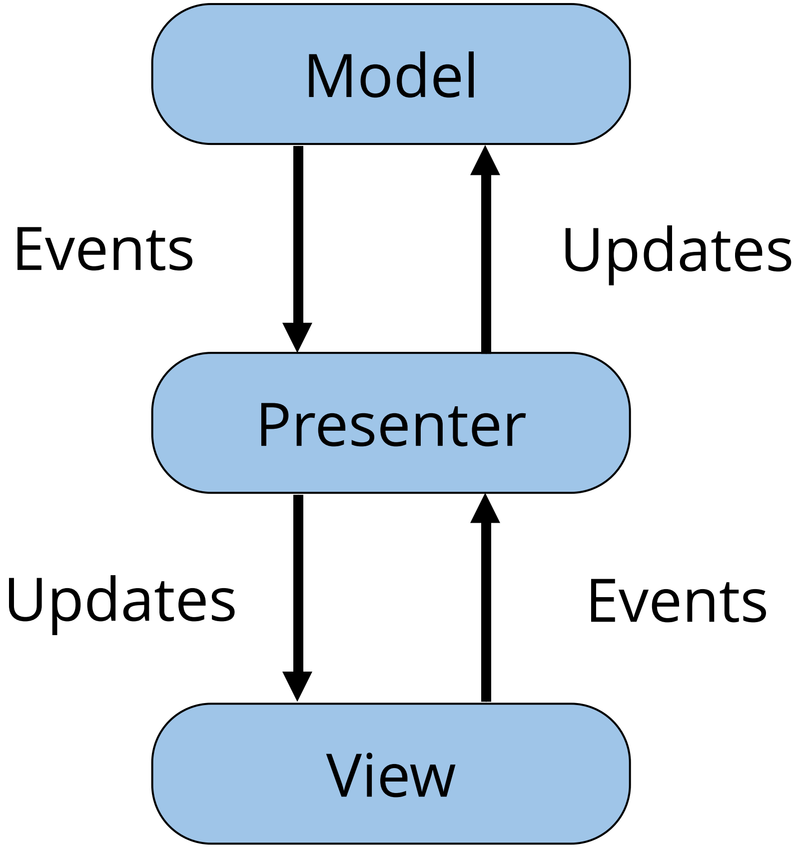

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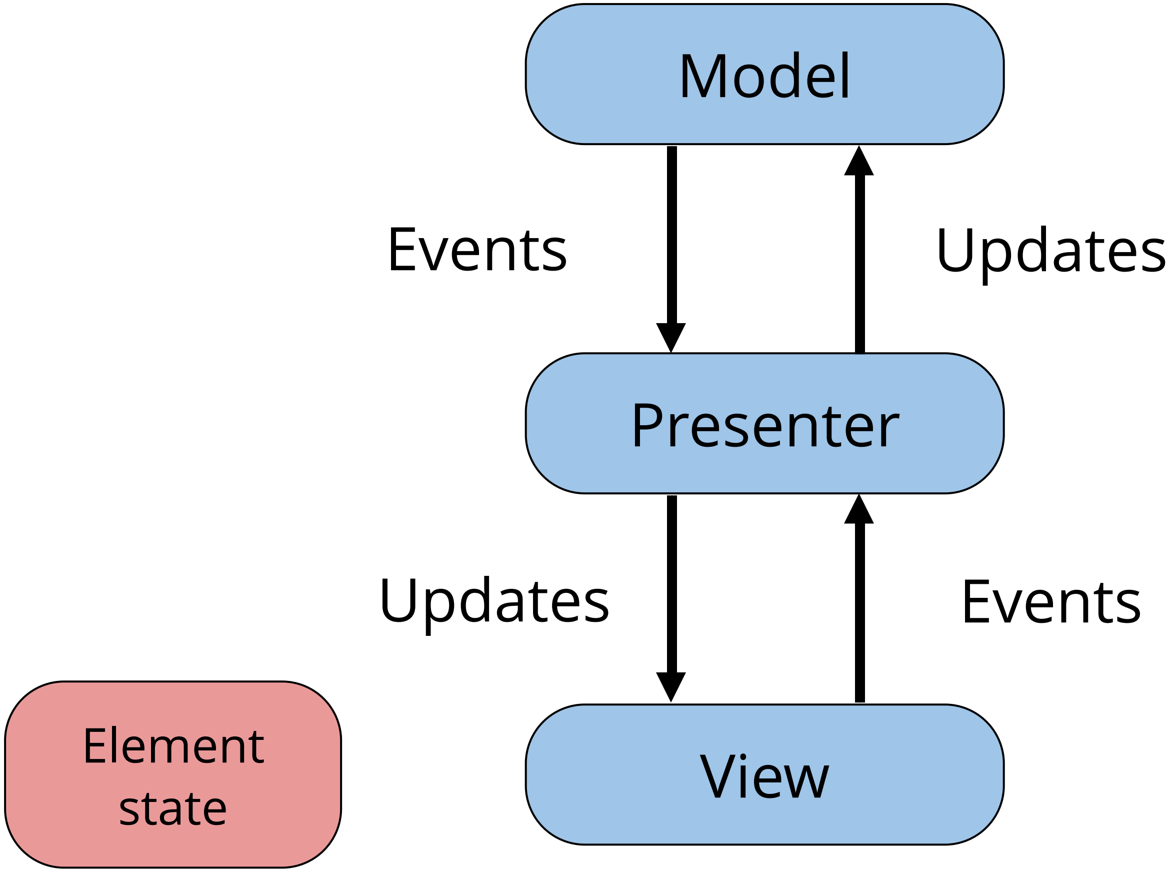

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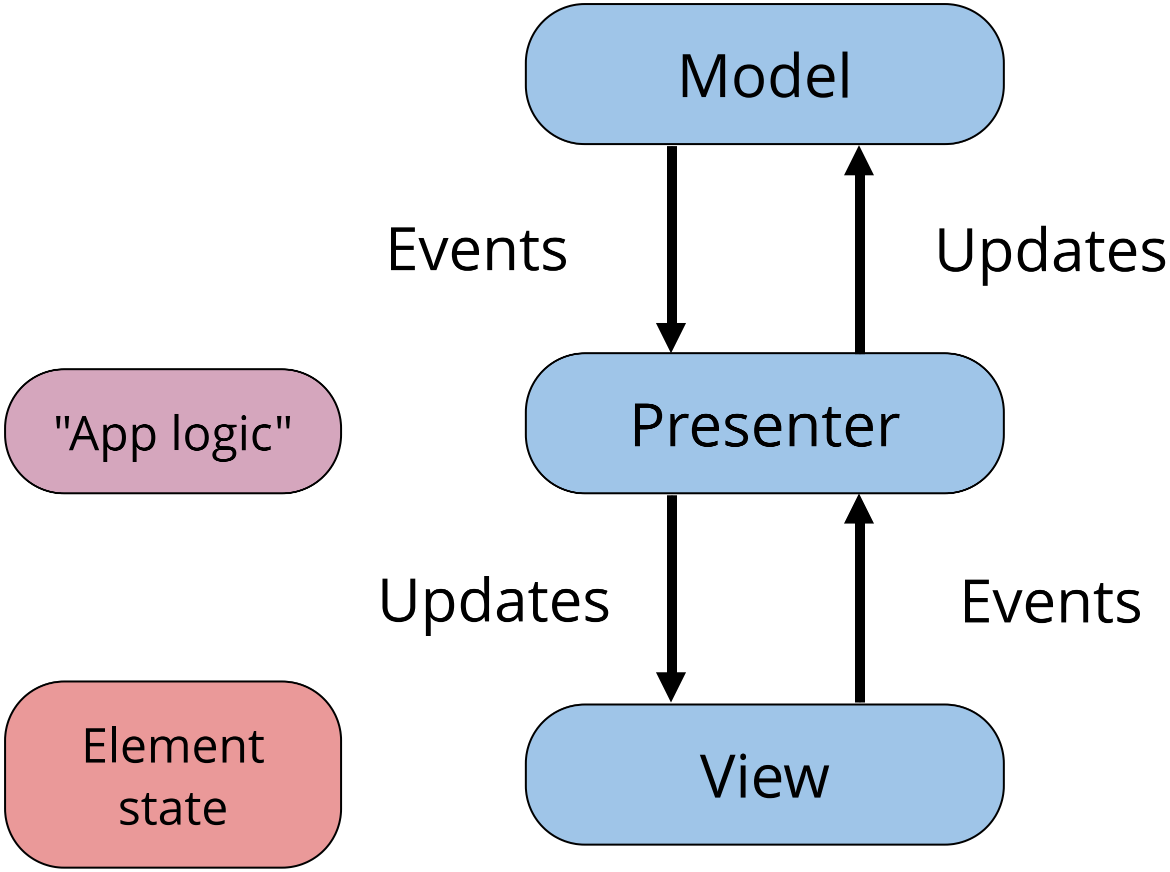

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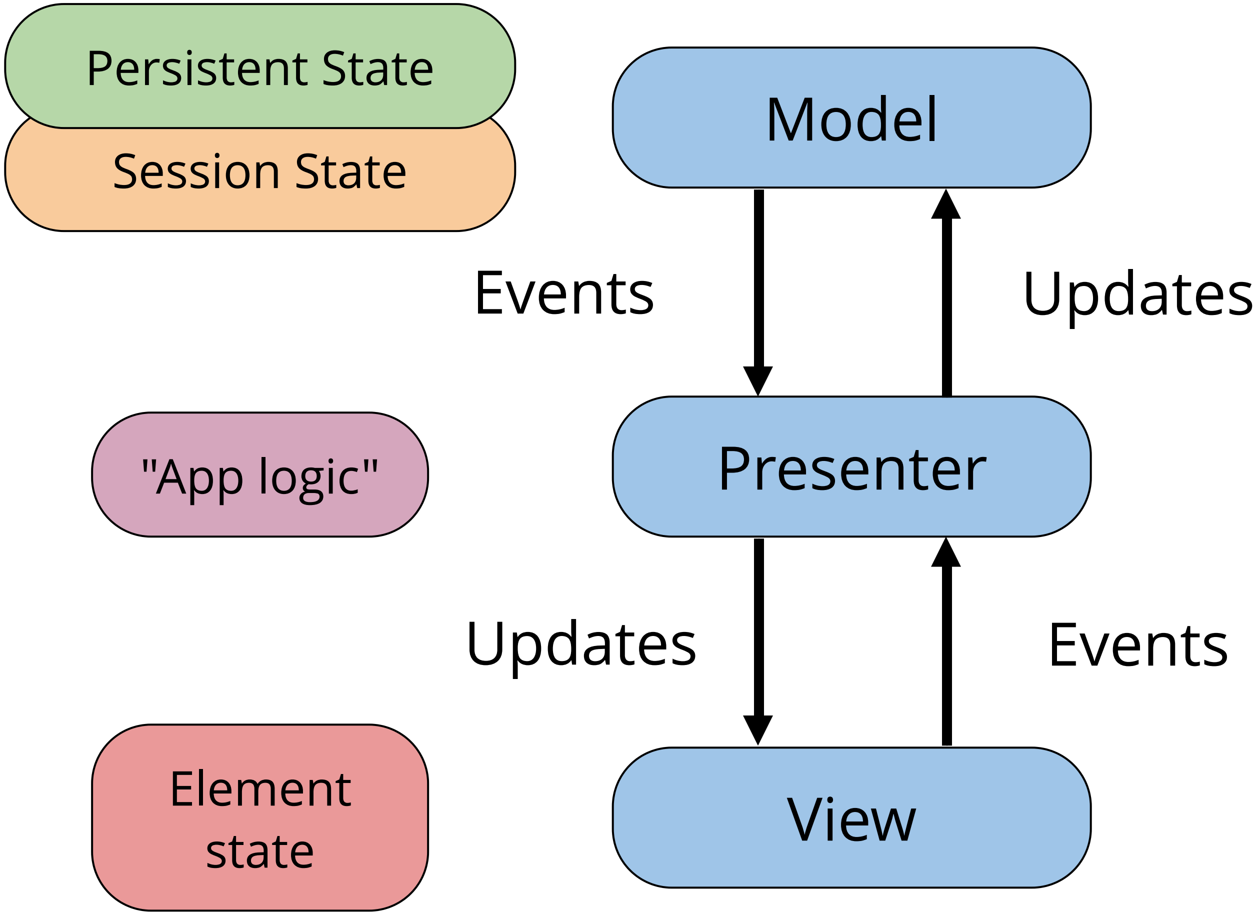

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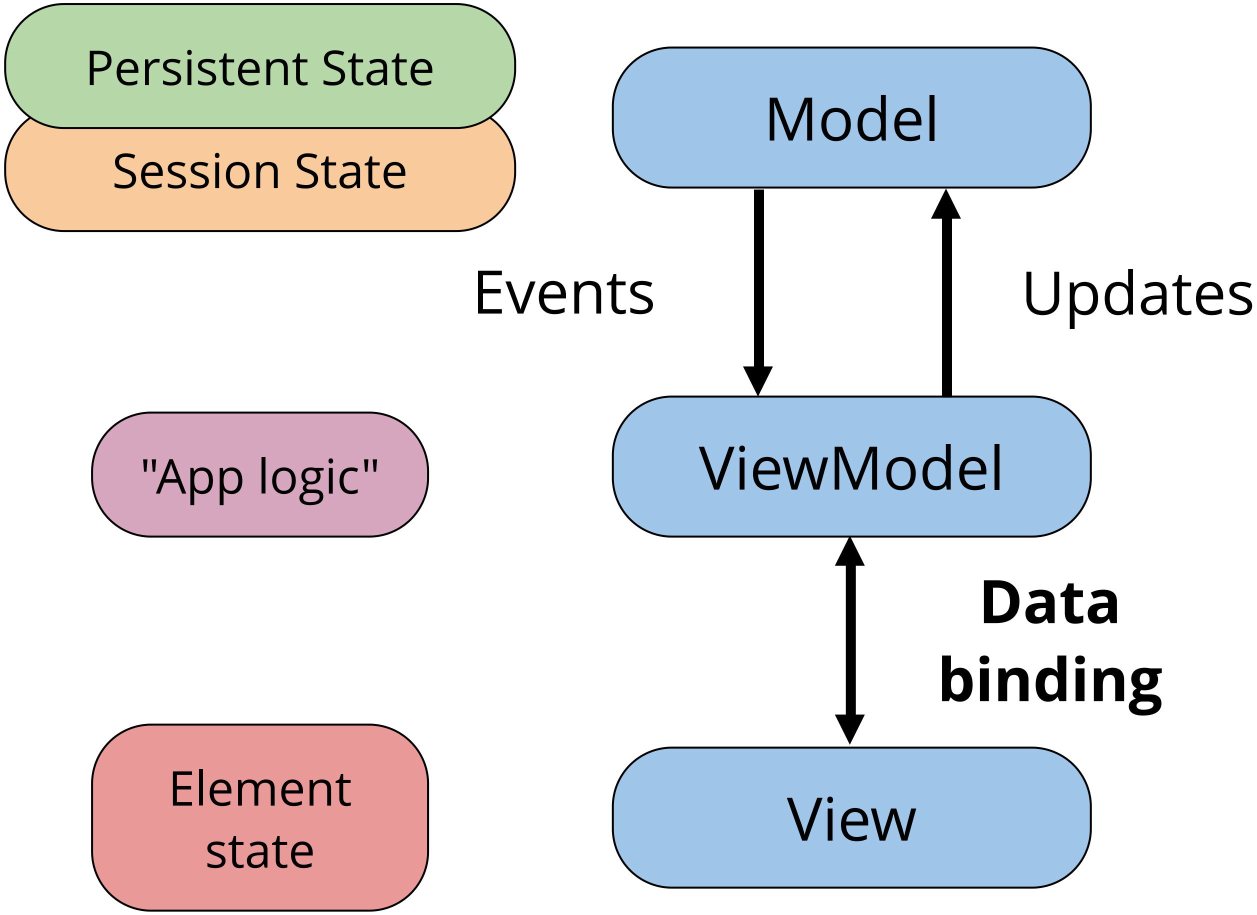
- Same considerations for server-side vs client-side rendering apply.

Model View ViewModel (MVVM)



Model View ViewModel

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- Very similar to MVP, but the relationship between the `View` and the `ViewModel` is *declarative*, while the relationship between the `Presenter` and the `View` is *imperative*.
  - `Presenter` listens to the events emitted by the `View` and manipulates it accordingly.
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- More robust to changes in the View hierarchy.
- Less verbose, data binding eliminates a lot of "boilerplate" code related to events.
- Most modern JavaScript frameworks (React, Svelte, Vue.js, ...) could be classified as MVVM (but most have other mechanisms, on top of MVVM, e.g. templates, that make this less clear)

We'll come back to declarative vs. imperative UI in the next lecture...

Part 7: Component-based design

Problem:

The UI Element hierarchy on its own is often quite hard to manage, even if we only consider "Element state" that has nothing to do with business logic. To achieve a specific style, we may need to combine a lot of Elements that need we to coordinate and thus expose unnecessary "implementation details".

UI Components

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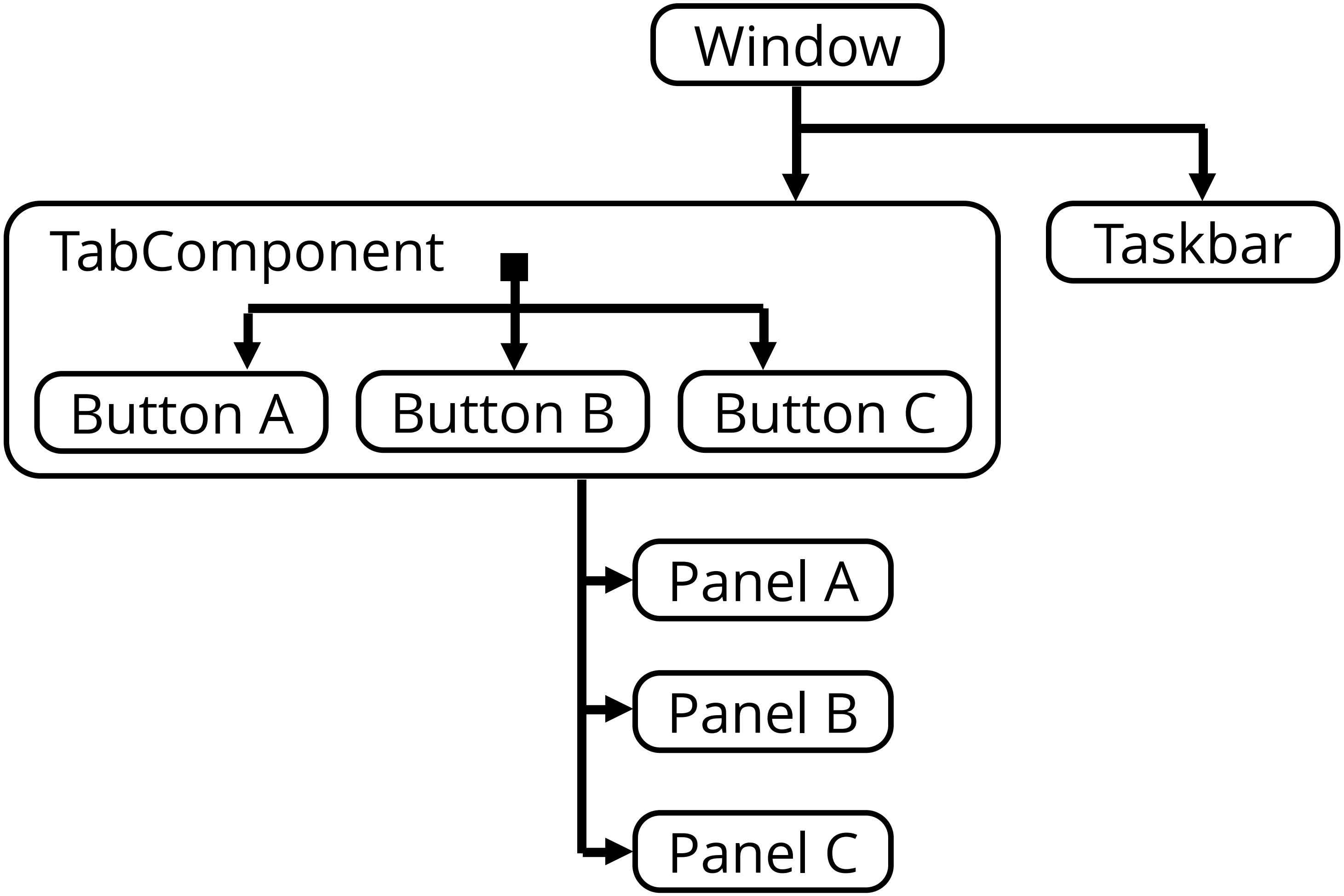
    - Architecturally, this allows us to convert some of the "Session-like" state into pure Element state.
- Was hugely popularized by React (now used by most JS frameworks), but similar ideas have existed outside of Web development before.


Window
TabComponent
Taskbar
Button A
Button B
Button C
Panel A
Panel B
Panel C

WebComponents

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- Each `Component` behaves just like an ordinary HTML `Element` with a custom tag name.
- A `Component` can have a *shadow DOM*, i.e. a hierarchy of HTML elements that is not accessible outside of the component.
- The standard adds a `<template>` tag to make writing reusable HTML markup easier.

WebComponents

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```
// Autonomous Web Component
class TabBar extends HTMLElement {
  constructor() {
    super();
  }
  // Element functionality written in here
}

customElements.define("tab-bar", TabBar);

// Usage in HTML:
// <tab-bar>Some content</tab-bar>
```

WebComponents

- Components have lifecycle events: `connected`, `adopted`, `disconnected`.

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```
// Autonomous Web Component
class TabBar extends HTMLElement {
  constructor() {
    super();
  }

  connectedCallback() {
    console.log("Custom element added to page.");
  }

  disconnectedCallback() {
    console.log("Custom element removed from page.");
  }

  adoptedCallback() {
    console.log("Custom element moved to new page.");
  }

}
```

WebComponents

- A *shadow DOM* is used to attach child elements that should not be discoverable through the normal DOM.
  - They won't appear as child `Elements` nor can they be discovered using `querySelector` or similar.
  - If mode: "open" is set, the shadow DOM is accessible through `element.shadowRoot`.

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    - If mode: "open" is set, the shadow DOM is accessible through `element.shadowRoot`.

```
// Autonomous Web Component
class TabBar extends HTMLElement {
  static observedAttributes = ["color", "size"];

  connectedCallback() {
    // Create a shadow root
    const shadow = this.attachShadow({ mode: "open" });

    // Create internal span tag
    const wrapper = document.createElement("span");
    wrapper.setAttribute("class", "wrapper");
    wrapper.innerHTML = "Shadow DOM content";

    shadow.appendChild(wrapper);
  }
}
```

WebComponents

- Templates provide a friendlier mechanism for declaring shadow DOM elements

WebComponents

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```
// Declared somewhere in our HTML:
<template id="tab-bar">
  <div id="tab-buttons"></div>
  <div id="tab-panels">
    <slot>Child elements will appear here.</slot>
  </div>
</template>

class TabBar extends HTMLElement {
  constructor() {
    super();
    let template = document.getElementById("tab-bar");
    let templateContent = template.content;

    const shadowRoot = this.attachShadow({ mode: "open" });
    shadowRoot.appendChild(templateContent.cloneNode(true));
  }
}
```

WebComponents

- Child elements can be placed depending on slot name.

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```
// Declared somewhere in our HTML:
<template id="tab-bar">
  <div id="tab-buttons">
    <slot name="header"></slot>
  </div>
  <div id="tab-panels">
    <slot>Child elements will appear here.</slot>
  </div>
</template>

// Usage with tab-bar:
<tab-bar>
    <span slot="header">Some header content.</span>
    <div>Other elements go to the default slot.</div>
</tab-bar>
```

WebComponents

- Same as JavaScript, the shadow DOM is also encapsulated from any "outside" CSS rules.
- We need to either add our own styles programmatically, or add a `<style>` (or `<link>`) directly into the shadow DOM.

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- We need to either add our own styles programmatically, or add a `<style>` (or `<link>`) directly into the shadow DOM.

```
<template id="tab-bar">
  <style>
    .tab-buttons {
      margin: 0 auto;
    }
  </style>
  <div id="tab-buttons">
    <slot name="header"></slot>
  </div>
  <div id="tab-panels">
    <slot>Child elements will appear here.</slot>
  </div>
</template>

```

More about WebComponents (and components in general) on the next seminar...

Takeaways

- User interfaces are represented as tree hierarchies of elements (widgets, views, ...).
- Interacting with elements triggers events.
- Events update application state. Managing state is one of the fundamental roles of UI frameworks.
- Very broadly, state can be understood as element state, session state and persistent state.
- Server-side vs. client-side rendering: where is the state converted into the UI hierarchy?
- MVC, MVP, MVVM: basic design patterns for separating state, logic and user interface.
- Component-based design: defining new UI elements that encapsulate non-trivial behavior.
- WebComponents, a modern standard for defining UI components in the browser.