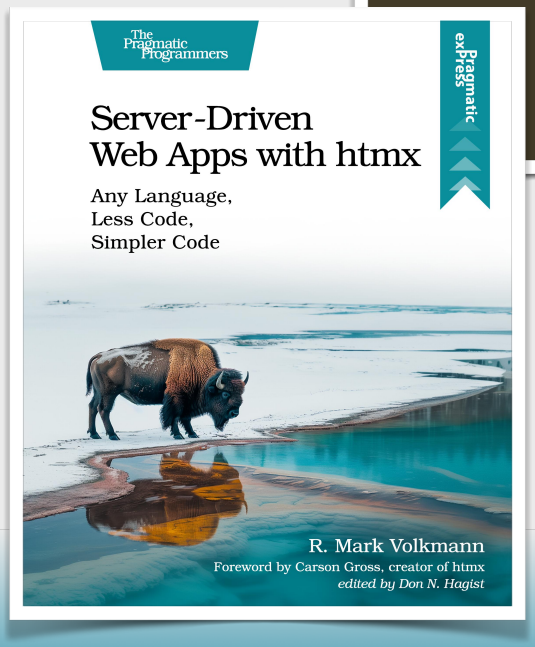
Web Components

R. Mark Volkmann
Object Computing, Inc.
https://mvolkmann.github.io/blog
r.mark.volkmann@gmail.com

Slides at **https://github.com/mvolkmann/talks/**

About Me

- Partner and Distinguished Software Engineer at Object Computing, Inc. in St. Louis, Missouri USA
- 44 years of professional software development experience
- Writer and speaker
- **Blog** at https://mvolkmann.github.io/blog/
- Author of Manning book "**Svelte ... in Action**"
- Author of Pragmatic Bookshelf book "**Server-Driven Web Apps with htmx**"



Web Components

- Define **custom HTML elements** that can be used like standard HTML elements
- Names must be all lower-case and contain at least one hyphen
- Tags cannot be self-closing

ex. `<radio-group></radio-group>`, **not** `<radio-group />`

Pros

- Standard way to implement web-based UI components
- Just use the “platform”
  - no libraries, tooling, or build process required
- Use in many places
  - any web page, with any web framework, and in Markdown files
  - share between projects using different frameworks
- Shadow DOM provides CSS and DOM encapsulation
  - styles defined in component do not affect HTML outside it
  - can control ability to style component from outside it
  - can prevent code outside component from querying and modifying its DOM

Some issues remain when using in **React-based frameworks**, mainly due to use of virtual DOM.

Cons

- Learning curve
  - relatively small
  - mostly learning more about the DOM, which is good to know
- Requires **more effort and code** unless using a library like Lit
  - than implementing components using a modern web framework like Angular, React, Svelte, or Vue
  - worthwhile for components that may someday be used in multiple apps that use multiple frameworks
  - not a great developer experience compared to using a framework
- Reactivity must be implemented manually unless using a library like wrec
- Server-side rendering is currently challenging Do you need it?

Standards Based ...

- **Custom Elements**
  - define custom HTML elements by creating a class that extends **`HTMLElement`** class or one of its subclasses
  - supports several lifecycle methods
  - each class defines a reusable component that has attributes, properties, and methods
- **Shadow DOM**
  - encapsulates styling and DOM of custom HTML elements
  - adds **`attachShadow`** method, **`ShadowRoot`** class, and **`shadowRoot`** property
  - supports “open” and “closed” modes more on these later

... Standards Based

- **HTML Templates**
  - adds HTML element **`template`** defined by **`HTMLTemplateElement`** class
  - **`content`** property is an instance of **`DocumentFragment`** that can be created **without rendering**
  - can be efficiently cloned and rendered later

- **ES Modules** (a.k.a. JavaScript Modules)
  - adds **`import`** and **`export`** syntax, module scope, asynchronous loading, and more
- **CSS Scoping**
  - defines scoping/encapsulation mechanisms for CSS, including scoped styles and the **`@scope`** rule, Shadow DOM selectors, and page/region-based styling
- **CSS Shadow Parts**
  - defines **`::part()`** pseudo-element on shadow hosts, allowing shadow hosts to selectively expose chosen elements from their shadow tree to outside page for styling

Implementation Options

- **Vanilla** from W3C
- **wrec** from me (more on this later)

No tooling or build process is required.

- **Lit** from Google
  - most popular web component library
  - can be used without tooling and a build process, but isn't typically
- **Stencil** from Ionic
- **FAST** from Microsoft

These require using tooling in a build process.

The name "**Lit**" is based on 3 things:
- it's a **lit**tle library
- it uses JS template **lit**erals
- it is "**lit**", as in amazing

Shadow DOM

- Encapsulates styling and content of a custom element
- Many standard HTML elements utilize a shadow DOM
  - **`input`**, **`textarea`**, **`select`**, **`audio`**, **`video`**, and more
- To use a shadow DOM in a web component

Inspect these elements in Chrome DevTools to see **`#shadow-root`** and their contents. This requires checking Settings ... Preferences ... Elements ... **Show user agent shadow DOM**. The **`#shadow-root`** of custom elements is always visible.

```
constructor() {
  super();
  this.attachShadow({mode: 'open'});
}
```

```
constructor() {
  super();
  this.#root = this.attachShadow({mode: 'closed'});
}
```

When mode is "**`closed`**", capture shadow root in a private property so it can be accessed in **`connectedCallback`**.

- To add content

```
connectedCallback() {
  this.shadowRoot.innerHTML = 'some HTML string';
  // OR
  this.shadowRoot.appendChild(someElement);
}
```

```
connectedCallback() {
  this.#root.innerHTML = 'some HTML string';
  // OR
  this.#root.appendChild(someElement);
}
```

Shadow DOM Access

- DOM provides many methods that find elements including **`querySelector`**, **`querySelectorAll`**, and **`getElementById`**
- Whether these methods can be used to find and manipulate elements in a web component depends on whether/how it uses a shadow DOM
  - see options on next slide

DOM Access Options

- **No shadow DOM**
  - document **can** query into web component DOM
- **Open shadow DOM** by far the most common
  - document **cannot accidentally** query into web component DOM
  - **can intentionally** query by calling methods on `shadowRoot` property
  - useful for implementing tests with tools like Playwright and Cypress
- **Closed shadow DOM**
  - document **cannot** query into web component DOM
  - `shadowRoot` property is not present
  - DevTools can still view and manipulate the elements

holds instance of `ShadowRoot` class which inherits from `DocumentFragment` class

Shadow DOM Example

- Suppose a document contains an instance of **`radio-group`** web component that uses shadow DOM in “open” mode
  - this **does not** find **`label`** elements inside web component

```
const labels = document.querySelectorAll('label');
```

  - this **does** find **`label`** elements inside web component

```
const labels = document.querySelector('radio-group').shadowRoot.querySelectorAll('label');
```

  - this changes the **`label`** of first radio button inside web component

```
document
  .querySelector('radio-group')
  .shadowRoot
  .querySelector('label')
  .textContent = 'Rouge'
```

Show Me Code!

- Simple web component

```
<hello-world></hello-world>

<hello-world name="Mark"></hello-world>
```

Hello, World!

Hello, Mark!

- We'll see five ways to implement
  - vanilla with no shadow DOM, setting innerHTML
  - vanilla with no shadow DOM, using DOM API
  - vanilla with shadow DOM, setting innerHTML
  - vanilla with shadow DOM, using DOM API
  - using Lit (a bit later)

Each requires
a small amount of code
that is easy to understand.

Starting Simple

None of these implement **attributeChangedCallback**, so modifying the **name** attribute in DevTools does not update the UI.

index.html

```
<html>
  <head>
    <script src="hello-world1.js" type="module"></script>
    <script src="hello-world2.js" type="module"></script>
    <script src="hello-world3.js" type="module"></script>
    <script src="hello-world4.js" type="module"></script>
  </head>
  <body>
    <hello-world1 name="innerHTML"></hello-world1>
    <hello-world2 name="appendChild"></hello-world2>
    <hello-world3 name="shadow-innerHTML"></hello-world3>
    <hello-world4 name="shadow-appendChild"></hello-world4>
  </body>
</html>
```

hello-world1.js

```
class HelloWorld1 extends HTMLElement {
  connectedCallback() {
    const name = this.getAttribute("name") || "World";
    this.innerHTML = `<p>Hello, ${name}!</p>`;
  }
}
customElements.define("hello-world1", HelloWorld1);
```

hello-world2.js

```
class HelloWorld2 extends HTMLElement {
  connectedCallback() {
    const name = this.getAttribute("name") || "World";
    const p = document.createElement("p");
    p.textContent = `Hello, ${name}!`;
    this.appendChild(p);
  }
}
customElements.define("hello-world2", HelloWorld2);
```

hello-world3.js

```
class HelloWorld3 extends HTMLElement {
  constructor() {
    super();
    this.attachShadow({ mode: "open" });
  }

  connectedCallback() {
    const name = this.getAttribute("name") || "World";
    this.shadowRoot.innerHTML = `<p>Hello, ${name}!</p>`;
  }
}
customElements.define("hello-world3", HelloWorld3);
```

hello-world4.js

```
class HelloWorld4 extends HTMLElement {
  constructor() {
    super();
    this.attachShadow({ mode: "open" });
  }

  connectedCallback() {
    const name = this.getAttribute("name") || "World";
    const p = document.createElement("p");
    p.textContent = `Hello, ${name}!`;
    this.shadowRoot.appendChild(p);
  }
}
customElements.define("hello-world4", HelloWorld4);
```

innerHTML vs. DOM API

- Two approaches for building web component DOM
- Set **`innerHTML`**
  - typically using JavaScript template strings
  - less verbose
  - faster for bulk updates
  - destroys existing nodes and loses event listeners
  - builds DOM synchronously so it can be queried immediately
  - danger of XSS when using untrusted content
- Call **DOM API** methods like **`createElement`** and **`appendChild`**
  - more fine-grained control
  - can preserve existing nodes and event listeners
  - avoids XSS from untrusted content

Middle Ground

- set **`innerHTML`** to render initial DOM
- in event handlers, use DOM API to make targeted updates

Template Strings

- JavaScript feature that can build a string of HTML for use as **`innerHTML`** value
- Capabilities include
  - conditional logic with ternary operator
    - one use is to conditionally add an attribute
  - iteration with **`map`** method
  - break up content rendering into multiple functions/methods

examples come from "Radio Group" component we will review later

```
html`<input
  type="radio"
  id="${option}"
  name="${this.#name}"
  value="${option}"
  ${option === this.value ? "checked" : ""}
/>`
```

```
html`<div class="radio-group">
  ${options.map(option => this.#makeRadio(option)).join("")}
</div>`
```

```
#makeRadio(option) {
  return html`
    ...
  `;
}
```

Preceding template string with tag **`css`** or **`html`** triggers **VS Code extension Prettier** to format code and **es6-string-html** extension to add syntax highlighting.

Can AI Tools Generate?

- **Request:** Write a hello-world vanilla web component that has a name attribute with a default value of “World”.
- **Contenders:**
  - **ChatGPT**, **Claude**, **Google Gemini**, **Microsoft Copilot**, and **Perplexity**
- While the generated code uses slightly different approaches, each successfully generated code that meets the requirements
  - Google Gemini produced worst code

Using Lit

package.json

```
{
  "name": "hello-world-web-components",
  "type": "module",
  "scripts": {
    "dev": "vite",
    "build": "vite build",
    "preview": "vite preview"
  },
  "dependencies": {
    "lit": "^3.0.0"
  },
  "devDependencies": {
    "typescript": "^5.0.0",
    "vite": "^5.0.0"
  }
}
```

tsconfig.json

```
{
  "compilerOptions": {
    "experimentalDecorators": true,
    "moduleResolution": "node",
    "target": "ES2022",
    "useDefineForClassFields": false
  }
}
```

When using Lit, modifying the **name** attribute in DevTools automatically updates the UI!

index.html

```
<html>
  <head>
    <script src="hello-world5.js" type="module"></script>
    <script src="hello-world6.ts" type="module"></script>
  </head>
  <body>
    <hello-world5 name="Lit JS"></hello-world5>
    <hello-world6 name="Lit TS"></hello-world6>
  </body>
</html>
```

hello-world5.js

JavaScript version

```
import { html, LitElement } from "lit";

class HelloWorld5 extends LitElement {
  static properties = { name: { type: String } };

  render() {
    return html`<p>Hello, ${this.name || "World"}!</p>`;
  }
}
customElements.define("hello-world5", HelloWorld5);
```

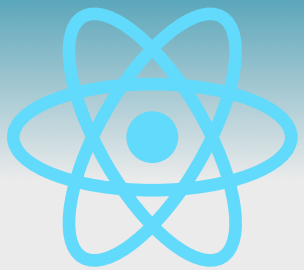
hello-world6.ts

TypeScript version

```
import { html, LitElement } from "lit";
import { customElement, property } from "lit/decorators.js";

@customElement("hello-world6")
export class HelloWorld6 extends LitElement {
  @property({ type: String }) name = "World";

  render() {
    return html`<p>Hello, ${this.name}!</p>`;
  }
}
```

The **render** method is called every time a property value changes.
It uses an approach similar to the React virtual DOM
to diff the new DOM with the previous DOM
and only update the parts that have changed.

React Comparison



- Steps to create
  - **`npm create vite@latest react-hello-world`**
    - select React and TypeScript
  - **`cd react-hello-world`**
  - **`npm install`**
  - create **`src/HelloWorld.tsx`**
  - modify **`App.tsx`**
  - **`npm run dev`**
  - browse localhost:5173
- Component can only be used in React apps
- Lots of libraries and tools required

HelloWorld.tsx

```tsx
import React from "react";

interface HelloWorldProps {
  name?: string;
}

const HelloWorld: React.FC<HelloWorldProps> =
  ({ name = "World" }) => {
    return <p>Hello, {name}!</p>;
  };

export default HelloWorld;
```

App.tsx

```tsx
import HelloWorld from "./HelloWorld";

function App() {
  return (
    <>
      <HelloWorld />
      <HelloWorld name="Mark" />
    </>
  );
}

export default App;
```

Hello, World!

Hello, Mark!

Including Web Components

- Include web components with **`script`** tags

```
<script src="hello-world.js" type="module"></script>
```

- Module benefits
  - top-level variables are scoped to the module — useful when using **`template`** element
  - execution is deferred, same as when **`defer`** attribute is included
    - fetches in parallel, but delays execution until DOM is built
  - uses strict mode for better error checking
  - can use **`import`** and **`export`** keywords
  - can use top-level **`await`**
  - enforces Cross Origin Resource Sharing (CORS) restrictions
    - prevents testing web components with **`file://`** URLs
    - have to run a local server (like Vite which is described next)

Vite Server

- Many options for starting an HTTP server that serves local files
- One option is to use Vite
  - has many other benefits including live reload
- Steps
  - make new directory and **`cd`** to it in a terminal window
  - create **`package.json`** file by entering **`npm init`**
  - install Vite by entering **`npm i -D vite`**
  - create **`index.html`**
  - start server by entering **`npm run dev`**
  - browse localhost:5173

If port is in use,
Vite will try 5174, 5175, ...
until it finds an open port.

minimal **`package.json`**
after installing Vite

```
{
  "name": "web-server",
  "scripts": {
    "dev": "vite"
  },
  "devDependencies": {
    "vite": "^7.0.1"
  }
}
```

Web Component Libraries

- **Shoelace** - https://shoelace.style/
  - “forward-thinking library of web components”
- **Web Awesome** - https://webawesome.com/
  - “make something awesome with open-source web components”
  - eventual successor to Shoelace; still in beta
- **FAST** from Microsoft - https://fast.design
  - “dedicated to providing support for native Web Components and modern Web Standards”
- **Lion** - https://lion.js.org/
  - “fundamental white label web components for building your design system”

Shoelace Example

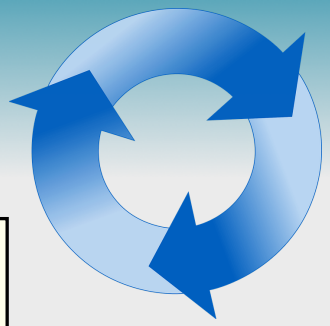
```
<html>
  <head>
    <link
      rel="stylesheet"
      href="https://cdn.jsdelivr.net/npm/@shoelace-style
        /shoelace@2.20.1/cdn/themes/light.css"
    />
    <style>
      sl-radio-group {
        margin-top: 1rem;
      }
      sl-radio-group::part(form-control),
      sl-radio-group::part(form-control-input) {
        display: flex;
        gap: 1rem;
      }
      sl-radio-group::part(form-control-label) {
        font-family: var(--sl-input-font-family);
        font-weight: bold;
      }
    </style>
    <script
      type="module"
      src="https://cdn.jsdelivr.net/npm/@shoelace-style
        /shoelace@2.20.1/cdn/shoelace-autoloader.js"
    ></script>
```

Happy?

Color: Red Green Blue

```
    <script>
      window.onload = () => {
        const slSwitch = document.querySelector("sl-switch");
        slSwitch.addEventListener("sl-change", (event) => {
          console.log("switch is",
            event.target.checked ? "on" : "off");
        });

        const slRadioGroup =
          document.querySelector("sl-radio-group");
        slRadioGroup.addEventListener("sl-change", (event) => {
          console.log("color =", event.target.value);
        });
      };
    </script>
  </head>
  <body>
    <div>
      <sl-switch>Happy?</sl-switch>
    </div>
    <sl-radio-group label="Color:" value="red">
      <sl-radio value="red">Red</sl-radio>
      <sl-radio value="green">Green</sl-radio>
      <sl-radio value="blue">Blue</sl-radio>
    </sl-radio-group>
  </body>
</html>
```

Lifecycle Methods ...



- **`constructor`**
  - called when an instance is created
  - recommended place to attach a **`ShadowRoot`**
- **`connectedCallback`**
  - called after an instance is added to DOM
  - recommended place to populate web component DOM and register event handlers
- **`attributeChangedCallback`**
  - called when the value of any “observed” attribute changes
  - specify with

```
constructor() {
  super();
  this.attachShadow({ mode: "open" });
}
```

`shadowRoot` property is set when mode is **`"open"`**, but not when it is **`"closed"`**

```
connectedCallback() {
  this.shadowRoot.innerHTML = `...some HTML...`;
  const button = this.shadowRoot.querySelector('button');
  button.addEventListener('click', event => {
    alert('got click');
  });
}
```

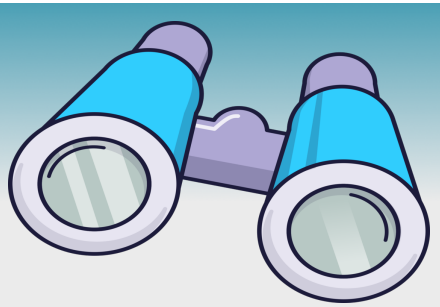
```
attributeChangedCallback(name, oldValue, newValue) {
  ...
}
```

```
static get observedAttributes() {
  return ['name1', 'name2', ...];
}
```

... Lifecycle Methods

- **`disconnectedCallback`** (rarely used)
  - called after an instance is removed from DOM
  - cleanup resources created in **`connectedCallback`**
    - resources could include event listeners, timeouts, intervals, and pending network requests
- **`adoptedCallback`** (rarely used)
  - called when an instance is moved to a different document

Observing Attributes



- Let's modify the **`HelloWorld1`** class to update what it renders when the **`name`** attribute is modified
  - same approach works for other **`HelloWorld*`** classes

```
class HelloWorld1 extends HTMLElement {
  static get observedAttributes() {
    return ["name"];
  }

  connectedCallback() {
    const name = this.getAttribute("name") || "World";
    this.innerHTML = `<p>Hello, ${name}!</p>`;
  }

  attributeChangedCallback(name, oldValue, newValue) {
    if (name === "name") {
      const p = this.querySelector("p");
      if (p) p.textContent = `Hello, ${newValue}!`;
    }
  }
}

customElements.define("hello-world1", HelloWorld1);
```

Cloning `template` Elements

- Faster than building component DOM from scratch for each instance

```
const template = document.createElement("template");
template.innerHTML = html`
  <p>Hello, <span id="name"></span>!</p>
`;

class HelloWorld7 extends HTMLElement {
  constructor() {
    super();
    this.attachShadow({ mode: "open" });
  }

  connectedCallback() {
    const { shadowRoot } = this;
    shadowRoot.appendChild(template.content.cloneNode(true));
    const span = shadowRoot.querySelector("#name");
    span.textContent = this.getAttribute("name") || "World";
  }
}

customElements.define("hello-world7", HelloWorld7);
```

When `script` tag includes `type="module"`, the `template` variable is scoped to this module.

deep clone

Dolly, the cloned sheep

Form Associated

- Instances of web components nested in a **`form`** element by default do not contribute to the set of name/value pairs that are submitted by the **`form`** focus still moves properly
  - prevented by shadow DOM
- Solution demonstrated in **`radio-group`** web component on next few slides
  - set static property **`formAssociated`** to **`true`**
  - declare private property **`#internals`**
  - initialize in constructor with
    `this.#internals = this.attachInternals();`
  - when value to contribute changes,
    call **`this.#internals.setFormValue(newValue);`**

Radio Group Component

- Renders a set of associated radio buttons
- Uses a vanilla web component
  with an “open” shadow DOM
- Will use to demonstrate approaches
  for styling from outside component

RadioGroup Component ...

Example instance

```
<radio-group
  name="favoriteColor"
  options="red,green,blue"
  default="blue"
  value="green"
><radio-group>
```

`default` attribute is optional and defaults to first option;

`value` attribute is optional and defaults to `default`

```
class RadioGroup extends HTMLElement {
  static formAssociated = true;
  #default;
  #internals;
  #name;
  #value;

  constructor() {
    super();
    this.attachShadow({ mode: "open" });
    this.#internals = this.attachInternals();
  }
```

radio-group.js

```
  connectedCallback() {
    this.#name = this.getAttribute("name");
    const options = this.getAttribute("options")
      .split(",")
      .map((option) => option.trim());
    this.#default = this.getAttribute("default") || options[0];
    this.#value = this.getAttribute("value") || this.#default;

    this.shadowRoot.innerHTML = html`
      <style>
        .radio-group {
          display: flex;
          gap: 0.25rem;

          > div {
            display: flex;
            align-items: center;
          }
        }
      </style>
      <div class="radio-group">
        ${options.map((option) => this.#makeRadio(option)).join("")}
      </div>
    `;

    // Add event listeners to the radio buttons.
    const inputs = this.shadowRoot.querySelectorAll("input");
    for (const input of inputs) {
      input.addEventListener("change", (event) => {
        this.value = event.target.value;
      });
    }
  }
}
```

invokes “set value” method on next slide

... RadioGroup Component

called when containing **form** is reset by clicking a button with **type="reset"** or calling **reset** method on DOM **Form** object

```
formResetCallback() {
  const value = (this.value = this.#default);
  for (const input of this.shadowRoot.querySelectorAll("input")) {
    input.checked = input.value === value;
  }
}

#makeRadio(option) {
  return html`
    <div>
      <input
        type="radio"
        id="${option}"
        name="${this.#name}"
        value="${option}"
        ${option === this.value ? "checked" : ""}
      />
      <label for="${option}">${option}</label>
    </div>
  `;
}
```

called in **connectedCallback** on previous slide to specify the DOM to be built

```
  get value() {
    return this.#value;
  }

  set value(newValue) {
    if (newValue === this.#value) return;
    this.#value = newValue;
    this.#internals.setFormValue(newValue);

    // This demonstrates how a web component
    // can contribute multiple values to a form.
    /*
    const data = new FormData();
    data.append(this.#name, newValue);
    data.append("favoriteNumber", 19);
    this.#internals.setFormValue(data);
    */
  }
}

customElements.define("radio-group", RadioGroup);
```

called when a value is assigned to **value** property

Shadow DOM Styling

- CSS rules defined in a web component
  do not leak out to affect external elements
  - enables using simple selectors like element names
- By default, web component styling is
  not affected by styles defined outside it
- Four ways to “pierce the Shadow DOM” to style from outside
  1. inherit CSS properties
  2. expose CSS variables
  3. use `part` attributes
  4. share CSS files

Inherit CSS Properties

- Inheritable CSS properties are automatically used by web components unless they specify other values in their own CSS
  - include **`color`**, **`cursor`**, **`font`**, **`font-family`**, **`font-size`**, **`font-style`**, **`font-variant`**, **`font-weight`**, **`letter-spacing`**, **`line-height`**, **`text-align`**, **`text-indent`**, **`text-transform`**, **`visibility`**, **`white-space`**, and **`word-spacing`**
- Example
  - in HTML that uses the web component, include this CSS rule which causes every element the web component renders that does not specify **`color`** to use **`blue`**
    - in this case it will be the **`label`** elements

```
radio-group {
  color: blue;
}
```

Despite the fact that **`inherit`** is not the default value of inheritable CSS properties, they inherit the value from their parent element, unless explicitly overridden.

Expose CSS Variables

- Web components can specify CSS properties in a way that allows them to be overridden by setting CSS variables (a.k.a. CSS custom properties)
- Example
  - in **`radio-group.js`**, include this CSS rule

```
label {
  color: var(--radio-group-label-color, black);
}
```

  - in HTML that uses the web component, include this CSS rule

```
radio-group {
  --radio-group-label-color: blue;
}
```

Use part Attributes

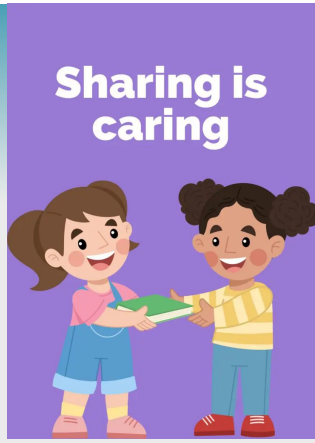
- Add part attributes to each web component element that wishes to allow external styling
- Example
  - in **`radio-group.js`**, include this attribute

```
<label for="${option}" part="radio-label">${option}</label>
```

  - in HTML that uses the web component, include this CSS rule

```
radio-group::part(radio-label) {
  color: blue;
}
```

Share CSS Files



- Define styles to be shared by multiple pages and web components in a **`.css`** file
- Add **`link`** element in each page and web component that refers to the **`.css`** file
  - only downloaded once and cached
- Example
  - create **`style.css`** containing this

```
label {
  color: blue;
}
```

  - in **`radio-group.js`**, include this **`link`** element

```
<link rel="stylesheet" href="style.css" />
```

CSS Concerns

- To specify inheritable CSS properties on a custom element so they are not inherited, use **`:host`** selector

```
:host {
  font-family: sans-serif;
}
```

- Style custom elements with the following CSS rule to avoid “Flash of Undefined Custom Elements” (FOUCE) and layout shift

```
:not(:defined) {
  visibility: hidden;
}
```

Events

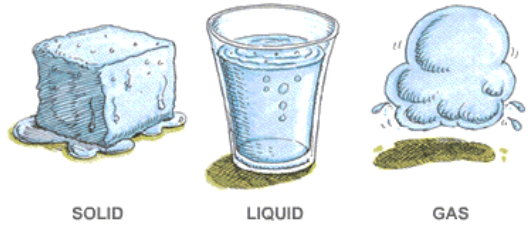
- Web components can dispatch any number of events, perhaps to advertise their state changes
- Code outside web components can listen for the events
- Example
  - in **`radio-group.js`**, add following at end of **`set value`** method

```
this.dispatchEvent(new Event("change"));
```

  - listen for event with code like this

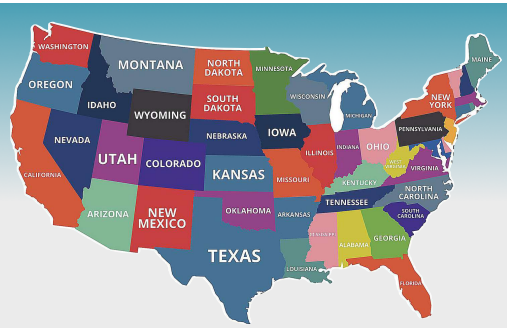
```
const rg = document.querySelector("radio-group");
rg.addEventListener("change", (event) => {
  const { value } = event.target;
  console.log("value =", value);
});
```

Sharing State ...



- Many approaches can be used to share state between web component instances
- A simple approach is to hold all shared state in a singleton object that
  - has a private property, public getter method, and public setter method for each piece of state
  - has a method that registers callback functions to be called when a specific piece of state changes
  - setter methods call each registered callback function when value changes

... Sharing State ...




```
class State {
  static instance = new State();
  #favoriteColor = "transparent";
  #propertyToCallbacksMap = new Map();

  constructor() {
    if (State.instance) {
      throw new Error(
        "get singleton instance with State.instance"
      );
    }
    State.instance = this;
  }

  addCallback(property, callback) {
    let callbacks = this.#propertyToCallbacksMap.get(property);
    if (!callbacks) {
      callbacks = [];
      this.#propertyToCallbacksMap.set(property, callbacks);
    }
    callbacks.push(callback);
  }

  changed(property) {
    const callbacks =
      this.#propertyToCallbacksMap.get(property) || [];
    for (const callback of callbacks) {
      callback(this[property]);
    }
  }
```

Add a private instance variable for each piece of state to be shared.

Add getter and setter methods like these for each piece of state to be shared.

```
  get favoriteColor() {
    return this.#favoriteColor;
  }

  set favoriteColor(color) {
    if (color === this.#favoriteColor) return;
    this.#favoriteColor = color;
    this.changed("favoriteColor");
  }
}

window.State = State;
```

... Sharing State

Add setter methods similar to this in each web component that wishes to tie its state to the singleton **`State`** object.

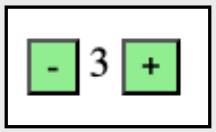
```
set value(newValue) {
  if (newValue === this.#value) return;

  this.#value = newValue;
  this.#internals.setFormValue(newValue);
  const input = this.shadowRoot.getElementById(newValue);
  if (input) input.checked = true;
  this.dispatchEvent(new Event("change"));
}
```

Add code similar to this to wire up web components to the singleton **`State`** object.

```
window.onload = () => {
  const state = State.instance;

  const rgs = document.querySelectorAll("radio-group");

  // Add an event listener to each radio-group web component.
  for (const rg of rgs) {
    rg.addEventListener("change", (event) => {
      state.favoriteColor = event.target.value;
    });
  }

  // When the favoriteColor state changes,
  // update all the radio-group web components.
  state.addListener("favoriteColor", (color) => {
    for (const rg of rgs) {
      rg.value = color;
    }
  });
};
```

Vanilla Counter Component

```
<counter-vanilla count="3"></counter-vanilla>
```



counter-vanilla.js

```
const template =
document.createElement("template");
template.innerHTML = html`
  <style>
    button {
      background-color: lightgreen;
    }
    button:disabled {
      background-color: gray;
    }
  </style>
  <div>
    <button
      id="decrement-btn"
      type="button"
    >-</button>
    <span></span>
    <button
      id="increment-btn"
      type="button"
    >+</button>
  </div>
`;
```

counter-vanilla.js

```
class CounterVanilla extends HTMLElement {
  static get observedAttributes() {
    return ["count"];
  }

  constructor() {
    super();
    this.attachShadow({ mode: "open" });
  }

  attributeChangedCallback() {
    this.#update();
  }

  connectedCallback() {
    const root = this.shadowRoot;
    root.appendChild(template.content.cloneNode(true));

    this.decrementBtn = root.querySelector("#decrement-btn");
    this.decrementBtn.addEventListener("click", () => {
      this.decrement();
    });
    root.querySelector("#increment-btn")
      .addEventListener("click", () => {
        this.increment();
      });

    this.span = root.querySelector("span");
    this.update();
  }
```

Vanilla Counter Component


```
  get count() {
    return this.getAttribute("count") || 0;
  }

  set count(newCount) {
    this.setAttribute("count", newCount);
  }

  decrement() {
    this.count--;
    if (this.count == 0) {
      this.decrementBtn.setAttribute("disabled", "disabled");
    }
    this.#update();
  }

  increment() {
    this.count++;
    this.decrementBtn.removeAttribute("disabled");
    this.#update();
  }

  #update() {
    if (this.span) this.span.textContent = this.count;
  }
}

customElements.define("counter-vanilla", CounterVanilla);
```

treating `count` attribute as source of truth

`this.count` gets converted to a string, so we need to use == instead === here

Simplifying Counter

- Previous example required a lot of code
- Can simplify using **`wrec`** (**W**eb **RE**active **C**omponent)
  - subclass of **`HTMLElement`**
  - **`npm install wrec`**
- Let's see how Wrec simplifies the counter component

Wrec Counter

```
import Wrec, {css, html} from "wrec";

class CounterWrec extends Wrec {
  static properties = {
    count: { type: Number },
  };

  static css = css`
    button {
      background-color: lightgreen;
    }
    button:disabled {
      background-color: gray;
    }
  `;

  static html = html`
    <button
      disabled="this.count === 0"
      onclick="this.count--"
      type="button"
    >-</button>
    <span>this.count</span>
    <button
      onclick="this.count++"
      type="button"
    >+</button>
  `;
}

CounterWrec.register();
```

- Looks for attribute values and text content containing **`this.`*`propertyName`*** and adds reactivity
- Looks for attributes whose name begins with "**`on`**" and whose value is a method name or JavaScript expression, and adds event listeners
- Add following class property to contribute to form submissions: **`static formAssociated = true;`**
- **More examples** of web components that use Wrec are in **`src`** directory at https://github.com/mvolkmann/wrec

Lit requires much more than this.

Wrec 2-Way Bindings

```
import Wrec, { css, html } from "../wrec.js";

class DataBinding extends Wrec {
  static properties = {
    color: { type: String },
    colors: { type: String, required: true },
  };

  static css = css`
    :host {
      display: flex;
      flex-direction: column;
      gap: 0.5rem;
    }
  `;

  static html = html`
    <div>
      <label>Color Options (comma-separated):</label>
      <input value="this.colors" />
    </div>
    <radio-group
      name="color1"
      options="this.colors"
      value="this.color"
    ></radio-group>
    <select-list
      name="color2"
      options="this.colors"
      value="this.color"
    ></select-list>
    <p>You selected the color <span>this.color</span>.</p>
  `;
}

DataBinding.register();
```

Color Options (comma-separated): red,green,blue

○ red ○ green ◉ blue

blue

You selected the color blue.

See `radio-group.js` and `select-list.js` at https://github.com/mvolkmann/wrec/tree/main/src.

Slots ...

- Web component instances can supply content to be inserted using a default slot and any number of named slots

```
<html>
  <head>
    <script src="slots-demo.js" type="module"></script>
  </head>
  <body>
    <slots-demo color="mediumorchid" width="12rem">
      <span slot="title">Breaking News</span>
      <span>
        Wrec is a new library for building web components
        that has several advantages over Lit.
      </span>
      <span slot="footer">&copy; 2025 Object Computing, Inc.</span>
    </slots-demo>
  </body>
</html>
```

elements with no `slot` attribute go in default slot

... Slots

```
import Wrec, { css, html } from "wrec";

class SlotsDemo extends Wrec {
  static properties = {
    color: { type: String, value: 'cornflowerblue' },
    width: { type: String, value: '20rem' },
  };

  static css = css`
    :host {
      --border-radius: 1rem;
      --color: this.color;
      --width: this.width;
      border: 1px solid var(--color);
      border-radius: var(--border-radius);
      display: inline-block;
      font-family: sans-serif;
      width: var(--width);
    }

    .content {
      padding: 1rem;
    }

    .footer {
      background-color: var(--color);
      border-bottom-left-radius: var(--border-radius);
      border-bottom-right-radius: var(--border-radius);
      font-size: 0.7rem;
      padding: 0.25rem;
      text-align: center;
    }

    .header {
      background-color: var(--color);
      border-top-left-radius: var(--border-radius);
      border-top-right-radius: var(--border-radius);
      font-size: 2rem;
      font-weight: bold;
      text-align: center;
    }
  `;
```

This demonstrates using slots in a web component defined using Wrec, but slots can be used in any web component.

```
  static html = html`
    <div class="card">
      <div class="header">
        <slot name="title"></slot>
      </div>
      <div class="content">
        <slot></slot>
      </div>
      <div class="footer">
        <slot name="footer"></slot>
      </div>
    </div>
  `;
}

SlotsDemo.register();
```

default slot

wrec Advantages Over Lit

- Simpler
  - just a single class to extend (**`Wrec`**)
- Much smaller
  - 8K (**`wrec.min.js`**) vs. 16K (**`lit-core.min.js`**)
- Cleaner syntax
  - don't need to surround JS expressions with **`${...}`**
- Automatic 2-way data binding
  - no need to dispatch custom events and listen for them
- Direct DOM manipulation, not virtual DOM
- No special syntax for Boolean attributes
- Can put JS expressions in **`textarea`** elements

Boolean attribute

textarea content

lit

```
<button
  @click=${() => this.count--}
  type="button"
  ?disabled=${this.count === 0}
>-</button>
```

wrec

```
<button
  onClick="this.count--"
  type="button"
  disabled="this.count === 0"
>-</button>
```

lit

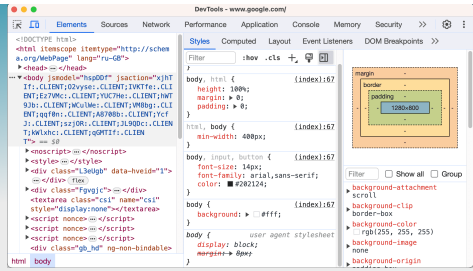
```
<textarea
  .value=${this.story}
  @input=${this.handleStoryChange}
></textarea>
...
handleStoryChange(event) {
  this.story = event.target.value;
}
```

wrec

```
<textarea>this.story</textarea>
```

DevTools Tips

These work in Chrome, Firefox, and Safari.



- **To change a web component attribute value**
  - select Elements tab
  - select web component
  - double-click an attribute value and enter a new value
  - commit change by pressing return or tab key, or clicking elsewhere
  - verify that the component UI updates

- **To change a web component property**
  - select Elements tab
  - select web component
  - select Console tab
  - enter `$0.propertyName = newValue`
  - verify that the component UI updates
  - verify that the corresponding attribute updates
  - enter `el = document.querySelector('component-name');`
  - enter `el.propertyName = newValue`
  - verify that the component UI updates

just a different way to get a reference to a custom element that can be used in code

Resources

- **My blog** - https://mvolkmann.github.io/blog/
  - select “Web Components”
- **These slides** - https://github.com/mvolkmann/talks/blob/master/web-components.key.pdf
- **Custom Elements Everywhere** - https://custom-elements-everywhere.com/
  - “making sure frameworks and custom elements can be BFFs”
- **Kinsta** - https://kinsta.com/blog/web-components/
  - “complete introduction to web components”
- **MDN docs** - https://developer.mozilla.org/en-US/docs/Web/API/Web_components
- **Open Web Components** - https://open-wc.org/
  - “guides, tools and libraries for developing web components”
- **WebComponents.org** - https://www.webcomponents.org/
  - “building blocks for the web”

Wrap Up

- Web components
  - provide a **nice alternative** to implementing UI components using popular frameworks
  - are **standards-based** and “use the platform”
  - **can be shared** across apps that use frameworks
  - don’t necessarily require libraries, tooling, or build processes
  - have a relatively **small learning curve**
- Checkout my npm package “wrec”!
  - https://www.npmjs.com/package/wrec