Part 2

Browser: Document, Events, Interfaces

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The last version of the tutorial is at https://javascript.info.

We constantly work to improve the tutorial. If you find any mistakes, please write at our github.

Learning how to manage the browser page: add elements, manipulate their size and position, dynamically create interfaces and interact with the visitor.

Document

Here we'll learn to manipulate a web-page using JavaScript.

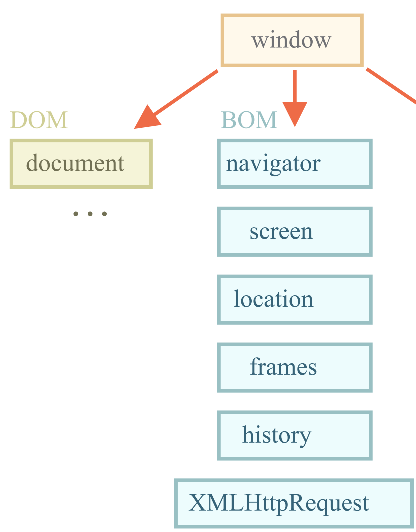
Browser environment, specs

The JavaScript language was initially created for web browsers. Since then it has evolved and become a language with many uses and platforms.

A platform may be a browser, or a web-server or another *host*, even a coffee machine. Each of them provides platform-specific functionality. The JavaScript specification calls that a *host environment*.

A host environment provides own objects and functions additional to the language core. Web browsers give a means to control web pages. Node.js provides server-side features, and so on.

Here's a bird's-eye view of what we have when JavaScript runs in a web-browser:



There's a "root" object called `window`. It has two roles:

1. First, it is a global object for JavaScript code, as described in the chapter Global object.
2. Second, it represents the "browser window" and provides methods to control it.

For instance, here we use it as a global object:

```
function sayHi() {
  alert("Hello");
}

// global functions are methods of the global object:
window.sayHi();
```

And here we use it as a browser window, to see the window height:

```
alert(window.innerHeight); // inner window height
```

There are more window-specific methods and properties, we'll cover them later.

DOM (Document Object Model)

Document Object Model, or DOM for short, represents all page content as objects that can be modified.

The `document` object is the main "entry point" to the page. We can change or create anything on the page using it.

For instance:

```
// change the background color to red
document.body.style.background = "red";

// change it back after 1 second
setTimeout(() => document.body.style.background = "", 1000);
```

Here we used `document.body.style`, but there's much, much more. Properties and methods are described in the specification:

- **DOM Living Standard** at https://dom.spec.whatwg.org

DOM is not only for browsers

The DOM specification explains the structure of a document and provides objects to manipulate it. There are non-browser instruments that use DOM too.

For instance, server-side scripts that download HTML pages and process them can also use DOM. They may support only a part of the specification though.

CSSOM for styling

CSS rules and stylesheets are structured in a different way than HTML. There's a separate specification, CSS Object Model (CSSOM), that explains how they are represented as objects, and how to read and write them.

CSSOM is used together with DOM when we modify style rules for the document. In practice though, CSSOM is rarely required, because usually CSS rules are static. We rarely need to add/remove CSS rules from JavaScript, but that's also possible.

BOM (Browser Object Model)

The Browser Object Model (BOM) represents additional objects provided by the browser (host environment) for working with everything except the document.

For instance:

- The navigator object provides background information about the browser and the operating system. There are many properties, but the two most widely known are: `navigator.userAgent` – about the current browser, and `navigator.platform` – about the platform (can help to differ between Windows/Linux/Mac etc).
- The location object allows us to read the current URL and can redirect the browser to a new one.

Here's how we can use the `location` object:

```
alert(location.href); // shows current URL
if (confirm("Go to Wikipedia?")) {
  location.href = "https://wikipedia.org"; // redirect the browser to another
URL
}
```

Functions `alert/confirm/prompt` are also a part of BOM: they are directly not related to the document, but represent pure browser methods of communicating with the user.

Specifications

BOM is the part of the general HTML specification .

Yes, you heard that right. The HTML spec at https://html.spec.whatwg.org is not only about the "HTML language" (tags, attributes), but also covers a bunch of objects, methods and browser-specific DOM extensions. That's "HTML in broad terms". Also, some parts have additional specs listed at https://spec.whatwg.org .

Summary

Talking about standards, we have:

DOM specification

Describes the document structure, manipulations and events, see https://dom.spec.whatwg.org .

CSSOM specification

Describes stylesheets and style rules, manipulations with them and their binding to documents, see https://www.w3.org/TR/cssom-1/ .

HTML specification

Describes the HTML language (e.g. tags) and also the BOM (browser object model) – various browser functions: `setTimeout`, `alert`, `location` and so on, see https://html.spec.whatwg.org. It takes the DOM specification and extends it with many additional properties and methods.

Additionally, some classes are described separately at https://spec.whatwg.org/.

Please note these links, as there's so much stuff to learn it's impossible to cover and remember everything.

When you'd like to read about a property or a method, the Mozilla manual at https://developer.mozilla.org/en-US/search is also a nice resource, but the corresponding spec may be better: it's more complex and longer to read, but will make your fundamental knowledge sound and complete.

To find something, it's often convenient to use an internet search "WHATWG [term]" or "MDN [term]", e.g https://google.com?q=whatwg+localstorage, https://google.com?q=mdn+localstorage.

Now we'll get down to learning DOM, because the document plays the central role in the UI.

DOM tree

The backbone of an HTML document is tags.

According to the Document Object Model (DOM), every HTML tag is an object. Nested tags are "children" of the enclosing one. The text inside a tag is an object as well.

All these objects are accessible using JavaScript, and we can use them to modify the page.

For example, `document.body` is the object representing the `<body>` tag.

Running this code will make the `<body>` red for 3 seconds:

```
document.body.style.background = 'red'; // make the background red

setTimeout(() => document.body.style.background = '', 3000); // return back
```

Here we used `style.background` to change the background color of `document.body`, but there are many other properties, such as:

- `innerHTML` – HTML contents of the node.
- `offsetWidth` – the node width (in pixels)
- …and so on.

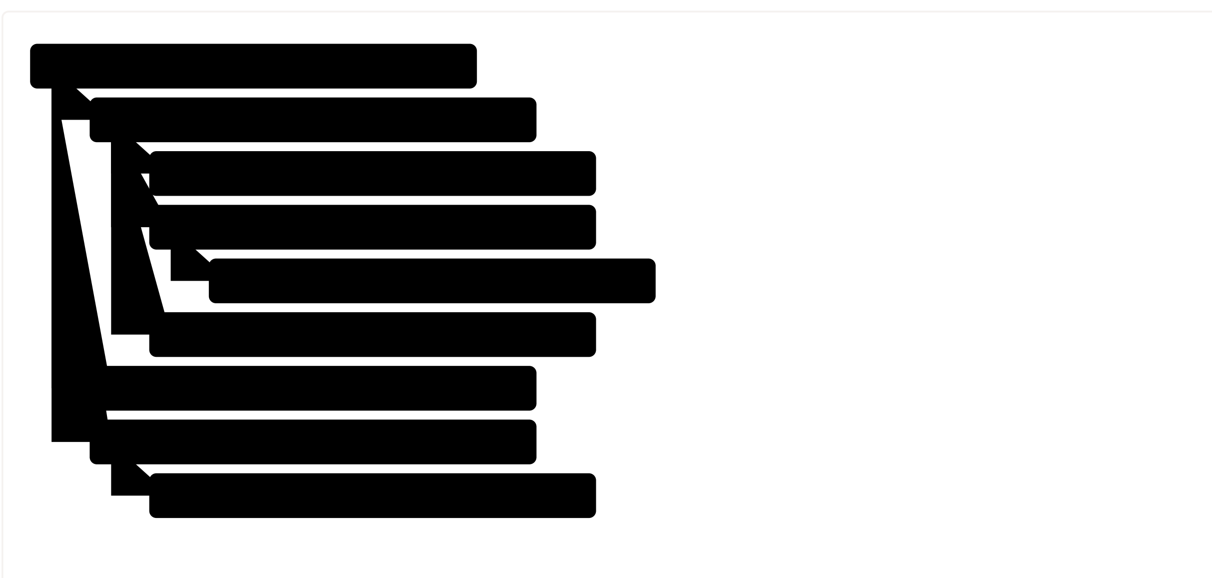
Soon we'll learn more ways to manipulate the DOM, but first we need to know about its structure.

An example of the DOM

Let's start with the following simple document:

```html
<!DOCTYPE HTML>
<html>
<head>
  <title>About elk</title>
</head>
<body>
  The truth about elk.
</body>
</html>
```

The DOM represents HTML as a tree structure of tags. Here's how it looks:



Every tree node is an object.

Tags are *element nodes* (or just elements) and form the tree structure: `<html>` is at the root, then `<head>` and `<body>` are its children, etc.

The text inside elements forms *text nodes*, labelled as `#text`. A text node contains only a string. It may not have children and is always a leaf of the tree.

For instance, the `<title>` tag has the text `"About elk"`.

Please note the special characters in text nodes:

- a newline: `↵` (in JavaScript known as `\n`)
- a space: `␣`

Spaces and newlines are totally valid characters, like letters and digits. They form text nodes and become a part of the DOM. So, for instance, in the example above the `<head>` tag contains some spaces before `<title>`, and that text becomes a `#text` node (it contains a newline and some spaces only).

There are only two top-level exclusions:

1. Spaces and newlines before `<head>` are ignored for historical reasons.
2. If we put something after `</body>`, then that is automatically moved inside the `body`, at the end, as the HTML spec requires that all content must be inside `<body>`. So there can't be any spaces after `</body>`.

In other cases everything's straightforward – if there are spaces (just like any character) in the document, then they become text nodes in the DOM, and if we remove them, then there won't be any.

Here are no space-only text nodes:

```
<!DOCTYPE HTML>
<html><head><title>About elk</title></head><body>The truth about elk.</body>
</html>
```

ℹ Spaces at string start/end and space-only text nodes are usually hidden in tools

Browser tools (to be covered soon) that work with DOM usually do not show spaces at the start/end of the text and empty text nodes (line-breaks) between tags.

Developer tools save screen space this way.

On further DOM pictures we'll sometimes omit them when they are irrelevant. Such spaces usually do not affect how the document is displayed.

Autocorrection

If the browser encounters malformed HTML, it automatically corrects it when making the DOM.

For instance, the top tag is always <html>. Even if it doesn't exist in the document, it will exist in the DOM, because the browser will create it. The same goes for <body>.

As an example, if the HTML file is the single word "Hello", the browser will wrap it into <html> and <body>, and add the required <head>, and the DOM will be:

[redacted]

While generating the DOM, browsers automatically process errors in the document, close tags and so on.

A document with unclosed tags:

```
<p>Hello
<li>Mom
<li>and
<li>Dad
```

...will become a normal DOM as the browser reads tags and restores the missing parts:

[redacted]

⚠ Tables always have `<tbody>`

An interesting "special case" is tables. By the DOM specification they must have `<tbody>`, but HTML text may (officially) omit it. Then the browser creates `<tbody>` in the DOM automatically.

For the HTML:

```
<table id="table"><tr><td>1</td></tr></table>
```

DOM-structure will be:

[redacted]

You see? The `<tbody>` appeared out of nowhere. You should keep this in mind while working with tables to avoid surprises.

Other node types

There are some other node types besides elements and text nodes.

For example, comments:

```
<!DOCTYPE HTML>
<html>
<body>
  The truth about elk.
  <ol>
    <li>An elk is a smart</li>
    <!-- comment -->
    <li>...and cunning animal!</li>
  </ol>
</body>
</html>
```

[redacted]

We can see here a new tree node type – *comment node*, labeled as `#comment`, between two text nodes.

We may think – why is a comment added to the DOM? It doesn't affect the visual representation in any way. But there's a rule – if something's in HTML, then it also must be in the DOM tree.

Everything in HTML, even comments, becomes a part of the DOM.

Even the `<!DOCTYPE...>` directive at the very beginning of HTML is also a DOM node. It's in the DOM tree right before `<html>`. We are not going to touch that node, we even don't draw it on diagrams for that reason, but it's there.

The `document` object that represents the whole document is, formally, a DOM node as well.

There are 12 node types. In practice we usually work with 4 of them:

1. `document` – the "entry point" into DOM.

2. element nodes – HTML-tags, the tree building blocks.
3. text nodes – contain text.
4. comments – sometimes we can put information there, it won't be shown, but JS can read it from the DOM.

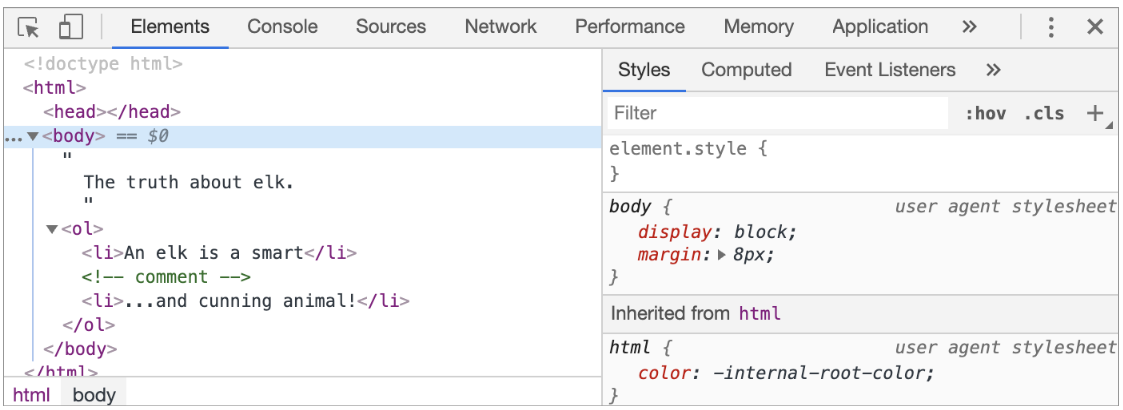
See it for yourself

To see the DOM structure in real-time, try Live DOM Viewer . Just type in the document, and it will show up as a DOM at an instant.

Another way to explore the DOM is to use the browser developer tools. Actually, that's what we use when developing.

To do so, open the web page elk.html, turn on the browser developer tools and switch to the Elements tab.

It should look like this:

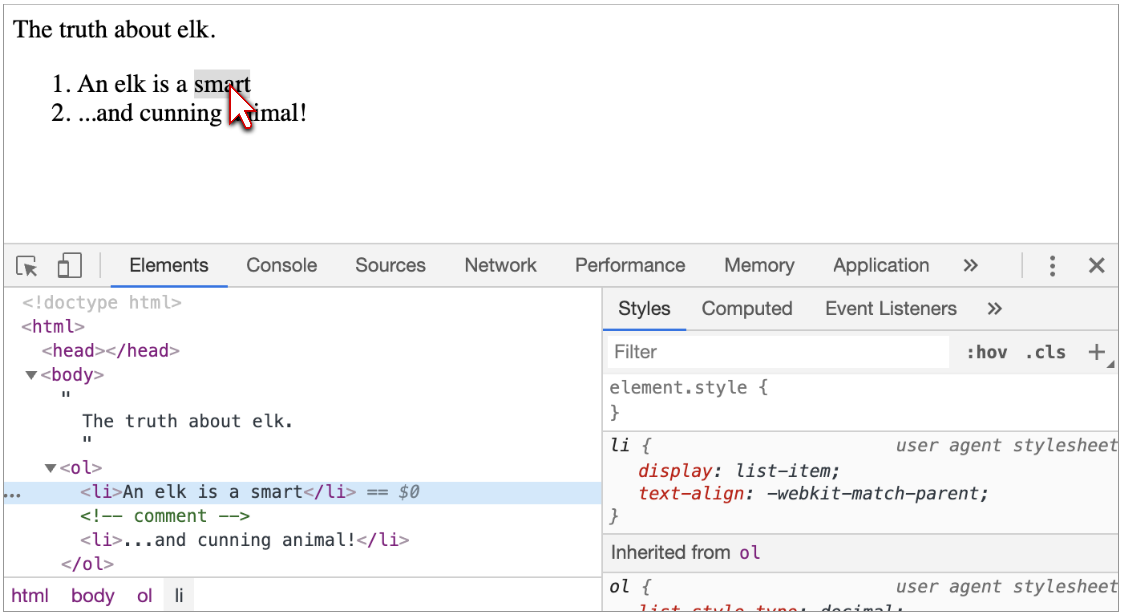


You can see the DOM, click on elements, see their details and so on.

Please note that the DOM structure in developer tools is simplified. Text nodes are shown just as text. And there are no "blank" (space only) text nodes at all. That's fine, because most of the time we are interested in element nodes.

Clicking the button in the left-upper corner allows us to choose a node from the webpage using a mouse (or other pointer devices) and "inspect" it (scroll to it in the Elements tab). This works great when we have a huge HTML page (and corresponding huge DOM) and would like to see the place of a particular element in it.

Another way to do it would be just right-clicking on a webpage and selecting “Inspect” in the context menu.



At the right part of the tools there are the following subtabs:

- **Styles** – we can see CSS applied to the current element rule by rule, including built-in rules (gray). Almost everything can be edited in-place, including the dimensions/margins/paddings of the box below.
- **Computed** – to see CSS applied to the element by property: for each property we can see a rule that gives it (including CSS inheritance and such).
- **Event Listeners** – to see event listeners attached to DOM elements (we’ll cover them in the next part of the tutorial).
- ...and so on.

The best way to study them is to click around. Most values are editable in-place.

Interaction with console

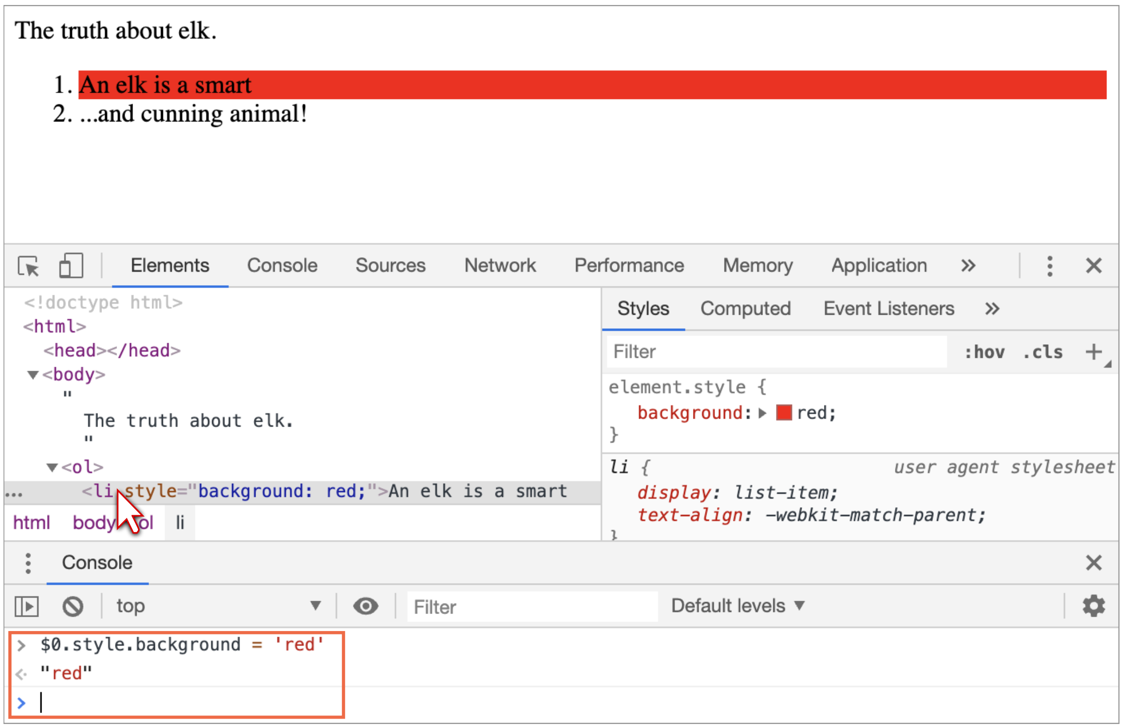
As we work the DOM, we also may want to apply JavaScript to it. Like: get a node and run some code to modify it, to see the result. Here are few tips to travel between the Elements tab and the console.

For the start:

1. Select the first `<li>` in the Elements tab.
2. Press `Esc` – it will open console right below the Elements tab.

Now the last selected element is available as `$0`, the previously selected is `$1` etc.

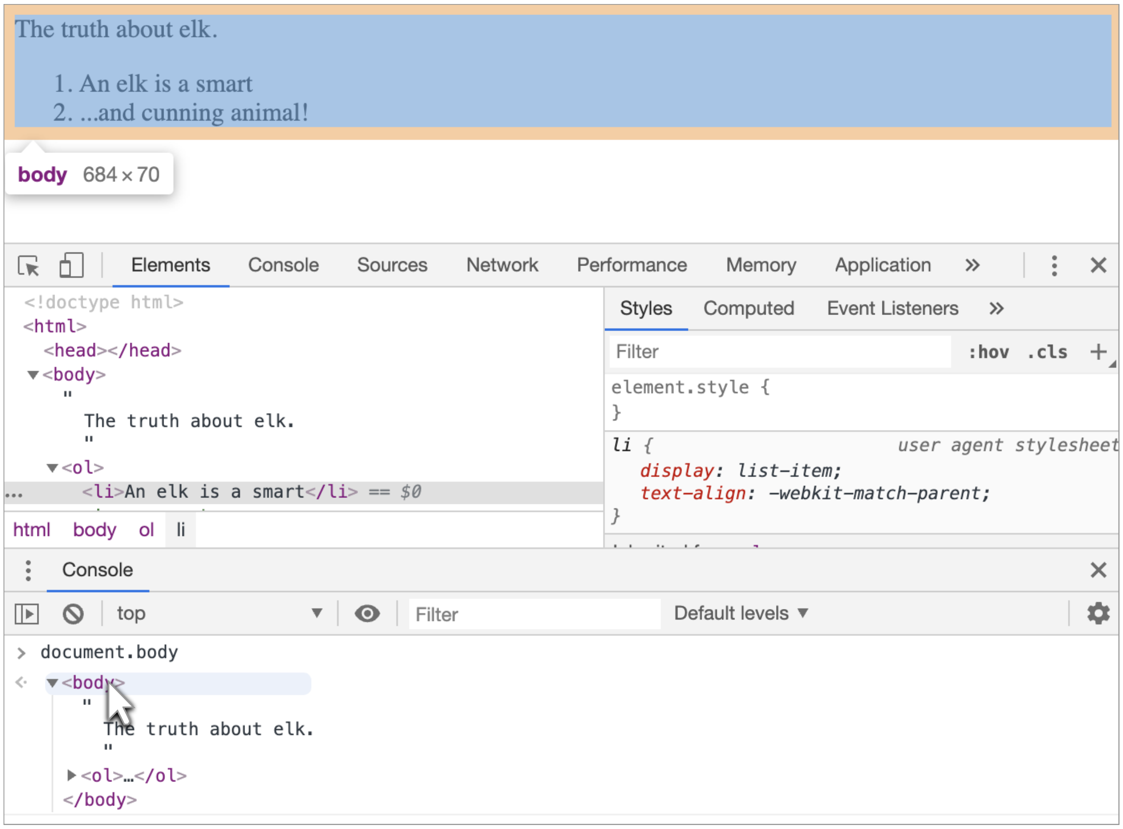
We can run commands on them. For instance, `$0.style.background = 'red'` makes the selected list item red, like this:



That's how to get a node from Elements in Console.

There's also a road back. If there's a variable referencing a DOM node, then we can use the command `inspect(node)` in Console to see it in the Elements pane.

Or we can just output the DOM node in the console and explore "in-place", like `document.body` below:



That's for debugging purposes of course. From the next chapter on we'll access and modify DOM using JavaScript.

The browser developer tools are a great help in development: we can explore the DOM, try things and see what goes wrong.

Summary

An HTML/XML document is represented inside the browser as the DOM tree.

- Tags become element nodes and form the structure.
- Text becomes text nodes.
- …etc, everything in HTML has its place in DOM, even comments.

We can use developer tools to inspect DOM and modify it manually.

Here we covered the basics, the most used and important actions to start with. There's an extensive documentation about Chrome Developer Tools at https://developers.google.com/web/tools/chrome-devtools . The best way to learn the tools is to click here and there, read menus: most options are obvious. Later, when you know them in general, read the docs and pick up the rest.

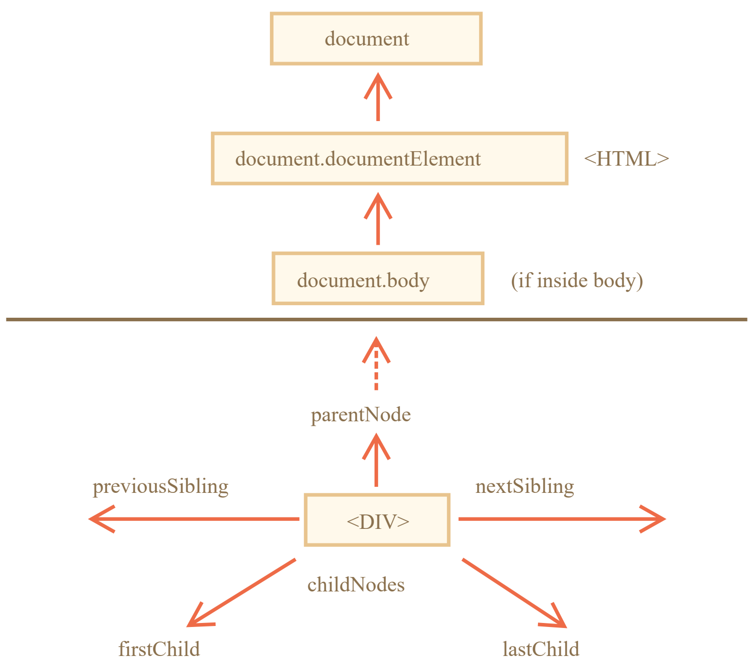
DOM nodes have properties and methods that allow us to travel between them, modify them, move around the page, and more. We'll get down to them in the next chapters.

Walking the DOM

The DOM allows us to do anything with elements and their contents, but first we need to reach the corresponding DOM object.

All operations on the DOM start with the `document` object. That's the main "entry point" to DOM. From it we can access any node.

Here's a picture of links that allow for travel between DOM nodes:



Let's discuss them in more detail.

On top: documentElement and body

The topmost tree nodes are available directly as `document` properties:

`<html>` = `document.documentElement`

The topmost document node is `document.documentElement`. That's the DOM node of the `<html>` tag.

`<body>` = `document.body`

Another widely used DOM node is the `<body>` element – `document.body`.

`<head>` = `document.head`

The `<head>` tag is available as `document.head`.

⚠ There's a catch: `document.body` can be `null`

A script cannot access an element that doesn't exist at the moment of running.

In particular, if a script is inside `<head>`, then `document.body` is unavailable, because the browser did not read it yet.

So, in the example below the first `alert` shows `null`:

```
<html>

<head>
  <script>
    alert( "From HEAD: " + document.body ); // null, there's no <body> yet
   </script>
</head>

<body>

  <script>
    alert( "From BODY: " + document.body ); // HTMLBodyElement, now it exists
   </script>

</body>
</html>
```

In the DOM world `null` means "doesn't exist"

In the DOM, the `null` value means "doesn't exist" or "no such node".

Children: childNodes, firstChild, lastChild

There are two terms that we'll use from now on:

- **Child nodes (or children)** – elements that are direct children. In other words, they are nested exactly in the given one. For instance, `<head>` and `<body>` are children of `<html>` element.
- **Descendants** – all elements that are nested in the given one, including children, their children and so on.

For instance, here `<body>` has children `<div>` and `<ul>` (and few blank text nodes):

```
<html>
<body>
  <div>Begin</div>

  <ul>
    <li>
      <b>Information</b>
    </li>
  </ul>
</body>
</html>
```

...And descendants of `<body>` are not only direct children `<div>`, `<ul>` but also more deeply nested elements, such as `<li>` (a child of `<ul>`) and `<b>` (a child of `<li>`) – the entire subtree.

The `childNodes` collection lists all child nodes, including text nodes.

The example below shows children of `document.body`:

```
<html>
<body>
  <div>Begin</div>

  <ul>
    <li>Information</li>
  </ul>

  <div>End</div>

  <script>
    for (let i = 0; i < document.body.childNodes.length; i++) {
      alert( document.body.childNodes[i] ); // Text, DIV, Text, UL, ..., SCRIPT
    }
  </script>
  ...more stuff...
</body>
</html>
```

Please note an interesting detail here. If we run the example above, the last element shown is `<script>`. In fact, the document has more stuff below, but at the moment of the script execution the browser did not read it yet, so the script doesn't see it.

Properties `firstChild` and `lastChild` give fast access to the first and last children.

They are just shorthands. If there exist child nodes, then the following is always true:

```
elem.childNodes[0] === elem.firstChild
elem.childNodes[elem.childNodes.length - 1] === elem.lastChild
```

There's also a special function `elem.hasChildNodes()` to check whether there are any child nodes.

DOM collections

As we can see, `childNodes` looks like an array. But actually it's not an array, but rather a *collection* – a special array-like iterable object.

There are two important consequences:

1. We can use `for..of` to iterate over it:

```
for (let node of document.body.childNodes) {
  alert(node); // shows all nodes from the collection
}
```

That's because it's iterable (provides the `Symbol.iterator` property, as required).

2. Array methods won't work, because it's not an array:

```
alert(document.body.childNodes.filter); // undefined (there's no filter
method!)
```

The first thing is nice. The second is tolerable, because we can use `Array.from` to create a "real" array from the collection, if we want array methods:

```
alert( Array.from(document.body.childNodes).filter ); // function
```

⚠ DOM collections are read-only

DOM collections, and even more – *all* navigation properties listed in this chapter are read-only.

We can't replace a child by something else by assigning `childNodes[i] = ...`.

Changing DOM needs other methods. We will see them in the next chapter.

⚠ DOM collections are live

Almost all DOM collections with minor exceptions are *live*. In other words, they reflect the current state of DOM.

If we keep a reference to `elem.childNodes`, and add/remove nodes into DOM, then they appear in the collection automatically.

⚠ Don't use `for..in` to loop over collections

Collections are iterable using `for..of`. Sometimes people try to use `for..in` for that.

Please, don't. The `for..in` loop iterates over all enumerable properties. And collections have some "extra" rarely used properties that we usually do not want to get:

```
<body>
<script>
  // shows 0, 1, length, item, values and more.
  for (let prop in document.body.childNodes)
alert(prop);
</script>
</body>
```

Siblings and the parent

Siblings are nodes that are children of the same parent.

For instance, here `<head>` and `<body>` are siblings:

```
<html>
  <head>...</head><body>...</body>
</html>
```

- `<body>` is said to be the "next" or "right" sibling of `<head>`,
- `<head>` is said to be the "previous" or "left" sibling of `<body>`.

The next sibling is in `nextSibling` property, and the previous one – in `previousSibling`.

The parent is available as `parentNode`.

For example:

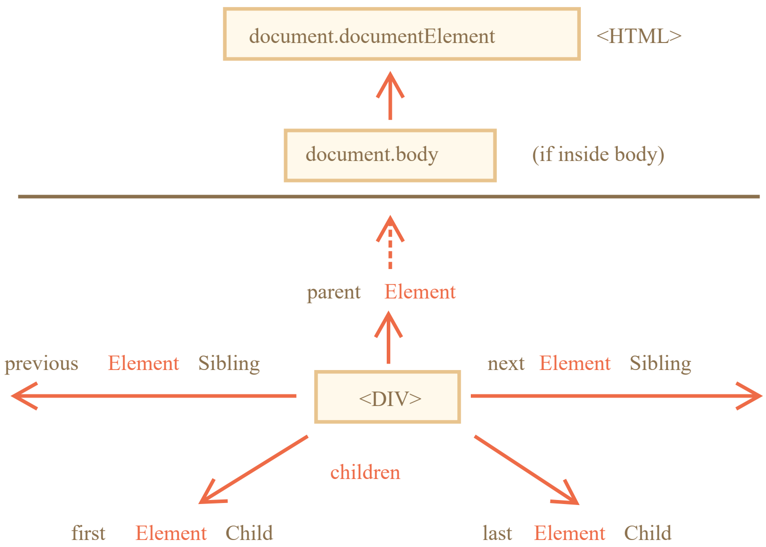
```
// parent of <body> is <html>
alert( document.body.parentNode === document.documentElement ); // true

// after <head> goes <body>
alert( document.head.nextSibling ); // HTMLBodyElement

// before <body> goes <head>
alert( document.body.previousSibling ); // HTMLHeadElement
```

Element-only navigation

Navigation properties listed above refer to *all* nodes. For instance, in `childNodes` we can see both text nodes, element nodes, and even comment nodes if there exist.

But for many tasks we don't want text or comment nodes. We want to manipulate element nodes that represent tags and form the structure of the page.

So let's see more navigation links that only take *element nodes* into account:



The links are similar to those given above, just with `Element` word inside:

- `children` – only those children that are element nodes.
- `firstElementChild`, `lastElementChild` – first and last element children.
- `previousElementSibling`, `nextElementSibling` – neighbor elements.
- `parentElement` – parent element.

Why `parentElement`? Can the parent be *not* an element?

The `parentElement` property returns the “element” parent, while `parentNode` returns “any node” parent. These properties are usually the same: they both get the parent.

With the one exception of `document.documentElement`:

```
alert( document.documentElement.parentNode ); // document
alert( document.documentElement.parentElement ); // null
```

The reason is that the root node `document.documentElement` (`<html>`) has `document` as its parent. But `document` is not an element node, so `parentNode` returns it and `parentElement` does not.

This detail may be useful when we want to travel up from an arbitrary element `elem` to `<html>`, but not to the `document`:

```
while(elem = elem.parentElement) { // go up till <html>
  alert( elem );
}
```

Let's modify one of the examples above: replace `childNodes` with `children`. Now it shows only elements:

```
<html>
<body>
  <div>Begin</div>

  <ul>
    <li>Information</li>
  </ul>

  <div>End</div>

  <script>
    for (let elem of document.body.children) {
      alert(elem); // DIV, UL, DIV, SCRIPT
    }
  </script>
  ...
</body>
</html>
```

More links: tables

Till now we described the basic navigation properties.

Certain types of DOM elements may provide additional properties, specific to their type, for convenience.

Tables are a great example of that, and represent a particularly important case:

The `<table>` element supports (in addition to the given above) these properties:

- `table.rows` – the collection of `<tr>` elements of the table.
- `table.caption/tHead/tFoot` – references to elements `<caption>`, `<thead>`, `<tfoot>`.
- `table.tBodies` – the collection of `<tbody>` elements (can be many according to the standard, but there will always be at least one – even if it is not in the source HTML, the browser will put it in the DOM).

`<thead>`, `<tfoot>`, `<tbody>` elements provide the `rows` property:

- `tbody.rows` – the collection of `<tr>` inside.

`<tr>`:

- `tr.cells` – the collection of `<td>` and `<th>` cells inside the given `<tr>`.
- `tr.sectionRowIndex` – the position (index) of the given `<tr>` inside the enclosing `<thead>/<tbody>/<tfoot>`.
- `tr.rowIndex` – the number of the `<tr>` in the table as a whole (including all table rows).

`<td>` and `<th>`:

- `td.cellIndex` – the number of the cell inside the enclosing `<tr>`.

An example of usage:

```
<table id="table">
  <tr>
    <td>one</td><td>two</td>
  </tr>
  <tr>
    <td>three</td><td>four</td>
  </tr>
</table>


<script>
```

```
  // get td with "two" (first row, second column)
  let td = table.rows[0].cells[1];
  td.style.backgroundColor = "red"; // highlight it
</script>
```

The specification: tabular data .

There are also additional navigation properties for HTML forms. We'll look at them later when we start working with forms.

Summary

Given a DOM node, we can go to its immediate neighbors using navigation properties.

There are two main sets of them:

- For all nodes: `parentNode`, `childNodes`, `firstChild`, `lastChild`, `previousSibling`, `nextSibling`.
- For element nodes only: `parentElement`, `children`, `firstElementChild`, `lastElementChild`, `previousElementSibling`, `nextElementSibling`.

Some types of DOM elements, e.g. tables, provide additional properties and collections to access their content.

Tasks

DOM children

importance: 5

Look at this page:

```
<html>
<body>
  <div>Users:</div>
  <ul>
    <li>John</li>
    <li>Pete</li>
```

```
  </ul>
</body>
</html>
```

For each of the following, give at least one way of how to access them:

- The `<div>` DOM node?
- The `<ul>` DOM node?
- The second `<li>` (with Pete)?

To solution

The sibling question

importance: 5

If `elem` – is an arbitrary DOM element node…

- Is it true that `elem.lastChild.nextSibling` is always `null`?
- Is it true that `elem.children[0].previousSibling` is always `null` ?

To solution

Select all diagonal cells

importance: 5

Write the code to paint all diagonal table cells in red.

You'll need to get all diagonal `<td>` from the `<table>` and paint them using the code:

```
// td should be the reference to the table cell
td.style.backgroundColor = 'red';
```

The result should be:

1:1	2:1	3:1	4:1	5:1
1:2	2:2	3:2	4:2	5:2
1:3	2:3	3:3	4:3	5:3
1:4	2:4	3:4	4:4	5:4
1:5	2:5	3:5	4:5	5:5

Open a sandbox for the task.

To solution

Searching: getElement*, querySelector*

DOM navigation properties are great when elements are close to each other. What if they are not? How to get an arbitrary element of the page?

There are additional searching methods for that.

document.getElementById or just id

If an element has the `id` attribute, we can get the element using the method `document.getElementById(id)`, no matter where it is.

For instance:

```
<div id="elem">
  <div id="elem-content">Element</div>
</div>

<script>
  // get the element
  let elem = document.getElementById('elem');

  // make its background red
  elem.style.background = 'red';
</script>
```

Also, there’s a global variable named by `id` that references the element:

```
<div id="elem">
  <div id="elem-content">Element</div>
</div>

<script>
  // elem is a reference to DOM-element with id="elem"
  elem.style.background = 'red';

  // id="elem-content" has a hyphen inside, so it can't be a variable name
  // ...but we can access it using square brackets: window['elem-content']
</script>
```

…That’s unless we declare a JavaScript variable with the same name, then it takes precedence:

```
<div id="elem"></div>

<script>
  let elem = 5; // now elem is 5, not a reference to <div id="elem">

  alert(elem); // 5
</script>
```

⚠ Please don’t use id-named global variables to access elements

This behavior is described in the specification, so it’s kind of standard. But it is supported mainly for compatibility.

The browser tries to help us by mixing namespaces of JS and DOM. That's fine for simple scripts, inlined into HTML, but generally isn't a good thing. There may be naming conflicts. Also, when one reads JS code and doesn't have HTML in view, it's not obvious where the variable comes from.

Here in the tutorial we use `id` to directly reference an element for brevity, when it's obvious where the element comes from.

In real life `document.getElementById` is the preferred method.

The `id` must be unique

The `id` must be unique. There can be only one element in the document with the given `id`.

If there are multiple elements with the same `id`, then the behavior of methods that use it is unpredictable, e.g. `document.getElementById` may return any of such elements at random. So please stick to the rule and keep `id` unique.

Only `document.getElementById`, not `anyElem.getElementById`

The method `getElementById` that can be called only on `document` object. It looks for the given `id` in the whole document.

querySelectorAll

By far, the most versatile method, `elem.querySelectorAll(css)` returns all elements inside `elem` matching the given CSS selector.

Here we look for all `<li>` elements that are last children:

```
<ul>
  <li>The</li>
  <li>test</li>
</ul>
<ul>
  <li>has</li>
  <li>passed</li>
</ul>
<script>
  let elements = document.querySelectorAll('ul >
li:last-child');

  for (let elem of elements) {
    alert(elem.innerHTML); // "test", "passed"
  }
</script>
```

This method is indeed powerful, because any CSS selector can be used.

Can use pseudo-classes as well

Pseudo-classes in the CSS selector like `:hover` and `:active` are also supported. For instance, `document.querySelectorAll(':hover')` will return the collection with elements that the pointer is over now (in nesting order: from the outermost `<html>` to the most nested one).

querySelector

The call to `elem.querySelector(css)` returns the first element for the given CSS selector.

In other words, the result is the same as `elem.querySelectorAll(css)[0]`, but the latter is looking for *all* elements and picking one, while `elem.querySelector` just looks for one. So it's faster and also shorter to write.

matches

Previous methods were searching the DOM.

The elem.matches(css) does not look for anything, it merely checks if `elem` matches the given CSS-selector. It returns `true` or `false`.

The method comes in handy when we are iterating over elements (like in an array or something) and trying to filter out those that interest us.

For instance:

```
<a href="http://example.com/file.zip">...</a>
<a href="http://ya.ru">...</a>

<script>
  // can be any collection instead of
document.body.children
  for (let elem of document.body.children) {
    if (elem.matches('a[href$="zip"]')) {
      alert("The archive reference: " +
elem.href );
    }
  }
</script>
```

closest

Ancestors of an element are: parent, the parent of parent, its parent and so on. The ancestors together form the chain of parents from the element to the top.

The method `elem.closest(css)` looks the nearest ancestor that matches the CSS-selector. The `elem` itself is also included in the search.

In other words, the method `closest` goes up from the element and checks each of parents. If it matches the selector, then the search stops, and the ancestor is returned.

For instance:

```
<h1>Contents</h1>

<div class="contents">
  <ul class="book">
    <li class="chapter">Chapter 1</li>
    <li class="chapter">Chapter 1</li>
  </ul>
</div>

<script>
  let chapter =
document.querySelector('.chapter'); // LI

  alert(chapter.closest('.book')); // UL
  alert(chapter.closest('.contents')); // DIV

  alert(chapter.closest('h1')); // null
(because h1 is not an ancestor)
</script>
```

getElementsBy*

There are also other methods to look for nodes by a tag, class, etc.

Today, they are mostly history, as `querySelector` is more powerful and shorter to write.

So here we cover them mainly for completeness, while you can still find them in the old scripts.

- `elem.getElementsByTagName(tag)` looks for elements with the given tag and returns the collection of them. The `tag` parameter can also be a star `"*"` for “any tags”.
- `elem.getElementsByClassName(className)` returns elements that have the given CSS class.
- `document.getElementsByName(name)` returns elements with the given `name` attribute, document-wide. very rarely used.

For instance:

```
// get all divs in the document
let divs = document.getElementsByTagName('div');
```

Let’s find all `input` tags inside the table:

```
<table id="table">
  <tr>
    <td>Your age:</td>

    <td>
      <label>
        <input type="radio" name="age" value="young" checked> less than
18
      </label>
      <label>
        <input type="radio" name="age" value="mature"> from 18 to 50
      </label>
      <label>
        <input type="radio" name="age" value="senior"> more than 60
      </label>
    </td>
  </tr>
</table>
```

```html
<script>
  let inputs =
table.getElementsByTagName('input');

  for (let input of inputs) {
    alert( input.value + ': ' + input.checked
);
  }
</script>
```

⚠ Don't forget the `"s"` letter!

Novice developers sometimes forget the letter `"s"`. That is, they try to call `getElementByTagName` instead of `getElementsByTagName`.

The `"s"` letter is absent in `getElementById`, because it returns a single element. But `getElementsByTagName` returns a collection of elements, so there's `"s"` inside.

⚠ It returns a collection, not an element!

Another widespread novice mistake is to write:

```js
// doesn't work
document.getElementsByTagName('input').value = 5;
```

That won't work, because it takes a *collection* of inputs and assigns the value to it rather than to elements inside it.

We should either iterate over the collection or get an element by its index, and then assign, like this:

```
// should work (if there's an input)
document.getElementsByTagName('input')[0].value = 5;
```

Looking for `.article` elements:

```
<form name="my-form">
  <div class="article">Article</div>
  <div class="long article">Long article</div>
</form>

<script>
  // find by name attribute
  let form = document.getElementsByName('my-form')[0];

  // find by class inside the form
  let articles = form.getElementsByClassName('article');
  alert(articles.length); // 2, found two elements with class "article"
</script>
```

Live collections

All methods `"getElementsBy*"` return a *live* collection. Such collections always reflect the current state of the document and “auto-update” when it changes.

In the example below, there are two scripts.

1. The first one creates a reference to the collection of `<div>`. As of now, its length is `1`.
2. The second scripts runs after the browser meets one more `<div>`, so its length is `2`.

```
<div>First div</div>

<script>
  let divs =
document.getElementsByTagName('div');
  alert(divs.length); // 1
</script>

<div>Second div</div>

<script>
  alert(divs.length); // 2
</script>
```

In contrast, `querySelectorAll` returns a *static* collection. It's like a fixed array of elements.

If we use it instead, then both scripts output `1`:

```
<div>First div</div>

<script>
  let divs = document.querySelectorAll('div');
  alert(divs.length); // 1
</script>

<div>Second div</div>

<script>
```

```
  alert(divs.length); // 1
</script>
```

Now we can easily see the difference. The static collection did not increase after the appearance of a new `div` in the document.

Summary

There are 6 main methods to search for nodes in DOM:

Method	Searches by...	Can call on an element?	Live?
`querySelector`	CSS-selector	✔	-
`querySelectorAll`	CSS-selector	✔	-
`getElementById`	`id`	-	-
`getElementsByName`	`name`	-	✔
`getElementsByTagName`	tag or `'*'`	✔	✔
`getElementsByClassName`	class	✔	✔

By far the most used are `querySelector` and `querySelectorAll`, but `getElementBy*` can be sporadically helpful or found in the old scripts.

Besides that:

- There is `elem.matches(css)` to check if `elem` matches the given CSS selector.

- There is `elem.closest(css)` to look for the nearest ancestor that matches the given CSS-selector. The `elem` itself is also checked.

And let's mention one more method here to check for the child-parent relationship, as it's sometimes useful:

- `elemA.contains(elemB)` returns true if `elemB` is inside `elemA` (a descendant of `elemA`) or when `elemA==elemB`.

Tasks

Search for elements

importance: 4

Here's the document with the table and form.

How to find?…

1. The table with `id="age-table"`.
2. All `label` elements inside that table (there should be 3 of them).
3. The first `td` in that table (with the word "Age").
4. The `form` with `name="search"`.
5. The first `input` in that form.
6. The last `input` in that form.

Open the page table.html in a separate window and make use of browser tools for that.

To solution

Node properties: type, tag and contents

Let's get a more in-depth look at DOM nodes.

In this chapter we'll see more into what they are and learn their most used properties.

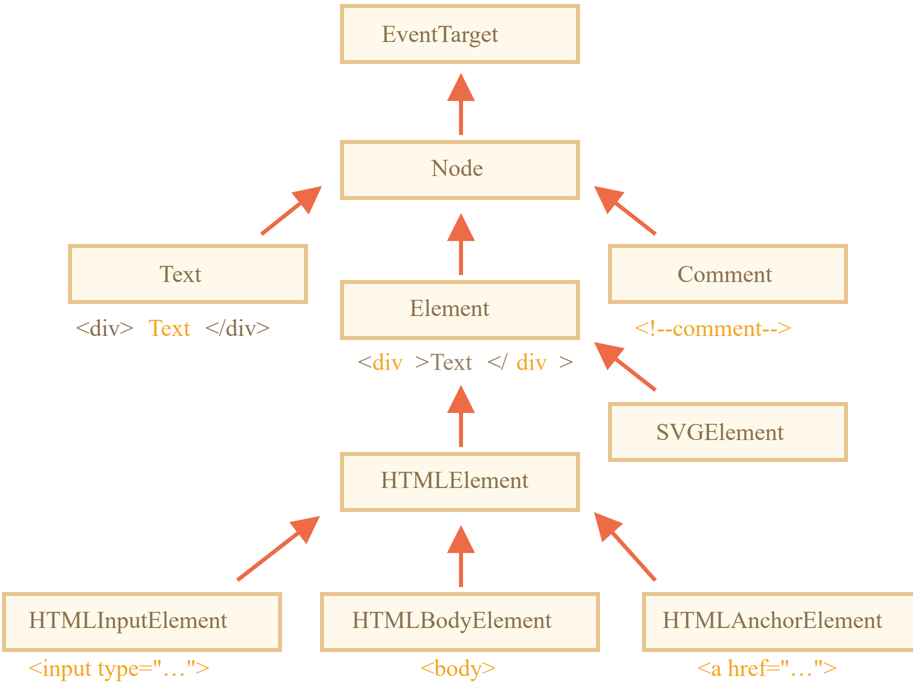
DOM node classes

Different DOM nodes may have different properties. For instance, an element node corresponding to tag `<a>` has link-related properties, and the one corresponding to `<input>` has input-related properties and so on. Text nodes are not the same as element nodes. But there are also common properties and methods between all of them, because all classes of DOM nodes form a single hierarchy.

Each DOM node belongs to the corresponding built-in class.

The root of the hierarchy is EventTarget, that is inherited by Node, and other DOM nodes inherit from it.

Here's the picture, explanations to follow:



The classes are:

- EventTarget – is the root "abstract" class. Objects of that class are never created. It serves as a base, so that all DOM nodes support so-called "events", we'll study them later.
- Node – is also an "abstract" class, serving as a base for DOM nodes. It provides the core tree functionality: `parentNode`, `nextSibling`, `childNodes` and so on (they are getters). Objects of `Node` class are never created. But there are concrete node classes that inherit from it, namely: `Text` for text nodes, `Element` for element nodes and more exotic ones like `Comment` for comment nodes.
- Element – is a base class for DOM elements. It provides element-level navigation like `nextElementSibling`, `children` and searching methods like `getElementsByTagName`, `querySelector`. A browser supports not only HTML, but also XML and SVG. The `Element` class serves as a base for more specific classes: `SVGElement`, `XMLElement` and `HTMLElement`.

- HTMLElement – is finally the basic class for all HTML elements. It is inherited by concrete HTML elements:
  - HTMLInputElement – the class for `<input>` elements,
  - HTMLBodyElement – the class for `<body>` elements,
  - HTMLAnchorElement – the class for `<a>` elements,
  - ...and so on, each tag has its own class that may provide specific properties and methods.

So, the full set of properties and methods of a given node comes as the result of the inheritance.

For example, let's consider the DOM object for an `<input>` element. It belongs to HTMLInputElement class.

It gets properties and methods as a superposition of (listed in inheritance order):

- `HTMLInputElement` – this class provides input-specific properties,
- `HTMLElement` – it provides common HTML element methods (and getters/setters),
- `Element` – provides generic element methods,
- `Node` – provides common DOM node properties,.
- `EventTarget` – gives the support for events (to be covered),
- ...and finally it inherits from `Object`, so "plain object" methods like `hasOwnProperty` are also available.

To see the DOM node class name, we can recall that an object usually has the `constructor` property. It references the class constructor, and `constructor.name` is its name:

```
alert( document.body.constructor.name ); // HTMLBodyElement
```

…Or we can just `toString` it:

```
alert( document.body ); // [object HTMLBodyElement]
```

We also can use `instanceof` to check the inheritance:

```
alert( document.body instanceof HTMLBodyElement ); // true
alert( document.body instanceof HTMLElement ); // true
alert( document.body instanceof Element ); // true
alert( document.body instanceof Node ); // true
alert( document.body instanceof EventTarget ); // true
```

As we can see, DOM nodes are regular JavaScript objects. They use prototype-based classes for inheritance.

That's also easy to see by outputting an element with `console.dir(elem)` in a browser. There in the console you can see `HTMLElement.prototype`, `Element.prototype` and so on.

`console.dir(elem)` versus `console.log(elem)`

Most browsers support two commands in their developer tools: `console.log` and `console.dir`. They output their arguments to the console. For JavaScript objects these commands usually do the same.

But for DOM elements they are different:

- `console.log(elem)` shows the element DOM tree.
- `console.dir(elem)` shows the element as a DOM object, good to explore its properties.

Try it on `document.body`.

IDL in the spec

In the specification, DOM classes aren't described by using JavaScript, but a special Interface description language (IDL), that is usually easy to understand.

In IDL all properties are prepended with their types. For instance, `DOMString`, `boolean` and so on.

Here's an excerpt from it, with comments:

```
// Define HTMLInputElement
// The colon ":" means that HTMLInputElement inherits from
HTMLElement
interface HTMLInputElement: HTMLElement {
  // here go properties and methods of <input> elements

  // "DOMString" means that the value of a property is a string
  attribute DOMString accept;
  attribute DOMString alt;
  attribute DOMString autocomplete;
  attribute DOMString value;

  // boolean value property (true/false)
  attribute boolean autofocus;
  ...
  // now the method: "void" means that the method returns no
value
  void select();
  ...
}
```

The “nodeType” property

The `nodeType` property provides one more, “old-fashioned” way to get the “type” of a DOM node.

It has a numeric value:

- `elem.nodeType == 1` for element nodes,
- `elem.nodeType == 3` for text nodes,
- `elem.nodeType == 9` for the document object,
- there are few other values in the specification .

For instance:

```html
<body>
  <script>
  let elem = document.body;

  // let's examine what it is?
  alert(elem.nodeType); // 1 => element

  // and the first child is...
  alert(elem.firstChild.nodeType); // 3 => text

  // for the document object, the type is 9
  alert( document.nodeType ); // 9
  </script>
</body>
```

In modern scripts, we can use `instanceof` and other class-based tests to see the node type, but sometimes `nodeType` may be simpler. We can only read `nodeType`, not change it.

Tag: nodeName and tagName

Given a DOM node, we can read its tag name from `nodeName` or `tagName` properties:

For instance:

```
alert( document.body.nodeName ); // BODY
alert( document.body.tagName ); // BODY
```

Is there any difference between `tagName` and `nodeName`?

Sure, the difference is reflected in their names, but is indeed a bit subtle.

- The `tagName` property exists only for `Element` nodes.
- The `nodeName` is defined for any `Node`:
  - for elements it means the same as `tagName`.
  - for other node types (text, comment, etc.) it has a string with the node type.

In other words, `tagName` is only supported by element nodes (as it originates from `Element` class), while `nodeName` can say something about other node types.

For instance, let's compare `tagName` and `nodeName` for the `document` and a comment node:

```
<body><!-- comment -->

  <script>
    // for comment
    alert( document.body.firstChild.tagName );
```

```
// undefined (not an element)
    alert( document.body.firstChild.nodeName );
// #comment

    // for document
    alert( document.tagName ); // undefined
(not an element)
    alert( document.nodeName ); // #document
  </script>
</body>
```

If we only deal with elements, then we can use both `tagName` and `nodeName` – there's no difference.

> **The tag name is always uppercase except in XML mode**
>
> The browser has two modes of processing documents: HTML and XML. Usually the HTML-mode is used for webpages. XML-mode is enabled when the browser receives an XML-document with the header: `Content-Type: application/xml+xhtml`.
>
> In HTML mode `tagName/nodeName` is always uppercased: it's `BODY` either for `<body>` or `<BoDy>`.
>
> In XML mode the case is kept "as is". Nowadays XML mode is rarely used.

innerHTML: the contents

The innerHTML property allows to get the HTML inside the element as a string.

We can also modify it. So it’s one of the most powerful ways to change the page.

The example shows the contents of `document.body` and then replaces it completely:

```
<body>
  <p>A paragraph</p>
  <div>A div</div>

  <script>
    alert( document.body.innerHTML ); // read
the current contents
    document.body.innerHTML = 'The new BODY!';
// replace it
   </script>

</body>
```

We can try to insert invalid HTML, the browser will fix our errors:

```
<body>

  <script>
    document.body.innerHTML = '<b>test'; //
forgot to close the tag
    alert( document.body.innerHTML ); //
<b>test</b> (fixed)
   </script>

</body>
```

Scripts don't execute

If `innerHTML` inserts a `<script>` tag into the document – it becomes a part of HTML, but doesn't execute.

Beware: "innerHTML+=" does a full overwrite

We can append HTML to an element by using `elem.innerHTML+="more html"`.

Like this:

```
chatDiv.innerHTML += "<div>Hello<img src='smile.gif'/> !</div>";
chatDiv.innerHTML += "How goes?";
```

But we should be very careful about doing it, because what's going on is *not* an addition, but a full overwrite.

Technically, these two lines do the same:

```
elem.innerHTML += "...";
// is a shorter way to write:
elem.innerHTML = elem.innerHTML + "..."
```

In other words, `innerHTML+=` does this:

1. The old contents is removed.
2. The new `innerHTML` is written instead (a concatenation of the old and the new one).

As the content is "zeroed-out" and rewritten from the scratch, all images and other resources will be reloaded.

In the `chatDiv` example above the line `chatDiv.innerHTML+="How goes?"` re-creates the HTML content and reloads `smile.gif` (hope it's cached). If `chatDiv` has a lot of other text and images, then the reload becomes clearly visible.

There are other side-effects as well. For instance, if the existing text was selected with the mouse, then most browsers will remove the selection upon rewriting `innerHTML`. And if there was an `<input>` with a text entered by the visitor, then the text will be removed. And so on.

Luckily, there are other ways to add HTML besides `innerHTML`, and we'll study them soon.

outerHTML: full HTML of the element

The `outerHTML` property contains the full HTML of the element. That's like `innerHTML` plus the element itself.

Here's an example:

```
<div id="elem">Hello <b>World</b></div>

<script>
  alert(elem.outerHTML); // <div id="elem">Hello <b>World</b></div>
</script>
```

Beware: unlike `innerHTML`, writing to `outerHTML` does not change the element. Instead, it replaces it in the DOM.

Yeah, sounds strange, and strange it is, that's why we make a separate note about it here. Take a look.

Consider the example:

```
<div>Hello, world!</div>

<script>
  let div = document.querySelector('div');

  // replace div.outerHTML with <p>...</p>
  div.outerHTML = '<p>A new element</p>'; //
(*)

  // Wow! 'div' is still the same!
  alert(div.outerHTML); // <div>Hello, world!
</div> (**)
</script>
```

Looks really odd, right?

In the line `(*)` we replaced `div` with `<p>A new element</p>`. In the outer document (the DOM) we can see the new content instead of the `<div>`. But, as we can see in line `(**)`, the value of the old `div` variable hasn't changed!

The `outerHTML` assignment does not modify the DOM element (the object referenced by, in this case, the variable 'div'), but removes it from the DOM and inserts the new HTML in its place.

So what happened in `div.outerHTML=...` is:

- `div` was removed from the document.
- Another piece of HTML `<p>A new element</p>` was inserted in its place.
- `div` still has its old value. The new HTML wasn't saved to any variable.

It's so easy to make an error here: modify `div.outerHTML` and then continue to work with `div` as if it had the new content in it. But it doesn't. Such thing is correct for `innerHTML`, but not for `outerHTML`.

We can write to `elem.outerHTML`, but should keep in mind that it doesn't change the element we're writing to ('elem'). It puts the new HTML in its place instead. We can get references to the new elements by querying the DOM.

nodeValue/data: text node content

The `innerHTML` property is only valid for element nodes.

Other node types, such as text nodes, have their counterpart: `nodeValue` and `data` properties. These two are almost the same for practical use, there are only minor specification differences. So we'll use `data`, because it's shorter.

An example of reading the content of a text node and a comment:

```
<body>
  Hello
  <!-- Comment -->
  <script>
    let text = document.body.firstChild;
    alert(text.data); // Hello

    let comment = text.nextSibling;
    alert(comment.data); // Comment
  </script>
</body>
```

For text nodes we can imagine a reason to read or modify them, but why comments?

Sometimes developers embed information or template instructions into HTML in them, like this:

```
<!-- if isAdmin -->
  <div>Welcome, Admin!</div>
<!-- /if -->
```

...Then JavaScript can read it from `data` property and process embedded instructions.

textContent: pure text

The `textContent` provides access to the *text* inside the element: only text, minus all `<tags>`.

For instance:

```
<div id="news">
  <h1>Headline!</h1>
  <p>Martians attack people!</p>
</div>

<script>
  // Headline! Martians attack people!
  alert(news.textContent);
</script>
```

As we can see, only text is returned, as if all `<tags>` were cut out, but the text in them remained.

In practice, reading such text is rarely needed.

Writing to `textContent` is much more useful, because it allows to write text the "safe way".

Let's say we have an arbitrary string, for instance entered by a user, and want to show it.

- With `innerHTML` we'll have it inserted "as HTML", with all HTML tags.
- With `textContent` we'll have it inserted "as text", all symbols are treated literally.

Compare the two:

```
<div id="elem1"></div>
<div id="elem2"></div>

<script>
  let name = prompt("What's your name?", "
<b>Winnie-the-pooh!</b>");

  elem1.innerHTML = name;
  elem2.textContent = name;
</script>
```

1. The first `<div>` gets the name "as HTML": all tags become tags, so we see the bold name.
2. The second `<div>` gets the name "as text", so we literally see `<b>Winnie-the-pooh!</b>`.

In most cases, we expect the text from a user, and want to treat it as text. We don't want unexpected HTML in our site. An assignment to `textContent` does exactly that.

The “hidden” property

The “hidden” attribute and the DOM property specifies whether the element is visible or not.

We can use it in HTML or assign using JavaScript, like this:

```
<div>Both divs below are hidden</div>

<div hidden>With the attribute "hidden"</div>

<div id="elem">JavaScript assigned the property "hidden"</div>

<script>
  elem.hidden = true;
</script>
```

Technically, `hidden` works the same as `style="display:none"`. But it’s shorter to write.

Here’s a blinking element:

```
<div id="elem">A blinking element</div>

<script>
  setInterval(() => elem.hidden = !elem.hidden, 1000);
</script>
```

More properties

DOM elements also have additional properties, in particular those that depend on the class:

- `value` – the value for `<input>`, `<select>` and `<textarea>` (`HTMLInputElement`, `HTMLSelectElement`…).
- `href` – the “href” for `<a href="...">` (`HTMLAnchorElement`).
- `id` – the value of “id” attribute, for all elements (`HTMLElement`).
- …and much more…

For instance:

```
<input type="text" id="elem" value="value">

<script>
  alert(elem.type); // "text"
  alert(elem.id); // "elem"
  alert(elem.value); // value
</script>
```

Most standard HTML attributes have the corresponding DOM property, and we can access it like that.

If we want to know the full list of supported properties for a given class, we can find them in the specification. For instance, `HTMLInputElement` is documented at https://html.spec.whatwg.org/#htmlinputelement .

Or if we’d like to get them fast or are interested in a concrete browser specification – we can always output the element using `console.dir(elem)` and read the properties. Or explore “DOM properties” in the Elements tab of the browser developer tools.

Summary

Each DOM node belongs to a certain class. The classes form a hierarchy. The full set of properties and methods come as the result of inheritance.

Main DOM node properties are:

`nodeType`

We can use it to see if a node is a text or an element node. It has a numeric value: `1` for elements,`3` for text nodes, and a few others for other node types. Read-only.

`nodeName/tagName`

For elements, tag name (uppercased unless XML-mode). For non-element nodes `nodeName` describes what it is. Read-only.

`innerHTML`

The HTML content of the element. Can be modified.

`outerHTML`

The full HTML of the element. A write operation into `elem.outerHTML` does not touch `elem` itself. Instead it gets replaced with the new HTML in the outer context.

`nodeValue/data`

The content of a non-element node (text, comment). These two are almost the same, usually we use `data`. Can be modified.

`textContent`

The text inside the element: HTML minus all `<tags>`. Writing into it puts the text inside the element, with all special characters and tags treated exactly as text. Can safely insert user-generated text and protect from unwanted HTML insertions.

`hidden`

When set to `true`, does the same as CSS `display:none`.

DOM nodes also have other properties depending on their class. For instance, `<input>` elements (`HTMLInputElement`) support `value`, `type`, while `<a>` elements (`HTMLAnchorElement`) support `href` etc. Most standard HTML attributes have a corresponding DOM property.

However, HTML attributes and DOM properties are not always the same, as we'll see in the next chapter.

Tasks

Count descendants

importance: 5

There's a tree structured as nested `ul/li`.

Write the code that for each `<li>` shows:

1. What's the text inside it (without the subtree)
2. The number of nested `<li>` – all descendants, including the deeply nested ones.

Demo in new window

Open a sandbox for the task.

To solution

What's in the nodeType?

importance: 5

What does the script show?

```html
<html>

<body>
  <script>
    alert(document.body.lastChild.nodeType);
  </script>
</body>

</html>
```

To solution

Tag in comment

importance: 3

What does this code show?

```html
<script>
  let body = document.body;

  body.innerHTML = "<!--" + body.tagName + "-->";

  alert( body.firstChild.data ); // what's here?
</script>
```

To solution

Where's the "document" in the hierarchy?

importance: 4

Which class does the `document` belong to?

What's its place in the DOM hierarchy?

Does it inherit from `Node` or `Element`, or maybe `HTMLElement`?

To solution

Attributes and properties

When the browser loads the page, it "reads" (another word: "parses") the HTML and generates DOM objects from it. For element nodes, most standard HTML attributes automatically become properties of DOM objects.

For instance, if the tag is `<body id="page">`, then the DOM object has `body.id="page"`.

But the attribute-property mapping is not one-to-one! In this chapter we'll pay attention to separate these two notions, to see how to work with them, when they are the same, and when they are different.

DOM properties

We've already seen built-in DOM properties. There are a lot. But technically no one limits us, and if there aren't enough, we can add our own.

DOM nodes are regular JavaScript objects. We can alter them.

For instance, let's create a new property in `document.body`:

```
document.body.myData = {
  name: 'Caesar',
```

```
  title: 'Imperator'
};

alert(document.body.myData.title); // Imperator
```

We can add a method as well:

```
document.body.sayTagName = function() {
  alert(this.tagName);
};

document.body.sayTagName(); // BODY (the value of "this" in the method is document.body)
```

We can also modify built-in prototypes like `Element.prototype` and add new methods to all elements:

```
Element.prototype.sayHi = function() {
  alert(`Hello, I'm ${this.tagName}`);
};

document.documentElement.sayHi(); // Hello, I'm HTML
document.body.sayHi(); // Hello, I'm BODY
```

So, DOM properties and methods behave just like those of regular JavaScript objects:

- They can have any value.
- They are case-sensitive (write `elem.nodeType`, not `elem.NoDeTyPe`).

HTML attributes

In HTML, tags may have attributes. When the browser parses the HTML to create DOM objects for tags, it recognizes *standard* attributes and creates DOM properties from them.

So when an element has `id` or another *standard* attribute, the corresponding property gets created. But that doesn't happen if the attribute is non-standard.

For instance:

```html
<body id="test" something="non-standard">
  <script>
    alert(document.body.id); // test
    // non-standard attribute does not yield a property
    alert(document.body.something); // undefined
  </script>
</body>
```

Please note that a standard attribute for one element can be unknown for another one. For instance, `"type"` is standard for `<input>` (HTMLInputElement), but not for `<body>` (HTMLBodyElement). Standard attributes are described in the specification for the corresponding element class.

Here we can see it:

```html
<body id="body" type="...">
  <input id="input" type="text">
  <script>
    alert(input.type); // text
    alert(body.type); // undefined: DOM property not created, because it's non-standard
```

```html
  </script>
</body>
```

So, if an attribute is non-standard, there won't be a DOM-property for it. Is there a way to access such attributes?

Sure. All attributes are accessible by using the following methods:

- `elem.hasAttribute(name)` – checks for existence.
- `elem.getAttribute(name)` – gets the value.
- `elem.setAttribute(name, value)` – sets the value.
- `elem.removeAttribute(name)` – removes the attribute.

These methods operate exactly with what's written in HTML.

Also one can read all attributes using `elem.attributes`: a collection of objects that belong to a built-in Attr class, with `name` and `value` properties.

Here's a demo of reading a non-standard property:

```html
<body something="non-standard">
  <script>
    alert(document.body.getAttribute('something')); // non-standard
  </script>
</body>
```

HTML attributes have the following features:

- Their name is case-insensitive (`id` is same as `ID`).
- Their values are always strings.

Here's an extended demo of working with attributes:

```
<body>
  <div id="elem" about="Elephant"></div>

  <script>
    alert( elem.getAttribute('About') ); // (1)
'Elephant', reading

    elem.setAttribute('Test', 123); // (2),
writing

    alert( elem.outerHTML ); // (3), see if the
attribute is in HTML (yes)

    for (let attr of elem.attributes) { // (4)
list all
      alert( `${attr.name} = ${attr.value}` );
    }
  </script>
</body>
```

Please note:

1. `getAttribute('About')` – the first letter is uppercase here, and in HTML it's all lowercase. But that doesn't matter: attribute names are case-insensitive.
2. We can assign anything to an attribute, but it becomes a string. So here we have `"123"` as the value.
3. All attributes including ones that we set are visible in `outerHTML`.
4. The `attributes` collection is iterable and has all the attributes of the element (standard and non-standard) as objects with `name`

and `value` properties.

Property-attribute synchronization

When a standard attribute changes, the corresponding property is auto-updated, and (with some exceptions) vice versa.

In the example below `id` is modified as an attribute, and we can see the property changed too. And then the same backwards:

```
<input>

<script>
  let input = document.querySelector('input');

  // attribute => property
  input.setAttribute('id', 'id');
  alert(input.id); // id (updated)

  // property => attribute
  input.id = 'newId';
  alert(input.getAttribute('id')); // newId
(updated)
</script>
```

But there are exclusions, for instance `input.value` synchronizes only from attribute → to property, but not back:

```
<input>

<script>
  let input = document.querySelector('input');
```

```
  // attribute => property
  input.setAttribute('value', 'text');
  alert(input.value); // text

  // NOT property => attribute
  input.value = 'newValue';
  alert(input.getAttribute('value')); // text
(not updated!)
</script>
```

In the example above:

- Changing the attribute `value` updates the property.
- But the property change does not affect the attribute.

That "feature" may actually come in handy, because the user actions may lead to `value` changes, and then after them, if we want to recover the "original" value from HTML, it's in the attribute.

DOM properties are typed

DOM properties are not always strings. For instance, the `input.checked` property (for checkboxes) is a boolean:

```
<input id="input" type="checkbox" checked> checkbox

<script>
  alert(input.getAttribute('checked')); // the
attribute value is: empty string
  alert(input.checked); // the property value
```

```
is: true
</script>
```

There are other examples. The `style` attribute is a string, but the `style` property is an object:

```
<div id="div" style="color:red;font-size:120%">Hello</div>

<script>
  // string
  alert(div.getAttribute('style')); // color:red;font-size:120%

  // object
  alert(div.style); // [object CSSStyleDeclaration]
  alert(div.style.color); // red
</script>
```

Most properties are strings though.

Quite rarely, even if a DOM property type is a string, it may differ from the attribute. For instance, the `href` DOM property is always a *full* URL, even if the attribute contains a relative URL or just a `#hash`.

Here’s an example:

```
<a id="a" href="#hello">link</a>
<script>
  // attribute
  alert(a.getAttribute('href')); // #hello
```

```
  // property
  alert(a.href ); // full URL in the form
http://site.com/page#hello
</script>
```

If we need the value of `href` or any other attribute exactly as written in the HTML, we can use `getAttribute`.

Non-standard attributes, dataset

When writing HTML, we use a lot of standard attributes. But what about non-standard, custom ones? First, let's see whether they are useful or not? What for?

Sometimes non-standard attributes are used to pass custom data from HTML to JavaScript, or to "mark" HTML-elements for JavaScript.

Like this:

```
<!-- mark the div to show "name" here -->
<div show-info="name"></div>
<!-- and age here -->
<div show-info="age"></div>

<script>
  // the code finds an element with the mark
and shows what's requested
  let user = {
    name: "Pete",
    age: 25
  };

  for(let div of
```

```
document.querySelectorAll('[show-info]')) {
    // insert the corresponding info into the field
    let field = div.getAttribute('show-info');
    div.innerHTML = user[field]; // first Pete into "name", then 25 into "age"
  }
</script>
```

Also they can be used to style an element.

For instance, here for the order state the attribute `order-state` is used:

```
<style>
  /* styles rely on the custom attribute "order-state" */
  .order[order-state="new"] {
    color: green;
  }

  .order[order-state="pending"] {
    color: blue;
  }

  .order[order-state="canceled"] {
    color: red;
  }
</style>

<div class="order" order-state="new">
  A new order.
</div>
```

```html
<div class="order" order-state="pending">
  A pending order.
</div>

<div class="order" order-state="canceled">
  A canceled order.
</div>
```

Why would using an attribute be preferable to having classes like `.order-state-new`, `.order-state-pending`, `order-state-canceled`?

Because an attribute is more convenient to manage. The state can be changed as easy as:

```js
// a bit simpler than removing old/adding a new class
div.setAttribute('order-state', 'canceled');
```

But there may be a possible problem with custom attributes. What if we use a non-standard attribute for our purposes and later the standard introduces it and makes it do something? The HTML language is alive, it grows, and more attributes appear to suit the needs of developers. There may be unexpected effects in such case.

To avoid conflicts, there exist data-* attributes.

All attributes starting with "data-" are reserved for programmers' use. They are available in the `dataset` property.

For instance, if an `elem` has an attribute named `"data-about"`, it's available as `elem.dataset.about`.

Like this:

```html
<body data-about="Elephants">
<script>
```

```
  alert(document.body.dataset.about); //
Elephants
</script>
```

Multiword attributes like `data-order-state` become camel-cased: `dataset.orderState`.

Here’s a rewritten “order state” example:

```
<style>
  .order[data-order-state="new"] {
    color: green;
  }

  .order[data-order-state="pending"] {
    color: blue;
  }

  .order[data-order-state="canceled"] {
    color: red;
  }
</style>

<div id="order" class="order" data-order-state="new">
  A new order.
</div>

<script>
  // read
  alert(order.dataset.orderState); // new

  // modify
```

```
  order.dataset.orderState = "pending"; // (*)
</script>
```

Using `data-*` attributes is a valid, safe way to pass custom data.

Please note that we can not only read, but also modify data-attributes. Then CSS updates the view accordingly: in the example above the last line `(*)` changes the color to blue.

Summary

- Attributes – is what's written in HTML.
- Properties – is what's in DOM objects.

A small comparison:

	Properties	Attributes
Type	Any value, standard properties have types described in the spec	A string
Name	Name is case-sensitive	Name is not case-sensitive

Methods to work with attributes are:

- `elem.hasAttribute(name)` – to check for existence.
- `elem.getAttribute(name)` – to get the value.
- `elem.setAttribute(name, value)` – to set the value.
- `elem.removeAttribute(name)` – to remove the attribute.
- `elem.attributes` is a collection of all attributes.

For most situations using DOM properties is preferable. We should refer to attributes only when DOM properties do not suit us, when we need exactly attributes, for instance:

- We need a non-standard attribute. But if it starts with `data-`, then we should use `dataset`.
- We want to read the value "as written" in HTML. The value of the DOM property may be different, for instance the `href` property is always a full URL, and we may want to get the "original" value.

Tasks

Get the attribute

importance: 5

Write the code to select the element with `data-widget-name` attribute from the document and to read its value.

```
<!DOCTYPE html>
<html>
<body>

  <div data-widget-name="menu">Choose the genre</div>

  <script>
    /* your code */
   </script>
</body>
</html>
```

To solution

Make external links orange

importance: 3

Make all external links orange by altering their `style` property.

A link is external if:

- Its `href` has `://` in it
- But doesn't start with `http://internal.com`.

Example:

```
<a name="list">the list</a>
<ul>
  <li><a href="http://google.com">http://google.com</a></li>
  <li><a href="/tutorial">/tutorial.html</a></li>
  <li><a href="local/path">local/path</a></li>
  <li><a href="ftp://ftp.com/my.zip">ftp://ftp.com/my.zip</a></li>
  <li><a href="http://nodejs.org">http://nodejs.org</a></li>
  <li><a href="http://internal.com/test">http://internal.com/test</a>
</li>
</ul>

<script>
  // setting style for a single link
  let link = document.querySelector('a');
  link.style.color = 'orange';
</script>
```

The result should be:

The list:

- http://google.com
- /tutorial.html
- local/path
- ftp://ftp.com/my.zip
- http://nodejs.org
- http://internal.com/test

Open a sandbox for the task.

To solution

Modifying the document

DOM modification is the key to creating “live” pages.

Here we'll see how to create new elements "on the fly" and modify the existing page content.

Example: show a message

Let's demonstrate using an example. We'll add a message on the page that looks nicer than `alert`.

Here's how it will look:

```
<style>
.alert {
  padding: 15px;
  border: 1px solid #d6e9c6;
  border-radius: 4px;
  color: #3c763d;
  background-color: #dff0d8;
}
</style>

<div class="alert">
  <strong>Hi there!</strong> You've read an important message.
</div>
```

Hi there! You've read an important message.

That was an HTML example. Now let's create the same `div` with JavaScript (assuming that the styles are in the HTML or an external CSS file).

Creating an element

To create DOM nodes, there are two methods:

`document.createElement(tag)`

Creates a new *element node* with the given tag:

```
let div = document.createElement('div');
```

`document.createTextNode(text)`

Creates a new *text node* with the given text:

```
let textNode = document.createTextNode('Here I am');
```

Creating the message

In our case the message is a `div` with `alert` class and the HTML in it:

```
let div = document.createElement('div');
div.className = "alert";
div.innerHTML = "<strong>Hi there!</strong> You've read an important message.";
```

We created the element, but as of now it's only in a variable. We can't see the element on the page, as it's not yet a part of the document.

Insertion methods

To make the `div` show up, we need to insert it somewhere into `document`. For instance, in `document.body`.

There's a special method `append` for that: `document.body.append(div)`.

Here's the full code:

```
<style>
.alert {
  padding: 15px;
  border: 1px solid #d6e9c6;
  border-radius: 4px;
  color: #3c763d;
  background-color: #dff0d8;
}
</style>

<script>
  let div = document.createElement('div');
  div.className = "alert";
  div.innerHTML = "<strong>Hi there!</strong>
You've read an important message.";

  document.body.append(div);
</script>
```

This set of methods provides more ways to insert:

- `node.append(...nodes or strings)` – append nodes or strings at the end of `node`,

- `node.prepend(...nodes or strings)` – insert nodes or strings at the beginning of `node`,
- `node.before(...nodes or strings)` –- insert nodes or strings before `node`,
- `node.after(...nodes or strings)` –- insert nodes or strings after `node`,
- `node.replaceWith(...nodes or strings)` –- replaces `node` with the given nodes or strings.

Here's an example of using these methods to add items to a list and the text before/after it:

```
<ol id="ol">
  <li>0</li>
  <li>1</li>
  <li>2</li>
</ol>

<script>
  ol.before('before'); // insert string
"before" before <ol>
  ol.after('after'); // insert string "after"
after <ol>

  let liFirst = document.createElement('li');
  liFirst.innerHTML = 'prepend';
  ol.prepend(liFirst); // insert liFirst at the
beginning of <ol>

  let liLast = document.createElement('li');
  liLast.innerHTML = 'append';
  ol.append(liLast); // insert liLast at the
```

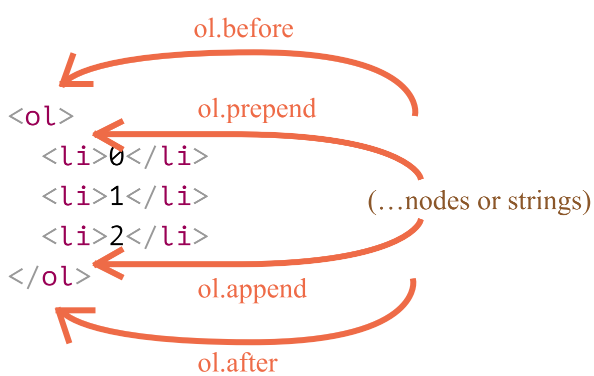
```
end of <ol>
</script>
```

before

1. prepend
2. 0
3. 1
4. 2
5. append

after

Here’s a visual picture what methods do:



So the final list will be:

```
before
<ol id="ol">
  <li>prepend</li>
  <li>0</li>
  <li>1</li>
  <li>2</li>
  <li>append</li>
</ol>
after
```

These methods can insert multiple lists of nodes and text pieces in a single call.

For instance, here a string and an element are inserted:

```
<div id="div"></div>
<script>
  div.before('<p>Hello</p>', document.createElement('hr'));
</script>
```

All text is inserted *as text*.

So the final HTML is:

```
&lt;p&gt;Hello&lt;/p&gt;
<hr>
<div id="div"></div>
```

In other words, strings are inserted in a safe way, like `elem.textContent` does it.

So, these methods can only be used to insert DOM nodes or text pieces.

But what if we want to insert HTML "as html", with all tags and stuff working, like `elem.innerHTML`?

insertAdjacentHTML/Text/Element

For that we can use another, pretty versatile method: `elem.insertAdjacentHTML(where, html)`.

The first parameter is a code word, specifying where to insert relative to `elem`. Must be one of the following:

- `"beforebegin"` – insert `html` immediately before `elem`,
- `"afterbegin"` – insert `html` into `elem`, at the beginning,
- `"beforeend"` – insert `html` into `elem`, at the end,
- `"afterend"` – insert `html` immediately after `elem`.

The second parameter is an HTML string, that is inserted "as HTML".

For instance:

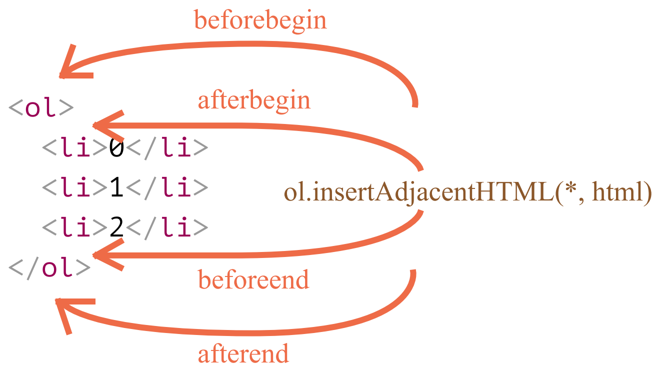
```
<div id="div"></div>
<script>
  div.insertAdjacentHTML('beforebegin', '<p>Hello</p>');
  div.insertAdjacentHTML('afterend', '<p>Bye</p>');
</script>
```

…Would lead to:

```
<p>Hello</p>
<div id="div"></div>
<p>Bye</p>
```

That's how we can append arbitrary HTML to the page.

Here's the picture of insertion variants:



We can easily notice similarities between this and the previous picture. The insertion points are actually the same, but this method inserts HTML.

The method has two brothers:

- `elem.insertAdjacentText(where, text)` – the same syntax, but a string of `text` is inserted "as text" instead of HTML,
- `elem.insertAdjacentElement(where, elem)` – the same syntax, but inserts an element.

They exist mainly to make the syntax "uniform". In practice, only `insertAdjacentHTML` is used most of the time. Because for elements and text, we have methods `append/prepend/before/after` – they are shorter to write and can insert nodes/text pieces.

So here's an alternative variant of showing a message:

```
<style>
.alert {
  padding: 15px;
  border: 1px solid #d6e9c6;
  border-radius: 4px;
  color: #3c763d;
```

```
  background-color: #dff0d8;
}
</style>

<script>

document.body.insertAdjacentHTML("afterbegin",
`<div class="alert">
    <strong>Hi there!</strong> You've read an
important message.
  </div>`);
</script>
```

Node removal

To remove a node, there's a method `node.remove()`.

Let's make our message disappear after a second:

```
<style>
.alert {
  padding: 15px;
  border: 1px solid #d6e9c6;
  border-radius: 4px;
  color: #3c763d;
  background-color: #dff0d8;
}
</style>

<script>
  let div = document.createElement('div');
  div.className = "alert";
  div.innerHTML = "<strong>Hi there!</strong>
```

```
You've read an important message.";

  document.body.append(div);
  setTimeout(() => div.remove(), 1000);
</script>
```

Please note: if we want to *move* an element to another place – there's no need to remove it from the old one.

All insertion methods automatically remove the node from the old place.

For instance, let's swap elements:

```
<div id="first">First</div>
<div id="second">Second</div>
<script>
  // no need to call remove
  second.after(first); // take #second and after it insert #first
</script>
```

Cloning nodes: cloneNode

How to insert one more similar message?

We could make a function and put the code there. But the alternative way would be to *clone* the existing `div` and modify the text inside it (if needed).

Sometimes when we have a big element, that may be faster and simpler.

- The call `elem.cloneNode(true)` creates a "deep" clone of the element – with all attributes and subelements. If we call `elem.cloneNode(false)`, then the clone is made without child elements.

An example of copying the message:

```
<style>
.alert {
  padding: 15px;
  border: 1px solid #d6e9c6;
  border-radius: 4px;
  color: #3c763d;
  background-color: #dff0d8;
}
</style>

<div class="alert" id="div">
  <strong>Hi there!</strong> You've read an important message.
</div>

<script>
  let div2 = div.cloneNode(true); // clone the message
  div2.querySelector('strong').innerHTML = 'Bye there!'; // change the clone

  div.after(div2); // show the clone after the existing div
</script>
```

DocumentFragment

`DocumentFragment` is a special DOM node that serves as a wrapper to pass around lists of nodes.

We can append other nodes to it, but when we insert it somewhere, then its content is inserted instead.

For example, `getListContent` below generates a fragment with `<li>` items, that are later inserted into `<ul>`:

```
<ul id="ul"></ul>

<script>
function getListContent() {
  let fragment = new DocumentFragment();

  for(let i=1; i<=3; i++) {
    let li = document.createElement('li');
    li.append(i);
    fragment.append(li);
  }

  return fragment;
}

ul.append(getListContent()); // (*)
</script>
```

Please note, at the last line `(*)` we append `DocumentFragment`, but it “blends in”, so the resulting structure will be:

```
<ul>
  <li>1</li>
  <li>2</li>
  <li>3</li>
</ul>
```

`DocumentFragment` is rarely used explicitly. Why append to a special kind of node, if we can return an array of nodes instead? Rewritten example:

```
<ul id="ul"></ul>

<script>
function getListContent() {
  let result = [];

  for(let i=1; i<=3; i++) {
    let li = document.createElement('li');
    li.append(i);
    result.push(li);
  }

  return result;
}

ul.append(...getListContent()); // append + "..." operator = friends!
</script>
```

We mention `DocumentFragment` mainly because there are some concepts on top of it, like template element, that we'll cover much later.

Old-school insert/remove methods

⚠ **Old school**

This information helps to understand old scripts, but not needed for new development.

There are also “old school” DOM manipulation methods, existing for historical reasons.

These methods come from really ancient times. Nowadays, there’s no reason to use them, as modern methods, such as `append`, `prepend`, `before`, `after`, `remove`, `replaceWith`, are more flexible.

The only reason we list these methods here is that you can find them in many old scripts:

`parentElem.appendChild(node)`

Appends `node` as the last child of `parentElem`.

The following example adds a new `<li>` to the end of `<ol>`:

```
<ol id="list">
  <li>0</li>
  <li>1</li>
  <li>2</li>
</ol>

<script>
  let newLi = document.createElement('li');
  newLi.innerHTML = 'Hello, world!';

  list.appendChild(newLi);
</script>
```

`parentElem.insertBefore(node, nextSibling)`

Inserts `node` before `nextSibling` into `parentElem`.

The following code inserts a new list item before the second `<li>`:

```html
<ol id="list">
  <li>0</li>
  <li>1</li>
  <li>2</li>
</ol>
<script>
  let newLi = document.createElement('li');
  newLi.innerHTML = 'Hello, world!';

  list.insertBefore(newLi, list.children[1]);
</script>
```

To insert `newLi` as the first element, we can do it like this:

```js
list.insertBefore(newLi, list.firstChild);
```

`parentElem.replaceChild(node, oldChild)`

Replaces `oldChild` with `node` among children of `parentElem`.

`parentElem.removeChild(node)`

Removes `node` from `parentElem` (assuming `node` is its child).

The following example removes first `<li>` from `<ol>`:

```html
<ol id="list">
  <li>0</li>
  <li>1</li>
  <li>2</li>
</ol>

<script>
  let li = list.firstElementChild;
```

```
  list.removeChild(li);
</script>
```

All these methods return the inserted/removed node. In other words, `parentElem.appendChild(node)` returns `node`. But usually the returned value is not used, we just run the method.

A word about “document.write”

There’s one more, very ancient method of adding something to a web-page: `document.write`.

The syntax:

```
<p>Somewhere in the page...</p>
<script>
  document.write('<b>Hello from JS</b>');
</script>
<p>The end</p>
```

The call to `document.write(html)` writes the `html` into page “right here and now”. The `html` string can be dynamically generated, so it’s kind of flexible. We can use JavaScript to create a full-fledged webpage and write it.

The method comes from times when there was no DOM, no standards… Really old times. It still lives, because there are scripts using it.

In modern scripts we can rarely see it, because of the following important limitation:

The call to `document.write` only works while the page is loading.

If we call it afterwards, the existing document content is erased.

For instance:

```
<p>After one second the contents of this page will be replaced...</p>
<script>
  // document.write after 1 second
  // that's after the page loaded, so it erases
the existing content
  setTimeout(() => document.write('<b>...By
this.</b>'), 1000);
</script>
```

So it's kind of unusable at "after loaded" stage, unlike other DOM methods we covered above.

That's the downside.

There's an upside also. Technically, when `document.write` is called while the browser is reading ("parsing") incoming HTML, and it writes something, the browser consumes it just as if it were initially there, in the HTML text.

So it works blazingly fast, because there's *no DOM modification* involved. It writes directly into the page text, while the DOM is not yet built.

So if we need to add a lot of text into HTML dynamically, and we're at page loading phase, and the speed matters, it may help. But in practice these requirements rarely come together. And usually we can see this method in scripts just because they are old.

Summary

- Methods to create new nodes:

- `document.createElement(tag)` – creates an element with the given tag,
- `document.createTextNode(value)` – creates a text node (rarely used),
- `elem.cloneNode(deep)` – clones the element, if `deep==true` then with all descendants.

- Insertion and removal:
  - `node.append(...nodes or strings)` – insert into `node`, at the end,
  - `node.prepend(...nodes or strings)` – insert into `node`, at the beginning,
  - `node.before(...nodes or strings)` –- insert right before `node`,
  - `node.after(...nodes or strings)` –- insert right after `node`,
  - `node.replaceWith(...nodes or strings)` –- replace `node`.
  - `node.remove()` –- remove the `node`.

  Text strings are inserted "as text".

- There are also "old school" methods:
  - `parent.appendChild(node)`
  - `parent.insertBefore(node, nextSibling)`
  - `parent.removeChild(node)`
  - `parent.replaceChild(newElem, node)`

  All these methods return `node`.

- Given some HTML in `html`, `elem.insertAdjacentHTML(where, html)` inserts it depending on the value of `where`:

  - `"beforebegin"` – insert `html` right before `elem`,
  - `"afterbegin"` – insert `html` into `elem`, at the beginning,
  - `"beforeend"` – insert `html` into `elem`, at the end,
  - `"afterend"` – insert `html` right after `elem`.

  Also there are similar methods, `elem.insertAdjacentText` and `elem.insertAdjacentElement`, that insert text strings and elements, but they are rarely used.
- To append HTML to the page before it has finished loading:
  - `document.write(html)`

  After the page is loaded such a call erases the document. Mostly seen in old scripts.

Tasks

---

createTextNode vs innerHTML vs textContent

importance: 5

We have an empty DOM element `elem` and a string `text`.

Which of these 3 commands do exactly the same?

1. `elem.append(document.createTextNode(text))`
2. `elem.innerHTML = text`
3. `elem.textContent = text`

To solution

Clear the element

importance: 5

Create a function `clear(elem)` that removes everything from the element.

```
<ol id="elem">
  <li>Hello</li>
  <li>World</li>
</ol>

<script>
  function clear(elem) { /* your code */ }

  clear(elem); // clears the list
</script>
```

To solution

Why does "aaa" remain?

importance: 1

In the example below, the call `table.remove()` removes the table from the document.

But if you run it, you can see that the text `"aaa"` is still visible.

Why does that happen?

```
<table id="table">
  aaa
  <tr>
    <td>Test</td>
  </tr>
```

```
</table>

<script>
  alert(table); // the table, as it should be

  table.remove();
  // why there's still aaa in the document?
</script>
```

To solution

Create a list

importance: 4

Write an interface to create a list from user input.

For every list item:

1. Ask a user about its content using `prompt`.
2. Create the `<li>` with it and add it to `<ul>`.
3. Continue until the user cancels the input (by pressing `Esc` or CANCEL in prompt).

All elements should be created dynamically.

If a user types HTML-tags, they should be treated like a text.

Demo in new window

To solution

Create a tree from the object

importance: 5

Write a function `createTree` that creates a nested `ul/li` list from the nested object.

For instance:

```
let data = {
  "Fish": {
    "trout": {},
    "salmon": {}
  },

  "Tree": {
    "Huge": {
      "sequoia": {},
      "oak": {}
    },
    "Flowering": {
      "apple tree": {},
      "magnolia": {}
    }
  }
};
```

The syntax:

```
let container = document.getElementById('container');
createTree(container, data); // creates the tree in the container
```

The result (tree) should look like this:

- Fish
  - trout
  - salmon
- Tree
  - Huge
    - sequoia
    - oak
  - Flowering
    - apple tree
    - magnolia

Choose one of two ways of solving this task:

1. Create the HTML for the tree and then assign to `container.innerHTML`.
2. Create tree nodes and append with DOM methods.

Would be great if you could do both.

P.S. The tree should not have "extra" elements like empty `<ul></ul>` for the leaves.

Open a sandbox for the task.

To solution

Show descendants in a tree

importance: 5

There's a tree organized as nested `ul/li`.

Write the code that adds to each `<li>` the number of its descendants. Skip leaves (nodes without children).

The result:

- Animals [9]
  - Mammals [4]
    - Cows
    - Donkeys
    - Dogs
    - Tigers
  - Other [3]
    - Snakes
    - Birds
    - Lizards
- Fishes [5]
  - Aquarium [2]

Open a sandbox for the task.

To solution

Create a calendar

importance: 4

Write a function `createCalendar(elem, year, month)`.

The call should create a calendar for the given year/month and put it inside `elem`.

The calendar should be a table, where a week is `<tr>`, and a day is `<td>`. The table top should be `<th>` with weekday names: the first day should be Monday, and so on till Sunday.

For instance, `createCalendar(cal, 2012, 9)` should generate in element `cal` the following calendar:

MO	TU	WE	TH	FR	SA	SU
					1	2
3	4	5	6	7	8	9
10	11	12	13	14	15	16
17	18	19	20	21	22	23
24	25	26	27	28	29	30

P.S. For this task it's enough to generate the calendar, should not yet be clickable.

Open a sandbox for the task.

To solution

Colored clock with setInterval

importance: 4

Create a colored clock like here:

10:59:39

Start Stop

Use HTML/CSS for the styling, JavaScript only updates time in elements.

Open a sandbox for the task.

To solution

Insert the HTML in the list

importance: 5

Write the code to insert `<li>2</li><li>3</li>` between two `<li>` here:

```
<ul id="ul">
  <li id="one">1</li>
  <li id="two">4</li>
</ul>
```

To solution

Sort the table

importance: 5

There's a table:

Name	Surname	Age
John	Smith	10
Pete	Brown	15
Ann	Lee	5
…	…	…

There may be more rows in it.

Write the code to sort it by the `"name"` column.

Open a sandbox for the task.

To solution

Styles and classes

Before we get into JavaScript's ways of dealing with styles and classes – here's an important rule. Hopefully it's obvious enough, but we still have to mention it.

There are generally two ways to style an element:

1. Create a class in CSS and add it: `<div class="...">`
2. Write properties directly into `style`: `<div style="...">`.

JavaScript can modify both classes and `style` properties.

We should always prefer CSS classes to `style`. The latter should only be used if classes "can't handle it".

For example, `style` is acceptable if we calculate coordinates of an element dynamically and want to set them from JavaScript, like this:

```
let top = /* complex calculations */;
let left = /* complex calculations */;

elem.style.left = left; // e.g '123px', calculated at run-time
elem.style.top = top; // e.g '456px'
```

For other cases, like making the text red, adding a background icon – describe that in CSS and then add the class (JavaScript can do that). That's more flexible and easier to support.

className and classList

Changing a class is one of the most often used actions in scripts.

In the ancient time, there was a limitation in JavaScript: a reserved word like `"class"` could not be an object property. That limitation does not exist now, but at that time it was impossible to have a `"class"` property, like `elem.class`.

So for classes the similar-looking property `"className"` was introduced: the `elem.className` corresponds to the `"class"` attribute.

For instance:

```
<body class="main page">
  <script>
    alert(document.body.className); // main page
  </script>
</body>
```

If we assign something to `elem.className`, it replaces the whole string of classes. Sometimes that's what we need, but often we want to add/remove a single class.

There's another property for that: `elem.classList`.

The `elem.classList` is a special object with methods to `add/remove/toggle` a single class.

For instance:

```
<body class="main page">
  <script>
    // add a class
    document.body.classList.add('article');
```

```
    alert(document.body.className); // main
page article
  </script>
</body>
```

So we can operate both on the full class string using `className` or on individual classes using `classList`. What we choose depends on our needs.

Methods of `classList`:

- `elem.classList.add/remove("class")` – adds/removes the class.
- `elem.classList.toggle("class")` – adds the class if it doesn't exist, otherwise removes it.
- `elem.classList.contains("class")` – checks for the given class, returns `true/false`.

Besides, `classList` is iterable, so we can list all classes with `for..of`, like this:

```
<body class="main page">
  <script>
    for (let name of document.body.classList) {
      alert(name); // main, and then page
    }
  </script>
</body>
```

Element style

The property `elem.style` is an object that corresponds to what's written in the `"style"` attribute. Setting `elem.style.width="100px"` works the same as if we had in the attribute `style` a string `width:100px`.

For multi-word property the camelCase is used:

```
background-color  => elem.style.backgroundColor
z-index           => elem.style.zIndex
border-left-width => elem.style.borderLeftWidth
```

For instance:

```
document.body.style.backgroundColor = prompt('background color?',
'green');
```

Prefixed properties

Browser-prefixed properties like `-moz-border-radius`, `-webkit-border-radius` also follow the same rule: a dash means upper case.

For instance:

```
button.style.MozBorderRadius = '5px';
button.style.WebkitBorderRadius = '5px';
```

Resetting the style property

Sometimes we want to assign a style property, and later remove it.

For instance, to hide an element, we can set `elem.style.display = "none"`.

Then later we may want to remove the `style.display` as if it were not set. Instead of `delete elem.style.display` we should assign an empty string to it: `elem.style.display = ""`.

```
// if we run this code, the <body> will blink
document.body.style.display = "none"; // hide

setTimeout(() => document.body.style.display = "", 1000); // back to normal
```

If we set `style.display` to an empty string, then the browser applies CSS classes and its built-in styles normally, as if there were no such `style.display` property at all.

Full rewrite with `style.cssText`

Normally, we use `style.*` to assign individual style properties. We can't set the full style like `div.style="color: red; width: 100px"`, because `div.style` is an object, and it's read-only.

To set the full style as a string, there's a special property `style.cssText`:

```
<div id="div">Button</div>

<script>
```

```
  // we can set special style flags like
"important" here
  div.style.cssText=`color: red
!important;
    background-color: yellow;
    width: 100px;
    text-align: center;
  `;

  alert(div.style.cssText);
</script>
```

This property is rarely used, because such assignment removes all existing styles: it does not add, but replaces them. May occasionally delete something needed. But we can safely use it for new elements, when we know we won't delete an existing style.

The same can be accomplished by setting an attribute: `div.setAttribute('style', 'color: red...')`.

Mind the units

Don't forget to add CSS units to values.

For instance, we should not set `elem.style.top` to `10`, but rather to `10px`. Otherwise it wouldn't work:

```
<body>
  <script>
    // doesn't work!
    document.body.style.margin = 20;
```

```
    alert(document.body.style.margin); // ''
(empty string, the assignment is ignored)

    // now add the CSS unit (px) - and it works
    document.body.style.margin = '20px';
    alert(document.body.style.margin); // 20px

    alert(document.body.style.marginTop); //
20px
    alert(document.body.style.marginLeft); //
20px
  </script>
</body>
```

Please note: the browser "unpacks" the property `style.margin` in the last lines and infers `style.marginLeft` and `style.marginTop` from it.

Computed styles: getComputedStyle

So, modifying a style is easy. But how to *read* it?

For instance, we want to know the size, margins, the color of an element. How to do it?

The `style` property operates only on the value of the `"style"` attribute, without any CSS cascade.

So we can't read anything that comes from CSS classes using `elem.style`.

For instance, here `style` doesn't see the margin:

```
<head>
  <style> body { color: red; margin: 5px } </style>
</head>
<body>

  The red text
  <script>
    alert(document.body.style.color); // empty
    alert(document.body.style.marginTop); //
empty
   </script>
</body>
```

…But what if we need, say, to increase the margin by `20px`? We would want the current value of it.

There's another method for that: `getComputedStyle`.

The syntax is:

```
getComputedStyle(element, [pseudo])
```

element

Element to read the value for.

pseudo

A pseudo-element if required, for instance `::before`. An empty string or no argument means the element itself.

The result is an object with styles, like `elem.style`, but now with respect to all CSS classes.

For instance:

```
<head>
  <style> body { color: red; margin: 5px } </style>
</head>
<body>

  <script>
    let computedStyle =
getComputedStyle(document.body);

    // now we can read the margin and the color
from it

    alert( computedStyle.marginTop ); // 5px
    alert( computedStyle.color ); // rgb(255,
0, 0)
   </script>

</body>
```

Computed and resolved values

There are two concepts in CSS:

1. A *computed* style value is the value after all CSS rules and CSS inheritance is applied, as the result of the CSS cascade. It can look like `height:1em` or `font-size:125%`.
2. A *resolved* style value is the one finally applied to the element. Values like `1em` or `125%` are relative. The browser takes the computed value and makes all units fixed and absolute, for instance: `height:20px` or `font-size:16px`. For geometry properties resolved values may have a floating point, like `width:50.5px`.

A long time ago `getComputedStyle` was created to get computed values, but it turned out that resolved values are much more convenient, and the standard changed.

So nowadays `getComputedStyle` actually returns the resolved value of the property, usually in `px` for geometry.

⚠ `getComputedStyle` requires the full property name

We should always ask for the exact property that we want, like `paddingLeft` or `marginTop` or `borderTopWidth`. Otherwise the correct result is not guaranteed.

For instance, if there are properties `paddingLeft/paddingTop`, then what should we get for `getComputedStyle(elem).padding`? Nothing, or maybe a "generated" value from known paddings? There's no standard rule here.

There are other inconsistencies. As an example, some browsers (Chrome) show `10px` in the document below, and some of them (Firefox) – do not:

```
<style>
  body {
    margin: 10px;
  }
</style>
<script>
  let style =
getComputedStyle(document.body);
  alert(style.margin); // empty string in
```

```
Firefox
</script>
```

Styles applied to `:visited` links are hidden!

Visited links may be colored using `:visited` CSS pseudoclass.

But `getComputedStyle` does not give access to that color, because otherwise an arbitrary page could find out whether the user visited a link by creating it on the page and checking the styles.

JavaScript may not see the styles applied by `:visited`. And also, there's a limitation in CSS that forbids applying geometry-changing styles in `:visited`. That's to guarantee that there's no side way for an evil page to test if a link was visited and hence to break the privacy.

Summary

To manage classes, there are two DOM properties:

- `className` – the string value, good to manage the whole set of classes.
- `classList` – the object with methods `add/remove/toggle/contains`, good for individual classes.

To change the styles:

- The `style` property is an object with camelCased styles. Reading and writing to it has the same meaning as modifying individual properties in the `"style"` attribute. To see how to apply

`important` and other rare stuff – there's a list of methods at MDN.
- The `style.cssText` property corresponds to the whole `"style"` attribute, the full string of styles.

To read the resolved styles (with respect to all classes, after all CSS is applied and final values are calculated):

- The `getComputedStyle(elem, [pseudo])` returns the style-like object with them. Read-only.

Tasks

Create a notification

importance: 5

Write a function `showNotification(options)` that creates a notification: `<div class="notification">` with the given content. The notification should automatically disappear after 1.5 seconds.

The options are:

```
// shows an element with the text "Hello" near the right-top of the window
showNotification({
  top: 10, // 10px from the top of the window (by default 0px)
  right: 10, // 10px from the right edge of the window (by default 0px)
  html: "Hello!", // the HTML of notification
  className: "welcome" // an additional class for the div (optional)
});
```

Demo in new window

Use CSS positioning to show the element at given top/right coordinates. The source document has the necessary styles.

Open a sandbox for the task.

To solution

Element size and scrolling

There are many JavaScript properties that allow us to read information about element width, height and other geometry features.

We often need them when moving or positioning elements in JavaScript.

Sample element

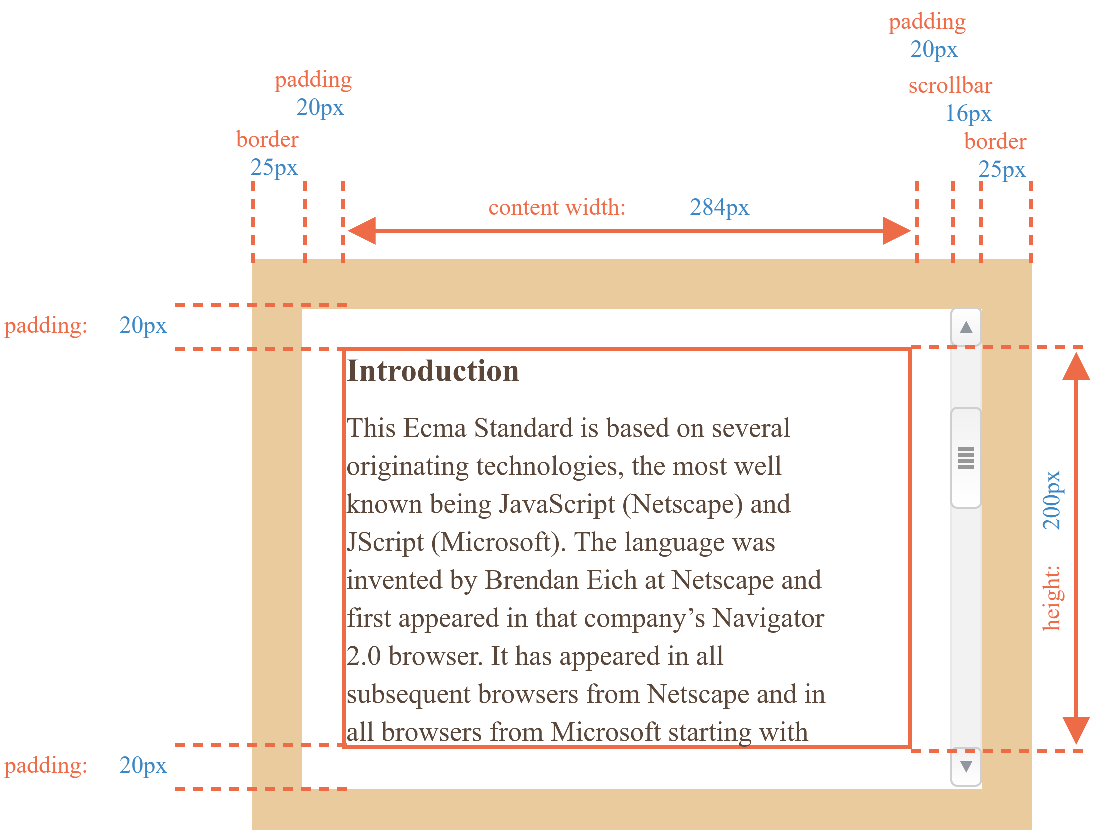
As a sample element to demonstrate properties we'll use the one given below:

```
<div id="example">
  ...Text...
</div>
<style>
  #example {
    width: 300px;
    height: 200px;
    border: 25px solid #E8C48F;
    padding: 20px;
    overflow: auto;
```

```
  }
</style>
```

It has the border, padding and scrolling. The full set of features. There are no margins, as they are not the part of the element itself, and there are no special properties for them.

The element looks like this:



You can open the document in the sandbox .

Mind the scrollbar

The picture above demonstrates the most complex case when the element has a scrollbar. Some browsers (not all) reserve the space for it by taking it from the content (labeled as "content width" above).

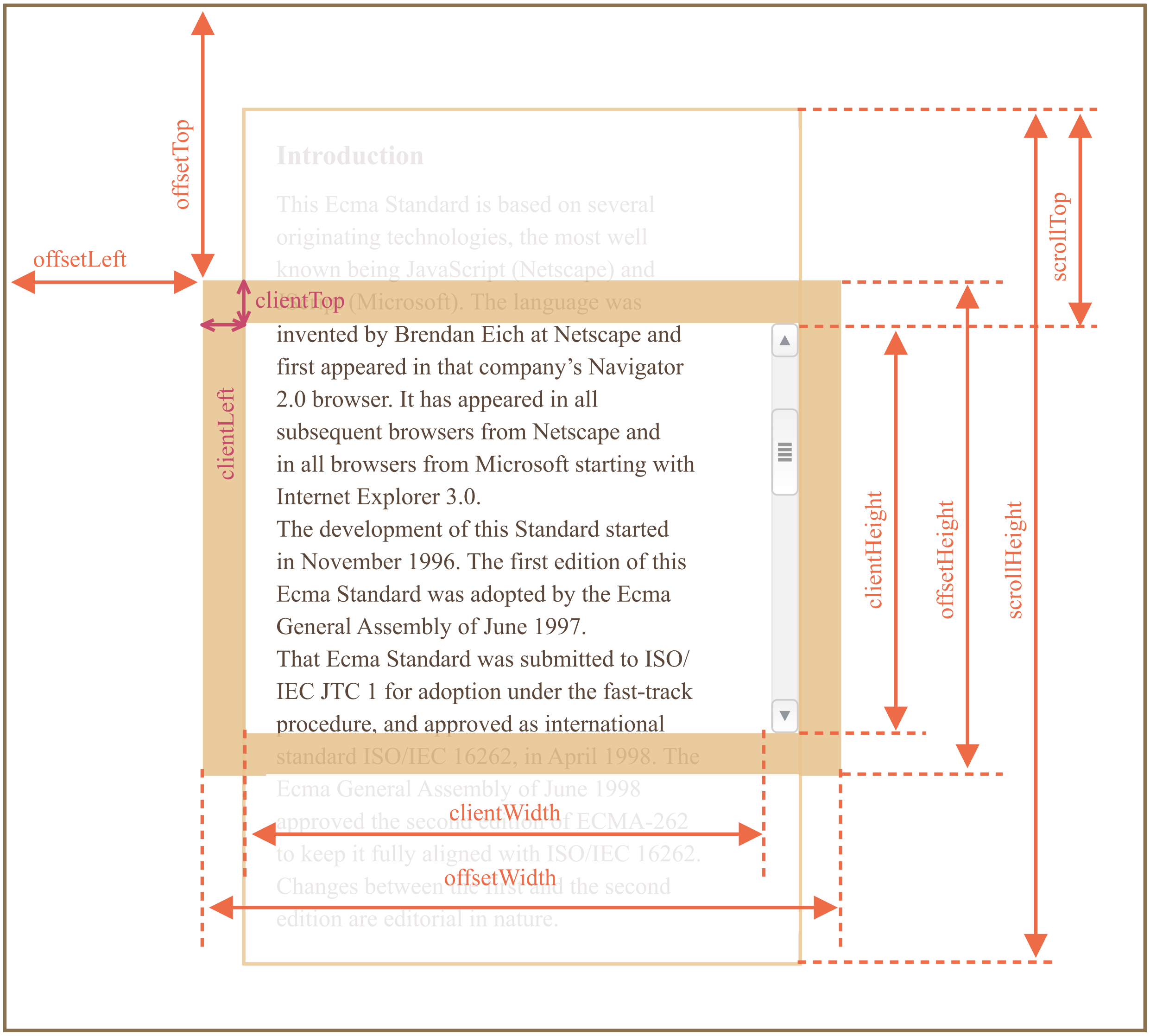
So, without scrollbar the content width would be `300px`, but if the scrollbar is `16px` wide (the width may vary between devices and browsers) then only `300 - 16 = 284px` remains, and we should take it into account. That's why examples from this chapter assume that there's a scrollbar. Without it, some calculations are simpler.

The `padding-bottom` area may be filled with text

Usually paddings are shown empty on our illustrations, but if there's a lot of text in the element and it overflows, then browsers show the "overflowing" text at `padding-bottom`, that's normal.

Geometry

Here’s the overall picture with geometry properties:



Values of these properties are technically numbers, but these numbers are “of pixels”, so these are pixel measurements.

Let’s start exploring the properties starting from the outside of the element.

offsetParent, offsetLeft/Top

These properties are rarely needed, but still they are the "most outer" geometry properties, so we'll start with them.

The `offsetParent` is the nearest ancestor that the browser uses for calculating coordinates during rendering.

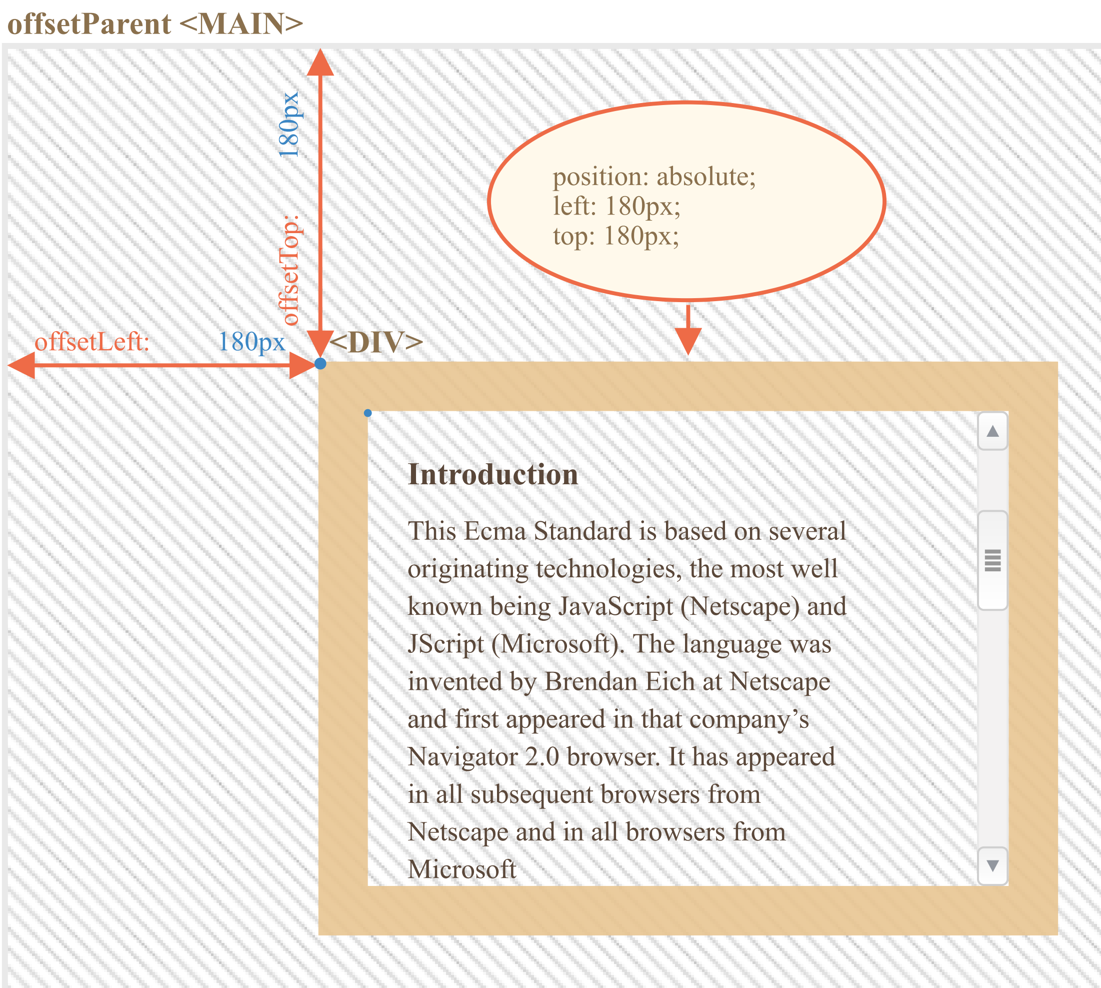
That's the nearest ancestor that is one of the following:

1. CSS-positioned (`position` is `absolute`, `relative`, `fixed` or `sticky`), or
2. `<td>`, `<th>`, or `<table>`, or
3. `<body>`.

Properties `offsetLeft/offsetTop` provide x/y coordinates relative to `offsetParent` upper-left corner.

In the example below the inner `<div>` has `<main>` as `offsetParent` and `offsetLeft/offsetTop` shifts from its upper-left corner (`180`):

```
<main style="position: relative" id="main">
  <article>
    <div id="example" style="position: absolute; left: 180px; top: 180px">...</div>
  </article>
</main>
<script>
  alert(example.offsetParent.id); // main
  alert(example.offsetLeft); // 180 (note: a number, not a string "180px")
  alert(example.offsetTop); // 180
</script>
```



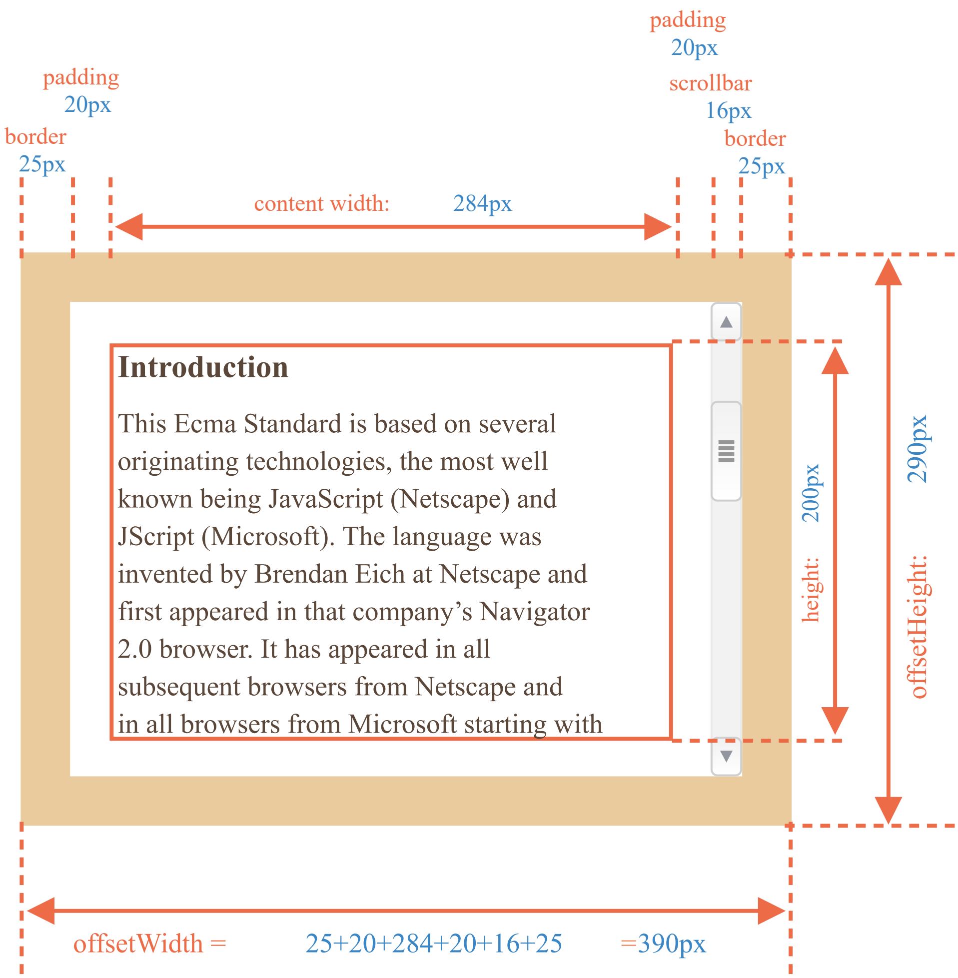
There are several occasions when `offsetParent` is `null`:

1. For not shown elements (`display:none` or not in the document).
2. For `<body>` and `<html>`.
3. For elements with `position:fixed`.

offsetWidth/Height

Now let's move on to the element itself.

These two properties are the simplest ones. They provide the "outer" width/height of the element. Or, in other words, its full size including borders.



For our sample element:

- `offsetWidth = 390` – the outer width, can be calculated as inner CSS-width (`300px`) plus paddings (`2 * 20px`) and borders (`2 * 25px`).
- `offsetHeight = 290` – the outer height.

> ### ℹ Geometry properties are zero/null for elements that are not displayed
>
> Geometry properties are calculated only for displayed elements.

If an element (or any of its ancestors) has `display:none` or is not in the document, then all geometry properties are zero (or `null` for `offsetParent`).

For example, `offsetParent` is `null`, and `offsetWidth`, `offsetHeight` are `0` when we created an element, but haven't inserted it into the document yet, or it (or it's ancestor) has `display:none`.

We can use this to check if an element is hidden, like this:

```
function isHidden(elem) {
  return !elem.offsetWidth && !elem.offsetHeight;
}
```

Please note that such `isHidden` returns `true` for elements that are on-screen, but have zero sizes (like an empty `<div>`).

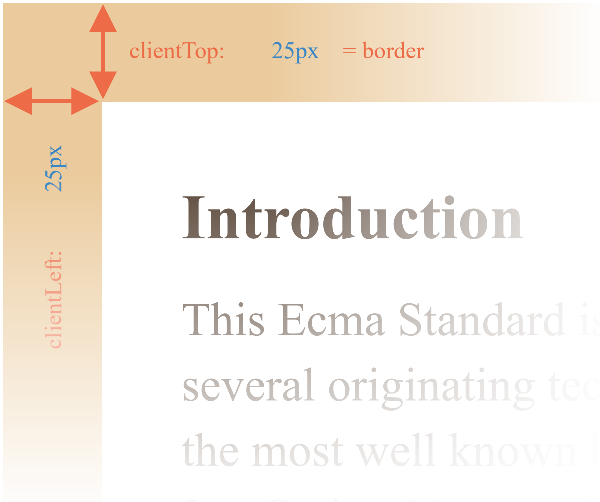
clientTop/Left

Inside the element we have the borders.

To measure them, there are properties `clientTop` and `clientLeft`.

In our example:

- `clientLeft = 25` – left border width
- `clientTop = 25` – top border width



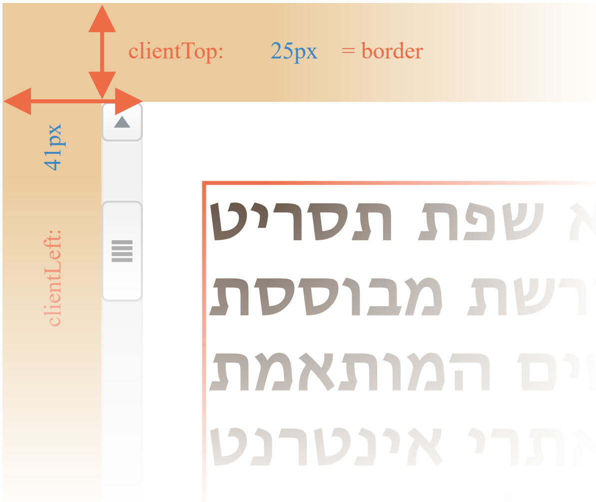
...But to be precise – these properties are not border width/height, but rather relative coordinates of the inner side from the outer side.

What's the difference?

It becomes visible when the document is right-to-left (the operating system is in Arabic or Hebrew languages). The scrollbar is then not on the right, but on the left, and then `clientLeft` also includes the scrollbar width.

In that case, `clientLeft` would be not `25`, but with the scrollbar width `25 + 16 = 41`.

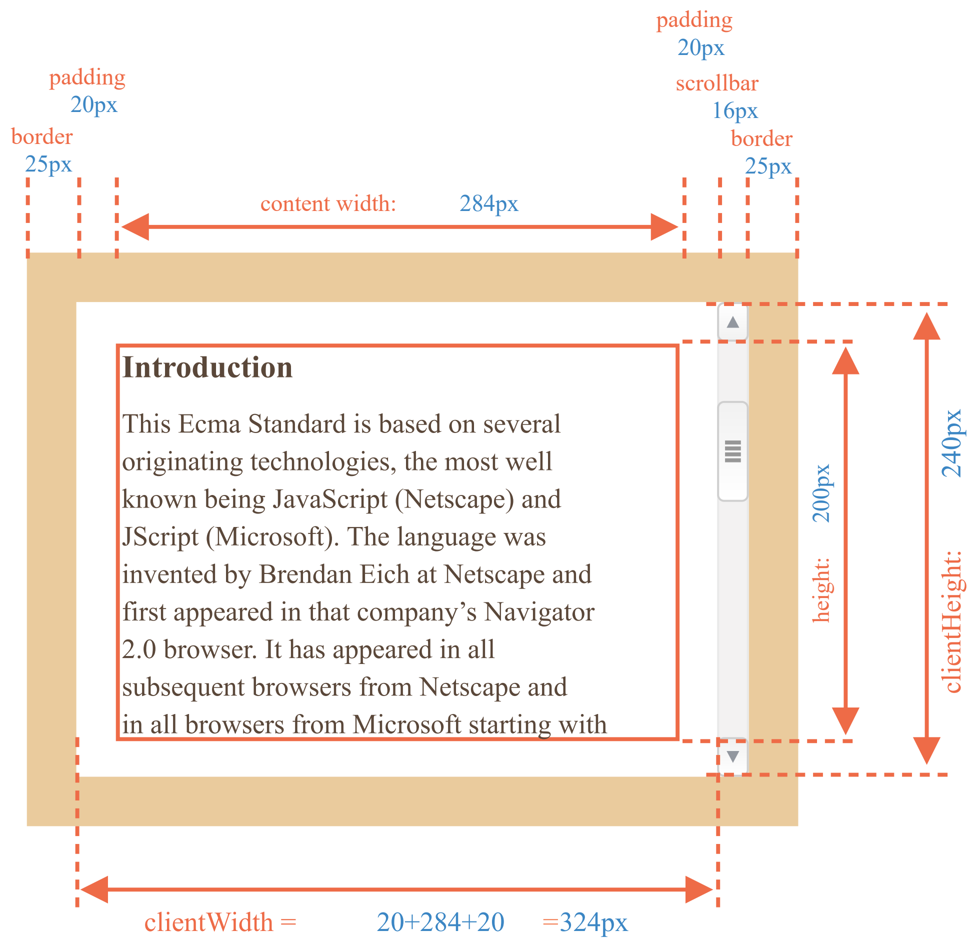
Here's the example in hebrew:



clientWidth/Height

These properties provide the size of the area inside the element borders.

They include the content width together with paddings, but without the scrollbar:

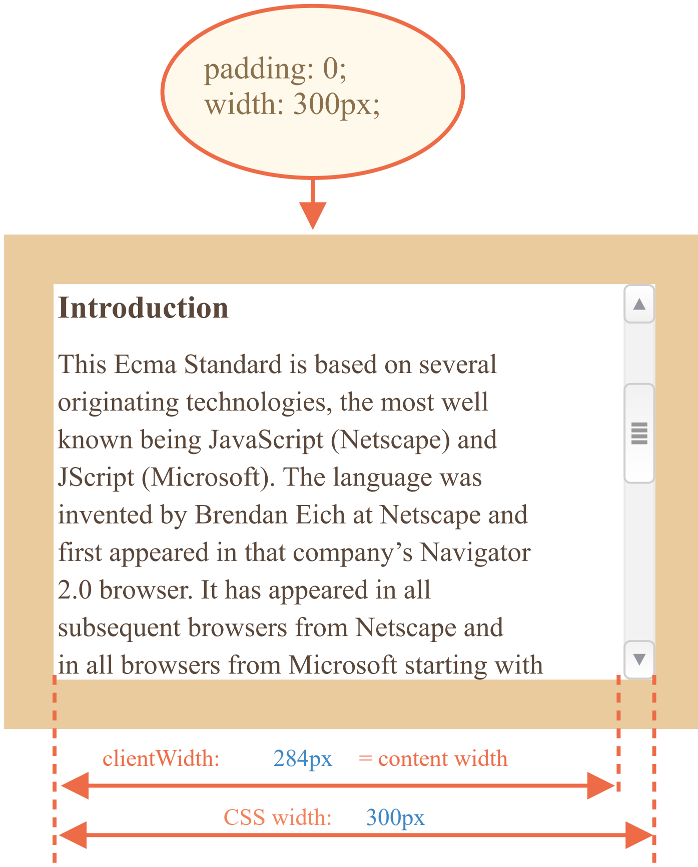


On the picture above let's first consider `clientHeight`.

There's no horizontal scrollbar, so it's exactly the sum of what's inside the borders: CSS-height `200px` plus top and bottom paddings (`2 * 20px`) total `240px`.

Now `clientWidth` – here the content width is not `300px`, but `284px`, because `16px` are occupied by the scrollbar. So the sum is `284px` plus left and right paddings, total `324px`.

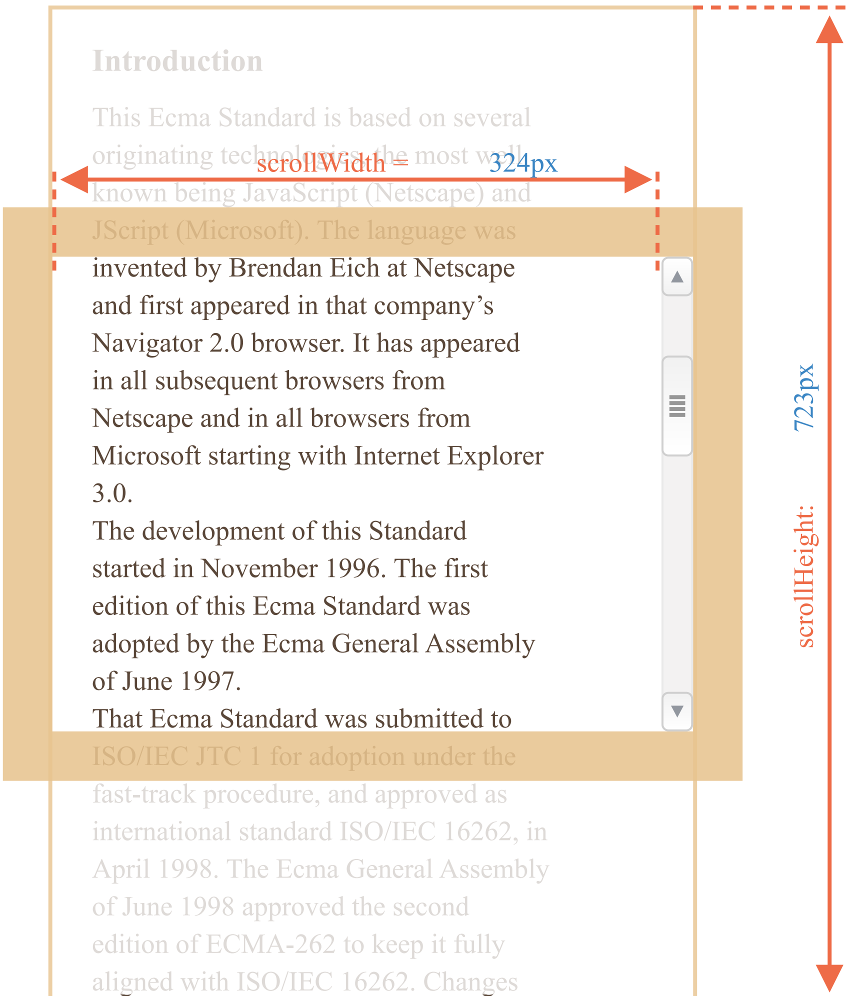
If there are no paddings, then `clientWidth/Height` is exactly the content area, inside the borders and the scrollbar (if any).



So when there's no padding we can use `clientWidth/clientHeight` to get the content area size.

scrollWidth/Height

These properties are like `clientWidth/clientHeight`, but they also include the scrolled out (hidden) parts:



On the picture above:

- `scrollHeight = 723` – is the full inner height of the content area including the scrolled out parts.
- `scrollWidth = 324` – is the full inner width, here we have no horizontal scroll, so it equals `clientWidth`.

We can use these properties to expand the element wide to its full width/height.

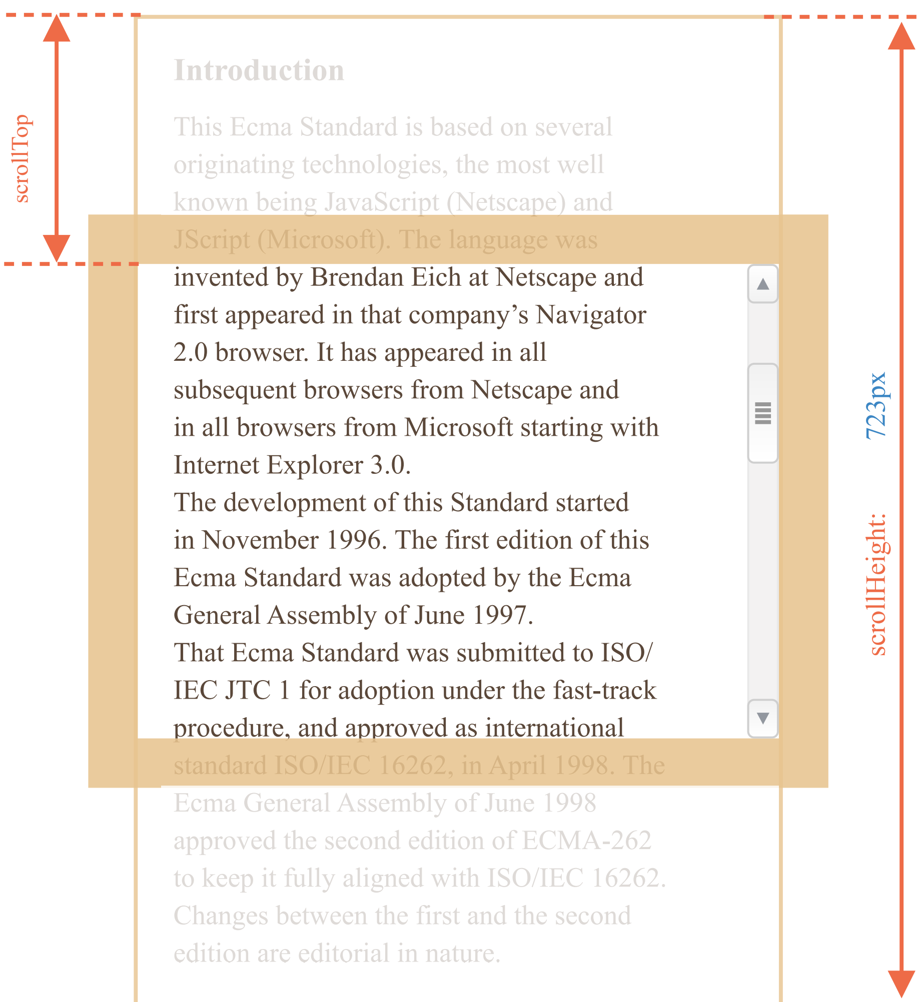
Like this:

```
// expand the element to the full content height
element.style.height = `${element.scrollHeight}px`;
```

scrollLeft/scrollTop

Properties `scrollLeft/scrollTop` are the width/height of the hidden, scrolled out part of the element.

On the picture below we can see `scrollHeight` and `scrollTop` for a block with a vertical scroll.



In other words, `scrollTop` is "how much is scrolled up".

> **`scrollLeft/scrollTop` can be modified**
>
> Most of the geometry properties here are read-only, but `scrollLeft/scrollTop` can be changed, and the browser will scroll the element.
>
> Setting `scrollTop` to `0` or `Infinity` will make the element scroll to the very top/bottom respectively.

Don't take width/height from CSS

We've just covered geometry properties of DOM elements, that can be used to get widths, heights and calculate distances.

But as we know from the chapter Styles and classes, we can read CSS-height and width using `getComputedStyle`.

So why not to read the width of an element with `getComputedStyle`, like this?

```
let elem = document.body;

alert( getComputedStyle(elem).width ); // show CSS width for elem
```

Why should we use geometry properties instead? There are two reasons:

1. First, CSS `width/height` depend on another property: `box-sizing` that defines "what is" CSS width and height. A change in `box-sizing` for CSS purposes may break such JavaScript.
2. Second, CSS `width/height` may be `auto`, for instance for an inline element:

```
<span id="elem">Hello!</span>

<script>
  alert( getComputedStyle(elem).width ); // auto
</script>
```

From the CSS standpoint, `width:auto` is perfectly normal, but in JavaScript we need an exact size in `px` that we can use in calculations. So here CSS width is useless.

And there's one more reason: a scrollbar. Sometimes the code that works fine without a scrollbar becomes buggy with it, because a scrollbar takes the space from the content in some browsers. So the real width available for the content is *less* than CSS width. And `clientWidth/clientHeight` take that into account.

...But with `getComputedStyle(elem).width` the situation is different. Some browsers (e.g. Chrome) return the real inner width, minus the scrollbar, and some of them (e.g. Firefox) – CSS width (ignore the scrollbar). Such cross-browser differences is the reason not to use `getComputedStyle`, but rather rely on geometry properties.

Please note that the described difference is only about reading `getComputedStyle(...).width` from JavaScript, visually everything is correct.

Summary

Elements have the following geometry properties:

- `offsetParent` – is the nearest positioned ancestor or `td`, `th`, `table`, `body`.

- `offsetLeft/offsetTop` – coordinates relative to the upper-left edge of `offsetParent`.
- `offsetWidth/offsetHeight` – “outer” width/height of an element including borders.
- `clientLeft/clientTop` – the distance from the upper-left outer corner the inner corner. For left-to-right OS they are always the widths of left/top borders. For right-to-left OS the vertical scrollbar is on the left so `clientLeft` includes its width too.
- `clientWidth/clientHeight` – the width/height of the content including paddings, but without the scrollbar.
- `scrollWidth/scrollHeight` – the width/height of the content, just like `clientWidth/clientHeight`, but also include scrolled-out, invisible part of the element.
- `scrollLeft/scrollTop` – width/height of the scrolled out upper part of the element, starting from its upper-left corner.

All properties are read-only except `scrollLeft/scrollTop` that make the browser scroll the element if changed.

Tasks

What's the scroll from the bottom?

importance: 5

The `elem.scrollTop` property is the size of the scrolled out part from the top. How to get the size of the bottom scroll (let’s call it `scrollBottom`)?

Write the code that works for an arbitrary `elem`.

P.S. Please check your code: if there's no scroll or the element is fully scrolled down, then it should return `0`.

To solution

What is the scrollbar width?

importance: 3

Write the code that returns the width of a standard scrollbar.

For Windows it usually varies between `12px` and `20px`. If the browser doesn't reserve any space for it (the scrollbar is half-translucent over the text, also happens), then it may be `0px`.

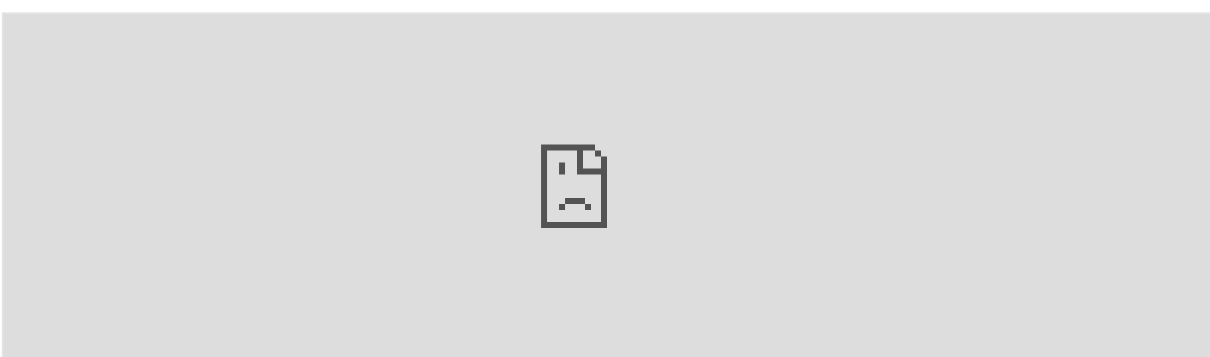
P.S. The code should work for any HTML document, do not depend on its content.

To solution

Place the ball in the field center

importance: 5

Here's how the source document looks:



What are coordinates of the field center?

Calculate them and use to place the ball into the center of the field:

- The element should be moved by JavaScript, not CSS.
- The code should work with any ball size (`10`, `20`, `30` pixels) and any field size, not be bound to the given values.

P.S. Sure, centering could be done with CSS, but here we want exactly JavaScript. Further we'll meet other topics and more complex situations when JavaScript must be used. Here we do a "warm-up".

Open a sandbox for the task.

To solution

The difference: CSS width versus clientWidth

importance: 5

What's the difference between `getComputedStyle(elem).width` and `elem.clientWidth`?

Give at least 3 differences. The more the better.

To solution

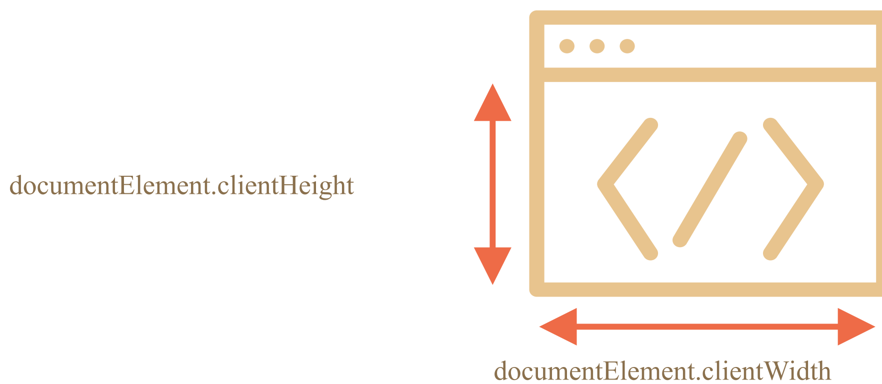
Window sizes and scrolling

How do we find the width and height of the browser window? How do we get the full width and height of the document, including the scrolled out part? How do we scroll the page using JavaScript?

For most such requests, we can use the root document element `document.documentElement`, that corresponds to the `<html>` tag. But there are additional methods and peculiarities important enough to consider.

Width/height of the window

To get window width and height we can use `clientWidth/clientHeight` of `document.documentElement`:



> ⚠ **Not `window.innerWidth/Height`**
>
> Browsers also support properties `window.innerWidth/innerHeight`. They look like what we want. So why not to use them instead?
>
> If there exists a scrollbar, and it occupies some space, `clientWidth/clientHeight` provide the width/height without it (subtract it). In other words, they return width/height of the visible part of the document, available for the content.

…And `window.innerWidth/innerHeight` include the scrollbar.

If there's a scrollbar, and it occupies some space, then these two lines show different values:

```
alert( window.innerWidth ); // full window width
alert( document.documentElement.clientWidth ); // window width
minus the scrollbar
```

In most cases we need the *available* window width: to draw or position something. That is: inside scrollbars if there are any. So we should use `documentElement.clientHeight/Width`.

⚠ `DOCTYPE` is important

Please note: top-level geometry properties may work a little bit differently when there's no `<!DOCTYPE HTML>` in HTML. Odd things are possible.

In modern HTML we should always write `DOCTYPE`.

Width/height of the document

Theoretically, as the root document element is `document.documentElement`, and it encloses all the content, we could measure document full size as `document.documentElement.scrollWidth/scrollHeight`.

But on that element, for the whole page, these properties do not work as intended. In Chrome/Safari/Opera if there's no scroll, then `documentElement.scrollHeight` may be even less than `documentElement.clientHeight`! Sounds like a nonsense, weird, right?

To reliably obtain the full document height, we should take the maximum of these properties:

```
let scrollHeight = Math.max(
  document.body.scrollHeight, document.documentElement.scrollHeight,
  document.body.offsetHeight, document.documentElement.offsetHeight,
  document.body.clientHeight, document.documentElement.clientHeight
);

alert('Full document height, with scrolled out part: ' + scrollHeight);
```

Why so? Better don't ask. These inconsistencies come from ancient times, not a "smart" logic.

Get the current scroll

DOM elements have their current scroll state in `elem.scrollLeft/scrollTop`.

For document scroll `document.documentElement.scrollLeft/Top` works in most browsers, except older WebKit-based ones, like Safari (bug 5991), where we should use `document.body` instead of `document.documentElement`.

Luckily, we don't have to remember these peculiarities at all, because the scroll is available in the special properties `window.pageXOffset/pageYOffset`:

```
alert('Current scroll from the top: ' + window.pageYOffset);
alert('Current scroll from the left: ' + window.pageXOffset);
```

These properties are read-only.

Scrolling: scrollTo, scrollBy, scrollIntoView

> ⚠ **Important:**
>
> To scroll the page from JavaScript, its DOM must be fully built.
>
> For instance, if we try to scroll the page from the script in `<head>`, it won't work.

Regular elements can be scrolled by changing `scrollTop/scrollLeft`.

We can do the same for the page using `document.documentElement.scrollTop/Left` (except Safari, where `document.body.scrollTop/Left` should be used instead).

Alternatively, there's a simpler, universal solution: special methods window.scrollBy(x,y) and window.scrollTo(pageX,pageY) .

- The method `scrollBy(x,y)` scrolls the page *relative to its current position*. For instance, `scrollBy(0,10)` scrolls the page `10px` down.
- The method `scrollTo(pageX,pageY)` scrolls the page *to absolute coordinates*, so that the top-left corner of the visible part has coordinates `(pageX, pageY)` relative to the document's top-left corner. It's like setting `scrollLeft/scrollTop`.

  To scroll to the very beginning, we can use `scrollTo(0,0)`.

These methods work for all browsers the same way.

scrollIntoView

For completeness, let's cover one more method: elem.scrollIntoView(top) .

The call to `elem.scrollIntoView(top)` scrolls the page to make `elem` visible. It has one argument:

- if `top=true` (that's the default), then the page will be scrolled to make `elem` appear on the top of the window. The upper edge of the element is aligned with the window top.
- if `top=false`, then the page scrolls to make `elem` appear at the bottom. The bottom edge of the element is aligned with the window bottom.

Forbid the scrolling

Sometimes we need to make the document "unscrollable". For instance, when we need to cover it with a large message requiring immediate attention, and we want the visitor to interact with that message, not with the document.

To make the document unscrollable, it's enough to set `document.body.style.overflow = "hidden"`. The page will freeze on its current scroll.

We can use the same technique to "freeze" the scroll for other elements, not just for `document.body`.

The drawback of the method is that the scrollbar disappears. If it occupied some space, then that space is now free, and the content "jumps" to fill it.

That looks a bit odd, but can be worked around if we compare `clientWidth` before and after the freeze, and if it increased (the scrollbar disappeared) then add `padding` to `document.body` in place of the scrollbar, to keep the content width the same.

Summary

Geometry:

- Width/height of the visible part of the document (content area width/height): `document.documentElement.clientWidth/Height`
- Width/height of the whole document, with the scrolled out part:

```
let scrollHeight = Math.max(
  document.body.scrollHeight, document.documentElement.scrollHeight,
  document.body.offsetHeight, document.documentElement.offsetHeight,
  document.body.clientHeight, document.documentElement.clientHeight
);
```

Scrolling:

- Read the current scroll: `window.pageYOffset/pageXOffset`.
- Change the current scroll:
  - `window.scrollTo(pageX,pageY)` – absolute coordinates,
  - `window.scrollBy(x,y)` – scroll relative the current place,
  - `elem.scrollIntoView(top)` – scroll to make `elem` visible (align with the top/bottom of the window).

Coordinates

To move elements around we should be familiar with coordinates.

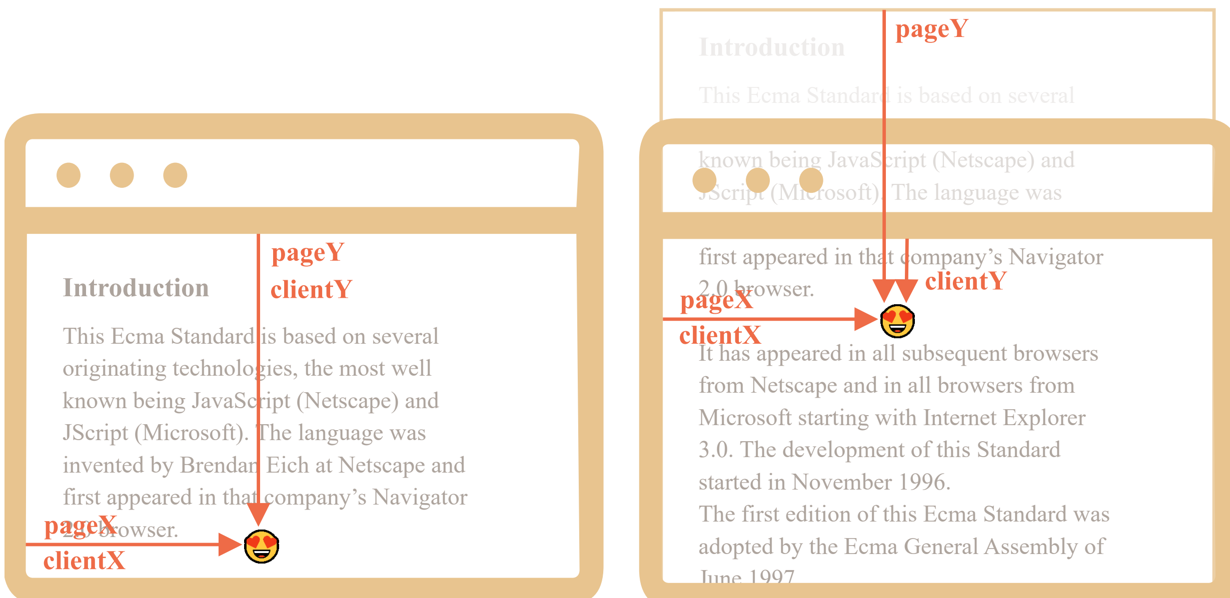
Most JavaScript methods deal with one of two coordinate systems:

1. **Relative to the window** – similar to `position:fixed`, calculated from the window top/left edge.
   - we'll denote these coordinates as `clientX/clientY`, the reasoning for such name will become clear later, when we study event properties.
2. **Relative to the document** – similar to `position:absolute` in the document root, calculated from the document top/left edge.

- we'll denote them `pageX/pageY`.

When the page is scrolled to the very beginning, so that the top/left corner of the window is exactly the document top/left corner, these coordinates equal each other. But after the document shifts, window-relative coordinates of elements change, as elements move across the window, while document-relative coordinates remain the same.

On this picture we take a point in the document and demonstrate its coordinates before the scroll (left) and after it (right):



When the document scrolled:

- `pageY` – document-relative coordinate stayed the same, it's counted from the document top (now scrolled out).
- `clientY` – window-relative coordinate did change (the arrow became shorter), as the same point became closer to window top.

Element coordinates: getBoundingClientRect

The method `elem.getBoundingClientRect()` returns window coordinates for a minimal rectangle that encloses `elem` as an object of built-in DOMRect class.

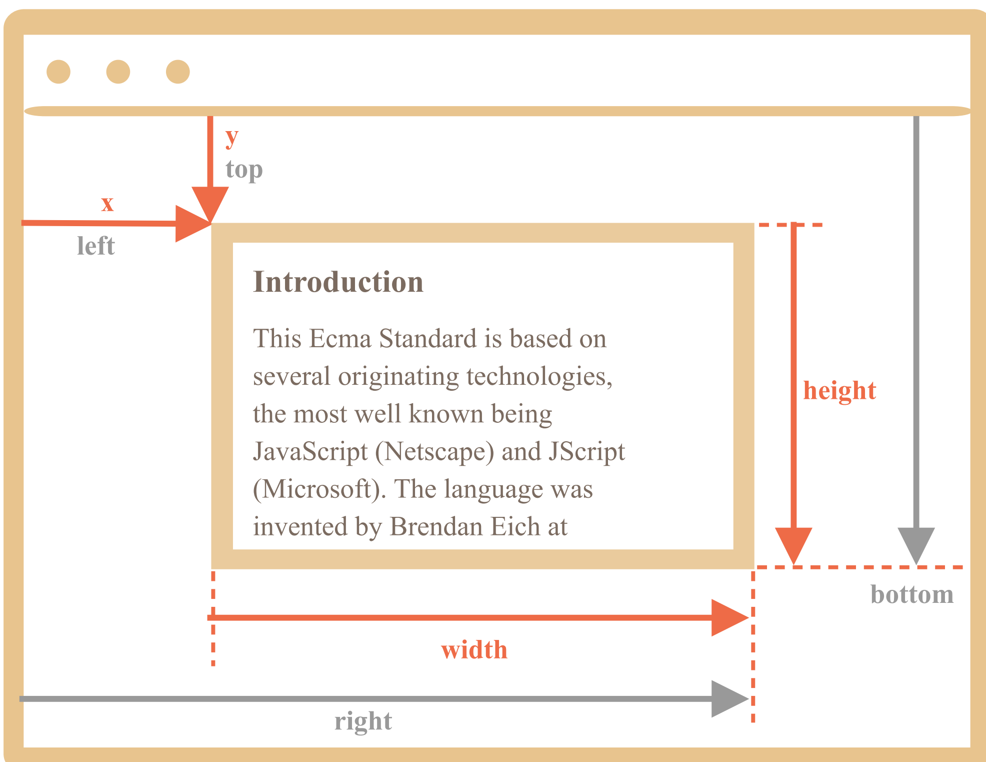
Main `DOMRect` properties:

- `x/y` – X/Y-coordinates of the rectangle origin relative to window,
- `width/height` – width/height of the rectangle (can be negative).

Additionally, there are derived properties:

- `top/bottom` – Y-coordinate for the top/bottom rectangle edge,
- `left/right` – X-coordinate for the left/right rectangle edge.

Here's the picture of `elem.getBoundingClientRect()` output:



As you can see, `x/y` and `width/height` fully describe the rectangle. Derived properties can be easily calculated from them:

- `left = x`

- `top = y`
- `right = x + width`
- `bottom = y + height`

Please note:

- Coordinates may be decimal fractions, such as `10.5`. That's normal, internally browser uses fractions in calculations. We don't have to round them when setting to `style.left/top`.
- Coordinates may be negative. For instance, if the page is scrolled so that `elem` is now above the window, then `elem.getBoundingClientRect().top` is negative.

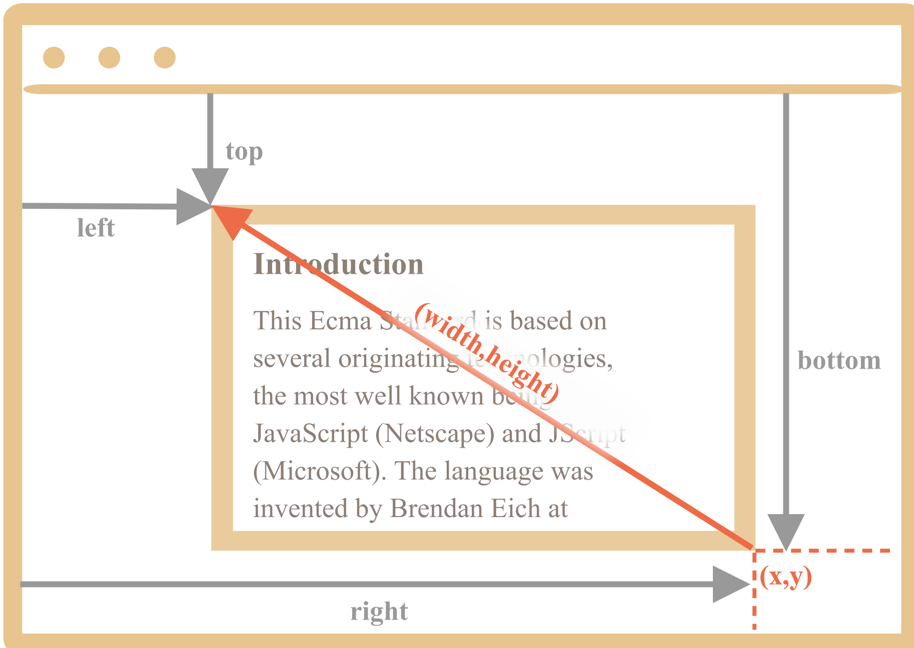
Why derived properties are needed? Why does `top/left` exist if there's `x/y`?

Mathematically, a rectangle is uniquely defined with its starting point `(x,y)` and the direction vector `(width,height)`. So the additional derived properties are for convenience.

Technically it's possible for `width/height` to be negative, that allows for "directed" rectangle, e.g. to represent mouse selection with properly marked start and end.

Negative `width/height` values mean that the rectangle starts at its bottom-right corner and then "grows" left-upwards.

Here's a rectangle with negative `width` and `height` (e.g. `width=-200`, `height=-100`):



As you can see, `left/top` do not equal `x/y` in such case.

In practice though, `elem.getBoundingClientRect()` always returns positive width/height, here we mention negative `width/height` only for you to understand why these seemingly duplicate properties are not actually duplicates.

⚠ Internet Explorer and Edge: no support for `x/y`

Internet Explorer and Edge don't support `x/y` properties for historical reasons.

So we can either make a polywill (add getters in `DomRect.prototype`) or just use `top/left`, as they are always the same as `x/y` for positive `width/height`, in particular in the result of `elem.getBoundingClientRect()`.

⚠ Coordinates right/bottom are different from CSS position properties

There are obvious similarities between window-relative coordinates and CSS `position:fixed`.

But in CSS positioning, `right` property means the distance from the right edge, and `bottom` property means the distance from the bottom edge.

If we just look at the picture above, we can see that in JavaScript it is not so. All window coordinates are counted from the top-left corner, including these ones.

elementFromPoint(x, y)

The call to `document.elementFromPoint(x, y)` returns the most nested element at window coordinates `(x, y)`.

The syntax is:

```
let elem = document.elementFromPoint(x, y);
```

For instance, the code below highlights and outputs the tag of the element that is now in the middle of the window:

```
let centerX = document.documentElement.clientWidth / 2;
let centerY = document.documentElement.clientHeight / 2;

let elem = document.elementFromPoint(centerX, centerY);

elem.style.background = "red";
alert(elem.tagName);
```

As it uses window coordinates, the element may be different depending on the current scroll position.

⚠ For out-of-window coordinates the `elementFromPoint` returns `null`

The method `document.elementFromPoint(x,y)` only works if `(x,y)` are inside the visible area.

If any of the coordinates is negative or exceeds the window width/height, then it returns `null`.

Here's a typical error that may occur if we don't check for it:

```
let elem = document.elementFromPoint(x, y);
// if the coordinates happen to be out of the window, then elem =
null
elem.style.background = ''; // Error!
```

Using for "fixed" positioning

Most of time we need coordinates in order to position something.

To show something near an element, we can use `getBoundingClientRect` to get its coordinates, and then CSS `position` together with `left/top` (or `right/bottom`).

For instance, the function `createMessageUnder(elem, html)` below shows the message under `elem`:

```
let elem = document.getElementById("coords-show-mark");

function createMessageUnder(elem, html) {
  // create message element
  let message = document.createElement('div');
```

```
  // better to use a css class for the style here
  message.style.cssText = "position:fixed; color: red";

  // assign coordinates, don't forget "px"!
  let coords = elem.getBoundingClientRect();

  message.style.left = coords.left + "px";
  message.style.top = coords.bottom + "px";

  message.innerHTML = html;

  return message;
}

// Usage:
// add it for 5 seconds in the document
let message = createMessageUnder(elem, 'Hello, world!');
document.body.append(message);
setTimeout(() => message.remove(), 5000);
```

The code can be modified to show the message at the left, right, below, apply CSS animations to “fade it in” and so on. That’s easy, as we have all the coordinates and sizes of the element.

But note the important detail: when the page is scrolled, the message flows away from the button.

The reason is obvious: the message element relies on `position:fixed`, so it remains at the same place of the window while the page scrolls away.

To change that, we need to use document-based coordinates and `position:absolute`.

Document coordinates

Document-relative coordinates start from the upper-left corner of the document, not the window.

In CSS, window coordinates correspond to `position:fixed`, while document coordinates are similar to `position:absolute` on top.

We can use `position:absolute` and `top/left` to put something at a certain place of the document, so that it remains there during a page scroll. But we need the right coordinates first.

There's no standard method to get the document coordinates of an element. But it's easy to write it.

The two coordinate systems are connected by the formula:

- `pageY` = `clientY` + height of the scrolled-out vertical part of the document.
- `pageX` = `clientX` + width of the scrolled-out horizontal part of the document.

The function `getCoords(elem)` will take window coordinates from `elem.getBoundingClientRect()` and add the current scroll to them:

```
// get document coordinates of the element
function getCoords(elem) {
  let box = elem.getBoundingClientRect();

  return {
    top: box.top + pageYOffset,
    left: box.left + pageXOffset
  };
}
```

If in the example above we used it with `position:absolute`, then the message would stay near the element on scroll.

The modified `createMessageUnder` function:

```
function createMessageUnder(elem, html) {
  let message = document.createElement('div');
  message.style.cssText = "position:absolute; color: red";

  let coords = getCoords(elem);
```

```
  message.style.left = coords.left + "px";
  message.style.top = coords.bottom + "px";

  message.innerHTML = html;

  return message;
}
```

Summary

Any point on the page has coordinates:

1. Relative to the window – `elem.getBoundingClientRect()`.
2. Relative to the document – `elem.getBoundingClientRect()` plus the current page scroll.

Window coordinates are great to use with `position:fixed`, and document coordinates do well with `position:absolute`.

Both coordinate systems have their pros and cons; there are times we need one or the other one, just like CSS `position` `absolute` and `fixed`.

Tasks

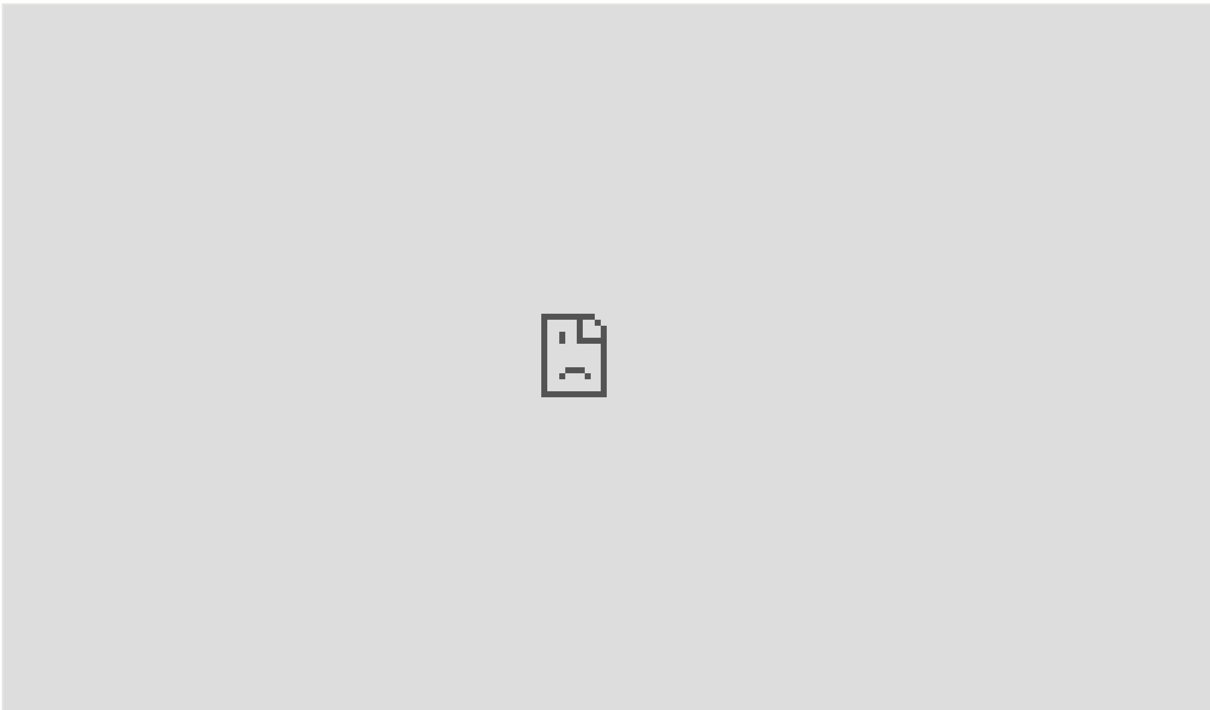
Find window coordinates of the field

importance: 5

In the iframe below you can see a document with the green “field”.

Use JavaScript to find window coordinates of corners pointed by with arrows.

There’s a small feature implemented in the document for convenience. A click at any place shows coordinates there.



Your code should use DOM to get window coordinates of:

1. Upper-left, outer corner (that’s simple).
2. Bottom-right, outer corner (simple too).
3. Upper-left, inner corner (a bit harder).
4. Bottom-right, inner corner (there are several ways, choose one).

The coordinates that you calculate should be the same as those returned by the mouse click.

P.S. The code should also work if the element has another size or border, not bound to any fixed values.

Open a sandbox for the task.

To solution

Show a note near the element

importance: 5

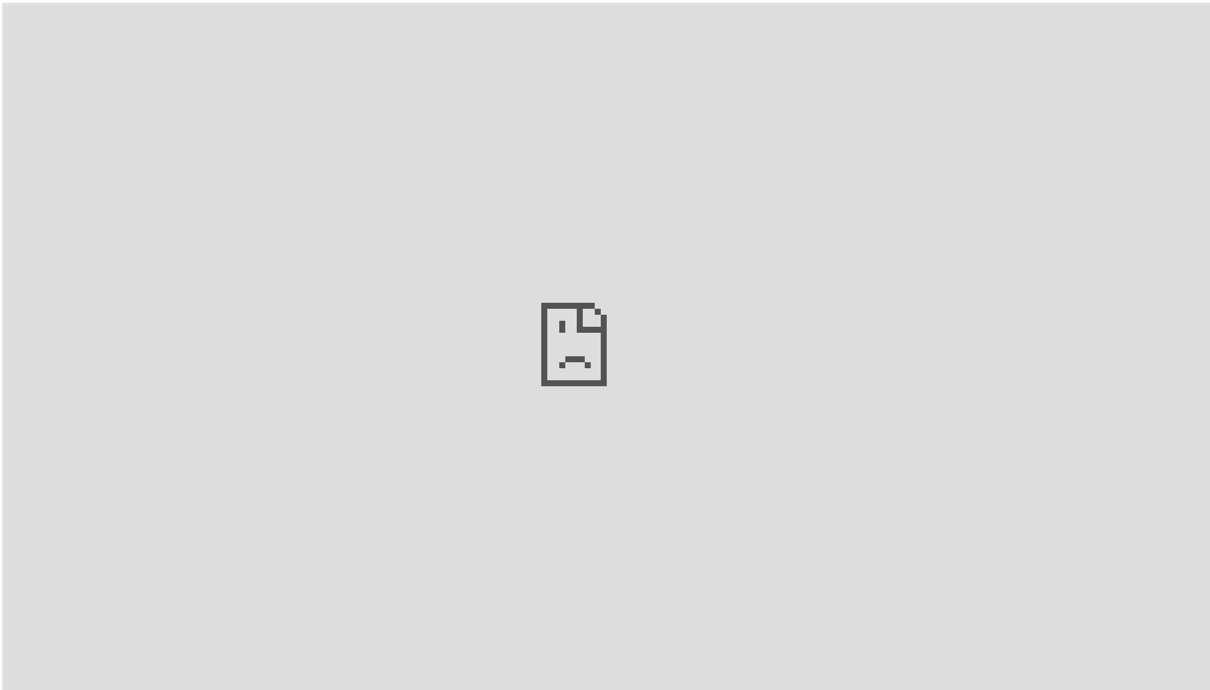
Create a function `positionAt(anchor, position, elem)` that positions `elem`, depending on `position` near `anchor` element.

The `position` must be a string with any one of 3 values:

- `"top"` – position `elem` right above `anchor`
- `"right"` – position `elem` immediately at the right of `anchor`
- `"bottom"` – position `elem` right below `anchor`

It's used inside function `showNote(anchor, position, html)`, provided in the task source code, that creates a "note" element with given `html` and shows it at the given `position` near the `anchor`.

Here's the demo of notes:



Open a sandbox for the task.

To solution

Show a note near the element (absolute)

importance: 5

Modify the solution of the previous task so that the note uses `position:absolute` instead of `position:fixed`.

That will prevent its “runaway” from the element when the page scrolls.

Take the solution of that task as a starting point. To test the scroll, add the style `<body style="height: 2000px">`.

To solution

Position the note inside (absolute)

importance: 5

Extend the previous task Show a note near the element (absolute): teach the function `positionAt(anchor, position, elem)` to insert `elem` inside the `anchor`.

New values for `position`:

- `top-out`, `right-out`, `bottom-out` – work the same as before, they insert the `elem` over/right/under `anchor`.
- `top-in`, `right-in`, `bottom-in` – insert `elem` inside the `anchor`: stick it to the upper/right/bottom edge.

For instance:

```
// shows the note above blockquote
positionAt(blockquote, "top-out", note);

// shows the note inside blockquote, at the top
positionAt(blockquote, "top-in", note);
```

The result:

As the source code, take the solution of the task Show a note near the element (absolute).

To solution

Introduction to Events

An introduction to browser events, event properties and handling patterns.

Introduction to browser events

An event is a signal that something has happened. All DOM nodes generate such signals (but events are not limited to DOM).

Here’s a list of the most useful DOM events, just to take a look at:

Mouse events:

- `click` – when the mouse clicks on an element (touchscreen devices generate it on a tap).
- `contextmenu` – when the mouse right-clicks on an element.
- `mouseover` / `mouseout` – when the mouse cursor comes over / leaves an element.
- `mousedown` / `mouseup` – when the mouse button is pressed / released over an element.
- `mousemove` – when the mouse is moved.

Form element events:

- `submit` – when the visitor submits a `<form>`.
- `focus` – when the visitor focuses on an element, e.g. on an `<input>`.

Keyboard events:

- `keydown` and `keyup` – when the visitor presses and then releases the button.

Document events:

- `DOMContentLoaded` – when the HTML is loaded and processed, DOM is fully built.

CSS events:

- `transitionend` – when a CSS-animation finishes.

There are many other events. We'll get into more details of particular events in next chapters.

Event handlers

To react on events we can assign a *handler* – a function that runs in case of an event.

Handlers are a way to run JavaScript code in case of user actions.

There are several ways to assign a handler. Let's see them, starting from the simplest one.

HTML-attribute

A handler can be set in HTML with an attribute named `on<event>`.

For instance, to assign a `click` handler for an `input`, we can use `onclick`, like here:

```
<input value="Click me" onclick="alert('Click!')" type="button">
```

On mouse click, the code inside `onclick` runs.

Please note that inside `onclick` we use single quotes, because the attribute itself is in double quotes. If we forget that the code is inside the attribute and use double quotes inside, like this: `onclick="alert("Click!")"`, then it won't work right.

An HTML-attribute is not a convenient place to write a lot of code, so we'd better create a JavaScript function and call it there.

Here a click runs the function `countRabbits()`:

```
<script>
  function countRabbits() {
    for(let i=1; i<=3; i++) {
      alert("Rabbit number " + i);
    }
  }
</script>

<input type="button" onclick="countRabbits()" value="Count rabbits!">
```

Count rabbits!

As we know, HTML attribute names are not case-sensitive, so `ONCLICK` works as well as `onClick` and `onCLICK`... But usually attributes are lowercased: `onclick`.

DOM property

We can assign a handler using a DOM property `on<event>`.

For instance, `elem.onclick`:

```
<input id="elem" type="button" value="Click me">
<script>
  elem.onclick = function() {
    alert('Thank you');
  };
</script>
```

Click me

If the handler is assigned using an HTML-attribute then the browser reads it, creates a new function from the attribute content and writes it to the DOM property.

So this way is actually the same as the previous one.

The handler is always in the DOM property: the HTML-attribute is just one of the ways to initialize it.

These two code pieces work the same:

1. Only HTML:

```
<input type="button" onclick="alert('Click!')" value="Button">
```

Button

2. HTML + JS:

```
<input type="button" id="button" value="Button">
<script>
  button.onclick = function() {
    alert('Click!');
  };
</script>
```

Button

As there's only one `onclick` property, we can't assign more than one event handler.

In the example below adding a handler with JavaScript overwrites the existing handler:

```
<input type="button" id="elem" onclick="alert('Before')" value="Click me">
<script>
  elem.onclick = function() { // overwrites the existing handler
    alert('After'); // only this will be shown
  };
</script>
```

Click me

By the way, we can assign an existing function as a handler directly:

```
function sayThanks() {
  alert('Thanks!');
}

elem.onclick = sayThanks;
```

To remove a handler – assign `elem.onclick = null`.

Accessing the element: this

The value of `this` inside a handler is the element. The one which has the handler on it.

In the code below `button` shows its contents using `this.innerHTML`:

```html
<button onclick="alert(this.innerHTML)">Click me</button>
```

Click me

Possible mistakes

If you're starting to work with events – please note some subtleties.

The function should be assigned as `sayThanks`, not `sayThanks()`.

```javascript
// right
button.onclick = sayThanks;

// wrong
button.onclick = sayThanks();
```

If we add parentheses, `sayThanks()` – is a function call. So the last line actually takes the *result* of the function execution, that is `undefined` (as the function returns nothing), and assigns it to `onclick`. That doesn't work.

…On the other hand, in the markup we do need the parentheses:

```html
<input type="button" id="button" onclick="sayThanks()">
```

The difference is easy to explain. When the browser reads the attribute, it creates a handler function with *body from its content*: `sayThanks()`.

So the markup generates this property:

```
button.onclick = function() {
  sayThanks(); // the attribute content
};
```

Use functions, not strings.

The assignment `elem.onclick = "alert(1)"` would work too. It works for compatibility reasons, but is strongly not recommended.

Don't use `setAttribute` for handlers.

Such a call won't work:

```
// a click on <body> will generate errors,
// because attributes are always strings, function becomes a string
document.body.setAttribute('onclick', function() { alert(1) });
```

DOM-property case matters.

Assign a handler to `elem.onclick`, not `elem.ONCLICK`, because DOM properties are case-sensitive.

addEventListener

The fundamental problem of the aforementioned ways to assign handlers – we can't assign multiple handlers to one event.

For instance, one part of our code wants to highlight a button on click, and another one wants to show a message.

We’d like to assign two event handlers for that. But a new DOM property will overwrite the existing one:

```
input.onclick = function() { alert(1); }
// ...
input.onclick = function() { alert(2); } // replaces the previous
handler
```

Web-standard developers understood that long ago and suggested an alternative way of managing handlers using special methods `addEventListener` and `removeEventListener`. They are free of such a problem.

The syntax to add a handler:

```
element.addEventListener(event, handler[, options]);
```

`event`

Event name, e.g. `"click"`.

`handler`

The handler function.

`options`

An additional optional object with properties:

- `once`: if `true`, then the listener is automatically removed after it triggers.
- `capture`: the phase where to handle the event, to be covered later in the chapter Bubbling and capturing. For historical reasons, `options` can also be `false/true`, that’s the same as `{capture: false/true}`.

- `passive`: if `true`, then the handler will not `preventDefault()`, we'll cover that later in Browser default actions.

To remove the handler, use `removeEventListener`:

```
element.removeEventListener(event, handler[, options]);
```

⚠ Removal requires the same function

To remove a handler we should pass exactly the same function as was assigned.

That doesn't work:

```
elem.addEventListener( "click" , () => alert('Thanks!'));
// ....
elem.removeEventListener( "click", () => alert('Thanks!'));
```

The handler won't be removed, because `removeEventListener` gets another function – with the same code, but that doesn't matter.

Here's the right way:

```
function handler() {
  alert( 'Thanks!' );
}

input.addEventListener("click", handler);
// ....
input.removeEventListener("click", handler);
```

Please note – if we don't store the function in a variable, then we can't remove it. There's no way to "read back" handlers assigned by `addEventListener`.

Multiple calls to `addEventListener` allow to add multiple handlers, like this:

```
<input id="elem" type="button" value="Click me"/>

<script>
  function handler1() {
    alert('Thanks!');
  };

  function handler2() {
    alert('Thanks again!');
  }

  elem.onclick = () => alert("Hello");
  elem.addEventListener("click", handler1); // Thanks!
  elem.addEventListener("click", handler2); // Thanks again!
</script>
```

As we can see in the example above, we can set handlers *both* using a DOM-property and `addEventListener`. But generally we use only one of these ways.

⚠ For some events, handlers only work with `addEventListener`

There exist events that can't be assigned via a DOM-property. Must use `addEventListener`.

For instance, the event `transitionend` (CSS animation finished) is like that.

Try the code below. In most browsers only the second handler works, not the first one.

```
<style>
  input {
    transition: width 1s;
    width: 100px;
  }

  .wide {
    width: 300px;
  }
</style>

<input type="button" id="elem"
onclick="this.classList.toggle('wide')" value="Click me">

<script>
  elem.ontransitionend = function() {
    alert("DOM property"); // doesn't work
  };

  elem.addEventListener("transitionend",
function() {
    alert("addEventListener"); // shows up
when the animation finishes
```

```
  });
</script>
```

Event object

To properly handle an event we'd want to know more about what's happened. Not just a "click" or a "keypress", but what were the pointer coordinates? Which key was pressed? And so on.

When an event happens, the browser creates an *event object*, puts details into it and passes it as an argument to the handler.

Here's an example of getting mouse coordinates from the event object:

```
<input type="button" value="Click me" id="elem">

<script>
  elem.onclick = function(event) {
    // show event type, element and coordinates of the click
    alert(event.type + " at " + event.currentTarget);
    alert("Coordinates: " + event.clientX + ":" + event.clientY);
  };
</script>
```

Some properties of `event` object:

`event.type`

Event type, here it's `"click"`.

`event.currentTarget`

Element that handled the event. That's exactly the same as `this`, unless the handler is an arrow function, or its `this` is bound to something else, then we can get the element from `event.currentTarget`.

`event.clientX / event.clientY`

Window-relative coordinates of the cursor, for mouse events.

There are more properties. They depend on the event type, so we'll study them later when we come to different events in details.

> **The event object is also accessible from HTML**
>
> If we assign a handler in HTML, we can also use the `event` object, like this:
>
> ```
> <input type="button" onclick="alert(event.type)" value="Event type">
> ```
>
> Event type
>
> That's possible because when the browser reads the attribute, it creates a handler like this: `function(event) { alert(event.type) }`. That is: its first argument is called `"event"`, and the body is taken from the attribute.

Object handlers: handleEvent

We can assign not just a function, but an object as an event handler using `addEventListener`. When an event occurs, its `handleEvent` method is called.

For instance:

```
<button id="elem">Click me</button>

<script>
  elem.addEventListener('click', {
    handleEvent(event) {
      alert(event.type + " at " +
event.currentTarget);
    }
  });
</script>
```

As we can see, when `addEventListener` receives an object as the handler, it calls `object.handleEvent(event)` in case of an event.

We could also use a class for that:

```
<button id="elem">Click me</button>

<script>
  class Menu {
    handleEvent(event) {
      switch(event.type) {
        case 'mousedown':
          elem.innerHTML = "Mouse button
pressed";
          break;
        case 'mouseup':
          elem.innerHTML += "...and released.";
          break;
```

```html
      }
    }
  }

  let menu = new Menu();
  elem.addEventListener('mousedown', menu);
  elem.addEventListener('mouseup', menu);
</script>
```

Here the same object handles both events. Please note that we need to explicitly setup the events to listen using `addEventListener`. The `menu` object only gets `mousedown` and `mouseup` here, not any other types of events.

The method `handleEvent` does not have to do all the job by itself. It can call other event-specific methods instead, like this:

```html
<button id="elem">Click me</button>

<script>
  class Menu {
    handleEvent(event) {
      // mousedown -> onMousedown
      let method = 'on' +
event.type[0].toUpperCase() +
event.type.slice(1);
      this[method](event);
    }

    onMousedown() {
      elem.innerHTML = "Mouse button pressed";
    }
```

```
    onMouseup() {
      elem.innerHTML += "...and released.";
    }
  }

  let menu = new Menu();
  elem.addEventListener('mousedown', menu);
  elem.addEventListener('mouseup', menu);
</script>
```

Now event handlers are clearly separated, that may be easier to support.

Summary

There are 3 ways to assign event handlers:

1. HTML attribute: `onclick="..."`.
2. DOM property: `elem.onclick = function`.
3. Methods: `elem.addEventListener(event, handler[, phase])` to add, `removeEventListener` to remove.

HTML attributes are used sparingly, because JavaScript in the middle of an HTML tag looks a little bit odd and alien. Also can't write lots of code in there.

DOM properties are ok to use, but we can't assign more than one handler of the particular event. In many cases that limitation is not pressing.

The last way is the most flexible, but it is also the longest to write. There are few events that only work with it, for instance `transtionend` and `DOMContentLoaded` (to be covered). Also `addEventListener` supports objects as event handlers. In that case the method `handleEvent` is called in case of the event.

No matter how you assign the handler – it gets an event object as the first argument. That object contains the details about what's happened.

We'll learn more about events in general and about different types of events in the next chapters.

✔ Tasks

Hide on click

importance: 5

Add JavaScript to the `button` to make `<div id="text">` disappear when we click it.

The demo:

Click to hide the text

Text

Open a sandbox for the task.

To solution

Hide self

importance: 5

Create a button that hides itself on click.

To solution

Which handlers run?

importance: 5

There's a button in the variable. There are no handlers on it.

Which handlers run on click after the following code? Which alerts show up?

```
button.addEventListener("click", () => alert("1"));

button.removeEventListener("click", () => alert("1"));

button.onclick = () => alert(2);
```

To solution

Move the ball across the field

importance: 5

Move the ball across the field to a click. Like this:

Requirements:

- The ball center should come exactly under the pointer on click (if possible without crossing the field edge).
- CSS-animation is welcome.
- The ball must not cross field boundaries.
- When the page is scrolled, nothing should break.

Notes:

- The code should also work with different ball and field sizes, not be bound to any fixed values.
- Use properties `event.clientX/event.clientY` for click coordinates.

Open a sandbox for the task.

To solution

Create a sliding menu

importance: 5

Create a menu that opens/collapses on click:

▶ Sweeties (click me)!

P.S. HTML/CSS of the source document is to be modified.

Open a sandbox for the task.

To solution

Add a closing button

importance: 5

There's a list of messages.

Use JavaScript to add a closing button to the right-upper corner of each message.

The result should look like this:

[x]

Horse

The horse is one of two extant subspecies of Equus ferus. It is an odd-toed ungulate mammal belonging to the taxonomic family Equidae. The horse has evolved over the past 45 to 55 million years from a small multi-toed creature, Eohippus, into the large, single-toed animal of today.

[x]

Donkey

The donkey or ass (Equus africanus asinus) is a domesticated member of the horse family, Equidae. The wild ancestor of the donkey is the African wild ass, E. africanus. The donkey has been used as a working animal for at least 5000 years.

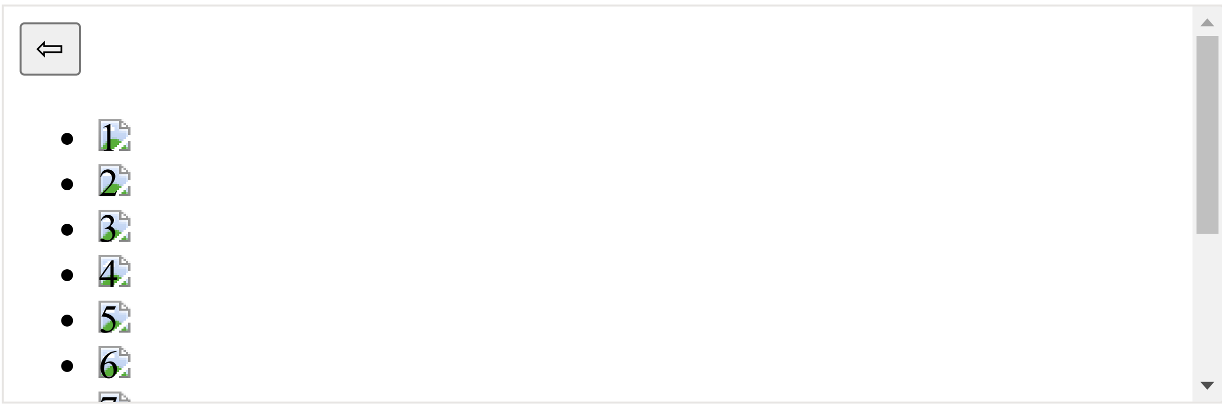
Open a sandbox for the task.

To solution

Carousel

importance: 4

Create a "carousel" – a ribbon of images that can be scrolled by clicking on arrows.



Later we can add more features to it: infinite scrolling, dynamic loading etc.

P.S. For this task HTML/CSS structure is actually 90% of the solution.

Open a sandbox for the task.

To solution

Bubbling and capturing

Let's start with an example.

This handler is assigned to `<div>`, but also runs if you click any nested tag like `<em>` or `<code>`:

```html
<div onclick="alert('The handler!')">
  <em>If you click on <code>EM</code>, the handler on <code>DIV</code> runs.</em>
</div>
```

If you click on `EM`, the handler on `DIV` runs.

Isn't it a bit strange? Why does the handler on `<div>` run if the actual click was on `<em>`?

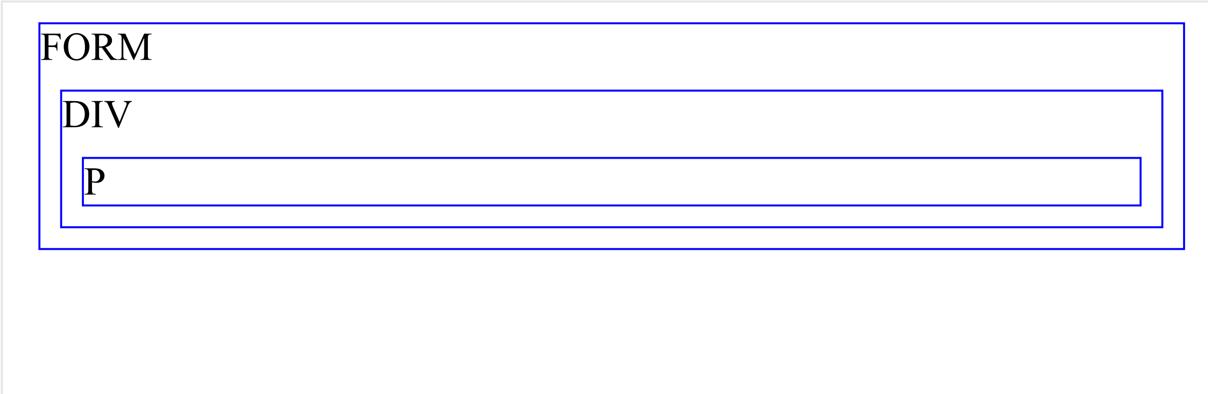
Bubbling

The bubbling principle is simple.

When an event happens on an element, it first runs the handlers on it, then on its parent, then all the way up on other ancestors.

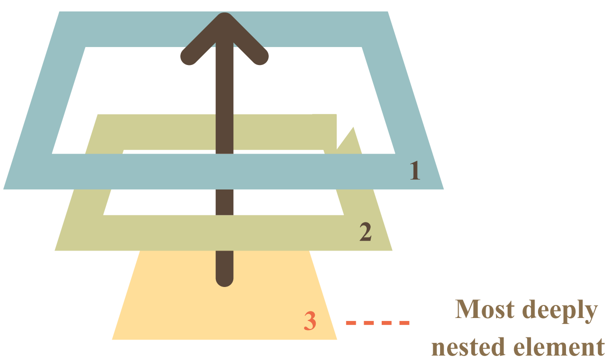
Let's say we have 3 nested elements `FORM > DIV > P` with a handler on each of them:

```html
<style>
  body * {
    margin: 10px;
    border: 1px solid blue;
  }
</style>

<form onclick="alert('form')">FORM
  <div onclick="alert('div')">DIV
    <p onclick="alert('p')">P</p>
  </div>
</form>
```



A click on the inner `<p>` first runs `onclick`:

1. On that `<p>`.
2. Then on the outer `<div>`.
3. Then on the outer `<form>`.
4. And so on upwards till the `document` object.



So if we click on `<p>`, then we'll see 3 alerts: `p` → `div` → `form`.

The process is called "bubbling", because events "bubble" from the inner element up through parents like a bubble in the water.

⚠ *Almost* all events bubble.

The key word in this phrase is "almost".

For instance, a `focus` event does not bubble. There are other examples too, we'll meet them. But still it's an exception, rather than a rule, most events do bubble.

event.target

A handler on a parent element can always get the details about where it actually happened.

The most deeply nested element that caused the event is called a *target* element, accessible as `event.target`.

Note the differences from `this` (=`event.currentTarget`):

- `event.target` – is the "target" element that initiated the event, it doesn't change through the bubbling process.
- `this` – is the "current" element, the one that has a currently running handler on it.

For instance, if we have a single handler `form.onclick`, then it can "catch" all clicks inside the form. No matter where the click happened, it bubbles up to `<form>` and runs the handler.

In `form.onclick` handler:

- `this` (=`event.currentTarget`) is the `<form>` element, because the handler runs on it.
- `event.target` is the actual element inside the form that was clicked.

Check it out:

https://plnkr.co/edit/iaPo3qfpDpHzXju0Jita?p=preview

It's possible that `event.target` could equal `this` – it happens when the click is made directly on the `<form>` element.

Stopping bubbling

A bubbling event goes from the target element straight up. Normally it goes upwards till `<html>`, and then to `document` object, and some events even reach `window`, calling all handlers on the path.

But any handler may decide that the event has been fully processed and stop the bubbling.

The method for it is `event.stopPropagation()`.

For instance, here `body.onclick` doesn't work if you click on `<button>`:

```
<body onclick="alert(`the bubbling doesn't reach here`)">
  <button onclick="event.stopPropagation()">Click me</button>
</body>
```

Click me

event.stopImmediatePropagation()

If an element has multiple event handlers on a single event, then even if one of them stops the bubbling, the other ones still execute.

In other words, `event.stopPropagation()` stops the move upwards, but on the current element all other handlers will run.

To stop the bubbling and prevent handlers on the current element from running, there's a method `event.stopImmediatePropagation()`. After it no other handlers execute.

⚠ Don’t stop bubbling without a need!

Bubbling is convenient. Don’t stop it without a real need: obvious and architecturally well thought out.

Sometimes `event.stopPropagation()` creates hidden pitfalls that later may become problems.

For instance:

1. We create a nested menu. Each submenu handles clicks on its elements and calls `stopPropagation` so that the outer menu won’t trigger.
2. Later we decide to catch clicks on the whole window, to track users’ behavior (where people click). Some analytic systems do that. Usually the code uses `document.addEventListener('click'…)` to catch all clicks.
3. Our analytic won’t work over the area where clicks are stopped by `stopPropagation`. Sadly, we’ve got a “dead zone”.

There’s usually no real need to prevent the bubbling. A task that seemingly requires that may be solved by other means. One of them is to use custom events, we’ll cover them later. Also we can write our data into the `event` object in one handler and read it in another one, so we can pass to handlers on parents information about the processing below.

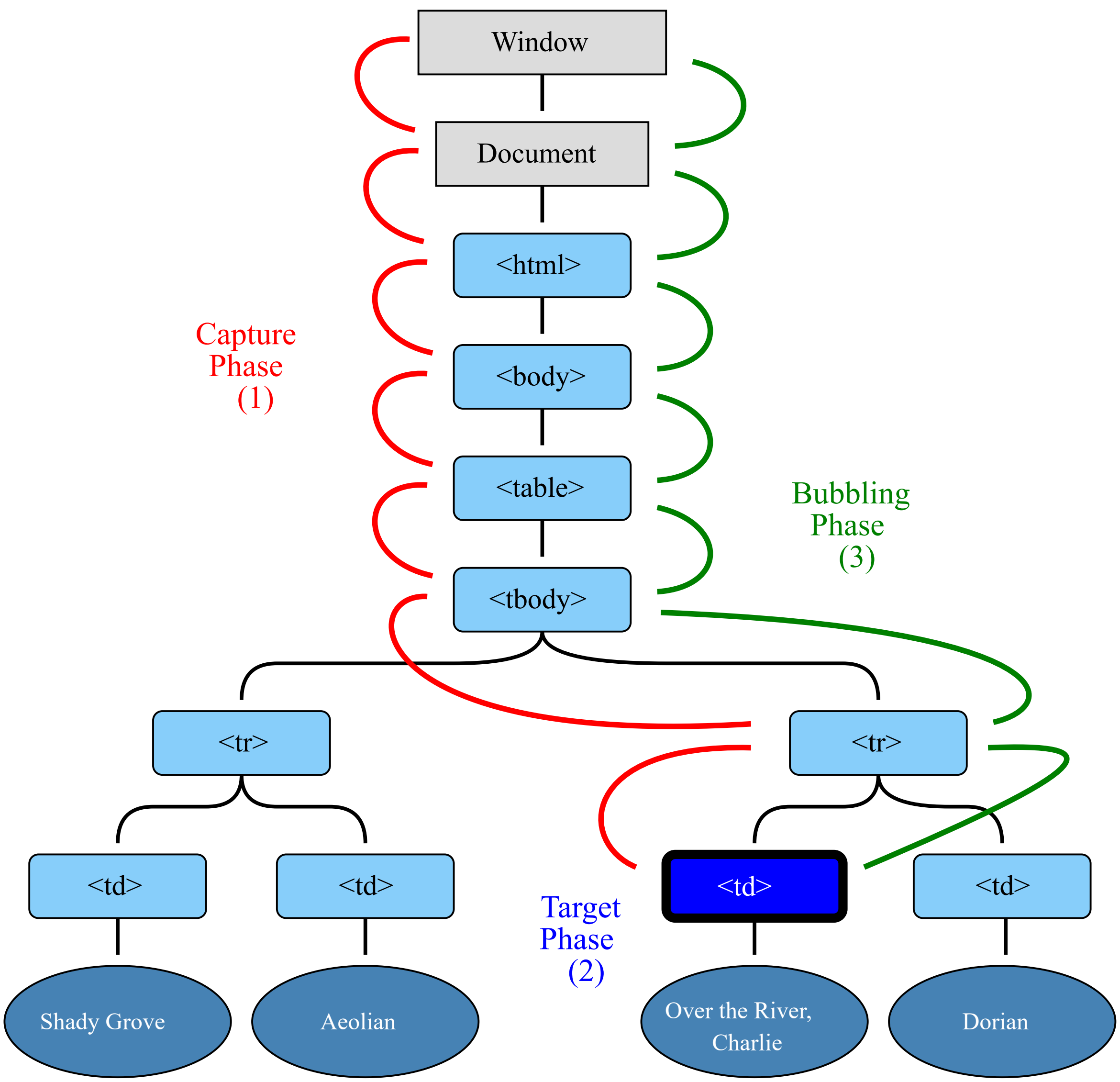
Capturing

There’s another phase of event processing called “capturing”. It is rarely used in real code, but sometimes can be useful.

The standard DOM Events describes 3 phases of event propagation:

1. Capturing phase – the event goes down to the element.
2. Target phase – the event reached the target element.
3. Bubbling phase – the event bubbles up from the element.

Here's the picture of a click on `<td>` inside a table, taken from the specification:



That is: for a click on `<td>` the event first goes through the ancestors chain down to the element (capturing phase), then it reaches the target and triggers there (target phase), and then it goes up (bubbling phase), calling handlers on its way.

Before we only talked about bubbling, because the capturing phase is rarely used. Normally it is invisible to us.

Handlers added using `on<event>`-property or using HTML attributes or using two-argument `addEventListener(event, handler)` don't know anything about capturing, they only run on the 2nd and 3rd phases.

To catch an event on the capturing phase, we need to set the handler `capture` option to `true`:

```
elem.addEventListener(..., {capture: true})
// or, just "true" is an alias to {capture: true}
elem.addEventListener(..., true)
```

There are two possible values of the `capture` option:

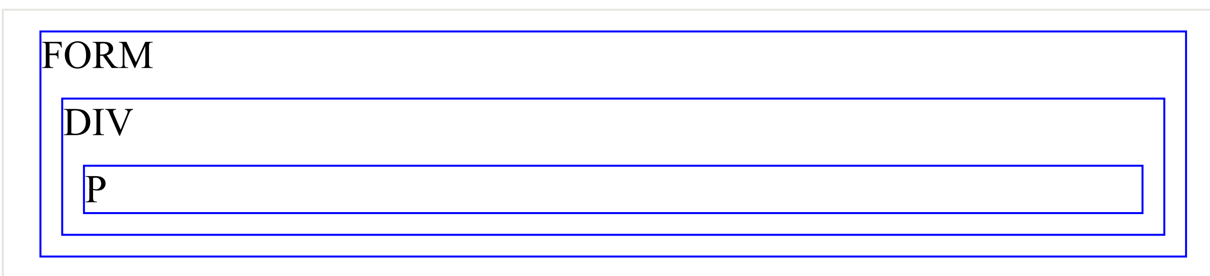
- If it's `false` (default), then the handler is set on the bubbling phase.
- If it's `true`, then the handler is set on the capturing phase.

Note that while formally there are 3 phases, the 2nd phase ("target phase": the event reached the element) is not handled separately: handlers on both capturing and bubbling phases trigger at that phase.

Let's see both capturing and bubbling in action:

```
<style>
  body * {
```

```
    margin: 10px;
    border: 1px solid blue;
  }
</style>

<form>FORM
  <div>DIV
    <p>P</p>
  </div>
</form>

<script>
  for(let elem of
document.querySelectorAll('*')) {
    elem.addEventListener("click", e =>
alert(`Capturing: ${elem.tagName}`), true);
    elem.addEventListener("click", e =>
alert(`Bubbling: ${elem.tagName}`));
  }
</script>
```



The code sets click handlers on *every* element in the document to see which ones are working.

If you click on `<p>`, then the sequence is:

1. `HTML` → `BODY` → `FORM` → `DIV` (capturing phase, the first listener):
2. `P` (target phrase, triggers two times, as we’ve set two listeners: capturing and bubbling)

3. `DIV` → `FORM` → `BODY` → `HTML` (bubbling phase, the second listener).

There's a property `event.eventPhase` that tells us the number of the phase on which the event was caught. But it's rarely used, because we usually know it in the handler.

> **To remove the handler, `removeEventListener` needs the same phase**
>
> If we `addEventListener(..., true)`, then we should mention the same phase in `removeEventListener(..., true)` to correctly remove the handler.

> **Listeners on same element and same phase run in their set order**
>
> If we have multiple event handlers on the same phase, assigned to the same element with `addEventListener`, they run in the same order as they are created:
>
> ```
> elem.addEventListener("click", e => alert(1)); // guaranteed to trigger first
> elem.addEventListener("click", e => alert(2));
> ```

Summary

When an event happens – the most nested element where it happens gets labeled as the "target element" (`event.target`).

- Then the event moves down from the document root to `event.target`, calling handlers assigned with `addEventListener(...., true)` on the way (`true` is a shorthand for `{capture: true}`).
- Then handlers are called on the target element itself.
- Then the event bubbles up from `event.target` up to the root, calling handlers assigned using `on<event>` and `addEventListener` without the 3rd argument or with the 3rd argument `false/{capture:false}`.

Each handler can access `event` object properties:

- `event.target` – the deepest element that originated the event.
- `event.currentTarget` (=`this`) – the current element that handles the event (the one that has the handler on it)
- `event.eventPhase` – the current phase (capturing=1, target=2, bubbling=3).

Any event handler can stop the event by calling `event.stopPropagation()`, but that's not recommended, because we can't really be sure we won't need it above, maybe for completely different things.

The capturing phase is used very rarely, usually we handle events on bubbling. And there's a logic behind that.

In real world, when an accident happens, local authorities react first. They know best the area where it happened. Then higher-level authorities if needed.

The same for event handlers. The code that set the handler on a particular element knows maximum details about the element and what it does. A handler on a particular `<td>` may be suited for that exactly `<td>`, it knows everything about it, so it should get the chance first. Then its immediate parent also knows about the context, but a little bit less, and so on till the very top element that handles general concepts and runs the last.

Bubbling and capturing lay the foundation for “event delegation” – an extremely powerful event handling pattern that we study in the next chapter.

Event delegation

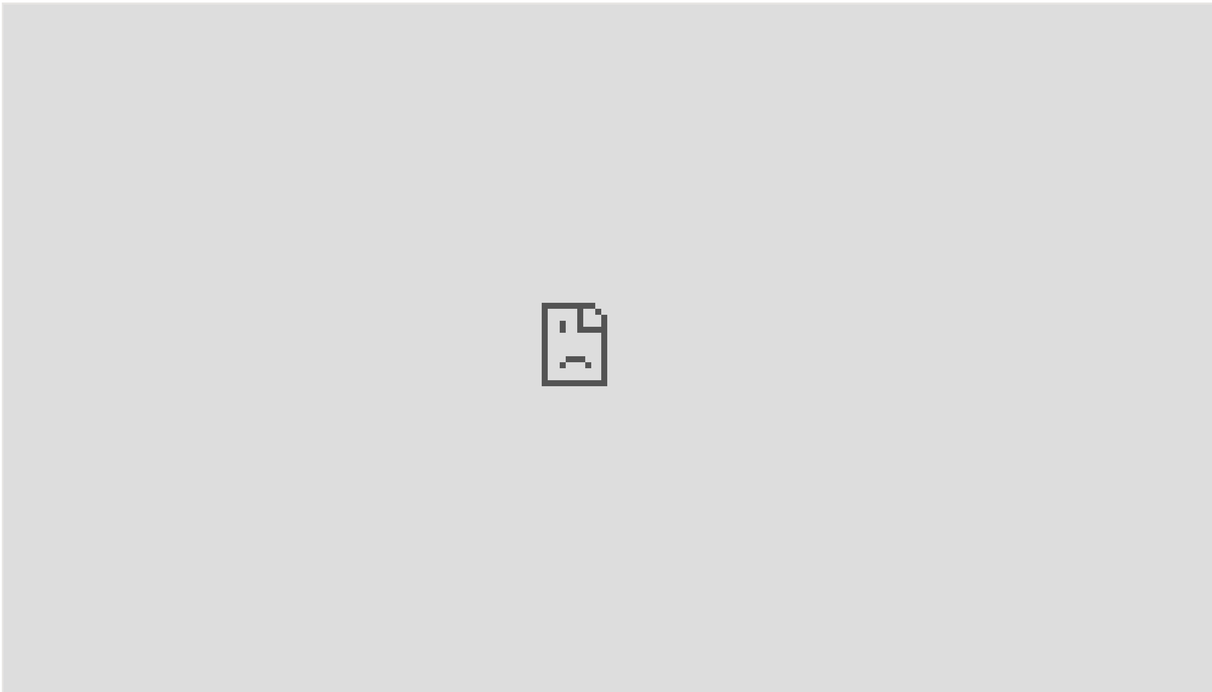
Capturing and bubbling allow us to implement one of most powerful event handling patterns called *event delegation*.

The idea is that if we have a lot of elements handled in a similar way, then instead of assigning a handler to each of them – we put a single handler on their common ancestor.

In the handler we get `event.target`, see where the event actually happened and handle it.

Let’s see an example – the Ba-Gua diagram reflecting the ancient Chinese philosophy.

Here it is:



The HTML is like this:

```
<table>
  <tr>
    <th colspan="3"><em>Bagua</em> Chart: Direction, Element, Color,
Meaning</th>
  </tr>
  <tr>
    <td class="nw"><strong>Northwest</strong>
<br>Metal<br>Silver<br>Elders</td>
    <td class="n">...</td>
    <td class="ne">...</td>
  </tr>
  <tr>...2 more lines of this kind...</tr>
  <tr>...2 more lines of this kind...</tr>
</table>
```

The table has 9 cells, but there could be 99 or 9999, doesn't matter.

Our task is to highlight a cell `<td>` on click.

Instead of assign an `onclick` handler to each `<td>` (can be many) – we'll setup the "catch-all" handler on `<table>` element.

It will use `event.target` to get the clicked element and highlight it.

The code:

```
let selectedTd;

table.onclick = function(event) {
  let target = event.target; // where was the click?

  if (target.tagName != 'TD') return; // not on TD? Then we're not
interested

  highlight(target); // highlight it
};

function highlight(td) {
  if (selectedTd) { // remove the existing highlight if any
    selectedTd.classList.remove('highlight');
  }
  selectedTd = td;
  selectedTd.classList.add('highlight'); // highlight the new td
}
```

Such a code doesn't care how many cells there are in the table. We can add/remove `<td>` dynamically at any time and the highlighting will still work.

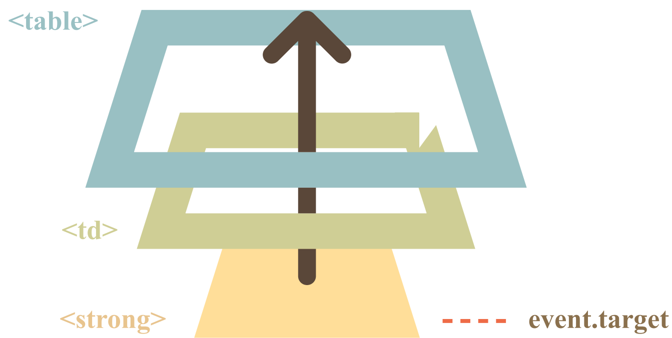
Still, there's a drawback.

The click may occur not on the `<td>`, but inside it.

In our case if we take a look inside the HTML, we can see nested tags inside `<td>`, like `<strong>`:

```
<td>
  <strong>Northwest</strong>
  ...
</td>
```

Naturally, if a click happens on that `<strong>` then it becomes the value of `event.target`.



In the handler `table.onclick` we should take such `event.target` and find out whether the click was inside `<td>` or not.

Here's the improved code:

```
table.onclick = function(event) {
  let td = event.target.closest('td'); // (1)

  if (!td) return; // (2)

  if (!table.contains(td)) return; // (3)

  highlight(td); // (4)
};
```

Explanations:

1. The method `elem.closest(selector)` returns the nearest ancestor that matches the selector. In our case we look for `<td>` on the way up from the source element.
2. If `event.target` is not inside any `<td>`, then the call returns `null`, and we don't have to do anything.

3. In case of nested tables, `event.target` may be a `<td>` lying outside of the current table. So we check if that's actually *our table's* `<td>`.
4. And, if it's so, then highlight it.

As the result, we have a fast, efficient highlighting code, that doesn't care about the total number of `<td>` in the table.

Delegation example: actions in markup

There are other uses for event delegation.

Let's say, we want to make a menu with buttons "Save", "Load", "Search" and so on. And there's an object with methods `save`, `load`, `search`… How to match them?

The first idea may be to assign a separate handler to each button. But there's a more elegant solution. We can add a handler for the whole menu and `data-action` attributes for buttons that has the method to call:

```
<button data-action="save">Click to Save</button>
```

The handler reads the attribute and executes the method. Take a look at the working example:

```
<div id="menu">
  <button data-action="save">Save</button>
  <button data-action="load">Load</button>
  <button data-action="search">Search</button>
</div>

<script>
  class Menu {
```

```
    constructor(elem) {
      this._elem = elem;
      elem.onclick = this.onClick.bind(this);
// (*)
    }

    save() {
      alert('saving');
    }

    load() {
      alert('loading');
    }

    search() {
      alert('searching');
    }

    onClick(event) {
      let action = event.target.dataset.action;
      if (action) {
        this[action]();
      }
    };
  }

  new Menu(menu);
</script>
```

Save Load Search

Please note that `this.onClick` is bound to `this` in `(*)`. That's important, because otherwise `this` inside it would reference the DOM element (`elem`), not the `Menu` object, and `this[action]` would not be what we need.

So, what advantages does delegation give us here?

- We don't need to write the code to assign a handler to each button. Just make a method and put it in the markup.
- The HTML structure is flexible, we can add/remove buttons at any time.

We could also use classes `.action-save`, `.action-load`, but an attribute `data-action` is better semantically. And we can use it in CSS rules too.

The “behavior” pattern

We can also use event delegation to add “behaviors” to elements *declaratively*, with special attributes and classes.

The pattern has two parts:

1. We add a custom attribute to an element that describes its behavior.
2. A document-wide handler tracks events, and if an event happens on an attributed element – performs the action.

Behavior: Counter

For instance, here the attribute `data-counter` adds a behavior: “increase value on click” to buttons:

```
Counter: <input type="button" value="1" data-counter>
One more counter: <input type="button" value="2" data-counter>

<script>
  document.addEventListener('click',
function(event) {

    if (event.target.dataset.counter !=
undefined) { // if the attribute exists...
      event.target.value++;
    }

  });
</script>
```

Counter: 1 One more counter: 2

If we click a button – its value is increased. Not buttons, but the general approach is important here.

There can be as many attributes with `data-counter` as we want. We can add new ones to HTML at any moment. Using the event delegation we "extended" HTML, added an attribute that describes a new behavior.

> ### ⚠ For document-level handlers – always `addEventListener`
>
> When we assign an event handler to the `document` object, we should always use `addEventListener`, not `document.on<event>`, because the latter will cause conflicts: new handlers overwrite old ones.
>
> For real projects it's normal that there are many handlers on `document` set by different parts of the code.

Behavior: Toggler

One more example of behavior. A click on an element with the attribute `data-toggle-id` will show/hide the element with the given `id`:

```
<button data-toggle-id="subscribe-mail">
  Show the subscription form
</button>

<form id="subscribe-mail" hidden>
  Your mail: <input type="email">
</form>

<script>
  document.addEventListener('click', function(event) {
```

```
    let id = event.target.dataset.toggleId;
    if (!id) return;

    let elem = document.getElementById(id);

    elem.hidden = !elem.hidden;
  });
</script>
```

Show the subscription form

Let's note once again what we did. Now, to add toggling functionality to an element – there's no need to know JavaScript, just use the attribute `data-toggle-id`.

That may become really convenient – no need to write JavaScript for every such element. Just use the behavior. The document-level handler makes it work for any element of the page.

We can combine multiple behaviors on a single element as well.

The "behavior" pattern can be an alternative to mini-fragments of JavaScript.

Summary

Event delegation is really cool! It's one of the most helpful patterns for DOM events.

It's often used to add the same handling for many similar elements, but not only for that.

The algorithm:

1. Put a single handler on the container.
2. In the handler – check the source element `event.target`.

3. If the event happened inside an element that interests us, then handle the event.

Benefits:

- Simplifies initialization and saves memory: no need to add many handlers.
- Less code: when adding or removing elements, no need to add/remove handlers.
- DOM modifications: we can mass add/remove elements with `innerHTML` and the like.

The delegation has its limitations of course:

- First, the event must be bubbling. Some events do not bubble. Also, low-level handlers should not use `event.stopPropagation()`.
- Second, the delegation may add CPU load, because the container-level handler reacts on events in any place of the container, no matter whether they interest us or not. But usually the load is negligible, so we don't take it into account.

Tasks

Hide messages with delegation

importance: 5

There’s a list of messages with removal buttons `[x]`. Make the buttons work.

Like this:

Horse

The horse is one of two extant subspecies of Equus ferus. It is an odd-toed ungulate mammal belonging to the taxonomic family Equidae. The horse has evolved over the past 45 to 55 million years from a small multi-toed creature, Eohippus, into the large, single-toed animal of today.

[x]

Donkey

The donkey or ass (Equus africanus asinus) is a domesticated member of the horse family, Equidae. The wild ancestor of the donkey is the African wild ass, E. africanus. The donkey has been used as a working animal for at least 5000 years.

P.S. Should be only one event listener on the container, use event delegation.

Open a sandbox for the task.

To solution

Tree menu

importance: 5

Create a tree that shows/hides node children on click:

- Animals
  - Mammals
    - Cows
    - Donkeys
    - Dogs
    - Tigers
  - Other
    - Snakes
    - Birds
    - Lizards
- Fishes
  - Aquarium

Requirements:

- Only one event handler (use delegation)
- A click outside the node title (on an empty space) should not do anything.

Open a sandbox for the task.

To solution

Sortable table

importance: 4

Make the table sortable: clicks on `<th>` elements should sort it by corresponding column.

Each `<th>` has the type in the attribute, like this:

```html
<table id="grid">
  <thead>
    <tr>
      <th data-type="number">Age</th>
      <th data-type="string">Name</th>
    </tr>
  </thead>
  <tbody>
    <tr>
      <td>5</td>
      <td>John</td>
    </tr>
    <tr>
      <td>10</td>
      <td>Ann</td>
    </tr>
    ...
  </tbody>
</table>
```

In the example above the first column has numbers, and the second one – strings. The sorting function should handle sort according to the type.

Only `"string"` and `"number"` types should be supported.

The working example:

Age	Name
5	John
2	Pete
12	Ann
9	Eugene
1	Ilya

P.S. The table can be big, with any number of rows and columns.

Open a sandbox for the task.

To solution

Tooltip behavior

importance: 5

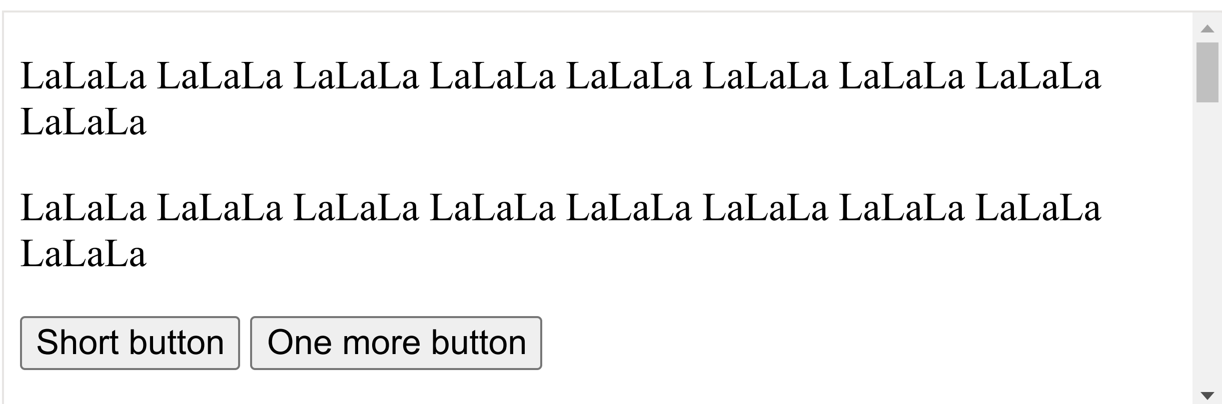
Create JS-code for the tooltip behavior.

When a mouse comes over an element with `data-tooltip`, the tooltip should appear over it, and when it's gone then hide.

An example of annotated HTML:

```
<button data-tooltip="the tooltip is longer than the element">Short
button</button>
<button data-tooltip="HTML<br>tooltip">One more button</button>
```

Should work like this:



In this task we assume that all elements with `data-tooltip` have only text inside. No nested tags (yet).

Details:

- The distance between the element and the tooltip should be `5px`.
- The tooltip should be centered relative to the element, if possible.
- The tooltip should not cross window edges. Normally it should be above the element, but if the element is at the page top and there's no space for the tooltip, then below it.
- The tooltip content is given in the `data-tooltip` attribute. It can be arbitrary HTML.

You'll need two events here:

- `mouseover` triggers when a pointer comes over an element.
- `mouseout` triggers when a pointer leaves an element.

Please use event delegation: set up two handlers on `document` to track all "overs" and "outs" from elements with `data-tooltip` and manage tooltips from there.

After the behavior is implemented, even people unfamiliar with JavaScript can add annotated elements.

P.S. Only one tooltip may show up at a time.

Open a sandbox for the task.

To solution

Browser default actions

Many events automatically lead to certain actions performed by the browser.

For instance:

- A click on a link – initiates navigation to its URL.
- A click on a form submit button – initiates its submission to the server.
- Pressing a mouse button over a text and moving it – selects the text.

If we handle an event in JavaScript, we may not want the corresponding browser action to happen, and want to implement another behavior instead.

Preventing browser actions

There are two ways to tell the browser we don't want it to act:

- The main way is to use the `event` object. There's a method `event.preventDefault()`.
- If the handler is assigned using `on<event>` (not by `addEventListener`), then returning `false` also works the same.

In this HTML a click on a link doesn't lead to navigation, browser doesn't do anything:

```
<a href="/" onclick="return false">Click here</a>
or
<a href="/" onclick="event.preventDefault()">here</a>
```

Click here or here

In the next example we'll use this technique to create a JavaScript-powered menu.

> ### ⚠️ Returning `false` from a handler is an exception
>
> The value returned by an event handler is usually ignored.
>
> The only exception is `return false` from a handler assigned using `on<event>`.
>
> In all other cases, `return` value is ignored. In particular, there's no sense in returning `true`.

Example: the menu

Consider a site menu, like this:

```html
<ul id="menu" class="menu">
  <li><a href="/html">HTML</a></li>
  <li><a href="/javascript">JavaScript</a></li>
  <li><a href="/css">CSS</a></li>
</ul>
```

Here's how it looks with some CSS:

Menu items are implemented as HTML-links `<a>`, not buttons `<button>`. There are several reasons to do so, for instance:

- Many people like to use "right click" – "open in a new window". If we use `<button>` or `<span>`, that doesn't work.
- Search engines follow `<a href="...">` links while indexing.

So we use `<a>` in the markup. But normally we intend to handle clicks in JavaScript. So we should prevent the default browser action.

Like here:

```
menu.onclick = function(event) {
  if (event.target.nodeName != 'A') return;

  let href = event.target.getAttribute('href');
  alert( href ); // ...can be loading from the server, UI generation
etc

  return false; // prevent browser action (don't go to the URL)
};
```

If we omit `return false`, then after our code executes the browser will do its “default action” – navigating to the URL in `href`. And we don’t need that here, as we’re handling the click by ourselves.

By the way, using event delegation here makes our menu very flexible. We can add nested lists and style them using CSS to “slide down”.

Follow-up events

Certain events flow one into another. If we prevent the first event, there will be no second.

For instance, `mousedown` on an `<input>` field leads to focusing in it, and the `focus` event. If we prevent the `mousedown` event, there’s no focus.

Try to click on the first `<input>` below – the `focus` event happens. But if you click the second one, there’s no focus.

```
<input value="Focus works" onfocus="this.value=''">
<input onmousedown="return false" onfocus="this.value=''"
value="Click me">
```

That’s because the browser action is canceled on `mousedown`. The focusing is still possible if we use another way to enter the input. For instance, the `Tab` key to switch from the 1st input into the 2nd. But not with the mouse click any more.

The “passive” handler option

The optional `passive: true` option of `addEventListener` signals the browser that the handler is not going to call `preventDefault()`.

Why that may be needed?

There are some events like `touchmove` on mobile devices (when the user moves their finger across the screen), that cause scrolling by default, but that scrolling can be prevented using `preventDefault()` in the handler.

So when the browser detects such event, it has first to process all handlers, and then if `preventDefault` is not called anywhere, it can proceed with scrolling. That may cause unnecessary delays and “jitters” in the UI.

The `passive: true` options tells the browser that the handler is not going to cancel scrolling. Then browser scrolls immediately providing a maximally fluent experience, and the event is handled by the way.

For some browsers (Firefox, Chrome), `passive` is `true` by default for `touchstart` and `touchmove` events.

event.defaultPrevented

The property `event.defaultPrevented` is `true` if the default action was prevented, and `false` otherwise.

There's an interesting use case for it.

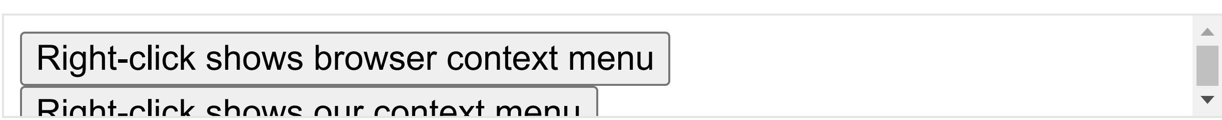
You remember in the chapter Bubbling and capturing we talked about `event.stopPropagation()` and why stopping bubbling is bad?

Sometimes we can use `event.defaultPrevented` instead, to signal other event handlers that the event was handled.

Let's see a practical example.

By default the browser on `contextmenu` event (right mouse click) shows a context menu with standard options. We can prevent it and show our own, like this:

```html
<button>Right-click shows browser context menu</button>

<button oncontextmenu="alert('Draw our menu'); return false">
  Right-click shows our context menu
</button>
```



Now, in addition to that context menu we'd like to implement document-wide context menu.

Upon right click, the closest context menu should show up.

```
<p>Right-click here for the document context menu</p>
<button id="elem">Right-click here for the button context menu</button>

<script>
  elem.oncontextmenu = function(event) {
    event.preventDefault();
    alert("Button context menu");
  };

  document.oncontextmenu = function(event) {
    event.preventDefault();
    alert("Document context menu");
  };
</script>
```

Right-click here for the document context menu

Right-click here for the button context menu

The problem is that when we click on `elem`, we get two menus: the button-level and (the event bubbles up) the document-level menu.

How to fix it? One of solutions is to think like: “When we handle right-click in the button handler, let’s stop its bubbling” and use `event.stopPropagation()`:

```
<p>Right-click for the document menu</p>
<button id="elem">Right-click for the button menu (fixed with
event.stopPropagation)</button>

<script>
  elem.oncontextmenu = function(event) {
```

```
    event.preventDefault();
    event.stopPropagation();
    alert("Button context menu");
  };

  document.oncontextmenu = function(event) {
    event.preventDefault();
    alert("Document context menu");
  };
</script>
```

Right-click for the document menu

Right-click for the button menu (fixed with event.stopPropagation)

Now the button-level menu works as intended. But the price is high. We forever deny access to information about right-clicks for any outer code, including counters that gather statistics and so on. That’s quite unwise.

An alternative solution would be to check in the `document` handler if the default action was prevented? If it is so, then the event was handled, and we don’t need to react on it.

```
<p>Right-click for the document menu (added a check for
event.defaultPrevented)</p>
<button id="elem">Right-click for the button menu</button>

<script>
  elem.oncontextmenu = function(event) {
    event.preventDefault();
    alert("Button context menu");
  };
```

```
  document.oncontextmenu = function(event) {
    if (event.defaultPrevented) return;

    event.preventDefault();
    alert("Document context menu");
  };
</script>
```

Right-click for the document menu (added a check for event.defaultPrevented)

Now everything also works correctly. If we have nested elements, and each of them has a context menu of its own, that would also work. Just make sure to check for `event.defaultPrevented` in each `contextmenu` handler.

event.stopPropagation() and event.preventDefault()

As we can clearly see, `event.stopPropagation()` and `event.preventDefault()` (also known as `return false`) are two different things. They are not related to each other.

Nested context menus architecture

There are also alternative ways to implement nested context menus. One of them is to have a single global object with a handler for `document.oncontextmenu`, and also methods that allow us to store other handlers in it.

> The object will catch any right-click, look through stored handlers and run the appropriate one.
>
> But then each piece of code that wants a context menu should know about that object and use its help instead of the own `contextmenu` handler.

Summary

There are many default browser actions:

- `mousedown` – starts the selection (move the mouse to select).
- `click` on `<input type="checkbox">` – checks/unchecks the `input`.
- `submit` – clicking an `<input type="submit">` or hitting `Enter` inside a form field causes this event to happen, and the browser submits the form after it.
- `keydown` – pressing a key may lead to adding a character into a field, or other actions.
- `contextmenu` – the event happens on a right-click, the action is to show the browser context menu.
- …there are more…

All the default actions can be prevented if we want to handle the event exclusively by JavaScript.

To prevent a default action – use either `event.preventDefault()` or `return false`. The second method works only for handlers assigned with `on<event>`.

The `passive: true` option of `addEventListener` tells the browser that the action is not going to be prevented. That's useful for some mobile events, like `touchstart` and `touchmove`, to tell the browser that it should not wait for all handlers to finish before scrolling.

If the default action was prevented, the value of `event.defaultPrevented` becomes `true`, otherwise it's `false`.

> ⚠️ **Stay semantic, don't abuse**
>
> Technically, by preventing default actions and adding JavaScript we can customize the behavior of any elements. For instance, we can make a link `<a>` work like a button, and a button `<button>` behave as a link (redirect to another URL or so).
>
> But we should generally keep the semantic meaning of HTML elements. For instance, `<a>` should perform navigation, not a button.
>
> Besides being "just a good thing", that makes your HTML better in terms of accessibility.
>
> Also if we consider the example with `<a>`, then please note: a browser allows us to open such links in a new window (by right-clicking them and other means). And people like that. But if we make a button behave as a link using JavaScript and even look like a link using CSS, then `<a>`-specific browser features still won't work for it.

Tasks

Why "return false" doesn't work?

importance: 3

Why in the code below `return false` doesn't work at all?

```
<script>
  function handler() {
    alert( "..." );
    return false;
  }
</script>

<a href="https://w3.org" onclick="handler()">the browser will go to
w3.org</a>
```

the browser will go to w3.org

The browser follows the URL on click, but we don't want it.

How to fix?

To solution

Catch links in the element

importance: 5

Make all links inside the element with `id="contents"` ask the user if they really want to leave. And if they don't then don't follow.

Like this:

#contents

How about to read Wikipedia or visit *W3.org* and learn about modern standards?

Details:

- HTML inside the element may be loaded or regenerated dynamically at any time, so we can’t find all links and put handlers on them. Use event delegation.
- The content may have nested tags. Inside links too, like `<a href=".."><i>...</i></a>`.

Open a sandbox for the task.

To solution

Image gallery

importance: 5

Create an image gallery where the main image changes by the click on a thumbnail.

Like this:

Large image

P.S. Use event delegation.

Open a sandbox for the task.

To solution

Dispatching custom events

We can not only assign handlers, but also generate events from JavaScript.

Custom events can be used to create "graphical components". For instance, a root element of our own JS-based menu may trigger events telling what happens with the menu: `open` (menu open), `select` (an item is selected) and so on. Another code may listen for the events and observe what's happening with the menu.

We can generate not only completely new events, that we invent for our own purposes, but also built-in ones, such as `click`, `mousedown` etc. That may be helpful for automated testing.

Event constructor

Build-in event classes form a hierarchy, similar to DOM element classes. The root is the built-in Event class.

We can create `Event` objects like this:

```
let event = new Event(type[, options]);
```

Arguments:

- *type* – event type, a string like `"click"` or our own like `"my-event"`.
- *options* – the object with two optional properties:
  - `bubbles: true/false` – if `true`, then the event bubbles.
  - `cancelable: true/false` – if `true`, then the "default action" may be prevented. Later we'll see what it means for custom events.

By default both are false: `{bubbles: false, cancelable: false}`.

dispatchEvent

After an event object is created, we should "run" it on an element using the call `elem.dispatchEvent(event)`.

Then handlers react on it as if it were a regular browser event. If the event was created with the `bubbles` flag, then it bubbles.

In the example below the `click` event is initiated in JavaScript. The handler works same way as if the button was clicked:

```
<button id="elem" onclick="alert('Click!');">Autoclick</button>

<script>
  let event = new Event("click");
  elem.dispatchEvent(event);
</script>
```

> **event.isTrusted**
>
> There is a way to tell a "real" user event from a script-generated one.
>
> The property `event.isTrusted` is `true` for events that come from real user actions and `false` for script-generated events.

Bubbling example

We can create a bubbling event with the name `"hello"` and catch it on `document`.

All we need is to set `bubbles` to `true`:

```
<h1 id="elem">Hello from the script!</h1>

<script>
  // catch on document...
  document.addEventListener("hello",
function(event) { // (1)
    alert("Hello from " +
event.target.tagName); // Hello from H1
  });

  // ...dispatch on elem!
  let event = new Event("hello", {bubbles:
true}); // (2)
  elem.dispatchEvent(event);

  // the handler on document will activate and
display the message.

</script>
```

Notes:

1. We should use `addEventListener` for our custom events, because `on<event>` only exists for built-in events, `document.onhello` doesn't work.

2. Must set `bubbles:true`, otherwise the event won't bubble up.

The bubbling mechanics is the same for built-in (`click`) and custom (`hello`) events. There are also capturing and bubbling stages.

MouseEvent, KeyboardEvent and others

Here's a short list of classes for UI Events from the UI Event specification:

- `UIEvent`
- `FocusEvent`
- `MouseEvent`
- `WheelEvent`
- `KeyboardEvent`
- …

We should use them instead of `new Event` if we want to create such events. For instance, `new MouseEvent("click")`.

The right constructor allows to specify standard properties for that type of event.

Like `clientX/clientY` for a mouse event:

```
let event = new MouseEvent("click", {
  bubbles: true,
  cancelable: true,
  clientX: 100,
  clientY: 100
});

alert(event.clientX); // 100
```

Please note: the generic `Event` constructor does not allow that.

Let's try:

```
let event = new Event("click", {
  bubbles: true, // only bubbles and cancelable
  cancelable: true, // work in the Event constructor
  clientX: 100,
  clientY: 100
});

alert(event.clientX); // undefined, the unknown property is ignored!
```

Technically, we can work around that by assigning directly `event.clientX=100` after creation. So that's a matter of convenience and following the rules. Browser-generated events always have the right type.

The full list of properties for different UI events is in the specification, for instance, MouseEvent.

Custom events

For our own, completely new events types like `"hello"` we should use `new CustomEvent`. Technically CustomEvent is the same as `Event`, with one exception.

In the second argument (object) we can add an additional property `detail` for any custom information that we want to pass with the event.

For instance:

```
<h1 id="elem">Hello for John!</h1>

<script>
```

```
  // additional details come with the event to
the handler
  elem.addEventListener("hello",
function(event) {
    alert(event.detail.name);
  });

  elem.dispatchEvent(new CustomEvent("hello", {
    detail: { name: "John" }
  }));
</script>
```

The `detail` property can have any data. Technically we could live without, because we can assign any properties into a regular `new Event` object after its creation. But `CustomEvent` provides the special `detail` field for it to evade conflicts with other event properties.

Besides, the event class describes "what kind of event" it is, and if the event is custom, then we should use `CustomEvent` just to be clear about what it is.

event.preventDefault()

Many browser events have a "default action", such as nagivating to a link, starting a selection, and so on.

For new, custom events, there are definitely no default browser actions, but a code that dispatches such event may have its own plans what to do after triggering the event.

By calling `event.preventDefault()`, an event handler may send a signal that those actions should be canceled.

In that case the call to `elem.dispatchEvent(event)` returns `false`. And the code that dispatched it knows that it shouldn't continue.

Let's see a practical example – a hiding rabbit (could be a closing menu or something else).

Below you can see a `#rabbit` and `hide()` function that dispatches `"hide"` event on it, to let all interested parties know that the rabbit is going to hide.

Any handler can listen for that event with `rabbit.addEventListener('hide',...)` and, if needed, cancel the action using `event.preventDefault()`. Then the rabbit won't disappear:

```
<pre id="rabbit">
  |\   /|
   \|_|/
   /. .\
  =\_Y_/=
   {>o<}
</pre>
<button onclick="hide()">Hide()</button>

<script>
  // hide() will be called automatically in 2 seconds
  function hide() {
    let event = new CustomEvent("hide", {
      cancelable: true // without that flag preventDefault doesn't work
    });
    if (!rabbit.dispatchEvent(event)) {
      alert('The action was prevented by a handler');
```

```
    } else {
      rabbit.hidden = true;
    }
  }

  rabbit.addEventListener('hide',
function(event) {
    if (confirm("Call preventDefault?")) {
      event.preventDefault();
    }
  });
</script>
```

```
  |\   /|
   \|_|/
   /. .\
  =\_Y_/=
   {>o<}
```

Hide()

Please note: the event must have the flag `cancelable: true`, otherwise the call `event.preventDefault()` is ignored.

Events-in-events are synchronous

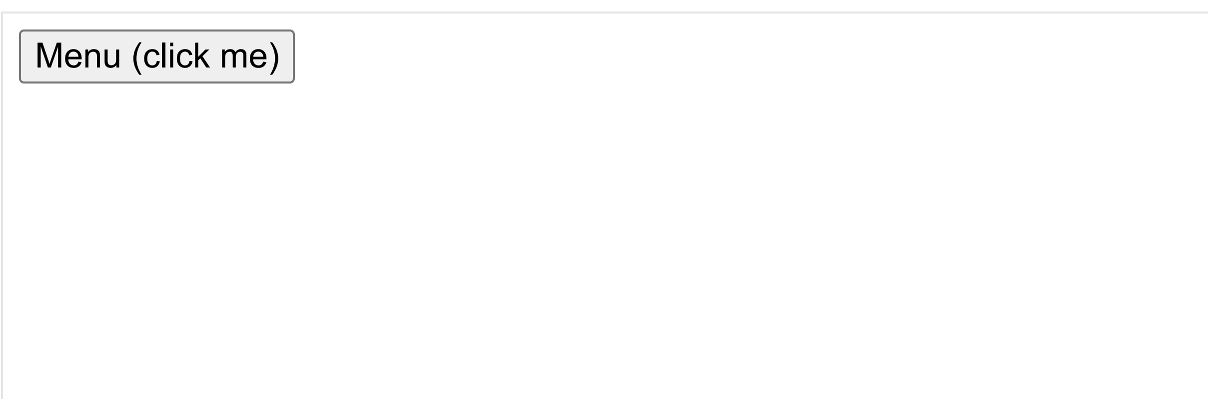
Usually events are processed asynchronously. That is: if the browser is processing `onclick` and in the process a new event occurs, then it waits until the `onclick` processing is finished.

The exception is when one event is initiated from within another one.

Then the control jumps to the nested event handler, and after it goes back.

For instance, here the nested `menu-open` event is processed synchronously, during the `onclick`:

```
<button id="menu">Menu (click me)</button>

<script>
  menu.onclick = function() {
    alert(1);

    // alert("nested")
    menu.dispatchEvent(new CustomEvent("menu-open", {
      bubbles: true
    }));

    alert(2);
  };

  document.addEventListener('menu-open', () => alert('nested'));
</script>
```



The output order is: 1 → nested → 2.

Please note that the nested event `menu-open` fully bubbles up and is handled on the `document`. The propagation and handling of the nested event must be fully finished before the processing gets back to the outer code (`onclick`).

That's not only about `dispatchEvent`, there are other cases. JavaScript in an event handler can call methods that lead to other events – they are too processed synchronously.

If we don't like it, we can either put the `dispatchEvent` (or other event-triggering call) at the end of `onclick` or, maybe better, wrap it in zero-delay `setTimeout`:

```
<button id="menu">Menu (click me)</button>

<script>
  menu.onclick = function() {
    alert(1);

    // alert(2)
    setTimeout(() => menu.dispatchEvent(new
CustomEvent("menu-open", {
      bubbles: true
    })));

    alert(2);
  };

  document.addEventListener('menu-open', () =>
alert('nested'));
</script>
```

Now `dispatchEvent` runs asynchronously after the current code execution is finished, including `mouse.onclick`, so event handlers are totally separate.

The output order becomes: 1 → 2 → nested.

Summary

To generate an event from code, we first need to create an event object.

The generic `Event(name, options)` constructor accepts an arbitrary event name and the `options` object with two properties:

- `bubbles: true` if the event should bubble.
- `cancelable: true` if the `event.preventDefault()` should work.

Other constructors of native events like `MouseEvent`, `KeyboardEvent` and so on accept properties specific to that event type. For instance, `clientX` for mouse events.

For custom events we should use `CustomEvent` constructor. It has an additional option named `detail`, we should assign the event-specific data to it. Then all handlers can access it as `event.detail`.

Despite the technical possibility to generate browser events like `click` or `keydown`, we should use with the great care.

We shouldn't generate browser events as it's a hacky way to run handlers. That's a bad architecture most of the time.

Native events might be generated:

- As a dirty hack to make 3rd-party libraries work the needed way, if they don't provide other means of interaction.

- For automated testing, to “click the button” in the script and see if the interface reacts correctly.

Custom events with our own names are often generated for architectural purposes, to signal what happens inside our menus, sliders, carousels etc.

UI Events

Here we cover most important user interface events and how to work with them.

Mouse events basics

In this chapter we'll get into more details about mouse events and their properties.

Please note: such events may come not only from “mouse devices”, but are also from other devices, such as phones and tablets, where they are emulated for compatibility.

Mouse event types

We can split mouse events into two categories: “simple” and “complex”

Simple events

The most used simple events are:

`mousedown/mouseup`

Mouse button is clicked/released over an element.

`mouseover/mouseout`

Mouse pointer comes over/out from an element.

`mousemove`

Every mouse move over an element triggers that event.

`contextmenu`

Triggers when opening a context menu is attempted. In the most common case, that happens when the right mouse button is pressed. Although, there are other ways to open a context menu, e.g. using a special keyboard key, so it’s not exactly the mouse event.

…There are several other event types too, we’ll cover them later.

Complex events

`click`

Triggers after `mousedown` and then `mouseup` over the same element if the left mouse button was used.

`dblclick`

Triggers after a double click over an element.

Complex events are made of simple ones, so in theory we could live without them. But they exist, and that’s good, because they are convenient.

Events order

An action may trigger multiple events.

For instance, a click first triggers `mousedown`, when the button is pressed, then `mouseup` and `click` when it’s released.

In cases when a single action initiates multiple events, their order is fixed. That is, the handlers are called in the order `mousedown` → `mouseup` → `click`.

Getting the button: which

Click-related events always have the `which` property, which allows to get the exact mouse button.

It is not used for `click` and `contextmenu` events, because the former happens only on left-click, and the latter – only on right-click.

But if we track `mousedown` and `mouseup`, then we need it, because these events trigger on any button, so `which` allows to distinguish between “right-mousedown” and “left-mousedown”.

There are the three possible values:

- `event.which == 1` – the left button
- `event.which == 2` – the middle button
- `event.which == 3` – the right button

The middle button is somewhat exotic right now and is very rarely used.

Modifiers: shift, alt, ctrl and meta

All mouse events include the information about pressed modifier keys.

Event properties:

- `shiftKey`: `Shift`
- `altKey`: `Alt` (or `Opt` for Mac)
- `ctrlKey`: `Ctrl`
- `metaKey`: `Cmd` for Mac

They are `true` if the corresponding key was pressed during the event.

For instance, the button below only works on `Alt+Shift`+click:

```
<button id="button">Alt+Shift+Click on me!</button>
```

```html
<script>
  button.onclick = function(event) {
    if (event.altKey && event.shiftKey) {
      alert('Hooray!');
    }
  };
</script>
```

Alt+Shift+Click on me!

⚠ Attention: on Mac it's usually `Cmd` instead of `Ctrl`

On Windows and Linux there are modifier keys `Alt`, `Shift` and `Ctrl`. On Mac there's one more: `Cmd`, corresponding to the property `metaKey`.

In most applications, when Windows/Linux uses `Ctrl`, on Mac `Cmd` is used.

That is: where a Windows user presses `Ctrl+Enter` or `Ctrl+A`, a Mac user would press `Cmd+Enter` or `Cmd+A`, and so on.

So if we want to support combinations like `Ctrl`+click, then for Mac it makes sense to use `Cmd`+click. That's more comfortable for Mac users.

Even if we'd like to force Mac users to `Ctrl`+click – that's kind of difficult. The problem is: a left-click with `Ctrl` is interpreted as a *right-click* on MacOS, and it generates the `contextmenu` event, not `click` like Windows/Linux.

So if we want users of all operating systems to feel comfortable, then together with `ctrlKey` we should check `metaKey`.

For JS-code it means that we should check `if (event.ctrlKey || event.metaKey)`.

⚠ There are also mobile devices

Keyboard combinations are good as an addition to the workflow. So that if the visitor has a keyboard – it works. And if their device doesn’t have it – then there should be another way to do the same.

Coordinates: clientX/Y, pageX/Y

All mouse events have coordinates in two flavours:

1. Window-relative: `clientX` and `clientY`.
2. Document-relative: `pageX` and `pageY`.

For instance, if we have a window of the size 500x500, and the mouse is in the left-upper corner, then `clientX` and `clientY` are `0`. And if the mouse is in the center, then `clientX` and `clientY` are `250`, no matter what place in the document it is, how far the document was scrolled. They are similar to `position:fixed`.

Document-relative coordinates `pageX`, `pageY` are counted from the left-upper corner of the document, not the window. You can read more about coordinates in the chapter Coordinates.

Disabling selection

Double mouse click has a side-effect that may be disturbing in some interfaces: it selects the text.

For instance, a double-click on the text below selects it in addition to our handler:

```
<span ondblclick="alert('dblclick')">Double-click me</span>
```

Double-click me

If one presses the left mouse button and, without releasing it, moves the mouse, that also makes the selection, often unwanted.

There are multiple ways to prevent the selection, that you can read in the chapter Selection and Range.

In this particular case the most reasonable way is to prevent the browser action on `mousedown`. It prevents both these selections:

```
Before...
<b ondblclick="alert('Click!')" onmousedown="return false">
  Double-click me
</b>
...After
```

Before... **Double-click me** ...After

Now the bold element is not selected on double clicks, and pressing the left button on it won't start the selection.

Please note: the text inside it is still selectable. However, the selection should start not on the text itself, but before or after it. Usually that's fine for users.

Preventing copying

If we want to disable selection to protect our page content from copy-pasting, then we can use another event: `oncopy`.

```
<div oncopy="alert('Copying forbidden!');return false">
  Dear user,
  The copying is forbidden for you.
  If you know JS or HTML, then you can get everything from the
page source though.
</div>
```

Dear user, The copying is forbidden for you. If you know JS or HTML, then you can get everything from the page source though.

If you try to copy a piece of text in the `<div>`, that won't work, because the default action `oncopy` is prevented.

Surely the user has access to HTML-source of the page, and can take the content from there, but not everyone knows how to do it.

Summary

Mouse events have the following properties:

- Button: `which`.
- Modifier keys (`true` if pressed): `altKey`, `ctrlKey`, `shiftKey` and `metaKey` (Mac).
    - If you want to handle `Ctrl`, then don't forget Mac users, they usually use `Cmd`, so it's better to check `if (e.metaKey || e.ctrlKey)`.

- Window-relative coordinates: `clientX/clientY`.
- Document-relative coordinates: `pageX/pageY`.

The default browser action of `mousedown` is text selection, if it's not good for the interface, then it should be prevented.

In the next chapter we'll see more details about events that follow pointer movement and how to track element changes under it.

Tasks

Selectable list

importance: 5

Create a list where elements are selectable, like in file-managers.

- A click on a list element selects only that element (adds the class `.selected`), deselects all others.
- If a click is made with `Ctrl` (`Cmd` for Mac), then the selection is toggled on the element, but other elements are not modified.

The demo:

Click on a list item to select it.

- Christopher Robin
- Winnie-the-Pooh
- Tigger
- Kanga
- Rabbit. Just rabbit.

P.S. For this task we can assume that list items are text-only. No nested tags.

P.P.S. Prevent the native browser selection of the text on clicks.

Open a sandbox for the task.

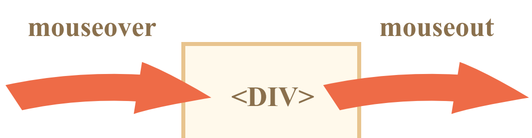
To solution

Moving the mouse: mouseover/out, mouseenter/leave

Let's dive into more details about events that happen when the mouse moves between elements.

Events mouseover/mouseout, relatedTarget

The `mouseover` event occurs when a mouse pointer comes over an element, and `mouseout` – when it leaves.



These events are special, because they have property `relatedTarget`. This property complements `target`. When a mouse leaves one element for another, one of them becomes `target`, and the other one – `relatedTarget`.

For `mouseover`:

- `event.target` – is the element where the mouse came over.
- `event.relatedTarget` – is the element from which the mouse came (`relatedTarget` → `target`).

For `mouseout` the reverse:

- `event.target` – is the element that the mouse left.
- `event.relatedTarget` – is the new under-the-pointer element, that mouse left for (`target` → `relatedTarget`).

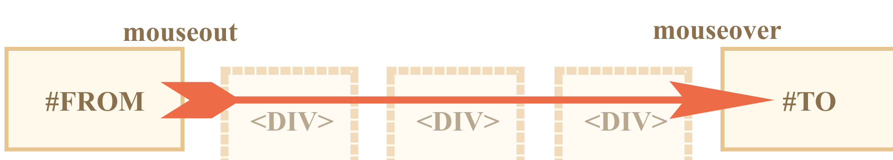
> ⚠️ **`relatedTarget` can be `null`**
>
> The `relatedTarget` property can be `null`.
>
> That's normal and just means that the mouse came not from another element, but from out of the window. Or that it left the window.
>
> We should keep that possibility in mind when using `event.relatedTarget` in our code. If we access `event.relatedTarget.tagName`, then there will be an error.

Skipping elements

The `mousemove` event triggers when the mouse moves. But that doesn't mean that every pixel leads to an event.

The browser checks the mouse position from time to time. And if it notices changes then triggers the events.

That means that if the visitor is moving the mouse very fast then some DOM-elements may be skipped:

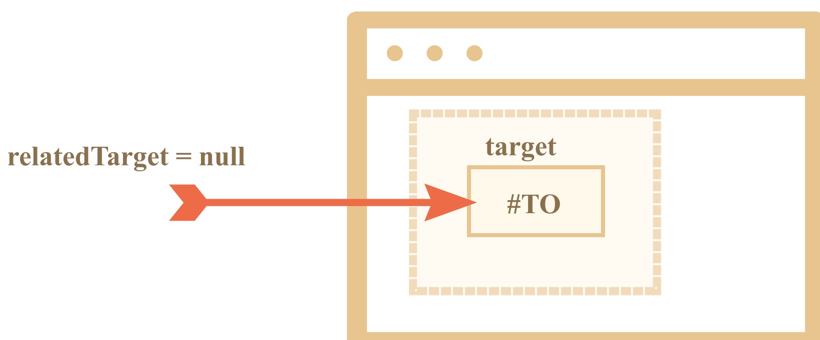


If the mouse moves very fast from `#FROM` to `#TO` elements as painted above, then intermediate `<div>` elements (or some of them) may be skipped. The `mouseout` event may trigger on `#FROM` and then immediately `mouseover` on `#TO`.

That's good for performance, because there may be many intermediate elements. We don't really want to process in and out of each one.

On the other hand, we should keep in mind that the mouse pointer doesn't "visit" all elements along the way. It can "jump".

In particular, it's possible that the pointer jumps right inside the middle of the page from out of the window. In that case `relatedTarget` is `null`, because it came from "nowhere":



ℹ If `mouseover` triggered, there must be `mouseout`

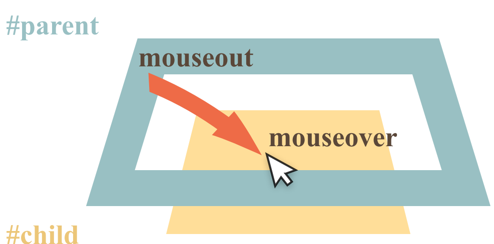
In case of fast mouse movements, intermediate elements may be ignored, but one thing we know for sure: if the pointer "officially" entered an element (`mouseover` event generated), then upon leaving it we always get `mouseout`.

Mouseout when leaving for a child

An important feature of `mouseout` – it triggers, when the pointer moves from an element to its descendant, e.g. from `#parent` to `#child` in this HTML:

```
<div id="parent">
  <div id="child">...</div>
</div>
```

If we're on `#parent` and then move the pointer deeper into `#child`, but we get `mouseout` on `#parent`!



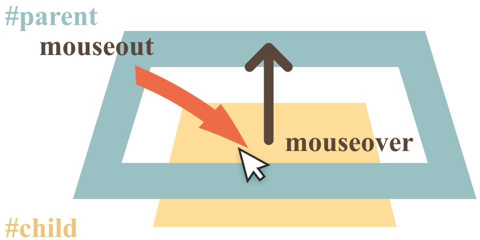
That may seem strange, but can be easily explained.

According to the browser logic, the mouse cursor may be only over a *single* element at any time – the most nested one and top by z-index.

So if it goes to another element (even a descendant), then it leaves the previous one.

Please note another important detail of event processing.

The `mouseover` event on a descendant bubbles up. So, if `#parent` has `mouseover` handler, it triggers:



As shown, when the pointer moves from `#parent` element to `#child`, two handlers trigger on the parent element: `mouseout` and `mouseover`:

```
parent.onmouseout = function(event) {
  /* event.target: parent element */
};
parent.onmouseover = function(event) {
  /* event.target: child element (bubbled) */
};
```

If we don't examine `event.target` inside the handlers, then it may seem that the mouse pointer left `#parent` element, and then immediately came back over it.

But that's not the case! The pointer is still over the parent, it just moved deeper into the child element.

If there are some actions upon leaving the parent element, e.g. an animation runs in `parent.onmouseout`, we usually don't want it when the pointer just goes deeper into `#parent`.

To avoid it, we can check `relatedTarget` in the handler and, if the mouse is still inside the element, then ignore such event.

Alternatively we can use other events: `mouseenter` и `mouseleave`, that we'll be covering now, as they don't have such problems.

Events mouseenter and mouseleave

Events `mouseenter/mouseleave` are like `mouseover/mouseout`. They trigger when the mouse pointer enters/leaves the element.

But there are two important differences:

1. Transitions inside the element, to/from descendants, are not counted.
2. Events `mouseenter/mouseleave` do not bubble.

These events are extremely simple.

When the pointer enters an element – `mouseenter` triggers. The exact location of the pointer inside the element or its descendants doesn't matter.

When the pointer leaves an element – `mouseleave` triggers.

Event delegation

Events `mouseenter/leave` are very simple and easy to use. But they do not bubble. So we can't use event delegation with them.

Imagine we want to handle mouse enter/leave for table cells. And there are hundreds of cells.

The natural solution would be – to set the handler on `<table>` and process events there. But `mouseenter/leave` don't bubble. So if such event happens on `<td>`, then only a handler on that `<td>` is able to catch it.

Handlers for `mouseenter/leave` on `<table>` only trigger when the pointer enters/leaves the table as a whole. It's impossible to get any information about transitions inside it.

So, let's use `mouseover/mouseout`.

Let's start with simple handlers that highlight the element under mouse:

```
// let's highlight an element under the pointer
table.onmouseover = function(event) {
  let target = event.target;
  target.style.background = 'pink';
};

table.onmouseout = function(event) {
  let target = event.target;
  target.style.background = '';
};
```

In our case we'd like to handle transitions between table cells `<td>`: entering a cell and leaving it. Other transitions, such as inside the cell or outside of any cells, don't interest us. Let's filter them out.

Here's what we can do:

- Remember the currently highlighted `<td>` in a variable, let's call it `currentElem`.
- On `mouseover` – ignore the event if we're still inside the current `<td>`.
- On `mouseout` – ignore if we didn't leave the current `<td>`.

Here's an example of code that accounts for all possible situations:

```
// <td> under the mouse right now (if any)
let currentElem = null;

table.onmouseover = function(event) {
  // before entering a new element, the mouse always leaves the
previous one
  // if currentElem is set, we didn't leave the previous <td>,
  // that's a mouseover inside it, ignore the event
  if (currentElem) return;
```

```
  let target = event.target.closest('td');

  // we moved not into a <td> - ignore
  if (!target) return;

  // moved into <td>, but outside of our table (possible in case of
nested tables)
  // ignore
  if (!table.contains(target)) return;

  // hooray! we entered a new <td>
  currentElem = target;
  onEnter(currentElem);
};


table.onmouseout = function(event) {
  // if we're outside of any <td> now, then ignore the event
  // that's probably a move inside the table, but out of <td>,
  // e.g. from <tr> to another <tr>
  if (!currentElem) return;

  // we're leaving the element – where to? Maybe to a descendant?
  let relatedTarget = event.relatedTarget;

  while (relatedTarget) {
    // go up the parent chain and check – if we're still inside
currentElem
    // then that's an internal transition – ignore it
    if (relatedTarget == currentElem) return;

    relatedTarget = relatedTarget.parentNode;
  }

  // we left the <td>. really.
  onLeave(currentElem);
  currentElem = null;
};

// any functions to handle entering/leaving an element
function onEnter(elem) {
  elem.style.background = 'pink';

  // show that in textarea
  text.value += `over ->
${currentElem.tagName}.${currentElem.className}\n`;
  text.scrollTop = 1e6;
}
```

```
function onLeave(elem) {
  elem.style.background = '';

  // show that in textarea
  text.value += `out <- ${elem.tagName}.${elem.className}\n`;
  text.scrollTop = 1e6;
}
```

Once again, the important features are:

1. It uses event delegation to handle entering/leaving of any `<td>` inside the table. So it relies on `mouseover/out` instead of `mouseenter/leave` that don't bubble and hence allow no delegation.
2. Extra events, such as moving between descendants of `<td>` are filtered out, so that `onEnter/Leave` runs only if the pointer leaves or enters `<td>` as a whole.

Summary

We covered events `mouseover`, `mouseout`, `mousemove`, `mouseenter` and `mouseleave`.

These things are good to note:

- A fast mouse move may skip intermediate elements.
- Events `mouseover/out` and `mouseenter/leave` have an additional property: `relatedTarget`. That's the element that we are coming from/to, complementary to `target`.

Events `mouseover/out` trigger even when we go from the parent element to a child element. The browser assumes that the mouse can be only over one element at one time – the deepest one.

Events `mouseenter/leave` are different in that aspect: they only trigger when the mouse comes in and out the element as a whole.

Also they do not bubble.

Tasks

Improved tooltip behavior

importance: 5

Write JavaScript that shows a tooltip over an element with the attribute `data-tooltip`. The value of this attribute should become the tooltip text.

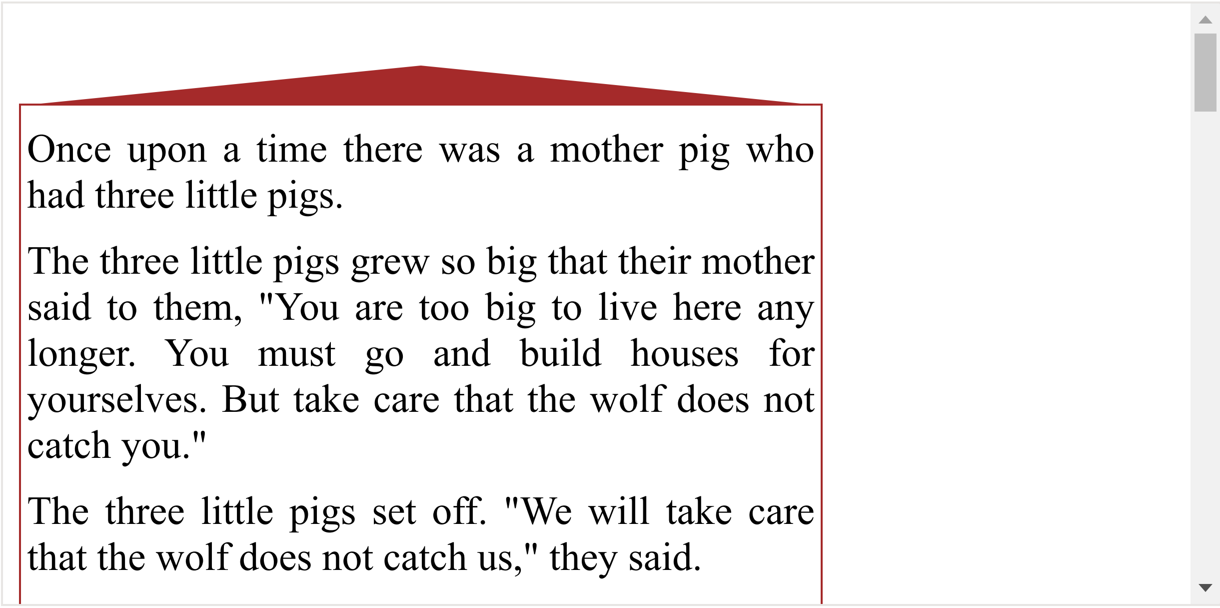
That's like the task Tooltip behavior, but here the annotated elements can be nested. The most deeply nested tooltip is shown.

Only one tooltip may show up at the same time.

For instance:

```
<div data-tooltip="Here – is the house interior" id="house">
  <div data-tooltip="Here – is the roof" id="roof"></div>
  ...
  <a href="https://en.wikipedia.org/wiki/The_Three_Little_Pigs" data-
tooltip="Read on…">Hover over me</a>
</div>
```

The result in iframe:



Open a sandbox for the task.

To solution

"Smart" tooltip

importance: 5

Write a function that shows a tooltip over an element only if the visitor moves the mouse *to it*, but not *through it*.

In other words, if the visitor moves the mouse to the element and stops there – show the tooltip. And if they just moved the mouse through, then no need, who wants extra blinking?

Technically, we can measure the mouse speed over the element, and if it's slow then we assume that it comes "over the element" and show the tooltip, if it's fast – then we ignore it.

Make a universal object `new HoverIntent(options)` for it.

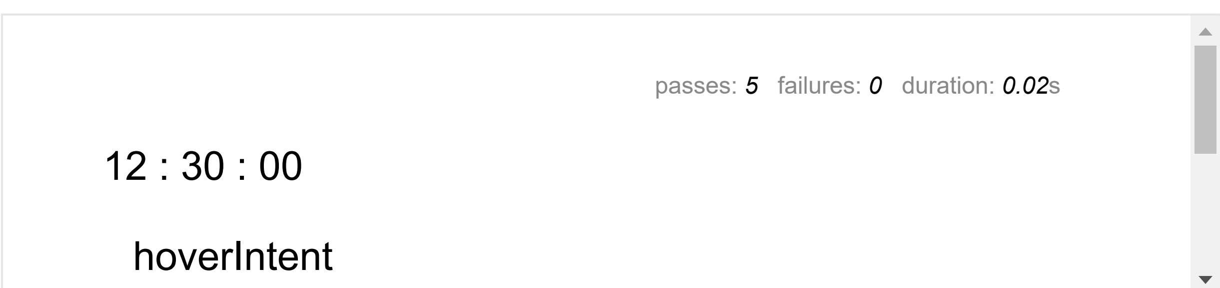
Its `options`:

- `elem` – element to track.
- `over` – a function to call if the mouse came to the element: that is, it moves slowly or stopped over it.
- `out` – a function to call when the mouse leaves the element (if `over` was called).

An example of using such object for the tooltip:

```
// a sample tooltip
let tooltip = document.createElement('div');
tooltip.className = "tooltip";
tooltip.innerHTML = "Tooltip";

// the object will track mouse and call over/out
new HoverIntent({
  elem,
  over() {
    tooltip.style.left = elem.getBoundingClientRect().left + 'px';
    tooltip.style.top = elem.getBoundingClientRect().bottom + 5 + 'px';
    document.body.append(tooltip);
  },
  out() {
    tooltip.remove();
  }
});
```

The demo:



If you move the mouse over the “clock” fast then nothing happens, and if you do it slow or stop on them, then there will be a tooltip.

Please note: the tooltip doesn’t “blink” when the cursor moves between the clock subelements.

Open a sandbox with tests.

To solution

Drag'n'Drop with mouse events

Drag’n’Drop is a great interface solution. Taking something and dragging and dropping it is a clear and simple way to do many things, from copying and moving documents (as in file managers) to ordering (dropping items into a cart).

In the modern HTML standard there’s a section about Drag and Drop with special events such as `dragstart`, `dragend`, and so on.

These events are useful in that they allow us to solve simple tasks easily. For instance, they allow us to handle the drag’n’drop of “external” files into the browser, so we can take a file in the OS file-manager and drop it into the browser window, thereby giving JavaScript access to its contents.

But native Drag Events also have limitations. For instance, we can’t limit dragging by a certain area. Also we can’t make it “horizontal” or “vertical” only. And there are other drag’n’drop tasks that can’t be done using that API. Also, mobile device support for such events is almost non-existant.

So here we’ll see how to implement Drag’n’Drop using mouse events.

Drag’n’Drop algorithm

The basic Drag’n’Drop algorithm looks like this:

1. On `mousedown` – prepare the element for moving, if needed (maybe create a copy of it).
2. Then on `mousemove` move it by changing `left/top` and `position:absolute`.
3. On `mouseup` – perform all actions related to a finished Drag’n’Drop.

These are the basics. Later we can extend it, for instance, by highlighting droppable (available for the drop) elements when hovering over them.

Here’s the algorithm for drag’n’drop of a ball:

```
ball.onmousedown = function(event) { // (1) start the process

  // (2) prepare to moving: make absolute and on top by z-index
  ball.style.position = 'absolute';
  ball.style.zIndex = 1000;
  // move it out of any current parents directly into body
  // to make it positioned relative to the body
  document.body.append(ball);
  // ...and put that absolutely positioned ball under the pointer

  moveAt(event.pageX, event.pageY);

  // centers the ball at (pageX, pageY) coordinates
  function moveAt(pageX, pageY) {
    ball.style.left = pageX - ball.offsetWidth / 2 + 'px';
    ball.style.top = pageY - ball.offsetHeight / 2 + 'px';
  }

  function onMouseMove(event) {
    moveAt(event.pageX, event.pageY);
  }

  // (3) move the ball on mousemove
  document.addEventListener('mousemove', onMouseMove);
```

```
  // (4) drop the ball, remove unneeded handlers
  ball.onmouseup = function() {
    document.removeEventListener('mousemove', onMouseMove);
    ball.onmouseup = null;
  };

};
```

If we run the code, we can notice something strange. On the beginning of the drag'n'drop, the ball "forks": we start dragging its "clone".

That's because the browser has its own Drag'n'Drop for images and some other elements that runs automatically and conflicts with ours.

To disable it:

```
ball.ondragstart = function() {
  return false;
};
```

Now everything will be all right.

Another important aspect – we track `mousemove` on `document`, not on `ball`. From the first sight it may seem that the mouse is always over the ball, and we can put `mousemove` on it.

But as we remember, `mousemove` triggers often, but not for every pixel. So after swift move the pointer can jump from the ball somewhere in the middle of document (or even outside of the window).

So we should listen on `document` to catch it.

Correct positioning

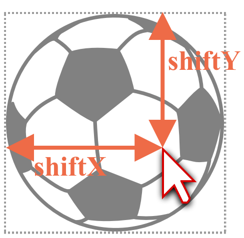
In the examples above the ball is always moved so, that it's center is under the pointer:

```
ball.style.left = pageX - ball.offsetWidth / 2 + 'px';
ball.style.top = pageY - ball.offsetHeight / 2 + 'px';
```

Not bad, but there's a side-effect. To initiate the drag'n'drop, we can `mousedown` anywhere on the ball. But if "take" it from its edge, then the ball suddenly "jumps" to become centered under the mouse pointer.

It would be better if we keep the initial shift of the element relative to the pointer.

For instance, if we start dragging by the edge of the ball, then the pointer should remain over the edge while dragging.



Let's update our algorithm:

1. When a visitor presses the button (`mousedown`) – remember the distance from the pointer to the left-upper corner of the ball in variables `shiftX/shiftY`. We'll keep that distance while dragging.

   To get these shifts we can substract the coordinates:

```
// onmousedown
let shiftX = event.clientX - ball.getBoundingClientRect().left;
let shiftY = event.clientY - ball.getBoundingClientRect().top;
```

2. Then while dragging we position the ball on the same shift relative to the pointer, like this:

```
// onmousemove
// ball has position:absoute
ball.style.left = event.pageX - shiftX + 'px';
ball.style.top = event.pageY - shiftY + 'px';
```

The final code with better positioning:

```
ball.onmousedown = function(event) {

  let shiftX = event.clientX - ball.getBoundingClientRect().left;
  let shiftY = event.clientY - ball.getBoundingClientRect().top;

  ball.style.position = 'absolute';
  ball.style.zIndex = 1000;
  document.body.append(ball);

  moveAt(event.pageX, event.pageY);

  // moves the ball at (pageX, pageY) coordinates
  // taking initial shifts into account
  function moveAt(pageX, pageY) {
    ball.style.left = pageX - shiftX + 'px';
    ball.style.top = pageY - shiftY + 'px';
  }

  function onMouseMove(event) {
    moveAt(event.pageX, event.pageY);
  }

  // move the ball on mousemove
  document.addEventListener('mousemove', onMouseMove);

  // drop the ball, remove unneeded handlers
  ball.onmouseup = function() {
```

```
    document.removeEventListener('mousemove', onMouseMove);
    ball.onmouseup = null;
  };

};

ball.ondragstart = function() {
  return false;
};
```

The difference is especially noticeable if we drag the ball by its right-bottom corner. In the previous example the ball "jumps" under the pointer. Now it fluently follows the pointer from the current position.

Potential drop targets (droppables)

In previous examples the ball could be dropped just "anywhere" to stay. In real-life we usually take one element and drop it onto another. For instance, a "file" into a "folder" or something else.

Speaking abstract, we take a "draggable" element and drop it onto "droppable" element.

We need to know:

- where the element was dropped at the end of Drag'n'Drop – to do the corresponding action,
- and, preferably, know the droppable we're dragging over, to highlight it.

The solution is kind-of interesting and just a little bit tricky, so let's cover it here.

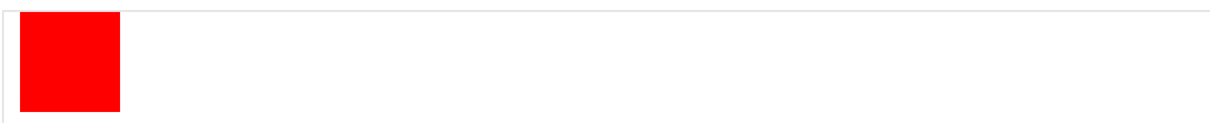
What may be the first idea? Probably to set `mouseover/mouseup` handlers on potential droppables?

But that doesn't work.

The problem is that, while we're dragging, the draggable element is always above other elements. And mouse events only happen on the top element, not on those below it.

For instance, below are two `<div>` elements, red one on top of the blue one (fully covers). There’s no way to catch an event on the blue one, because the red is on top:

```
<style>
  div {
    width: 50px;
    height: 50px;
    position: absolute;
    top: 0;
  }
</style>
<div style="background:blue" onmouseover="alert('never
works')"></div>
<div style="background:red" onmouseover="alert('over
red!')"></div>
```



The same with a draggable element. The ball is always on top over other elements, so events happen on it. Whatever handlers we set on lower elements, they won’t work.

That’s why the initial idea to put handlers on potential droppables doesn’t work in practice. They won’t run.

So, what to do?

There’s a method called `document.elementFromPoint(clientX, clientY)`. It returns the most nested element on given window-relative coordinates (or `null` if given coordinates are out of the window).

We can use it in any of our mouse event handlers to detect the potential droppable under the pointer, like this:

```
// in a mouse event handler
ball.hidden = true; // (*) hide the element that we drag

let elemBelow = document.elementFromPoint(event.clientX,
event.clientY);
// elemBelow is the element below the ball, may be droppable

ball.hidden = false;
```

Please note: we need to hide the ball before the call `(*)`. Otherwise we'll usually have a ball on these coordinates, as it's the top element under the pointer: `elemBelow=ball`. So we hide it and immediately show again.

We can use that code to check what element we're "flying over" at any time. And handle the drop when it happens.

An extended code of `onMouseMove` to find "droppable" elements:

```
// potential droppable that we're flying over right now
let currentDroppable = null;

function onMouseMove(event) {
  moveAt(event.pageX, event.pageY);

  ball.hidden = true;
  let elemBelow = document.elementFromPoint(event.clientX,
event.clientY);
  ball.hidden = false;

  // mousemove events may trigger out of the window (when the ball is
dragged off-screen)
  // if clientX/clientY are out of the window, then elementFromPoint
returns null
  if (!elemBelow) return;

  // potential droppables are labeled with the class "droppable" (can
```

```
be other logic)
  let droppableBelow = elemBelow.closest('.droppable');

  if (currentDroppable != droppableBelow) {
    // we're flying in or out...
    // note: both values can be null
    //   currentDroppable=null if we were not over a droppable before
this event (e.g over an empty space)
    //   droppableBelow=null if we're not over a droppable now, during
this event

    if (currentDroppable) {
      // the logic to process "flying out" of the droppable (remove
highlight)
      leaveDroppable(currentDroppable);
    }
    currentDroppable = droppableBelow;
    if (currentDroppable) {
      // the logic to process "flying in" of the droppable
      enterDroppable(currentDroppable);
    }
  }
}
```

In the example below when the ball is dragged over the soccer gate, the gate is highlighted.

https://plnkr.co/edit/VdbuAVBTO0X3sIR8o66m?p=preview

Now we have the current "drop target", that we're flying over, in the variable `currentDroppable` during the whole process and can use it to highlight or any other stuff.

Summary

We considered a basic Drag'n'Drop algorithm.

The key components:

1. Events flow: `ball.mousedown` → `document.mousemove` → `ball.mouseup` (don't forget to cancel native `ondragstart`).

2. At the drag start – remember the initial shift of the pointer relative to the element: `shiftX/shiftY` and keep it during the dragging.
3. Detect droppable elements under the pointer using `document.elementFromPoint`.

We can lay a lot on this foundation.

- On `mouseup` we can intellectually finalize the drop: change data, move elements around.
- We can highlight the elements we're flying over.
- We can limit dragging by a certain area or direction.
- We can use event delegation for `mousedown/up`. A large-area event handler that checks `event.target` can manage Drag'n'Drop for hundreds of elements.
- And so on.

There are frameworks that build architecture over it: `DragZone`, `Droppable`, `Draggable` and other classes. Most of them do the similar stuff to described above, so it should be easy to understand them now. Or roll our own, as you can see that's easy enough to do, sometimes easier than adapting a third-part solution.

Tasks

Slider

importance: 5

Create a slider:

Drag the blue thumb with the mouse and move it.

Important details:

- When the mouse button is pressed, during the dragging the mouse may go over or below the slider. The slider will still work (convenient for the user).
- If the mouse moves very fast to the left or to the right, the thumb should stop exactly at the edge.

Open a sandbox for the task.

To solution

Drag superheroes around the field

importance: 5

This task can help you to check understanding of several aspects of Drag'n'Drop and DOM.

Make all elements with class `draggable` – draggable. Like a ball in the chapter.

Requirements:

- Use event delegation to track drag start: a single event handler on `document` for `mousedown`.
- If elements are dragged to top/bottom window edges – the page scrolls up/down to allow further dragging.
- There is no horizontal scroll (this makes the task a bit simpler, adding it is easy).

- Draggable elements or their parts should never leave the window, even after swift mouse moves.

The demo is too big to fit it here, so here's the link.

Demo in new window

Open a sandbox for the task.

To solution

Keyboard: keydown and keyup

Before we get to keyboard, please note that on modern devices there are other ways to "input something". For instance, people use speech recognition (especially on mobile devices) or copy/paste with the mouse.

So if we want to track any input into an `<input>` field, then keyboard events are not enough. There's another event named `input` to track changes of an `<input>` field, by any means. And it may be a better choice for such task. We'll cover it later in the chapter Events: change, input, cut, copy, paste.

Keyboard events should be used when we want to handle keyboard actions (virtual keyboard also counts). For instance, to react on arrow keys `Up` and `Down` or hotkeys (including combinations of keys).

Teststand

To better understand keyboard events, you can use the teststand .

Keydown and keyup

The `keydown` events happens when a key is pressed down, and then `keyup` – when it's released.

event.code and event.key

The `key` property of the event object allows to get the character, while the `code` property of the event object allows to get the "physical key code".

For instance, the same key `Z` can be pressed with or without `Shift`. That gives us two different characters: lowercase `z` and uppercase `Z`.

The `event.key` is exactly the character, and it will be different. But `event.code` is the same:

Key	`event.key`	`event.code`
`Z`	`z` (lowercase)	`KeyZ`
`Shift+Z`	`Z` (uppercase)	`KeyZ`

If a user works with different languages, then switching to another language would make a totally different character instead of `"Z"`. That will become the value of `event.key`, while `event.code` is always the same: `"KeyZ"`.

"KeyZ" and other key codes

Every key has the code that depends on its location on the keyboard. Key codes described in the UI Events code specification.

For instance:

- Letter keys have codes `"Key<letter>"`: `"KeyA"`, `"KeyB"` etc.
- Digit keys have codes: `"Digit<number>"`: `"Digit0"`, `"Digit1"` etc.
- Special keys are coded by their names: `"Enter"`, `"Backspace"`, `"Tab"` etc.

There are several widespread keyboard layouts, and the specification gives key codes for each of them.

Read the alphanumeric section of the spec for more codes, or just press a key in the teststand above.

⚠ Case matters: `"KeyZ"`, not `"keyZ"`

Seems obvious, but people still make mistakes.

Please evade mistypes: it's `KeyZ`, not `keyZ`. The check like `event.code=="keyZ"` won't work: the first letter of `"Key"` must be uppercase.

What if a key does not give any character? For instance, `Shift` or `F1` or others. For those keys, `event.key` is approximately the same as `event.code`:

Key	`event.key`	`event.code`
`F1`	`F1`	`F1`
`Backspace`	`Backspace`	`Backspace`
`Shift`	`Shift`	`ShiftRight` or `ShiftLeft`

Please note that `event.code` specifies exactly which key is pressed. For instance, most keyboards have two `Shift` keys: on the left and on the right side. The `event.code` tells us exactly which one was pressed, and `event.key` is responsible for the "meaning" of the key: what it is (a "Shift").

Let's say, we want to handle a hotkey: `Ctrl+Z` (or `Cmd+Z` for Mac). Most text editors hook the "Undo" action on it. We can set a listener on `keydown` and check which key is pressed.

There's a dilemma here: in such a listener, should we check the value of `event.key` or `event.code`?

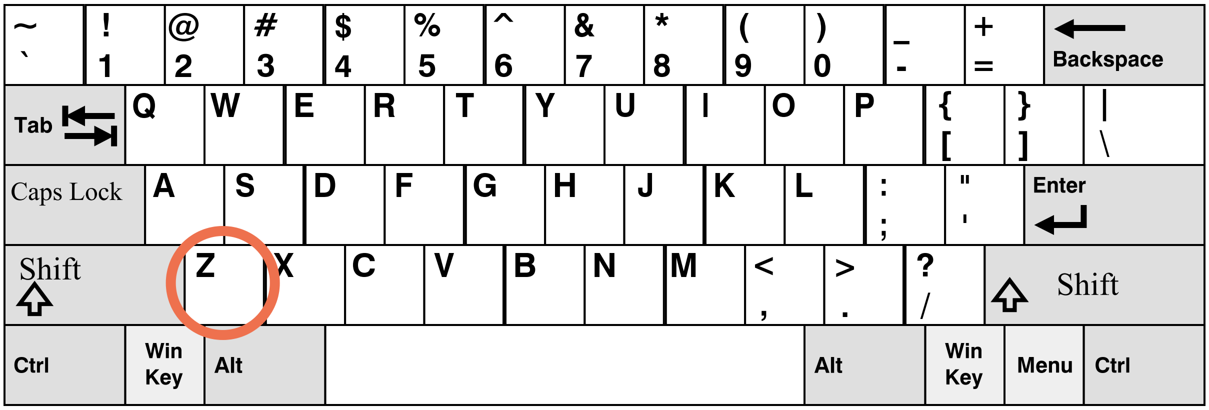
On one hand, the value of `event.key` is a character, it changes depending on the language. If the visitor has several languages in OS and switches between them, the same key gives different characters. So it makes sense to check `event.code`, it's always the same.

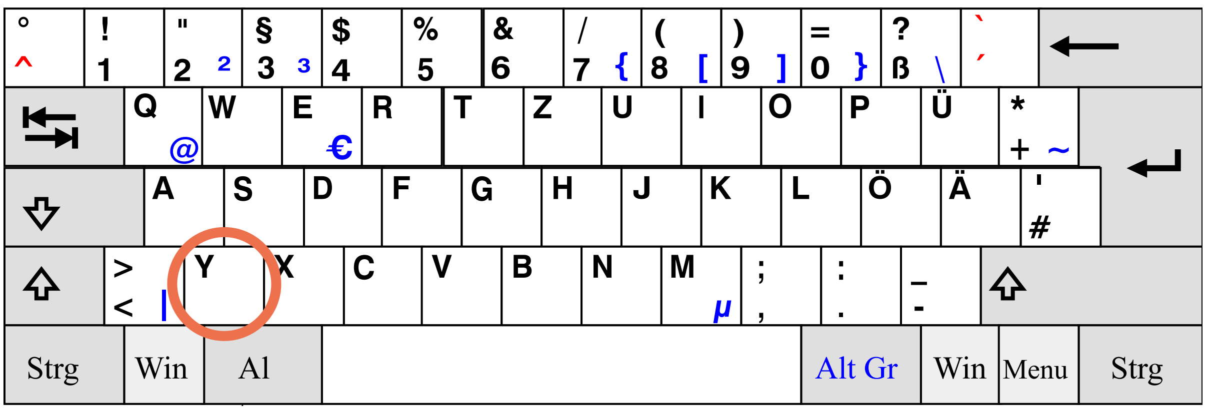
Like this:

```
document.addEventListener('keydown', function(event) {
  if (event.code == 'KeyZ' && (event.ctrlKey || event.metaKey)) {
    alert('Undo!')
  }
});
```

On the other hand, there's a problem with `event.code`. For different keyboard layouts, the same key may have different characters.

For example, here are US layout ("QWERTY") and German layout ("QWERTZ") under it (from Wikipedia):





For the same key, US layout has “Z”, while German layout has “Y” (letters are swapped).

Literally, `event.code` will equal `KeyZ` for people with German layout when they press Y.

If we check `event.code == 'KeyZ'` in our code, then for people with German layout such test will pass when they press Y.

That sounds really odd, but so it is. The specification explicitly mentions such behavior.

So, `event.code` may match a wrong character for unexpected layout. Same letters in different layouts may map to different physical keys, leading to different codes. Luckily, that happens only with several codes, e.g. `keyA`, `keyQ`, `keyZ` (as we’ve seen), and doesn’t happen with special keys such as `Shift`. You can find the list in the specification .

To reliably track layout-dependent characters, `event.key` may be a better way.

On the other hand, `event.code` has the benefit of staying always the same, bound to the physical key location, even if the visitor changes languages. So hotkeys that rely on it work well even in case of a language switch.

Do we want to handle layout-dependant keys? Then `event.key` is the way to go.

Or we want a hotkey to work even after a language switch? Then `event.code` may be better.

Auto-repeat

If a key is being pressed for a long enough time, it starts to "auto-repeat": the `keydown` triggers again and again, and then when it's released we finally get `keyup`. So it's kind of normal to have many `keydown` and a single `keyup`.

For events triggered by auto-repeat, the event object has `event.repeat` property set to `true`.

Default actions

Default actions vary, as there are many possible things that may be initiated by the keyboard.

For instance:

- A character appears on the screen (the most obvious outcome).
- A character is deleted (`Delete` key).
- The page is scrolled (`PageDown` key).
- The browser opens the "Save Page" dialog (`Ctrl+S`)
- …and so on.

Preventing the default action on `keydown` can cancel most of them, with the exception of OS-based special keys. For instance, on Windows `Alt+F4` closes the current browser window. And there's no way to stop it by preventing the default action in JavaScript.

For instance, the `<input>` below expects a phone number, so it does not accept keys except digits, `+`, `()` or `-`:

```
<script>
function checkPhoneKey(key) {
  return (key >= '0' && key <= '9') || key == '+' || key == '(' || key == ')' || key == '-';
}
</script>
<input onkeydown="return checkPhoneKey(event.key)" placeholder="Phone, please" type="tel">
```

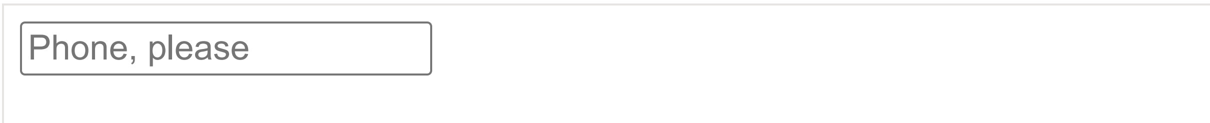
Phone, please

Please note that special keys, such as `Backspace`, `Left`, `Right`, `Ctrl+V`, do not work in the input. That's a side-effect of the strict filter `checkPhoneKey`.

Let's relax it a little bit:

```
<script>
function checkPhoneKey(key) {
  return (key >= '0' && key <= '9') || key == '+' || key == '(' || key == ')' || key == '-' ||
    key == 'ArrowLeft' || key == 'ArrowRight' || key == 'Delete' || key == 'Backspace';
```

```
}
</script>
<input onkeydown="return checkPhoneKey(event.key)" placeholder="Phone, please" type="tel">
```



Now arrows and deletion works well.

…But we still can enter anything by using a mouse and right-click + Paste. So the filter is not 100% reliable. We can just let it be like that, because most of time it works. Or an alternative approach would be to track the `input` event – it triggers after any modification. There we can check the new value and highlight/modify it when it's invalid.

Legacy

In the past, there was a `keypress` event, and also `keyCode`, `charCode`, `which` properties of the event object.

There were so many browser incompatibilities while working with them, that developers of the specification had no way, other than deprecating all of them and creating new, modern events (described above in this chapter). The old code still works, as browsers keep supporting them, but there's totally no need to use those any more.

Summary

Pressing a key always generates a keyboard event, be it symbol keys or special keys like `Shift` or `Ctrl` and so on. The only exception is `Fn` key that sometimes presents on a laptop keyboard. There's no keyboard event for it, because it's often implemented on lower level than OS.

Keyboard events:

- `keydown` – on pressing the key (auto-repeats if the key is pressed for long),
- `keyup` – on releasing the key.

Main keyboard event properties:

- `code` – the "key code" (`"KeyA"`, `"ArrowLeft"` and so on), specific to the physical location of the key on keyboard.
- `key` – the character (`"A"`, `"a"` and so on), for non-character keys, such as `Esc`, usually has the same value as `code`.

In the past, keyboard events were sometimes used to track user input in form fields. That's not reliable, because the input can come from various sources. We have `input` and `change` events to handle any input (covered later in the chapter Events: change, input, cut, copy, paste). They trigger after any kind of input, including copy-pasting or speech recognition.

We should use keyboard events when we really want keyboard. For example, to react on hotkeys or special keys.

Tasks

Extended hotkeys

importance: 5

Create a function `runOnKeys(func, code1, code2, ... code_n)` that runs `func` on simultaneous pressing of keys with codes `code1`, `code2`, …, `code_n`.

For instance, the code below shows `alert` when `"Q"` and `"W"` are pressed together (in any language, with or without CapsLock)

```
runOnKeys(
  () => alert("Hello!"),
  "KeyQ",
  "KeyW"
);
```

Demo in new window

To solution

Scrolling

The `scroll` event allows to react on a page or element scrolling. There are quite a few good things we can do here.

For instance:

- Show/hide additional controls or information depending on where in the document the user is.
- Load more data when the user scrolls down till the end of the page.

Here's a small function to show the current scroll:

```
window.addEventListener('scroll', function() {
  document.getElementById('showScroll').innerHTML = pageYOffset + 'px';
});
```

The `scroll` event works both on the `window` and on scrollable elements.

Prevent scrolling

How do we make something unscrollable?

We can't prevent scrolling by using `event.preventDefault()` in `onscroll` listener, because it triggers *after* the scroll has already happened.

But we can prevent scrolling by `event.preventDefault()` on an event that causes the scroll, for instance `keydown` event for `pageUp` and `pageDown`.

If we add an event handler to these events and `event.preventDefault()` in it, then the scroll won't start.

There are many ways to initiate a scroll, so it's more reliable to use CSS, `overflow` property.

Here are few tasks that you can solve or look through to see the applications on `onscroll`.

Tasks

Endless page

importance: 5

Create an endless page. When a visitor scrolls it to the end, it auto-appends current date-time to the text (so that a visitor can scroll more).

Like this:

Scroll me

Date: Sun Dec 01 2019 11:00:14 GMT+0300 (Moscow Standard Time)

Date: Sun Dec 01 2019 11:00:14 GMT+0300 (Moscow Standard Time)

Date: Sun Dec 01 2019 11:00:14 GMT+0300 (Moscow Standard Time)

Please note two important features of the scroll:

1. **The scroll is "elastic".** We can scroll a little beyond the document start or end in some browsers/devices (empty space below is shown, and then the document will automatically "bounces back" to normal).
2. **The scroll is imprecise.** When we scroll to page end, then we may be in fact like 0-50px away from the real document bottom.

So, "scrolling to the end" should mean that the visitor is no more than 100px away from the document end.

P.S. In real life we may want to show "more messages" or "more goods".

Open a sandbox for the task.

To solution

Up/down button

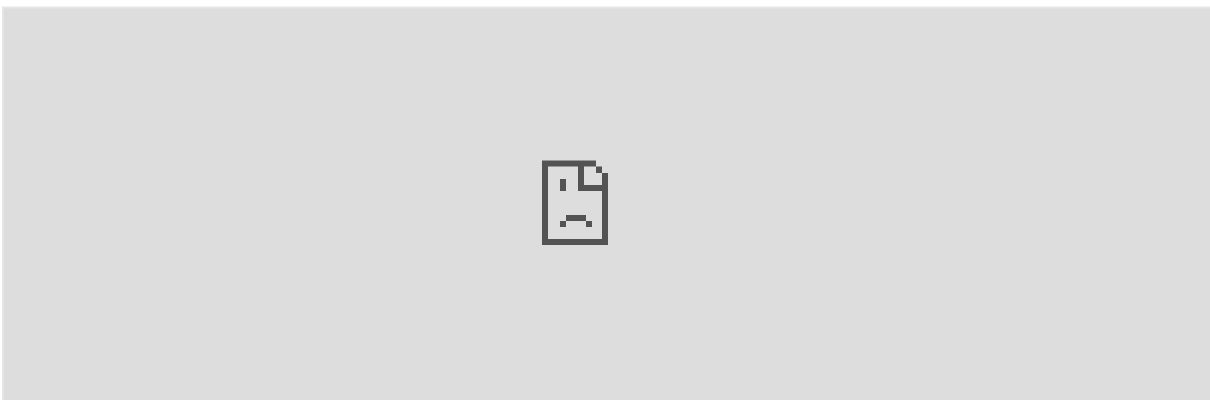
importance: 5

Create a "to the top" button to help with page scrolling.

It should work like this:

- While the page is not scrolled down at least for the window height – it's invisible.
- When the page is scrolled down more than the window height – there appears an "upwards" arrow in the left-top corner. If the page is scrolled back, it disappears.
- When the arrow is clicked, the page scrolls to the top.

Like this (top-left corner, scroll to see):



Open a sandbox for the task.

To solution

Load visible images

importance: 4

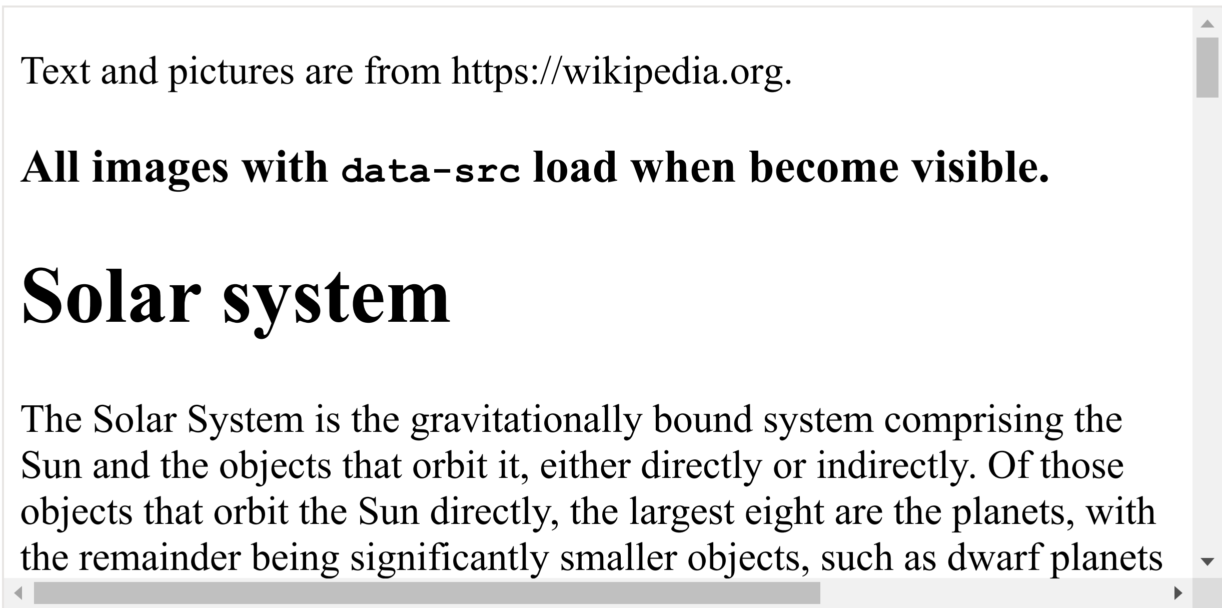
Let's say we have a slow-speed client and want to save their mobile traffic.

For that purpose we decide not to show images immediately, but rather replace them with placeholders, like this:

```html
<img src="placeholder.svg" width="128" height="128" data-src="real.jpg">
```

So, initially all images are `placeholder.svg`. When the page scrolls to the position where the user can see the image – we change `src` to the one in `data-src`, and so the image loads.

Here's an example in `iframe`:



Scroll it to see images load "on-demand".

Requirements:

- When the page loads, those images that are on-screen should load immediately, prior to any scrolling.
- Some images may be regular, without `data-src`. The code should not touch them.
- Once an image is loaded, it should not reload any more when scrolled in/out.

P.S. If you can, make a more advanced solution that would “preload” images that are one page below/after the current position.

P.P.S. Only vertical scroll is to be handled, no horizontal scrolling.

Open a sandbox for the task.

To solution

Forms, controls

Special properties and events for forms `<form>` and controls: `<input>`, `<select>` and other.

Form properties and methods

Forms and control elements, such as `<input>` have a lot of special properties and events.

Working with forms will be much more convenient when we learn them.

Navigation: form and elements

Document forms are members of the special collection `document.forms`.

That's a so-called "named collection": it's both named and ordered. We can use both the name or the number in the document to get the form.

```
document.forms.my - the form with name="my"
document.forms[0] - the first form in the document
```

When we have a form, then any element is available in the named collection `form.elements`.

For instance:

```
<form name="my">
  <input name="one" value="1">
  <input name="two" value="2">
</form>

<script>
  // get the form
  let form = document.forms.my; // <form
```

```
name="my"> element

  // get the element
  let elem = form.elements.one; // <input
name="one"> element

  alert(elem.value); // 1
</script>
```

There may be multiple elements with the same name, that's often the case with radio buttons.

In that case `form.elements[name]` is a collection, for instance:

```
<form>
  <input type="radio" name="age" value="10">
  <input type="radio" name="age" value="20">
</form>

<script>
let form = document.forms[0];

let ageElems = form.elements.age;

alert(ageElems[0]); // [object HTMLInputElement]
</script>
```

These navigation properties do not depend on the tag structure. All control elements, no matter how deep they are in the form, are available in `form.elements`.

Fieldsets as "subforms"

A form may have one or many `<fieldset>` elements inside it. They also have `elements` property that lists form controls inside them.

For instance:

```
<body>
  <form id="form">
    <fieldset name="userFields">
      <legend>info</legend>
      <input name="login" type="text">
    </fieldset>
  </form>

  <script>
    alert(form.elements.login); // <input name="login">

    let fieldset = form.elements.userFields;
    alert(fieldset); // HTMLFieldSetElement

    // we can get the input by name both from the form and from the fieldset
    alert(fieldset.elements.login == form.elements.login); // true
  </script>
</body>
```

⚠ Shorter notation: `form.name`

There's a shorter notation: we can access the element as `form[index/name]`.

In other words, instead of `form.elements.login` we can write `form.login`.

That also works, but there's a minor issue: if we access an element, and then change its `name`, then it is still available under the old name (as well as under the new one).

That's easy to see in an example:

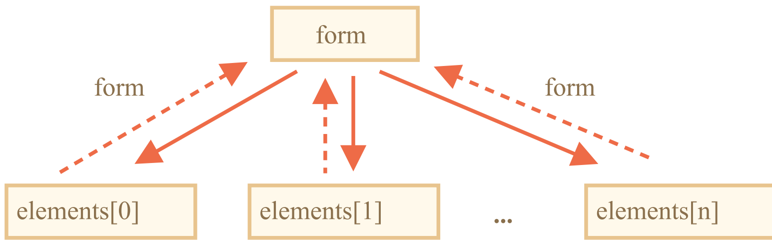
```
<form id="form">
  <input name="login">
</form>

<script>
  alert(form.elements.login == form.login); // true, the same <input>

  form.login.name = "username"; // change the name of the input

  // form.elements updated the name:
  alert(form.elements.login); // undefined
  alert(form.elements.username); // input

  // form allows both names: the new one and the old one
  alert(form.username == form.login); // true
</script>
```

That's usually not a problem, because we rarely change names of form elements.

Backreference: element.form

For any element, the form is available as `element.form`. So a form references all elements, and elements reference the form.

Here's the picture:



For instance:

```
<form id="form">
  <input type="text" name="login">
</form>

<script>
   // form -> element
   let login = form.login;

   // element -> form
   alert(login.form); // HTMLFormElement
</script>
```

Form elements

Let's talk about form controls.

input and textarea

We can access their value as `input.value` (string) or `input.checked` (boolean) for checkboxes.

Like this:

```
input.value = "New value";
textarea.value = "New text";

input.checked = true; // for a checkbox or radio button
```

⚠️ **Use `textarea.value`, not `textarea.innerHTML`**

Please note that even though `<textarea>...</textarea>` holds its value as nested HTML, we should never use `textarea.innerHTML` to access it.

It stores only the HTML that was initially on the page, not the current value.

select and option

A `<select>` element has 3 important properties:

1. `select.options` – the collection of `<option>` subelements,
2. `select.value` – the value of the currently selected `<option>`,
3. `select.selectedIndex` – the number of the currently selected `<option>`.

They provide three different ways of setting a value for a `<select>`:

1. Find the corresponding `<option>` element and set `option.selected` to `true`.
2. Set `select.value` to the value.
3. Set `select.selectedIndex` to the number of the option.

The first way is the most obvious, but `(2)` and `(3)` are usually more convenient.

Here is an example:

```
<select id="select">
  <option value="apple">Apple</option>
  <option value="pear">Pear</option>
  <option value="banana">Banana</option>
</select>


<script>
```

```
  // all three lines do the same thing
  select.options[2].selected = true;
  select.selectedIndex = 2;
  select.value = 'banana';
</script>
```

Unlike most other controls, `<select>` allows to select multiple options at once if it has `multiple` attribute. That's feature is rarely used. In that case we need to use the first way: add/remove the `selected` property from `<option>` subelements.

We can get their collection as `select.options`, for instance:

```
<select id="select" multiple>
  <option value="blues" selected>Blues</option>
  <option value="rock" selected>Rock</option>
  <option value="classic">Classic</option>
</select>

<script>
  // get all selected values from multi-select
  let selected = Array.from(select.options)
    .filter(option => option.selected)
    .map(option => option.value);

  alert(selected); // blues,rock
</script>
```

The full specification of the `<select>` element is available in the specification https://html.spec.whatwg.org/multipage/forms.html#the-select-element .

new Option

This is rarely used on its own. But there's still an interesting thing.

In the specification there's a nice short syntax to create `<option>` elements:

```
option = new Option(text, value, defaultSelected, selected);
```

Parameters:

- `text` – the text inside the option,
- `value` – the option value,
- `defaultSelected` – if `true`, then `selected` HTML-attribute is created,
- `selected` – if `true`, then the option is selected.

There may be a small confusion about `defaultSelected` and `selected`. That's simple: `defaultSelected` sets HTML-attribute, that we can get using `option.getAttribute('selected')`. And `selected` – whether the option is selected or not, that's more important. Usually both values are either set to `true` or not set (same as `false`).

For instance:

```
let option = new Option("Text", "value");
// creates <option value="value">Text</option>
```

The same element selected:

```
let option = new Option("Text", "value", true, true);
```

Option elements have properties:

`option.selected`

Is the option selected.

`option.index`

The number of the option among the others in its `<select>`.

`option.text`

Text content of the option (seen by the visitor).

References

- Specification: https://html.spec.whatwg.org/multipage/forms.html .

Summary

Form navigation:

`document.forms`

A form is available as `document.forms[name/index]`.

`form.elements`

Form elements are available as `form.elements[name/index]`, or can use just `form[name/index]`. The `elements` property also works for `<fieldset>`.

`element.form`

Elements reference their form in the `form` property.

Value is available as `input.value`, `textarea.value`, `select.value` etc, or `input.checked` for checkboxes and radio buttons.

For `<select>` we can also get the value by the index `select.selectedIndex` or through the options collection `select.options`.

These are the basics to start working with forms. We'll meet many examples further in the tutorial.

In the next chapter we'll cover `focus` and `blur` events that may occur on any element, but are mostly handled on forms.

Tasks

Add an option to select

importance: 5

There's a `<select>`:

```
<select id="genres">
  <option value="rock">Rock</option>
  <option value="blues" selected>Blues</option>
</select>
```

Use JavaScript to:

1. Show the value and the text of the selected option.
2. Add an option: `<option value="classic">Classic</option>`.
3. Make it selected.

Note, if you've done everything right, your alert should show `blues`.

To solution

Focusing: focus/blur

An element receives a focus when the user either clicks on it or uses the `Tab` key on the keyboard. There's also an `autofocus` HTML attribute that puts the focus into an element by default when a page loads and other means of getting a focus.

Focusing on an element generally means: "prepare to accept the data here", so that's the moment when we can run the code to initialize the required functionality.

The moment of losing the focus ("blur") can be even more important. That's when a user clicks somewhere else or presses `Tab` to go to the next form field, or there are other means as well.

Losing the focus generally means: “the data has been entered”, so we can run the code to check it or even to save it to the server and so on.

There are important peculiarities when working with focus events. We’ll do the best to cover them further on.

Events focus/blur

The `focus` event is called on focusing, and `blur` – when the element loses the focus.

Let’s use them for validation of an input field.

In the example below:

- The `blur` handler checks if the field the email is entered, and if not – shows an error.
- The `focus` handler hides the error message (on `blur` it will be checked again):

```
<style>
  .invalid { border-color: red; }
  #error { color: red }
</style>

Your email please: <input type="email" id="input">

<div id="error"></div>

<script>
input.onblur = function() {
  if (!input.value.includes('@')) { // not email
    input.classList.add('invalid');
    error.innerHTML = 'Please enter a correct
email.'
  }
};
```

```
input.onfocus = function() {
  if (this.classList.contains('invalid')) {
    // remove the "error" indication, because the user wants to re-enter something
    this.classList.remove('invalid');
    error.innerHTML = "";
  }
};
</script>
```

Your email please:

Modern HTML allows to do many validations using input attributes: `required`, `pattern` and so on. And sometimes they are just what we need. JavaScript can be used when we want more flexibility. Also we could automatically send the changed value to the server if it’s correct.

Methods focus/blur

Methods `elem.focus()` and `elem.blur()` set/unset the focus on the element.

For instance, let’s make the visitor unable to leave the input if the value is invalid:

```
<style>
  .error {
    background: red;
  }
</style>

Your email please: <input type="email" id="input">
<input type="text" style="width:220px" placeholder="make email invalid and try to focus here">
```

```
<script>
  input.onblur = function() {
    if (!this.value.includes('@')) { // not email
      // show the error
      this.classList.add("error");
      // ...and put the focus back
      input.focus();
    } else {
      this.classList.remove("error");
    }
  };
</script>
```

Your email please: make email invalid and try to

It works in all browsers except Firefox (bug).

If we enter something into the input and then try to use `Tab` or click away from the `<input>`, then `onblur` returns the focus back.

Please note that we can't "prevent losing focus" by calling `event.preventDefault()` in `onblur`, because `onblur` works *after* the element lost the focus.

⚠ JavaScript-initiated focus loss

A focus loss can occur for many reasons.

One of them is when the visitor clicks somewhere else. But also JavaScript itself may cause it, for instance:

- An `alert` moves focus to itself, so it causes the focus loss at the element (`blur` event), and when the `alert` is dismissed, the focus comes back (`focus` event).

- If an element is removed from DOM, then it also causes the focus loss. If it is reinserted later, then the focus doesn't return.

These features sometimes cause `focus/blur` handlers to misbehave – to trigger when they are not needed.

The best recipe is to be careful when using these events. If we want to track user-initiated focus-loss, then we should avoid causing it ourselves.

Allow focusing on any element: tabindex

By default many elements do not support focusing.

The list varies a bit between browsers, but one thing is always correct: `focus/blur` support is guaranteed for elements that a visitor can interact with: `<button>`, `<input>`, `<select>`, `<a>` and so on.

From the other hand, elements that exist to format something, such as `<div>`, `<span>`, `<table>` – are unfocusable by default. The method `elem.focus()` doesn't work on them, and `focus/blur` events are never triggered.

This can be changed using HTML-attribute `tabindex`.

Any element becomes focusable if it has `tabindex`. The value of the attribute is the order number of the element when `Tab` (or something like that) is used to switch between them.

That is: if we have two elements, the first has `tabindex="1"`, and the second has `tabindex="2"`, then pressing `Tab` while in the first element – moves the focus into the second one.

The switch order is: elements with `tabindex` from `1` and above go first (in the `tabindex` order), and then elements without `tabindex` (e.g. a regular `<input>`).

Elements with matching `tabindex` are switched in the document source order (the default order).

There are two special values:

- `tabindex="0"` puts an element among those without `tabindex`. That is, when we switch elements, elements with `tabindex=0` go after elements with `tabindex ≥ 1`.

  Usually it's used to make an element focusable, but keep the default switching order. To make an element a part of the form on par with `<input>`.

- `tabindex="-1"` allows only programmatic focusing on an element. The `Tab` key ignores such elements, but method `elem.focus()` works.

For instance, here's a list. Click the first item and press `Tab`:

```
Click the first item and press Tab. Keep track of the order. Please note
that many subsequent Tabs can move the focus out of the iframe with the
example.
<ul>
  <li tabindex="1">One</li>
  <li tabindex="0">Zero</li>
  <li tabindex="2">Two</li>
  <li tabindex="-1">Minus one</li>
</ul>

<style>
  li { cursor: pointer; }
  :focus { outline: 1px dashed green; }
</style>
```

Click the first item and press Tab. Keep track of the order. Please note that many subsequent Tabs can move the focus out of the iframe with the example.

- One
- Zero
- Two
- Minus one

The order is like this: `1 - 2 - 0`. Normally, `<li>` does not support focusing, but `tabindex` full enables it, along with events and styling with `:focus`.

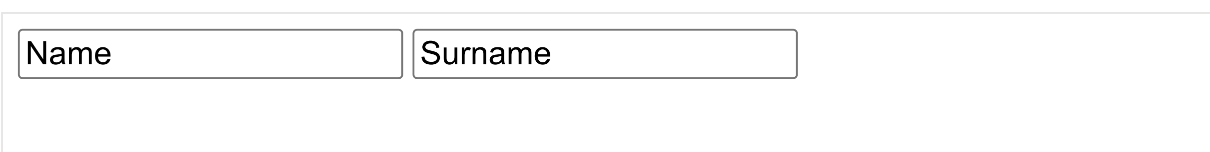
> **ℹ The property `elem.tabIndex` works too**
>
> We can add `tabindex` from JavaScript by using the `elem.tabIndex` property. That has the same effect.

Delegation: focusin/focusout

Events `focus` and `blur` do not bubble.

For instance, we can't put `onfocus` on the `<form>` to highlight it, like this:

```html
<!-- on focusing in the form -- add the class -->
<form onfocus="this.className='focused'">
  <input type="text" name="name" value="Name">
  <input type="text" name="surname" value="Surname">
</form>

<style> .focused { outline: 1px solid red; } </style>
```



The example above doesn't work, because when user focuses on an `<input>`, the `focus` event triggers on that input only. It doesn't bubble up. So `form.onfocus` never triggers.

There are two solutions.

First, there's a funny historical feature: `focus/blur` do not bubble up, but propagate down on the capturing phase.

This will work:

```
<form id="form">
  <input type="text" name="name" value="Name">
  <input type="text" name="surname" value="Surname">
</form>

<style> .focused { outline: 1px solid red; } </style>

<script>
  // put the handler on capturing phase (last
argument true)
  form.addEventListener("focus", () =>
form.classList.add('focused'), true);
  form.addEventListener("blur", () =>
form.classList.remove('focused'), true);
</script>
```

Name Surname

Second, there are `focusin` and `focusout` events – exactly the same as `focus/blur`, but they bubble.

Note that they must be assigned using `elem.addEventListener`, not `on<event>`.

So here's another working variant:

```
<form id="form">
  <input type="text" name="name" value="Name">
  <input type="text" name="surname" value="Surname">
</form>

<style> .focused { outline: 1px solid red; } </style>

<script>
```

```
  form.addEventListener("focusin", () =>
form.classList.add('focused'));
  form.addEventListener("focusout", () =>
form.classList.remove('focused'));
</script>
```

Name Surname

Summary

Events `focus` and `blur` trigger on focusing/losing focus on the element.

Their specials are:

- They do not bubble. Can use capturing state instead or `focusin/focusout`.
- Most elements do not support focus by default. Use `tabindex` to make anything focusable.

The current focused element is available as `document.activeElement`.

Tasks

Editable div

importance: 5

Create a `<div>` that turns into `<textarea>` when clicked.

The textarea allows to edit the HTML in the `<div>`.

When the user presses `Enter` or it loses focus, the `<textarea>` turns back into `<div>`, and its content becomes HTML in `<div>`.

Demo in new window

Open a sandbox for the task.

To solution

Edit TD on click

importance: 5

Make table cells editable on click.

- On click – the cell should became “editable” (textarea appears inside), we can change HTML. There should be no resize, all geometry should remain the same.
- Buttons OK and CANCEL appear below the cell to finish/cancel the editing.
- Only one cell may be editable at a moment. While a `<td>` is in “edit mode”, clicks on other cells are ignored.
- The table may have many cells. Use event delegation.

The demo:

Click on a table cell to edit it. Press OK or CANCEL when you finish.

***Bagua* Chart: Direction, Element, Color, Meaning**

Northwest Metal Silver Elders	**North** Water Blue Change	**Northeast** Earth Yellow Direction
West Metal Gold Youth	**Center** All Purple Harmony	**East** Wood Blue Future
Southwest Earth Brown Tranquility	**South** Fire Orange Fame	**Southeast** Wood Green Romance

Open a sandbox for the task.

To solution

Keyboard-driven mouse

importance: 4

Focus on the mouse. Then use arrow keys to move it:

Demo in new window

P.S. Don't put event handlers anywhere except the `#mouse` element.

P.P.S. Don't modify HTML/CSS, the approach should be generic and work with any element.

Open a sandbox for the task.

To solution

Events: change, input, cut, copy, paste

Let’s cover various events that accompany data updates.

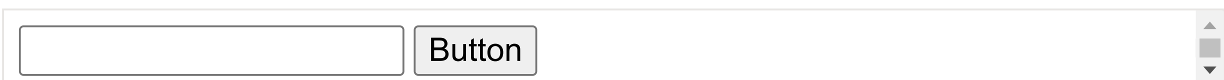
Event: change

The `change` event triggers when the element has finished changing.

For text inputs that means that the event occurs when it loses focus.

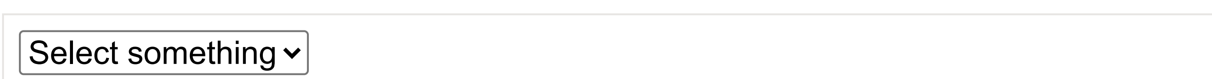
For instance, while we are typing in the text field below – there’s no event. But when we move the focus somewhere else, for instance, click on a button – there will be a `change` event:

```html
<input type="text" onchange="alert(this.value)">
<input type="button" value="Button">
```



For other elements: `select`, `input type=checkbox/radio` it triggers right after the selection changes:

```html
<select onchange="alert(this.value)">
  <option value="">Select something</option>
  <option value="1">Option 1</option>
  <option value="2">Option 2</option>
  <option value="3">Option 3</option>
</select>
```



Event: input

The `input` event triggers every time after a value is modified by the user.

Unlike keyboard events, it triggers on any value change, even those that does not involve keyboard actions: pasting with a mouse or using speech recognition to dictate the text.

For instance:

```
<input type="text" id="input"> oninput: <span id="result"></span>
<script>
  input.oninput = function() {
    result.innerHTML = input.value;
  };
</script>
```

oninput:

If we want to handle every modification of an `<input>` then this event is the best choice.

On the other hand, `input` event doesn't trigger on keyboard input and other actions that do not involve value change, e.g. pressing arrow keys ⇦ ⇨ while in the input.

> **Can't prevent anything in `oninput`**
>
> The `input` event occurs after the value is modified.
>
> So we can't use `event.preventDefault()` there – it's just too late, there would be no effect.

Events: cut, copy, paste

These events occur on cutting/copying/pasting a value.

They belong to ClipboardEvent class and provide access to the data that is copied/pasted.

We also can use `event.preventDefault()` to abort the action, then nothing gets copied/pasted.

For instance, the code below prevents all such events and shows what we are trying to cut/copy/paste:

```html
<input type="text" id="input">
<script>
  input.oncut = input.oncopy = input.onpaste = function(event) {
    alert(event.type + ' - ' + event.clipboardData.getData('text/plain'));
    return false;
  };
</script>
```

Please note, that it's possible to copy/paste not just text, but everything. For instance, we can copy a file in the OS file manager, and paste it.

There's a list of methods in the specification that can work with different data types including files, read/write to the clipboard.

But please note that clipboard is a "global" OS-level thing. Most browsers allow read/write access to the clipboard only in the scope of certain user actions for the safety, e.g. in `onclick` event handlers.

Also it's forbidden to generate "custom" clipboard events with `dispatchEvent` in all browsers except Firefox.

Summary

Data change events:

Event	Description	Specials
`change`	A value was changed.	For text inputs triggers on focus loss.

Event	Description	Specials
`input`	For text inputs on every change.	Triggers immediately unlike `change`.
`cut/copy/paste`	Cut/copy/paste actions.	The action can be prevented. The `event.clipboardData` property gives read/write access to the clipboard.

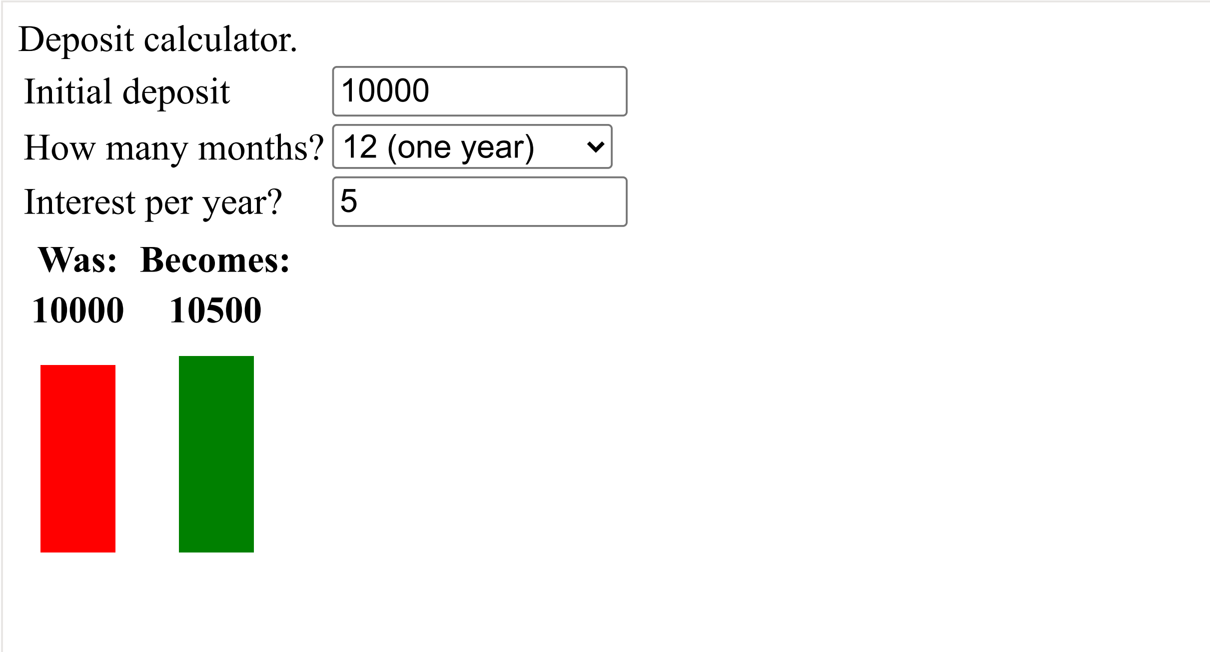
Tasks

Deposit calculator

importance: 5

Create an interface that allows to enter a sum of bank deposit and percentage, then calculates how much it will be after given periods of time.

Here's the demo:



Any input change should be processed immediately.

The formula is:

```
// initial: the initial money sum
// interest: e.g. 0.05 means 5% per year
// years: how many years to wait
let result = Math.round(initial * (1 + interest * years));
```

Open a sandbox for the task.

To solution

Forms: event and method submit

The `submit` event triggers when the form is submitted, it is usually used to validate the form before sending it to the server or to abort the submission and process it in JavaScript.

The method `form.submit()` allows to initiate form sending from JavaScript. We can use it to dynamically create and send our own forms to server.

Let’s see more details of them.

Event: submit

There are two main ways to submit a form:

1. The first – to click `<input type="submit">` or `<input type="image">`.
2. The second – press `Enter` on an input field.

Both actions lead to `submit` event on the form. The handler can check the data, and if there are errors, show them and call `event.preventDefault()`, then the form won’t be sent to the server.

In the form below:

1. Go into the text field and press `Enter`.
2. Click `<input type="submit">`.

Both actions show `alert` and the form is not sent anywhere due to `return false`:

```
<form onsubmit="alert('submit!');return false">
  First: Enter in the input field <input type="text" value="text"><br>
  Second: Click "submit": <input type="submit" value="Submit">
</form>
```

First: Enter in the input field [text]
Second: Click "submit": [Submit]

Relation between `submit` and `click`

When a form is sent using `Enter` on an input field, a `click` event triggers on the `<input type="submit">`.

That's rather funny, because there was no click at all.

Here's the demo:

```html
<form onsubmit="return false">
 <input type="text" size="30" value="Focus here and press enter">
 <input type="submit" value="Submit" onclick="alert('click')">
</form>
```

Focus here and press enter | Submit

Method: submit

To submit a form to the server manually, we can call `form.submit()`.

Then the `submit` event is not generated. It is assumed that if the programmer calls `form.submit()`, then the script already did all related processing.

Sometimes that's used to manually create and send a form, like this:

```javascript
let form = document.createElement('form');
form.action = 'https://google.com/search';
form.method = 'GET';

form.innerHTML = '<input name="q" value="test">';

// the form must be in the document to submit it
document.body.append(form);

form.submit();
```

Tasks

Modal form

importance: 5

Create a function `showPrompt(html, callback)` that shows a form with the message `html`, an input field and buttons `OK/CANCEL`.

- A user should type something into a text field and press `Enter` or the OK button, then `callback(value)` is called with the value they entered.
- Otherwise if the user presses `Esc` or CANCEL, then `callback(null)` is called.

In both cases that ends the input process and removes the form.

Requirements:

- The form should be in the center of the window.
- The form is *modal*. In other words, no interaction with the rest of the page is possible until the user closes it.
- When the form is shown, the focus should be inside the `<input>` for the user.
- Keys `Tab`/`Shift+Tab` should shift the focus between form fields, don't allow it to leave for other page elements.

Usage example:

```
showPrompt("Enter something<br>...smart :)", function(value) {
  alert(value);
});
```

A demo in the iframe:

P.S. The source document has HTML/CSS for the form with fixed positioning, but it’s up to you to make it modal.

Open a sandbox for the task.

To solution

Document and resource loading

Page: DOMContentLoaded, load, beforeunload, unload

The lifecycle of an HTML page has three important events:

- `DOMContentLoaded` – the browser fully loaded HTML, and the DOM tree is built, but external resources like pictures `<img>` and stylesheets may be not yet loaded.
- `load` – not only HTML is loaded, but also all the external resources: images, styles etc.
- `beforeunload/unload` – the user is leaving the page.

Each event may be useful:

- `DOMContentLoaded` event – DOM is ready, so the handler can lookup DOM nodes, initialize the interface.
- `load` event – external resources are loaded, so styles are applied, image sizes are known etc.
- `beforeunload` event – the user is leaving: we can check if the user saved the changes and ask them whether they really want to leave.
- `unload` – the user almost left, but we still can initiate some operations, such as sending out statistics.

Let’s explore the details of these events.

DOMContentLoaded

The `DOMContentLoaded` event happens on the `document` object.

We must use `addEventListener` to catch it:

```
document.addEventListener("DOMContentLoaded", ready);
// not "document.onDOMContentLoaded = ..."
```

For instance:

```
<script>
  function ready() {
    alert('DOM is ready');

    // image is not yet loaded (unless was cached), so the size is 0x0
    alert(`Image size: ${img.offsetWidth}x${img.offsetHeight}`);
  }

  document.addEventListener("DOMContentLoaded", ready);
</script>

<img id="img" src="https://en.js.cx/clipart/train.gif?speed=1&cache=0">
```

In the example the `DOMContentLoaded` handler runs when the document is loaded, so it can see all the elements, including `<img>` below.

But it doesn’t wait for the image to load. So `alert` shows zero sizes.

At first sight, the `DOMContentLoaded` event is very simple. The DOM tree is ready – here’s the event. There are few peculiarities though.

DOMContentLoaded and scripts

When the browser processes an HTML-document and comes across a `<script>` tag, it needs to execute before continuing building the

DOM. That's a precaution, as scripts may want to modify DOM, and even `document.write` into it, so `DOMContentLoaded` has to wait.

So DOMContentLoaded definitely happens after such scripts:

```
<script>
  document.addEventListener("DOMContentLoaded",
() => {
    alert("DOM ready!");
  });
</script>

<script
src="https://cdnjs.cloudflare.com/ajax/libs/lodash.js/4.3.0/lodash.js">
</script>

<script>
  alert("Library loaded, inline script
executed");
</script>
```

In the example above, we first see "Library loaded…", and then "DOM ready!" (all scripts are executed).

⚠ Scripts that don't block DOMContentLoaded

There are two exceptions from this rule:

1. Scripts with the `async` attribute, that we'll cover a bit later, don't block `DOMContentLoaded`.
2. Scripts that are generated dynamically with `document.createElement('script')` and then added to the webpage also don't block this event.

DOMContentLoaded and styles

External style sheets don't affect DOM, so `DOMContentLoaded` does not wait for them.

But there's a pitfall. If we have a script after the style, then that script must wait until the stylesheet loads:

```
<link type="text/css" rel="stylesheet" href="style.css">
<script>
  // the script doesn't not execute until the stylesheet is loaded
  alert(getComputedStyle(document.body).marginTop);
</script>
```

The reason for this is that the script may want to get coordinates and other style-dependent properties of elements, like in the example above. Naturally, it has to wait for styles to load.

As `DOMContentLoaded` waits for scripts, it now waits for styles before them as well.

Built-in browser autofill

Firefox, Chrome and Opera autofill forms on `DOMContentLoaded`.

For instance, if the page has a form with login and password, and the browser remembered the values, then on `DOMContentLoaded` it may try to autofill them (if approved by the user).

So if `DOMContentLoaded` is postponed by long-loading scripts, then autofill also awaits. You probably saw that on some sites (if you use browser autofill) – the login/password fields don't get autofilled immediately, but there's a delay till the page fully loads. That's actually the delay until the `DOMContentLoaded` event.

window.onload

The `load` event on the `window` object triggers when the whole page is loaded including styles, images and other resources.

The example below correctly shows image sizes, because `window.onload` waits for all images:

```
<script>
  window.onload = function() {
    alert('Page loaded');

    // image is loaded at this time
    alert(`Image size:
${img.offsetWidth}x${img.offsetHeight}`);
  };
</script>

<img id="img" src="https://en.js.cx/clipart/train.gif?speed=1&cache=0">
```

window.onunload

When a visitor leaves the page, the `unload` event triggers on `window`. We can do something there that doesn’t involve a delay, like closing related popup windows.

The notable exception is sending analytics.

Let’s say we gather data about how the page is used: mouse clicks, scrolls, viewed page areas, and so on.

Naturally, `unload` event is when the user leaves us, and we’d like to save the data on our server.

There exists a special `navigator.sendBeacon(url, data)` method for such needs, described in the specification https://w3c.github.io/beacon/ .

It sends the data in background. The transition to another page is not delayed: the browser leaves the page, but still performs `sendBeacon`.

Here's how to use it:

```
let analyticsData = { /* object with gathered data */ };

window.addEventListener("unload", function() {
  navigator.sendBeacon("/analytics", JSON.stringify(analyticsData));
};
```

- The request is sent as POST.
- We can send not only a string, but also forms and other formats, as described in the chapter Fetch, but usually it's a stringified object.
- The data is limited by 64kb.

When the `sendBeacon` request is finished, the browser probably has already left the document, so there's no way to get server response (which is usually empty for analytics).

There's also a `keepalive` flag for doing such "after-page-left" requests in fetch method for generic network requests. You can find more information in the chapter Fetch API.

If we want to cancel the transition to another page, we can't do it here. But we can use another event – `onbeforeunload`.

window.onbeforeunload

If a visitor initiated navigation away from the page or tries to close the window, the `beforeunload` handler asks for additional confirmation.

If we cancel the event, the browser may ask the visitor if they are sure.

You can try it by running this code and then reloading the page:

```
window.onbeforeunload = function() {
  return false;
};
```

For historical reasons, returning a non-empty string also counts as canceling the event. Some time ago browsers used show it as a message, but as the modern specification says, they shouldn't.

Here's an example:

```
window.onbeforeunload = function() {
  return "There are unsaved changes. Leave now?";
};
```

The behavior was changed, because some webmasters abused this event handler by showing misleading and annoying messages. So right now old browsers still may show it as a message, but aside of that – there's no way to customize the message shown to the user.

readyState

What happens if we set the `DOMContentLoaded` handler after the document is loaded?

Naturally, it never runs.

There are cases when we are not sure whether the document is ready or not. We'd like our function to execute when the DOM is loaded, be it now or later.

The `document.readyState` property tells us about the current loading state.

There are 3 possible values:

- `"loading"` – the document is loading.
- `"interactive"` – the document was fully read.
- `"complete"` – the document was fully read and all resources (like images) are loaded too.

So we can check `document.readyState` and setup a handler or execute the code immediately if it's ready.

Like this:

```
function work() { /*...*/ }

if (document.readyState == 'loading') {
  // loading yet, wait for the event
  document.addEventListener('DOMContentLoaded', work);
} else {
  // DOM is ready!
  work();
}
```

There's also the `readystatechange` event that triggers when the state changes, so we can print all these states like this:

```
// current state
console.log(document.readyState);
```

```
// print state changes
document.addEventListener('readystatechange', () =>
console.log(document.readyState));
```

The `readystatechange` event is an alternative mechanics of tracking the document loading state, it appeared long ago. Nowadays, it is rarely used.

Let's see the full events flow for the completeness.

Here's a document with `<iframe>`, `<img>` and handlers that log events:

```
<script>
  log('initial readyState:' +
document.readyState);

  document.addEventListener('readystatechange',
() => log('readyState:' +
document.readyState));
  document.addEventListener('DOMContentLoaded',
() => log('DOMContentLoaded'));

  window.onload = () => log('window onload');
</script>

<iframe src="iframe.html" onload="log('iframe onload')"></iframe>

<img src="http://en.js.cx/clipart/train.gif" id="img">
<script>
  img.onload = () => log('img onload');
</script>
```

The working example is in the sandbox .

The typical output:

1. [1] initial readyState:loading
2. [2] readyState:interactive
3. [2] DOMContentLoaded
4. [3] iframe onload
5. [4] img onload
6. [4] readyState:complete
7. [4] window onload

The numbers in square brackets denote the approximate time of when it happens. Events labeled with the same digit happen approximately at the same time (± a few ms).

- `document.readyState` becomes `interactive` right before `DOMContentLoaded`. These two things actually mean the same.
- `document.readyState` becomes `complete` when all resources (`iframe` and `img`) are loaded. Here we can see that it happens in about the same time as `img.onload` (`img` is the last resource) and `window.onload`. Switching to `complete` state means the same as `window.onload`. The difference is that `window.onload` always works after all other `load` handlers.

Summary

Page load events:

- The `DOMContentLoaded` event triggers on `document` when the DOM is ready. We can apply JavaScript to elements at this stage.
  - Script such as `<script>...</script>` or `<script src="..."></script>` block DOMContentLoaded, the browser waits for them to execute.
  - Images and other resources may also still continue loading.

- The `load` event on `window` triggers when the page and all resources are loaded. We rarely use it, because there's usually no need to wait for so long.
- The `beforeunload` event on `window` triggers when the user wants to leave the page. If we cancel the event, browser asks whether the user really wants to leave (e.g we have unsaved changes).
- `The unload` event on `window` triggers when the user is finally leaving, in the handler we can only do simple things that do not involve delays or asking a user. Because of that limitation, it's rarely used. We can send out a network request with `navigator.sendBeacon`.
- `document.readyState` is the current state of the document, changes can be tracked in the `readystatechange` event:
  - `loading` – the document is loading.
  - `interactive` – the document is parsed, happens at about the same time as `DOMContentLoaded`, but before it.
  - `complete` – the document and resources are loaded, happens at about the same time as `window.onload`, but before it.

Scripts: async, defer

In modern websites, scripts are often "heavier" than HTML: their download size is larger, and processing time is also longer.

When the browser loads HTML and comes across a `<script>...</script>` tag, it can't continue building the DOM. It must execute the script right now. The same happens for external scripts `<script src="..."></script>`: the browser must wait until the script downloads, execute it, and only after process the rest of the page.

That leads to two important issues:

1. Scripts can't see DOM elements below them, so they can't add handlers etc.
2. If there's a bulky script at the top of the page, it "blocks the page". Users can't see the page content till it downloads and runs:

```
<p>...content before script...</p>

<script src="https://javascript.info/article/script-async-defer/long.js?speed=1"></script>

<!-- This isn't visible until the script loads -->
<p>...content after script...</p>
```

There are some workarounds to that. For instance, we can put a script at the bottom of the page. Then it can see elements above it, and it doesn't block the page content from showing:

```
<body>
  ...all content is above the script...

  <script src="https://javascript.info/article/script-async-defer/long.js?speed=1"></script>
</body>
```

But this solution is far from perfect. For example, the browser notices the script (and can start downloading it) only after it downloaded the full HTML document. For long HTML documents, that may be a noticeable delay.

Such things are invisible for people using very fast connections, but many people in the world still have slow internet speeds and use a far-from-perfect mobile internet connection.

Luckily, there are two `<script>` attributes that solve the problem for us: `defer` and `async`.

defer

The `defer` attribute tells the browser that it should go on working with the page, and load the script "in background", then run the script when it loads.

Here's the same example as above, but with `defer`:

```
<p>...content before script...</p>

<script defer src="https://javascript.info/article/script-async-defer/long.js?speed=1"></script>

<!-- visible immediately -->
<p>...content after script...</p>
```

- Scripts with `defer` never block the page.
- Scripts with `defer` always execute when the DOM is ready, but before `DOMContentLoaded` event.

The following example demonstrates that:

```
<p>...content before scripts...</p>

<script>
  document.addEventListener('DOMContentLoaded', () => alert("DOM ready after defer!")); // (2)
</script>

<script defer src="https://javascript.info/article/script-async-defer/long.js?speed=1"></script>

<p>...content after scripts...</p>
```

1. The page content shows up immediately.

2. `DOMContentLoaded` waits for the deferred script. It only triggers when the script `(2)` is downloaded and executed.

Deferred scripts keep their relative order, just like regular scripts.

So, if we have a long script first, and then a smaller one, then the latter one waits.

```
<script defer src="https://javascript.info/article/script-async-defer/long.js"></script>
<script defer src="https://javascript.info/article/script-async-defer/small.js"></script>
```

The small script downloads first, runs second

Browsers scan the page for scripts and download them in parallel, to improve performance. So in the example above both scripts download in parallel. The `small.js` probably makes it first.

But the specification requires scripts to execute in the document order, so it waits for `long.js` to execute.

The `defer` attribute is only for external scripts

The `defer` attribute is ignored if the `<script>` tag has no `src`.

async

The `async` attribute means that a script is completely independent:

- The page doesn't wait for async scripts, the contents are processed and displayed.
- `DOMContentLoaded` and async scripts don't wait for each other:
  - `DOMContentLoaded` may happen both before an async script (if an async script finishes loading after the page is complete)
  - …or after an async script (if an async script is short or was in HTTP-cache)
- Other scripts don't wait for `async` scripts, and `async` scripts don't wait for them.

So, if we have several `async` scripts, they may execute in any order. Whatever loads first – runs first:

```
<p>...content before scripts...</p>

<script>
  document.addEventListener('DOMContentLoaded', () => alert("DOM ready!"));
</script>

<script async src="https://javascript.info/article/script-async-defer/long.js"></script>
<script async src="https://javascript.info/article/script-async-defer/small.js"></script>

<p>...content after scripts...</p>
```

1. The page content shows up immediately: `async` doesn't block it.
2. `DOMContentLoaded` may happen both before and after `async`, no guarantees here.
3. Async scripts don't wait for each other. A smaller script `small.js` goes second, but probably loads before `long.js`, so runs first. That's called a "load-first" order.

Async scripts are great when we integrate an independent third-party script into the page: counters, ads and so on, as they don't depend on our scripts, and our scripts shouldn't wait for them:

```
<!-- Google Analytics is usually added like this -->
<script async src="https://google-analytics.com/analytics.js"></script>
```

Dynamic scripts

We can also add a script dynamically using JavaScript:

```
let script = document.createElement('script');
script.src = "/article/script-async-defer/long.js";
document.body.append(script); // (*)
```

The script starts loading as soon as it's appended to the document `(*)`.

Dynamic scripts behave as "async" by default.

That is:

- They don't wait for anything, nothing waits for them.
- The script that loads first – runs first ("load-first" order).

```
let script = document.createElement('script');
script.src = "/article/script-async-defer/long.js";

script.async = false;

document.body.append(script);
```

For example, here we add two scripts. Without `script.async=false` they would execute in load-first order (the `small.js` probably first). But with that flag the order is “as in the document”:

```
function loadScript(src) {
  let script = document.createElement('script');
  script.src = src;
  script.async = false;
  document.body.append(script);
}

// long.js runs first because of async=false
loadScript("/article/script-async-defer/long.js");
loadScript("/article/script-async-defer/small.js");
```

Summary

Both `async` and `defer` have one common thing: downloading of such scripts doesn’t block page rendering. So the user can read page content and get acquainted with the page immediately.

But there are also essential differences between them:

	Order	`DOMContentLoaded`
`async`	*Load-first order*. Their document order doesn’t matter – which loads first	Irrelevant. May load and execute while the document has not yet been fully downloaded. That happens if scripts are small or cached, and the document is long enough.
`defer`	*Document order* (as they go in the document).	Execute after the document is loaded and parsed (they wait if needed), right before `DOMContentLoaded`.

> ⚠️ **Page without scripts should be usable**
>
> Please note that if you're using `defer`, then the page is visible *before* the script loads.
>
> So the user may read the page, but some graphical components are probably not ready yet.
>
> There should be "loading" indications in the proper places, and disabled buttons should show as such, so the user can clearly see what's ready and what's not.

In practice, `defer` is used for scripts that need the whole DOM and/or their relative execution order is important. And `async` is used for independent scripts, like counters or ads. And their relative execution order does not matter.

Resource loading: onload and onerror

The browser allows us to track the loading of external resources – scripts, iframes, pictures and so on.

There are two events for it:

- `onload` – successful load,
- `onerror` – an error occurred.

Loading a script

Let's say we need to load a third-party script and call a function that resides there.

We can load it dynamically, like this:

```
let script = document.createElement('script');
script.src = "my.js";

document.head.append(script);
```

…But how to run the function that is declared inside that script? We need to wait until the script loads, and only then we can call it.

> **Please note:**
>
> For our own scripts we could use JavaScript modules here, but they are not widely adopted by third-party libraries.

script.onload

The main helper is the `load` event. It triggers after the script was loaded and executed.

For instance:

```
let script = document.createElement('script');

// can load any script, from any domain
script.src =
"https://cdnjs.cloudflare.com/ajax/libs/lodash.js/4.3.0/lodash.js"
document.head.append(script);

script.onload = function() {
  // the script creates a helper function "_"
  alert(_); // the function is available
};
```

So in `onload` we can use script variables, run functions etc.

…And what if the loading failed? For instance, there's no such script (error 404) or the server is down (unavailable).

script.onerror

Errors that occur during the loading of the script can be tracked in an `error` event.

For instance, let's request a script that doesn't exist:

```
let script = document.createElement('script');
script.src = "https://example.com/404.js"; // no such script
document.head.append(script);

script.onerror = function() {
  alert("Error loading " + this.src); // Error loading
https://example.com/404.js
};
```

Please note that we can't get HTTP error details here. We don't know if it was an error 404 or 500 or something else. Just that the loading failed.

> ⚠ **Important:**
>
> Events `onload`/`onerror` track only the loading itself.
>
> Errors that may occur during script processing and execution are out of scope for these events. That is: if a script loaded successfully, then `onload` triggers, even if it has programming errors in it. To track script errors, one can use `window.onerror` global handler.

Other resources

The `load` and `error` events also work for other resources, basically for any resource that has an external `src`.

For example:

```
let img = document.createElement('img');
img.src = "https://js.cx/clipart/train.gif"; // (*)

img.onload = function() {
  alert(`Image loaded, size ${img.width}x${img.height}`);
};

img.onerror = function() {
  alert("Error occurred while loading image");
};
```

There are some notes though:

- Most resources start loading when they are added to the document. But `<img>` is an exception. It starts loading when it gets a src `(*)`.
- For `<iframe>`, the `iframe.onload` event triggers when the iframe loading finished, both for successful load and in case of an error.

That's for historical reasons.

Crossorigin policy

There's a rule: scripts from one site can't access contents of the other site. So, e.g. a script at `https://facebook.com` can't read the user's mailbox at `https://gmail.com`.

Or, to be more precise, one origin (domain/port/protocol triplet) can't access the content from another one. So even if we have a subdomain, or just another port, these are different origins, no access to each other.

This rule also affects resources from other domains.

If we're using a script from another domain, and there's an error in it, we can't get error details.

For example, let's take a script `error.js` that consists of a single (bad) function call:

```
// 📁 error.js
noSuchFunction();
```

Now load it from the same site where it's located:

```
<script>
window.onerror = function(message, url, line, col, errorObj) {
  alert(`${message}\n${url}, ${line}:${col}`);
};
</script>
<script src="/article/onload-onerror/crossorigin/error.js"></script>
```

We can see a good error report, like this:

```
Uncaught ReferenceError: noSuchFunction is not defined
https://javascript.info/article/onload-onerror/crossorigin/error.js, 1:1
```

Now let's load the same script from another domain:

```
<script>
window.onerror = function(message, url, line, col, errorObj) {
  alert(`${message}\n${url}, ${line}:${col}`);
};
</script>
```

```html
<script src="https://cors.javascript.info/article/onload-onerror/crossorigin/error.js"></script>
```

The report is different, like this:

```
Script error.
, 0:0
```

Details may vary depending on the browser, but the idea is the same: any information about the internals of a script, including error stack traces, is hidden. Exactly because it's from another domain.

Why do we need error details?

There are many services (and we can build our own) that listen for global errors using `window.onerror`, save errors and provide an interface to access and analyze them. That's great, as we can see real errors, triggered by our users. But if a script comes from another origin, then there's no much information about errors in it, as we've just seen.

Similar cross-origin policy (CORS) is enforced for other types of resources as well.

To allow cross-origin access, the `<script>` tag needs to have the `crossorigin` attribute, plus the remote server must provide special headers.

There are three levels of cross-origin access:

1. **No `crossorigin` attribute** – access prohibited.
2. **`crossorigin="anonymous"`** – access allowed if the server responds with the header `Access-Control-Allow-Origin` with `*` or our origin. Browser does not send authorization information and cookies to remote server.

3. **`crossorigin="use-credentials"`** – access allowed if the server sends back the header `Access-Control-Allow-Origin` with our origin and `Access-Control-Allow-Credentials: true`. Browser sends authorization information and cookies to remote server.

> **Please note:**
>
> You can read more about cross-origin access in the chapter Fetch: Cross-Origin Requests. It describes the `fetch` method for network requests, but the policy is exactly the same.
>
> Such thing as "cookies" is out of our current scope, but you can read about them in the chapter Cookies, document.cookie.

In our case, we didn't have any crossorigin attribute. So the cross-origin access was prohibited. Let's add it.

We can choose between `"anonymous"` (no cookies sent, one server-side header needed) and `"use-credentials"` (sends cookies too, two server-side headers needed).

If we don't care about cookies, then `"anonymous"` is the way to go:

```
<script>
window.onerror = function(message, url, line, col, errorObj) {
  alert(`${message}\n${url}, ${line}:${col}`);
};
</script>
<script crossorigin="anonymous" src="https://cors.javascript.info/article/onload-onerror/crossorigin/error.js"></script>
```

Now, assuming that the server provides an `Access-Control-Allow-Origin` header, everything's fine. We have the full error report.

Summary

Images `<img>`, external styles, scripts and other resources provide `load` and `error` events to track their loading:

- `load` triggers on a successful load,
- `error` triggers on a failed load.

The only exception is `<iframe>`: for historical reasons it always triggers `load`, for any load completion, even if the page is not found.

The `readystatechange` event also works for resources, but is rarely used, because `load/error` events are simpler.

Tasks

Load images with a callback

importance: 4

Normally, images are loaded when they are created. So when we add `<img>` to the page, the user does not see the picture immediately. The browser needs to load it first.

To show an image immediately, we can create it "in advance", like this:

```
let img = document.createElement('img');
```

```
img.src = 'my.jpg';
```

The browser starts loading the image and remembers it in the cache. Later, when the same image appears in the document (no matter how), it shows up immediately.

Create a function `preloadImages(sources, callback)` that loads all images from the array `sources` and, when ready, runs `callback`.

For instance, this will show an `alert` after the images are loaded:

```
function loaded() {
  alert("Images loaded")
}

preloadImages(["1.jpg", "2.jpg", "3.jpg"], loaded);
```

In case of an error, the function should still assume the picture “loaded”.

In other words, the `callback` is executed when all images are either loaded or errored out.

The function is useful, for instance, when we plan to show a gallery with many scrollable images, and want to be sure that all images are loaded.

In the source document you can find links to test images, and also the code to check whether they are loaded or not. It should output `300`.

Open a sandbox for the task.

To solution

Miscellaneous

Mutation observer

`MutationObserver` is a built-in object that observes a DOM element and fires a callback in case of changes.

We'll first take a look at the syntax, and then explore a real-world use case.

Syntax

`MutationObserver` is easy to use.

First, we create an observer with a callback-function:

```
let observer = new MutationObserver(callback);
```

And then attach it to a DOM node:

```
observer.observe(node, config);
```

`config` is an object with boolean options "what kind of changes to react on":

- `childList` – changes in the direct children of `node`,
- `subtree` – in all descendants of `node`,
- `attributes` – attributes of `node`,
- `attributeFilter` – an array of attribute names, to observe only selected ones.
- `characterData` – whether to observe `node.data` (text content),

Few other options:

- `attributeOldValue` – if `true`, pass both the old and the new value of attribute to callback (see below), otherwise only the new one (needs `attributes` option),

- `characterDataOldValue` – if `true`, pass both the old and the new value of `node.data` to callback (see below), otherwise only the new one (needs `characterData` option).

Then after any changes, the `callback` is executed: changes are passed in the first argument as a list of MutationRecord objects, and the observer itself as the second argument.

MutationRecord objects have properties:

- `type` – mutation type, one of
  - `"attributes"`: attribute modified
  - `"characterData"`: data modified, used for text nodes,
  - `"childList"`: child elements added/removed,
- `target` – where the change occurred: an element for `"attributes"`, or text node for `"characterData"`, or an element for a `"childList"` mutation,
- `addedNodes/removedNodes` – nodes that were added/removed,
- `previousSibling/nextSibling` – the previous and next sibling to added/removed nodes,
- `attributeName/attributeNamespace` – the name/namespace (for XML) of the changed attribute,
- `oldValue` – the previous value, only for attribute or text changes, if the corresponding option is set `attributeOldValue`/`characterDataOldValue`.

For example, here's a `<div>` with a `contentEditable` attribute. That attribute allows us to focus on it and edit.

```
<div contentEditable id="elem">Click and <b>edit</b>, please</div>

<script>
let observer = new MutationObserver(mutationRecords
=> {
  console.log(mutationRecords); // console.log(the
```

```
changes)
});

// observe everything except attributes
observer.observe(elem, {
  childList: true, // observe direct children
  subtree: true, // and lower descendants too
  characterDataOldValue: true // pass old data to
callback
});
</script>
```

Now if we change the text inside `<b>edit</b>`, we’ll get a single mutation:

```
mutationRecords = [{
  type: "characterData",
  oldValue: "edit",
  target: <text node>,
  // other properties empty
}];
```

If we select and remove the `<b>edit</b>` altogether, we’ll get multiple mutations:

```
mutationRecords = [{
  type: "childList",
  target: <div#elem>,
  removedNodes: [<b>],
  nextSibling: <text node>,
  previousSibling: <text node>
  // other properties empty
}, {
  type: "characterData"
  target: <text node>
  // ...mutation details depend on how the browser handles such removal
  // it may coalesce two adjacent text nodes "edit " and ", please" into one
node
  // or it may leave them separate text nodes
}];
```

So, `MutationObserver` allows to react on any changes within DOM subtree.

Usage for integration

When such thing may be useful?

Imagine the situation when you attach a third-party script that adds useful functionality on the page, but also does something unwanted, e.g. shows ads `<div class="ads">Unwanted ads</div>`.

Naturally, the third-party script provides no mechanisms to remove it.

Using `MutationObserver`, we can detect when such element appears in our DOM and remove it. While leaving the useful functionality intact. Surely though, creators of that script won't be happy that you took their useful stuff and removed the ads.

There are other situations when a third-party script adds something into our document, and we'd like to detect, when it happens, to adapt our page, dynamically resize something etc.

`MutationObserver` can easily handle this.

Usage for architecture

There are also situations when `MutationObserver` is good from architectural standpoint.

Let's say we're making a website about programming. Naturally, articles and other materials may contain source code snippets.

Such snippet in an HTML markup looks like this:

```
...
<pre class="language-javascript"><code>
  // here's the code
  let hello = "world";
</code></pre>
...
```

Also we'll use a JavaScript highlighting library on our site, e.g. Prism.js. A call to `Prism.highlightElem(pre)` examines the contents of such `pre` elements and adds into them special tags and styles for colored syntax highlighting, similar to what you see in examples here, at this page.

When exactly to run that highlighting method? We can do it on `DOMContentLoaded` event, or at the bottom of the page. At that moment we have our DOM ready, can search for elements `pre[class*="language"]` and call `Prism.highlightElem` on them:

```
// highlight all code snippets on the page
document.querySelectorAll('pre[class*="language"]').forEach(Prism.highlightElem
);
```

Everything's simple so far, right? There are `<pre>` code snippets in HTML, we highlight them.

Now let's go on. Let's say we're going to dynamically fetch materials from a server. We'll study methods for that later in the tutorial. For now it only matters that we fetch an HTML article from a webserver and display it on demand:

```
let article = /* fetch new content from server */
articleElem.innerHTML = article;
```

The new `article` HTML may contain code snippets. We need to call `Prism.highlightElem` on them, otherwise they won't get highlighted.

Where and when to call `Prism.highlightElem` for a dynamically loaded article?

We could append that call to the code that loads an article, like this:

```
let article = /* fetch new content from server */
articleElem.innerHTML = article;

let snippets = articleElem.querySelectorAll('pre[class*="language-"]');
snippets.forEach(Prism.highlightElem);
```

…But imagine, we have many places in the code where we load contents: articles, quizzes, forum posts. Do we need to put the highlighting call everywhere? That's not very convenient, and also easy to forget.

And what if the content is loaded by a third-party module? E.g. we have a forum written by someone else, that loads contents dynamically, and we'd like to add syntax highlighting to it. No one likes to patch third-party scripts.

Luckily, there's another option.

We can use `MutationObserver` to automatically detect when code snippets are inserted in the page and highlight them.

So we'll handle the highlighting functionality in one place, relieving us from the need to integrate it.

Dynamic highlight demo

Here's the working example.

If you run this code, it starts observing the element below and highlighting any code snippets that appear there:

```
let observer = new MutationObserver(mutations => {

  for(let mutation of mutations) {
    // examine new nodes, is there anything to highlight?

    for(let node of mutation.addedNodes) {
      // we track only elements, skip other nodes (e.g. text nodes)
      if (!(node instanceof HTMLElement)) continue;

      // check the inserted element for being a code snippet
      if (node.matches('pre[class*="language-"]')) {
        Prism.highlightElement(node);
      }

      // or maybe there's a code snippet somewhere in its subtree?
      for(let elem of node.querySelectorAll('pre[class*="language-"]')) {
        Prism.highlightElement(elem);
      }
    }
  }

});

let demoElem = document.getElementById('highlight-demo');
```

```
observer.observe(demoElem, {childList: true, subtree: true});
```

Here, below, there's an HTML-element and JavaScript that dynamically fills it using `innerHTML`.

Please run the previous code (above, observes that element), and then the code below. You'll see how `MutationObserver` detects and highlights the snippet.

A demo-element with `id="highlight-demo"`, run the code above to observe it.

The following code populates its `innerHTML`. Please run the code above first, it will watch and highlight the new content:

```
let demoElem = document.getElementById('highlight-demo');

// dynamically insert content with code snippets
demoElem.innerHTML = `A code snippet is below:
  <pre class="language-javascript"><code> let hello = "world!"; </code></pre>
  <div>Another one:</div>
  <div>
    <pre class="language-css"><code>.class { margin: 5px; } </code></pre>
  </div>
`;
```

Now we have `MutationObserver` that can track all highlighting in observed elements or the whole `document`. We can add/remove code snippets in HTML without thinking about it.

Additional methods

There's a method to stop observing the node:

- `observer.disconnect()` – stops the observation.

Another method often used with it:

- `mutationRecords = observer.takeRecords()` – gets a list of unprocessed mutation records, those that happened, but the callback did not handle them.

```
// we'd like to stop tracking changes
observer.disconnect();

// it might have not yet handled some mutations
let mutationRecords = observer.takeRecords();
// process mutationRecords
```

Garbage collection

Observers use weak references to nodes internally. That is: if a node is removed from DOM, and becomes unreachable, then it becomes garbage collected, an observer doesn't prevent that.

Summary

`MutationObserver` can react on changes in DOM: attributes, added/removed elements, text content.

We can use it to track changes introduced by other parts of our code, as well as to integrate with third-party scripts.

`MutationObserver` can track any changes. The config "what to observe" options are used for optimizations, not to spend resources on unneeded callback invocations.

Selection and Range

In this chapter we'll cover selection in the document, as well as selection in form fields, such as `<input>`.

JavaScript can do get the existing selection, select/deselect both as a whole or partially, remove the selected part from the document, wrap it into a tag, and so on.

You can get ready to use recipes at the end, in "Summary" section. But you'll get much more if you read the whole chapter. The underlying `Range` and `Selection` objects are easy to grasp, and then you'll need no recipes to make them do what you want.

Range

The basic concept of selection is [Range](#): basically, a pair of “boundary points”: range start and range end.

Each point represented as a parent DOM node with the relative offset from its start. If the parent node is an element element node, then the offset is a child number, for a text node it’s the position in the text. Examples to follow.

Let’s select something.

First, we can create a range (the constructor has no parameters):

```
let range = new Range();
```

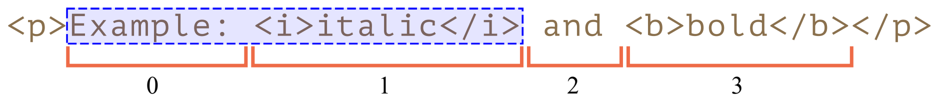
Then we can set the selection boundaries using `range.setStart(node, offset)` and `range.setEnd(node, offset)`.

For example, consider this fragment of HTML:

```
<p id="p">Example: <i>italic</i> and <b>bold</b></p>
```

Here’s its DOM structure, note that here text nodes are important for us:

Let’s select `"Example: <i>italic</i>"`. That’s two first children of `<p>` (counting text nodes):




```
<p id="p">Example: <i>italic</i> and <b>bold</b></p>

<script>
  let range = new Range();

  range.setStart(p, 0);
  range.setEnd(p, 2);

  // toString of a range returns its content as text (without tags)
  alert(range); // Example: italic

  // apply this range for document selection (explained later)
  document.getSelection().addRange(range);
</script>
```

- `range.setStart(p, 0)` – sets the start at the 0th child of `<p>` (that’s a text node `"Example: "`).
- `range.setEnd(p, 2)` – spans the range up to (but not including) 2nd child of `<p>` (that’s a text node `" and "`, but as the end is not included, so the last selected node is `<i>`).

Here’s a more flexible test stand where you try more variants:

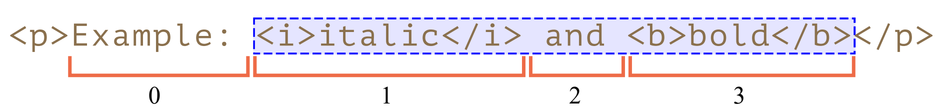
```
<p id="p">Example: <i>italic</i> and <b>bold</b></p>

From <input id="start" type="number" value=1> – To <input id="end" type="number" value=4>
```

```
<button id="button">Click to select</button>
<script>
  button.onclick = () => {
    let range = new Range();

    range.setStart(p, start.value);
    range.setEnd(p, end.value);

    // apply the selection, explained later
    document.getSelection().removeAllRanges();
    document.getSelection().addRange(range);
  };
</script>
```

Example: *italic* and **bold**

From 1 – To 4 Click to select

E.g. selecting from `1` to `4` gives range `<i>italic</i> and <b>bold</b>`.



We don't have to use the same node in `setStart` and `setEnd`. A range may span across many unrelated nodes. It's only important that the end is after the start.

Selecting parts of text nodes

Let's select the text partially, like this:

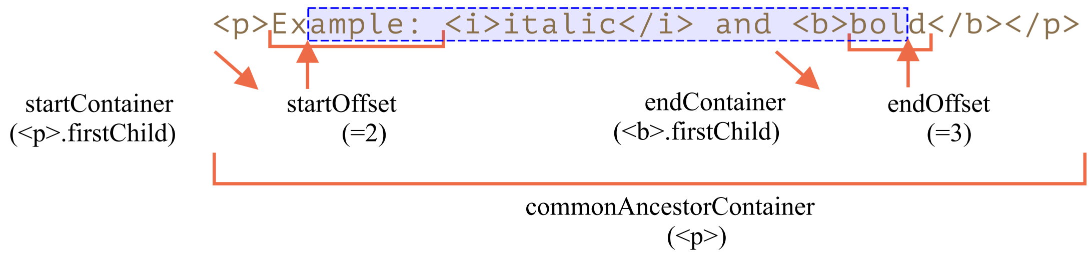
That’s also possible, we just need to set the start and the end as a relative offset in text nodes.

We need to create a range, that:

- starts from position 2 in `<p>` first child (taking all but two first letters of "Ex**ample:** ")
- ends at the position 3 in `<b>` first child (taking first three letters of “**bol**d”, but no more):

```
<p id="p">Example: <i>italic</i> and <b>bold</b></p>

<script>
  let range = new Range();

  range.setStart(p.firstChild, 2);
  range.setEnd(p.querySelector('b').firstChild, 3);

  alert(range); // ample: italic and bol

  // use this range for selection (explained later)
  window.getSelection().addRange(range);
</script>
```

The range object has following properties:



- `startContainer`, `startOffset` – node and offset of the start,
  - in the example above: first text node inside `<p>` and `2`.
- `endContainer`, `endOffset` – node and offset of the end,
  - in the example above: first text node inside `<b>` and `3`.
- `collapsed` – boolean, `true` if the range starts and ends on the same point (so there's no content inside the range),
  - in the example above: `false`
- `commonAncestorContainer` – the nearest common ancestor of all nodes within the range,
  - in the example above: `<p>`

Range methods

There are many convenience methods to manipulate ranges.

Set range start:

- `setStart(node, offset)` set start at: position `offset` in `node`
- `setStartBefore(node)` set start at: right before `node`
- `setStartAfter(node)` set start at: right after `node`

Set range end (similar methods):

- `setEnd(node, offset)` set end at: position `offset` in `node`
- `setEndBefore(node)` set end at: right before `node`
- `setEndAfter(node)` set end at: right after `node`

As it was demonstrated, `node` can be both a text or element node: for text nodes `offset` skips that many of characters, while for element nodes that many child nodes.

Others:

- `selectNode(node)` set range to select the whole `node`
- `selectNodeContents(node)` set range to select the whole `node` contents
- `collapse(toStart)` if `toStart=true` set end=start, otherwise set start=end, thus collapsing the range
- `cloneRange()` creates a new range with the same start/end

To manipulate the content within the range:

- `deleteContents()` – remove range content from the document
- `extractContents()` – remove range content from the document and return as DocumentFragment
- `cloneContents()` – clone range content and return as DocumentFragment
- `insertNode(node)` – insert `node` into the document at the beginning of the range
- `surroundContents(node)` – wrap `node` around range content. For this to work, the range must contain both opening and closing tags for all elements inside it: no partial ranges like `<i>abc`.

With these methods we can do basically anything with selected nodes.

Here's the test stand to see them in action:

```
Click buttons to run methods on the selection, "resetExample" to reset it.

<p id="p">Example: <i>italic</i> and <b>bold</b></p>

<p id="result"></p>
<script>
  let range = new Range();

  // Each demonstrated method is represented here:
```

```
  let methods = {
    deleteContents() {
      range.deleteContents()
    },
    extractContents() {
      let content = range.extractContents();
      result.innerHTML = "";
      result.append("extracted: ", content);
    },
    cloneContents() {
      let content = range.cloneContents();
      result.innerHTML = "";
      result.append("cloned: ", content);
    },
    insertNode() {
      let newNode = document.createElement('u');
      newNode.innerHTML = "NEW NODE";
      range.insertNode(newNode);
    },
    surroundContents() {
      let newNode = document.createElement('u');
      try {
        range.surroundContents(newNode);
      } catch(e) { alert(e) }
    },
    resetExample() {
      p.innerHTML = `Example: <i>italic</i> and
<b>bold</b>`;
      result.innerHTML = "";

      range.setStart(p.firstChild, 2);
      range.setEnd(p.querySelector('b').firstChild,
3);

      window.getSelection().removeAllRanges();
```

```
      window.getSelection().addRange(range);
    }
  };

  for(let method in methods) {
    document.write(`<div><button
onclick="methods.${method}()">${method}</button>
</div>`);
  }

  methods.resetExample();
</script>
```

Click buttons to run methods on the selection, "resetExample" to reset it.

Example: *italic* and **bold**

deleteContents
extractContents
cloneContents
insertNode
surroundContents
resetExample

There also exist methods to compare ranges, but these are rarely used. When you need them, please refer to the spec or MDN manual.

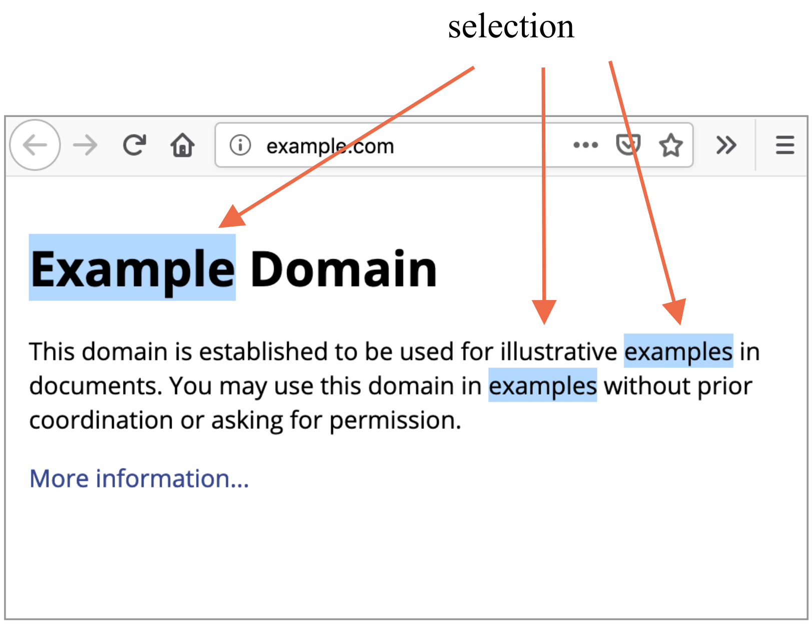
Selection

`Range` is a generic object for managing selection ranges. We may create such objects, pass them around – they do not visually select anything on their own.

The document selection is represented by `Selection` object, that can be obtained as `window.getSelection()` or `document.getSelection()`.

A selection may include zero or more ranges. At least, the Selection API specification says so. In practice though, only Firefox allows to select multiple ranges in the document by using `Ctrl+click` (`Cmd+click` for Mac).

Here's a screenshot of a selection with 3 ranges, made in Firefox:



Other browsers support at maximum 1 range. As we'll see, some of `Selection` methods imply that there may be many ranges, but again, in all browsers except Firefox, there's at maximum 1.

Selection properties

Similar to a range, a selection has a start, called "anchor", and the end, called "focus".

The main selection properties are:

- `anchorNode` – the node where the selection starts,
- `anchorOffset` – the offset in `anchorNode` where the selection starts,
- `focusNode` – the node where the selection ends,
- `focusOffset` – the offset in `focusNode` where the selection ends,

- `isCollapsed` – `true` if selection selects nothing (empty range), or doesn't exist.
- `rangeCount` – count of ranges in the selection, maximum `1` in all browsers except Firefox.

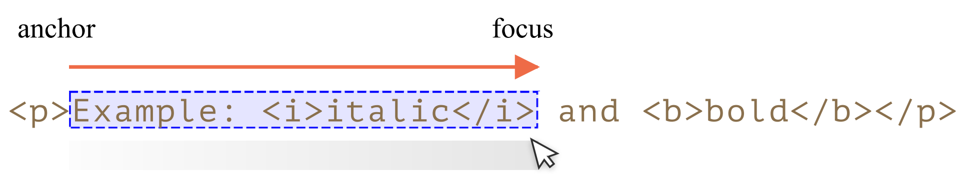
Selection end may be in the document before start

There are many ways to select the content, depending on the user agent: mouse, hotkeys, taps on a mobile etc.

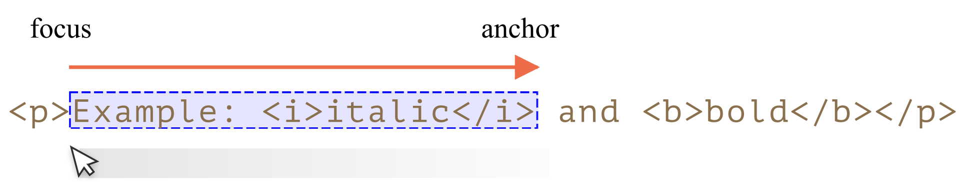
Some of them, such as a mouse, allow the same selection can be created in two directions: "left-to-right" and "right-to-left".

If the start (anchor) of the selection goes in the document before the end (focus), this selection is said to have "forward" direction.

E.g. if the user starts selecting with mouse and goes from "Example" to "italic":



Otherwise, if they go from the end of "italic" to "Example", the selection is directed "backward", its focus will be before the anchor:



That's different from `Range` objects that are always directed forward: the range start can't be after its end.

Selection events

There are events on to keep track of selection:

- `elem.onselectstart` – when a selection starts on `elem`, e.g. the user starts moving mouse with pressed button.
  - Preventing the default action makes the selection not start.
- `document.onselectionchange` – whenever a selection changes.
  - Please note: this handler can be set only on `document`.

Selection tracking demo

Here's a small demo that shows selection boundaries dynamically as it changes:

```
<p id="p">Select me: <i>italic</i> and <b>bold</b></p>

From <input id="from" disabled> – To <input id="to" disabled>
<script>
  document.onselectionchange = function() {
    let {anchorNode, anchorOffset, focusNode,
focusOffset} = document.getSelection();

    from.value = `${anchorNode &&
anchorNode.data}:${anchorOffset}`;
    to.value = `${focusNode &&
focusNode.data}:${focusOffset}`;
  };
</script>
```

Selection getting demo

To get the whole selection:

- As text: just call `document.getSelection().toString()`.
- As DOM nodes: get the underlying ranges and call their `cloneContents()` method (only first range if we don't support Firefox multiselection).

And here’s the demo of getting the selection both as text and as DOM nodes:

```
<p id="p">Select me: <i>italic</i> and <b>bold</b></p>

Cloned: <span id="cloned"></span>
<br>
As text: <span id="astext"></span>

<script>
  document.onselectionchange = function() {
    let selection = document.getSelection();

    cloned.innerHTML = astext.innerHTML = "";

    // Clone DOM nodes from ranges (we support
multiselect here)
    for (let i = 0; i < selection.rangeCount; i++) {

cloned.append(selection.getRangeAt(i).cloneContents()
);
    }

    // Get as text
    astext.innerHTML += selection;
  };
</script>
```

Selection methods

Selection methods to add/remove ranges:

- `getRangeAt(i)` – get i-th range, starting from `0`. In all browsers except firefox, only `0` is used.
- `addRange(range)` – add `range` to selection. All browsers except Firefox ignore the call, if the selection already has an associated range.
- `removeRange(range)` – remove `range` from the selection.
- `removeAllRanges()` – remove all ranges.

- `empty()` – alias to `removeAllRanges`.

Also, there are convenience methods to manipulate the selection range directly, without `Range`:

- `collapse(node, offset)` – replace selected range with a new one that starts and ends at the given `node`, at position `offset`.
- `setPosition(node, offset)` – alias to `collapse`.
- `collapseToStart()` – collapse (replace with an empty range) to selection start,
- `collapseToEnd()` – collapse to selection end,
- `extend(node, offset)` – move focus of the selection to the given `node`, position `offset`,
- `setBaseAndExtent(anchorNode, anchorOffset, focusNode, focusOffset)` – replace selection range with the given start `anchorNode/anchorOffset` and end `focusNode/focusOffset`. All content in-between them is selected.
- `selectAllChildren(node)` – select all children of the `node`.
- `deleteFromDocument()` – remove selected content from the document.
- `containsNode(node, allowPartialContainment = false)` – checks whether the selection contains `node` (partically if the second argument is `true`)

So, for many tasks we can call `Selection` methods, no need to access the underlying `Range` object.

For example, selecting the whole contents of the paragraph `<p>`:

```
<p id="p">Select me: <i>italic</i> and <b>bold</b></p>

<script>
  // select from 0th child of <p> to the last child
  document.getSelection().setBaseAndExtent(p, 0, p,
p.childNodes.length);
</script>
```

The same thing using ranges:

```
<p id="p">Select me: <i>italic</i> and <b>bold</b></p>

<script>
  let range = new Range();
  range.selectNodeContents(p); // or selectNode(p) to
select the <p> tag too

  document.getSelection().removeAllRanges(); // clear
existing selection if any
  document.getSelection().addRange(range);
</script>
```

> **To select, remove the existing selection first**
>
> If the selection already exists, empty it first with `removeAllRanges()`. And then add ranges. Otherwise, all browsers except Firefox ignore new ranges.
>
> The exception is some selection methods, that replace the existing selection, like `setBaseAndExtent`.

Selection in form controls

Form elements, such as `input` and `textarea` provide special API for selection, without `Selection` or `Range` objects. As an input value is a pure text, not HTML, there's no need for such objects, everything's much simpler.

Properties:

- `input.selectionStart` – position of selection start (writeable),
- `input.selectionEnd` – position of selection end (writeable),
- `input.selectionDirection` – selection direction, one of: “forward”, “backward” or “none” (if e.g. selected with a double mouse click),

Events:

- `input.onselect` – triggers when something is selected.

Methods:

- `input.select()` – selects everything in the text control (can be `textarea` instead of `input`),
- `input.setSelectionRange(start, end, [direction])` – change the selection to span from position `start` till `end`, in the given direction (optional).
- `input.setRangeText(replacement, [start], [end], [selectionMode])` – replace a range of text with the new text.

  Optional arguments `start` and `end`, if provided, set the range start and end, otherwise user selection is used.

  The last argument, `selectionMode`, determines how the selection will be set after the text has been replaced. The possible values are:

  - `"select"` – the newly inserted text will be selected.
  - `"start"` – the selection range collapses just before the inserted text (the cursor will be immediately before it).
  - `"end"` – the selection range collapses just after the inserted text (the cursor will be right after it).
  - `"preserve"` – attempts to preserve the selection. This is the default.

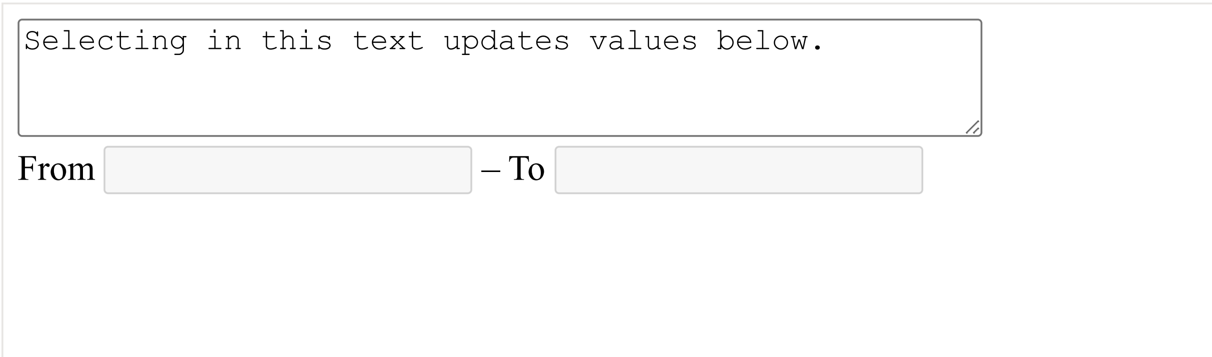
Now let's see these methods in action.

Example: tracking selection

For example, this code uses `onselect` event to track selection:

```
<textarea id="area" style="width:80%;height:60px">
Selecting in this text updates values below.
</textarea>
<br>
From <input id="from" disabled> – To <input id="to" disabled>


<script>
```

```
  area.onselect = function() {
    from.value = area.selectionStart;
    to.value = area.selectionEnd;
  };
</script>
```



Please note:

- `onselect` triggers when something is selected, but not when the selection is removed.
- `document.onselectionchange` event should not trigger for selections inside a form control, according to the spec, as it's not related to `document` selection and ranges. Some browsers generate it, but we shouldn't rely on it.

Example: moving cursor

We can change `selectionStart` and `selectionEnd`, that sets the selection.

An important edge case is when `selectionStart` and `selectionEnd` equal each other. Then it's exactly the cursor position. Or, to rephrase, when nothing is selected, the selection is collapsed at the cursor position.

So, by setting `selectionStart` and `selectionEnd` to the same value, we move the cursor.

For example:

```
<textarea id="area" style="width:80%;height:60px">
Focus on me, the cursor will be at position 10.
</textarea>
```

```
<script>
  area.onfocus = () => {
    // zero delay setTimeout to run after browser "focus" action finishes
    setTimeout(() => {
      // we can set any selection
      // if start=end, the cursor it exactly at that place
      area.selectionStart = area.selectionEnd = 10;
    });
  };
</script>
```

Focus on me, the cursor will be at position 10.

Example: modifying selection

To modify the content of the selection, we can use `input.setRangeText()` method. Of course, we can read `selectionStart/End` and, with the knowledge of the selection, change the corresponding substring of `value`, but `setRangeText` is more powerful and often more convenient.

That's a somewhat complex method. In its simplest one-argument form it replaces the user selected range and removes the selection.

For example, here the user selection will be wrapped by `*...*`:

```
<input id="input" style="width:200px" value="Select here and click the button">
<button id="button">Wrap selection in stars *...*</button>
```

```
<script>
button.onclick = () => {
  if (input.selectionStart == input.selectionEnd) {
    return; // nothing is selected
  }

  let selected =
input.value.slice(input.selectionStart,
input.selectionEnd);
  input.setRangeText(`*${selected}*`);
};
</script>
```

Select here and click the b | Wrap selection in stars *...*

With more arguments, we can set range `start` and `end`.

In this example we find `"THIS"` in the input text, replace it and keep the replacement selected:

```
<input id="input"  style="width:200px" value="Replace THIS in text">
<button id="button">Replace THIS</button>

<script>
button.onclick = () => {
  let pos = input.value.indexOf("THIS");
  if (pos >= 0) {
    input.setRangeText("*THIS*", pos, pos + 4,
"select");
    input.focus(); // focus to make selection visible
```

```
  }
};
</script>
```

Replace THIS in text   Replace THIS

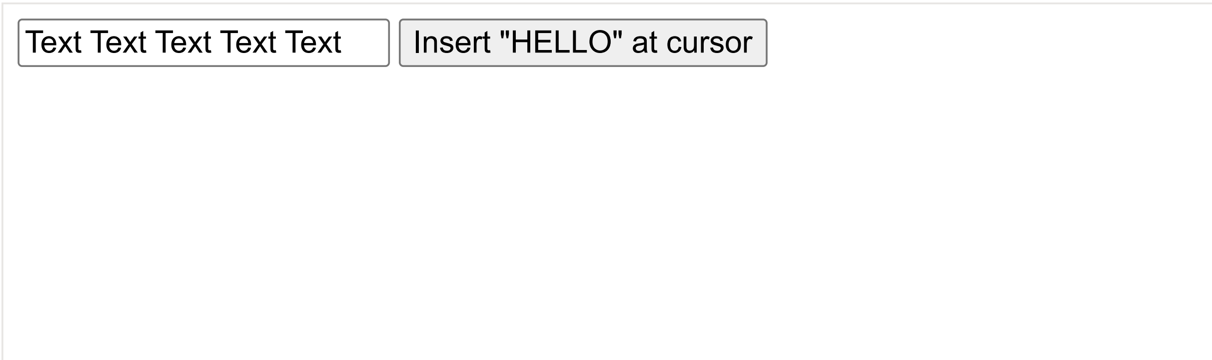
Example: insert at cursor

If nothing is selected, or we use equal `start` and `end` in `setRangeText`, then the new text is just inserted, nothing is removed.

We can also insert something “at the cursor” using `setRangeText`.

Here’s an button that inserts `"HELLO"` at the cursor position and puts the cursor immediately after it. If the selection is not empty, then it gets replaced (we can do detect in by comparing `selectionStart!=selectionEnd` and do something else instead):

```
<input id="input" style="width:200px" value="Text Text Text Text
Text">
<button id="button">Insert "HELLO" at cursor</button>

<script>
  button.onclick = () => {
    input.setRangeText("HELLO", input.selectionStart,
input.selectionEnd, "end");
    input.focus();
  };
</script>
```



Making unselectable

To make something unselectable, there are three ways:

1. Use CSS property `user-select: none`.

   ```
   <style>
   #elem {
     user-select: none;
   }
   </style>
   <div>Selectable <div id="elem">Unselectable</div> Selectable</div>
   ```

   This doesn’t allow the selection to start at `elem`. But the user may start the selection elsewhere and include `elem` into it.

   Then `elem` will become a part of `document.getSelection()`, so the selection actully happens, but its content is usually ignored in copy-paste.

2. Prevent default action in `onselectstart` or `mousedown` events.

   ```
   <div>Selectable <div id="elem">Unselectable</div> Selectable</div>

   <script>
     elem.onselectstart = () => false;
   </script>
   ```

This prevents starting the selection on `elem`, but the visitor may start it at another element, then extend to `elem`.

That's convenient when there's another event handler on the same action that triggers the select (e.g. `mousedown`). So we disable the selection to avoid conflict, still allowing `elem` contents to be copied.

3. We can also clear the selection post-factum after it happens with `document.getSelection().empty()`. That's rarely used, as this causes unwanted blinking as the selection appears-disappears.

References

- DOM spec: Range
- Selection API
- HTML spec: APIs for the text control selections

Summary

We covered two different APIs for selections:

1. For document: `Selection` and `Range` objects.
2. For `input`, `textarea`: additional methods and properties.

The second API is very simple, as it works with text.

The most used recipes are probably:

1. Getting the selection:

```
let selection = document.getSelection();

let cloned = /* element to clone the selected nodes to */;

// then apply Range methods to selection.getRangeAt(0)
// or, like here, to all ranges to support multi-select
for (let i = 0; i < selection.rangeCount; i++) {
  cloned.append(selection.getRangeAt(i).cloneContents());
}
```

2. Setting the selection

```
let selection = document.getSelection();

// directly:
selection.setBaseAndExtent(...from...to...);

// or we can create a range and:
selection.removeAllRanges();
selection.addRange(range);
```

And finally, about the cursor. The cursor position in editable elements, like `<textarea>` is always at the start or the end of the selection. We can use it to get cursor position or to move the cursor by setting `elem.selectionStart` and `elem.selectionEnd`.

Event loop: microtasks and macrotasks

Browser JavaScript execution flow, as well as in Node.js, is based on an *event loop*.

Understanding how event loop works is important for optimizations, and sometimes for the right architecture.

In this chapter we first cover theoretical details about how things work, and then see practical applications of that knowledge.

Event Loop

The concept of *event loop* is very simple. There's an endless loop, when JavaScript engine waits for tasks, executes them and then sleeps waiting for more tasks.

The general algorithm of the engine:

1. While there are tasks:
   - execute them, starting with the oldest task.
2. Sleep until a task appears, then go to 1.

That's a formalization for what we see when browsing a page. JavaScript engine does nothing most of the time, only runs if a script/handler/event activates.

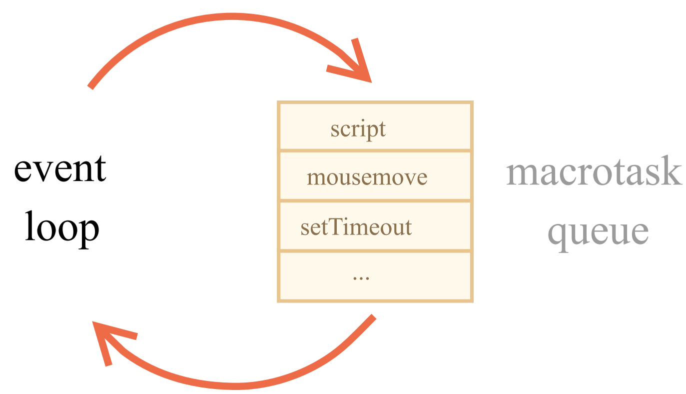
Examples of tasks:

- When an external script `<script src="...">` loads, the task is to execute it.
- When a user moves their mouse, the task is to dispatch `mousemove` event and execute handlers.
- When the time is due for a scheduled `setTimeout`, the task is to run its callback.
- ...and so on.

Tasks are set – the engine handles them – then waits for more tasks (while sleeping and consuming close to zero CPU).

It may happen that a task comes while the engine is busy, then it's enqueued.

The tasks form a queue, so-called "macrotask queue" (v8 term):



For instance, while the engine is busy executing a `script`, a user may move their mouse causing `mousemove`, and `setTimeout` may be due and so on, these tasks form a queue, as illustrated on the picture above.

Tasks from the queue are processed on "first come – first served" basis. When the engine browser is done with the `script`, it handles `mousemove` event, then `setTimeout` handler, and so on.

So far, quite simple, right?

Two more details:

1. Rendering never happens while the engine executes a task. Doesn't matter if the task takes a long time. Changes to DOM are painted only after the

task is complete.
2. If a task takes too long, the browser can't do other tasks, process user events, so after a time it raises an alert like "Page Unresponsive" suggesting to kill the task with the whole page. That happens when there are a lot of complex calculations or a programming error leading to infinite loop.

That was a theory. Now let's see how we can apply that knowledge.

Use-case 1: splitting CPU-hungry tasks

Let's say we have a CPU-hungry task.

For example, syntax-highlighting (used to colorize code examples on this page) is quite CPU-heavy. To highlight the code, it performs the analysis, creates many colored elements, adds them to the document – for a big text that takes a lot of time.

While the engine is busy with syntax highlighting, it can't do other DOM-related stuff, process user events, etc. It may even cause the browser to "hiccup" or even "hang" for a bit, which is unacceptable.

We can evade problems by splitting the big task into pieces. Highlight first 100 lines, then schedule `setTimeout` (with zero-delay) another 100 lines, and so on.

To demonstrate the approach, for the sake of simplicity, instead of syntax-highlighting let's take a function that counts from `1` to `1000000000`.

If you run the code below, the engine will "hang" for some time. For server-side JS that's clearly noticeable, and if you are running it in-browser, then try to click other buttons on the page – you'll see that no other events get handled until the counting finishes.

```
let i = 0;

let start = Date.now();

function count() {

  // do a heavy job
  for (let j = 0; j < 1e9; j++) {
    i++;
```

```
  }

  alert("Done in " + (Date.now() - start) + 'ms');
}

count();
```

The browser may even show “the script takes too long” warning.

Let’s split the job using nested `setTimeout`:

```
let i = 0;

let start = Date.now();

function count() {

  // do a piece of the heavy job (*)
  do {
    i++;
  } while (i % 1e6 != 0);

  if (i == 1e9) {
    alert("Done in " + (Date.now() - start) + 'ms');
  } else {
    setTimeout(count); // schedule the new call (**)
  }

}

count();
```

Now the browser interface is fully functional during the “counting” process.

A single run of `count` does a part of the job `(*)`, and then re-schedules itself `(**)` if needed:

1. First run counts: `i=1...1000000`.
2. Second run counts: `i=1000001..2000000`.
3. ...and so on.

Now, if a new side task (e.g. `onclick` event) appears while the engine is busy executing part 1, it gets queued and then executes when part 1 finished, before the next part. Periodic returns to event loop between `count` executions provide just enough “air” for the JavaScript engine to do something else, to react on other user actions.

The notable thing is that both variants – with and without splitting the job by `setTimeout` – are comparable in speed. There’s no much difference in the overall counting time.

To make them closer, let’s make an improvement.

We’ll move the scheduling in the beginning of the `count()`:

```
let i = 0;

let start = Date.now();

function count() {

  // move the scheduling at the beginning
  if (i < 1e9 - 1e6) {
    setTimeout(count); // schedule the new call
  }

  do {
    i++;
  } while (i % 1e6 != 0);

  if (i == 1e9) {
    alert("Done in " + (Date.now() - start) + 'ms');
  }

}

count();
```

Now when we start to `count()` and see that we’ll need to `count()` more, we schedule that immediately, before doing the job.

If you run it, it’s easy to notice that it takes significantly less time.

Why?

That’s simple: as you remember, there’s the in-browser minimal delay of 4ms for many nested `setTimeout` calls. Even if we set `0`, it’s `4ms` (or a bit more). So the earlier we schedule it – the faster it runs.

Finally, we've split a CPU-hungry task into parts – now it doesn't block the user interface. And its overall execution time isn't much longer.

Use case 2: progress indication

Another benefit of splitting heavy tasks for browser scripts is that we can show progress indication.

Usually the browser renders after the currently running code is complete. Doesn't matter if the task takes a long time. Changes to DOM are painted only after the task is finished.

From one hand, that's great, because our function may create many elements, add them one-by-one to the document and change their styles – the visitor won't see any "intermediate", unfinished state. An important thing, right?

Here's the demo, the changes to `i` won't show up until the function finishes, so we'll see only the last value:

```
<div id="progress"></div>

<script>

  function count() {
    for (let i = 0; i < 1e6; i++) {
      i++;
      progress.innerHTML = i;
    }
  }

  count();
</script>
```

...But we also may want to show something during the task, e.g. a progress bar.

If we split the heavy task into pieces using `setTimeout`, then changes are painted out in-between them.

This looks prettier:

```
<div id="progress"></div>

<script>
  let i = 0;

  function count() {

    // do a piece of the heavy job (*)
    do {
      i++;
      progress.innerHTML = i;
    } while (i % 1e3 != 0);

    if (i < 1e7) {
      setTimeout(count);
    }

  }

  count();
</script>
```

Now the `<div>` shows increasing values of `i`, a kind of a progress bar.

Use case 3: doing something after the event

In an event handler we may decide to postpone some actions until the event bubbled up and was handled on all levels. We can do that by wrapping the code in zero delay `setTimeout`.

In the chapter Dispatching custom events we saw an example: custom event `menu-open` is dispatched in `setTimeout`, so that it happens after the "click" event is fully handled.

```
menu.onclick = function() {
  // ...

  // create a custom event with the clicked menu item data
  let customEvent = new CustomEvent("menu-open", {
    bubbles: true
  });

  // dispatch the custom event asynchronously
  setTimeout(() => menu.dispatchEvent(customEvent));
};
```

Macrotasks and Microtasks

Along with *macrotasks*, described in this chapter, there exist *microtasks*, mentioned in the chapter Microtasks.

Microtasks come solely from our code. They are usually created by promises: an execution of `.then/catch/finally` handler becomes a microtask. Microtasks are used "under the cover" of `await` as well, as it's another form of promise handling.

There's also a special function `queueMicrotask(func)` that queues `func` for execution in the microtask queue.

Immediately after every *macrotask*, the engine executes all tasks from *microtask* queue, prior to running any other macrotasks or rendering or anything else.

For instance, take a look:

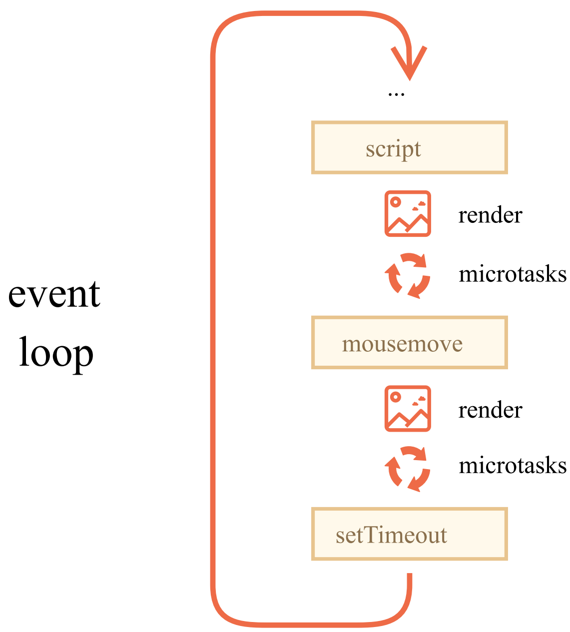
```
setTimeout(() => alert("timeout"));

Promise.resolve()
  .then(() => alert("promise"));

alert("code");
```

What's going to be the order here?

1. `code` shows first, because it's a regular synchronous call.

2. `promise` shows second, because `.then` passes through the microtask queue, and runs after the current code.
3. `timeout` shows last, because it's a macrotask.

The richer event loop picture looks like this:



All microtasks are completed before any other event handling or rendering or any other macrotask takes place.

That's important, as it guarantees that the application environment is basically the same (no mouse coordinate changes, no new network data, etc) between microtasks.

If we'd like to execute a function asynchronously (after the current code), but before changes are rendered or new events handled, we can schedule it with `queueMicrotask`.

Here's an example with "counting progress bar", similar to the one shown previously, but `queueMicrotask` is used instead of `setTimeout`. You can see that it renders at the very end. Just like the synchronous code:

```
<div id="progress"></div>
```

```
<script>
  let i = 0;

  function count() {

    // do a piece of the heavy job (*)
    do {
      i++;
      progress.innerHTML = i;
    } while (i % 1e3 != 0);

    if (i < 1e6) {
      queueMicrotask(count);
    }

  }

  count();
</script>
```

Summary

The more detailed algorithm of the event loop (though still simplified compare to the specification):

1. Dequeue and run the oldest task from the *macrotask* queue (e.g. “script”).
2. Execute all *microtasks*:
   - While the microtask queue is not empty:
     - Dequeue and run the oldest microtask.
3. Render changes if any.
4. If the macrotask queue is empty, wait till a macrotask appears.
5. Go to step 1.

To schedule a new *macrotask*:

- Use zero delayed `setTimeout(f)`.

That may be used to split a big calculation-heavy task into pieces, for the browser to be able to react on user events and show progress between them.

Also, used in event handlers to schedule an action after the event is fully handled (bubbling done).

To schedule a new *microtask*

- Use `queueMicrotask(f)`.
- Also promise handlers go through the microtask queue.

There's no UI or network event handling between microtasks: they run immediately one after another.

So one may want to `queueMicrotask` to execute a function asynchronously, but within the environment state.

> ### Web Workers
>
> For long heavy calculations that shouldn't block the event loop, we can use Web Workers.
>
> That's a way to run code in another, parallel thread.
>
> Web Workers can exchange messages with the main process, but they have their own variables, and their own event loop.
>
> Web Workers do not have access to DOM, so they are useful, mainly, for calculations, to use multiplle CPU cores simultaneously.

Solutions

Walking the DOM

DOM children

There are many ways, for instance:

The `<div>` DOM node:

```
document.body.firstElementChild
// or
document.body.children[0]
// or (the first node is space, so we take 2nd)
document.body.childNodes[1]
```

The `<ul>` DOM node:

```
document.body.lastElementChild
// or
document.body.children[1]
```

The second `<li>` (with Pete):

```
// get <ul>, and then get its last element child
document.body.lastElementChild.lastElementChild
```

To formulation

The sibling question

1. Yes, true. The element `elem.lastChild` is always the last one, it has no `nextSibling`.

2. No, wrong, because `elem.children[0]` is the first child *among elements*. But there may exist non-element nodes before it. So `previousSibling` may be a text node.

Please note: for both cases if there are no children, then there will be an error.

If there are no children, `elem.lastChild` is `null`, so we can't access `elem.lastChild.nextSibling`. And the collection `elem.children` is empty (like an empty array `[]`).

To formulation

Select all diagonal cells

We'll be using `rows` and `cells` properties to access diagonal table cells.

Open the solution in a sandbox.

To formulation

Searching: getElement*, querySelector*

Search for elements

There are many ways to do it.

Here are some of them:

```
// 1. The table with `id="age-table"`.
let table = document.getElementById('age-table')
```

```
// 2. All label elements inside that table
table.getElementsByTagName('label')
// or
document.querySelectorAll('#age-table label')

// 3. The first td in that table (with the word "Age")
table.rows[0].cells[0]
// or
table.getElementsByTagName('td')[0]
// or
table.querySelector('td')

// 4. The form with the name "search"
// assuming there's only one element with name="search" in the
document
let form = document.getElementsByName('search')[0]
// or, form specifically
document.querySelector('form[name="search"]')

// 5. The first input in that form.
form.getElementsByTagName('input')[0]
// or
form.querySelector('input')

// 6. The last input in that form
let inputs = form.querySelectorAll('input') // find all inputs
inputs[inputs.length-1] // take the last one
```

To formulation

Node properties: type, tag and contents

Count descendants

Let’s make a loop over `<li>`:

```
for (let li of document.querySelectorAll('li')) {
  ...
}
```

In the loop we need to get the text inside every `li`.

We can read the text from the first child node of `li`, that is the text node:

```
for (let li of document.querySelectorAll('li')) {
  let title = li.firstChild.data;

  // title is the text in <li> before any other nodes
}
```

Then we can get the number of descendants as `li.getElementsByTagName('li').length`.

Open the solution in a sandbox.

To formulation

What's in the nodeType?

There’s a catch here.

At the time of `<script>` execution the last DOM node is exactly `<script>`, because the browser did not process the rest of the page yet.

So the result is `1` (element node).

```
<html>

<body>
  <script>
    alert(document.body.lastChild.nodeType);
  </script>
</body>
```

```
</html>
```

To formulation

Tag in comment

The answer: `BODY`.

```
<script>
  let body = document.body;

  body.innerHTML = "<!--" + body.tagName + "-->";

  alert( body.firstChild.data ); // BODY
</script>
```

What’s going on step by step:

1. The content of `<body>` is replaced with the comment. The comment is `<!--BODY-->`, because `body.tagName == "BODY"`. As we remember, `tagName` is always uppercase in HTML.
2. The comment is now the only child node, so we get it in `body.firstChild`.
3. The `data` property of the comment is its contents (inside `<!--...-->`): `"BODY"`.

To formulation

Where's the "document" in the hierarchy?

We can see which class it belongs by outputting it, like:

```
alert(document); // [object HTMLDocument]
```

Or:

```
alert(document.constructor.name); // HTMLDocument
```

So, `document` is an instance of `HTMLDocument` class.

What's its place in the hierarchy?

Yeah, we could browse the specification, but it would be faster to figure out manually.

Let's traverse the prototype chain via `__proto__`.

As we know, methods of a class are in the `prototype` of the constructor. For instance, `HTMLDocument.prototype` has methods for documents.

Also, there's a reference to the constructor function inside the `prototype`:

```
alert(HTMLDocument.prototype.constructor === HTMLDocument); // true
```

To get a name of the class as a string, we can use `constructor.name`. Let's do it for the whole `document` prototype chain, till class `Node`:

```
alert(HTMLDocument.prototype.constructor.name); // HTMLDocument
alert(HTMLDocument.prototype.__proto__.constructor.name); //
Document
```

```
alert(HTMLDocument.prototype.__proto__.__proto__.constructor.name);
// Node
```

That's the hierarchy.

We also could examine the object using `console.dir(document)` and see these names by opening `__proto__`. The console takes them from `constructor` internally.

To formulation

Attributes and properties

Get the attribute

```
<!DOCTYPE html>
<html>
<body>

  <div data-widget-name="menu">Choose the genre</div>

  <script>
    // getting it
    let elem = document.querySelector('[data-widget-name]');

    // reading the value
    alert(elem.dataset.widgetName);
    // or
    alert(elem.getAttribute('data-widget-name'));
  </script>
```

```
</body>
</html>
```

To formulation

Make external links orange

First, we need to find all external references.

There are two ways.

The first is to find all links using `document.querySelectorAll('a')` and then filter out what we need:

```
let links = document.querySelectorAll('a');

for (let link of links) {
  let href = link.getAttribute('href');
  if (!href) continue; // no attribute

  if (!href.includes('://')) continue; // no protocol

  if (href.startsWith('http://internal.com')) continue; // internal

  link.style.color = 'orange';
}
```

Please note: we use `link.getAttribute('href')`. Not `link.href`, because we need the value from HTML.

…Another, simpler way would be to add the checks to CSS selector:

```
// look for all links that have :// in href
// but href doesn't start with http://internal.com
let selector = 'a[href*="://"]:not([href^="http://internal.com"])';
let links = document.querySelectorAll(selector);
```

```
links.forEach(link => link.style.color = 'orange');
```

Open the solution in a sandbox.

To formulation

Modifying the document

createTextNode vs innerHTML vs textContent

Answer: **1 and 3**.

Both commands result in adding the `text` “as text” into the `elem`.

Here’s an example:

```
<div id="elem1"></div>
<div id="elem2"></div>
<div id="elem3"></div>
<script>
  let text = '<b>text</b>';


elem1.append(document.createTextNode(text));
  elem2.innerHTML = text;
  elem3.textContent = text;
</script>
```

To formulation

Clear the element

First, let’s see how *not* to do it:

```
function clear(elem) {
  for (let i=0; i < elem.childNodes.length; i++) {
      elem.childNodes[i].remove();
  }
}
```

That won’t work, because the call to `remove()` shifts the collection `elem.childNodes`, so elements start from the index `0` every time. But `i` increases, and some elements will be skipped.

The `for..of` loop also does the same.

The right variant could be:

```
function clear(elem) {
  while (elem.firstChild) {
    elem.firstChild.remove();
  }
}
```

And also there’s a simpler way to do the same:

```
function clear(elem) {
  elem.innerHTML = '';
}
```

To formulation

Why does "aaa" remain?

The HTML in the task is incorrect. That's the reason of the odd thing.

The browser has to fix it automatically. But there may be no text inside the `<table>`: according to the spec only table-specific tags are allowed. So the browser adds `"aaa"` *before* the `<table>`.

Now it's obvious that when we remove the table, it remains.

The question can be easily answered by exploring the DOM using the browser tools. It shows `"aaa"` before the `<table>`.

The HTML standard specifies in detail how to process bad HTML, and such behavior of the browser is correct.

To formulation

Create a list

Please note the usage of `textContent` to assign the `<li>` content.

Open the solution in a sandbox.

To formulation

Create a tree from the object

The easiest way to walk the object is to use recursion.

1. The solution with innerHTML .
2. The solution with DOM .

To formulation

Show descendants in a tree

To append text to each `<li>` we can alter the text node `data`.

Open the solution in a sandbox.

To formulation

Create a calendar

We'll create the table as a string: `"<table>...</table>"`, and then assign it to `innerHTML`.

The algorithm:

1. Create the table header with `<th>` and weekday names.
2. Create the date object `d = new Date(year, month-1)`. That's the first day of `month` (taking into account that months in JavaScript start from `0`, not `1`).
3. First few cells till the first day of the month `d.getDay()` may be empty. Let's fill them in with `<td></td>`.
4. Increase the day in `d`: `d.setDate(d.getDate()+1)`. If `d.getMonth()` is not yet the next month, then add the new cell `<td>` to the calendar. If that's a Sunday, then add a newline `“</tr><tr>”`.
5. If the month has finished, but the table row is not yet full, add empty `<td>` into it, to make it square.

Open the solution in a sandbox.

To formulation

Colored clock with setInterval

First, let’s make HTML/CSS.

Each component of the time would look great in its own `<span>`:

```
<div id="clock">
  <span class="hour">hh</span>:<span class="min">mm</span>:<span
class="sec">ss</span>
</div>
```

Also we’ll need CSS to color them.

The `update` function will refresh the clock, to be called by `setInterval` every second:

```
function update() {
  let clock = document.getElementById('clock');
  let date = new Date(); // (*)
  let hours = date.getHours();
  if (hours < 10) hours = '0' + hours;
  clock.children[0].innerHTML = hours;

  let minutes = date.getMinutes();
  if (minutes < 10) minutes = '0' + minutes;
  clock.children[1].innerHTML = minutes;

  let seconds = date.getSeconds();
  if (seconds < 10) seconds = '0' + seconds;
  clock.children[2].innerHTML = seconds;
}
```

In the line `(*)` we every time check the current date. The calls to `setInterval` are not reliable: they may happen with delays.

The clock-managing functions:

```
let timerId;

function clockStart() { // run the clock
  timerId = setInterval(update, 1000);
  update(); // (*)
}

function clockStop() {
  clearInterval(timerId);
  timerId = null;
}
```

Please note that the call to `update()` is not only scheduled in `clockStart()`, but immediately run in the line `(*)`. Otherwise the visitor would have to wait till the first execution of `setInterval`. And the clock would be empty till then.

Open the solution in a sandbox.

To formulation

Insert the HTML in the list

When we need to insert a piece of HTML somewhere, `insertAdjacentHTML` is the best fit.

The solution:

```
one.insertAdjacentHTML('afterend', '<li>2</li><li>3</li>');
```

To formulation

Sort the table

The solution is short, yet may look a bit tricky, so here I provide it with extensive comments:

```
let sortedRows = Array.from(table.rows)
  .slice(1)
  .sort((rowA, rowB) => rowA.cells[0].innerHTML >
rowB.cells[0].innerHTML ? 1 : -1);

table.tBodies[0].append(...sortedRows);
```

1. Get all `<tr>`, like `table.querySelectorAll('tr')`, then make an array from them, cause we need array methods.

2. The first TR (`table.rows[0]`) is actually a table header, so we take the rest by `.slice(1)`.

3. Then sort them comparing by the content of the first `<td>` (the name field).

4. Now insert nodes in the right order by `.append(...sortedRows)`.

   Tables always have an implicit `<tbody>` element, so we need to take it and insert into it: a simple `table.append(...)` would fail.

   Please note: we don't have to remove them, just "re-insert", they leave the old place automatically.

Open the solution in a sandbox.

To formulation

Styles and classes

Create a notification

Open the solution in a sandbox.

To formulation

Element size and scrolling

What's the scroll from the bottom?

The solution is:

```
let scrollBottom = elem.scrollHeight - elem.scrollTop -
elem.clientHeight;
```

In other words: (full height) minus (scrolled out top part) minus (visible part) – that's exactly the scrolled out bottom part.

To formulation

What is the scrollbar width?

To get the scrollbar width, we can create an element with the scroll, but without borders and paddings.

Then the difference between its full width `offsetWidth` and the inner content area width `clientWidth` will be exactly the scrollbar:

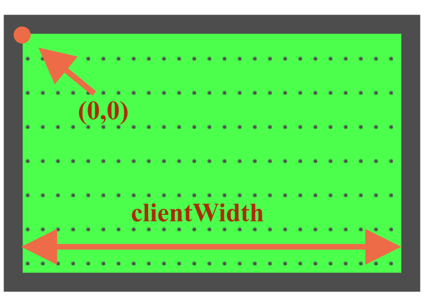
```
// create a div with the scroll
let div = document.createElement('div');

div.style.overflowY = 'scroll';
div.style.width = '50px';
div.style.height = '50px';

// must put it in the document, otherwise sizes will be 0
document.body.append(div);
let scrollWidth = div.offsetWidth - div.clientWidth;

div.remove();

alert(scrollWidth);
```

To formulation

Place the ball in the field center

The ball has `position:absolute`. It means that its `left/top` coordinates are measured from the nearest positioned element, that is `#field` (because it has `position:relative`).

The coordinates start from the inner left-upper corner of the field:

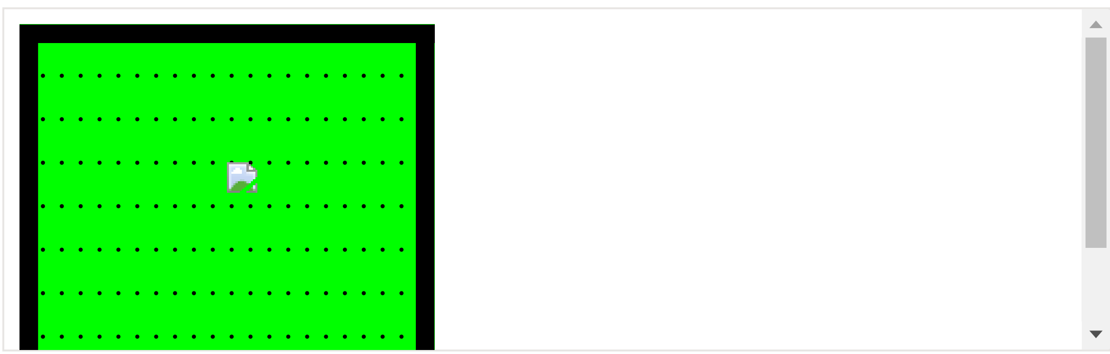


The inner field width/height is `clientWidth/clientHeight`. So the field center has coordinates `(clientWidth/2, clientHeight/2)`.

...But if we set `ball.style.left/top` to such values, then not the ball as a whole, but the left-upper edge of the ball would be in the center:

```
ball.style.left = Math.round(field.clientWidth / 2) + 'px';
ball.style.top = Math.round(field.clientHeight / 2) + 'px';
```

Here’s how it looks:



To align the ball center with the center of the field, we should move the ball to the half of its width to the left and to the half of its height to the top:

```
ball.style.left = Math.round(field.clientWidth / 2 -
ball.offsetWidth / 2) + 'px';
ball.style.top = Math.round(field.clientHeight / 2 -
ball.offsetHeight / 2) + 'px';
```

Attention: the pitfall!

The code won’t work reliably while `<img>` has no width/height:

```html
<img src="ball.png" id="ball">
```

When the browser does not know the width/height of an image (from tag attributes or CSS), then it assumes them to equal `0` until the image finishes loading.

After the first load browser usually caches the image, and on next loads it will have the size immediately. But on the first load the value of `ball.offsetWidth` is `0`. That leads to wrong coordinates.

We should fix that by adding `width/height` to `<img>`:

```html
<img src="ball.png" width="40" height="40" id="ball">
```

…Or provide the size in CSS:

```css
#ball {
  width: 40px;
  height: 40px;
}
```

Open the solution in a sandbox.

To formulation

The difference: CSS width versus clientWidth

Differences:

1. `clientWidth` is numeric, while `getComputedStyle(elem).width` returns a string with `px` at the end.

2. `getComputedStyle` may return non-numeric width like `"auto"` for an inline element.

3. `clientWidth` is the inner content area of the element plus paddings, while CSS width (with standard `box-sizing`) is the inner content area *without paddings*.

4. If there's a scrollbar and the browser reserves the space for it, some browser substract that space from CSS width (cause it's not available for content any more), and some do not. The `clientWidth` property is always the same: scrollbar size is substracted if reserved.

To formulation

Coordinates

Find window coordinates of the field

Outer corners

Outer corners are basically what we get from elem.getBoundingClientRect().

Coordinates of the upper-left corner `answer1` and the bottom-right corner `answer2`:

```
let coords = elem.getBoundingClientRect();

let answer1 = [coords.left, coords.top];
let answer2 = [coords.right, coords.bottom];
```

Left-upper inner corner

That differs from the outer corner by the border width. A reliable way to get the distance is `clientLeft/clientTop`:

```
let answer3 = [coords.left + field.clientLeft, coords.top +
field.clientTop];
```

Right-bottom inner corner

In our case we need to substract the border size from the outer coordinates.

We could use CSS way:

```
let answer4 = [
  coords.right - parseInt(getComputedStyle(field).borderRightWidth),
  coords.bottom -
parseInt(getComputedStyle(field).borderBottomWidth)
];
```

An alternative way would be to add `clientWidth/clientHeight` to coordinates of the left-upper corner. That's probably even better:

```
let answer4 = [
  coords.left + elem.clientLeft + elem.clientWidth,
  coords.top + elem.clientTop + elem.clientHeight
];
```

Open the solution in a sandbox.

To formulation

Show a note near the element

In this task we only need to accurately calculate the coordinates. See the code for details.

Please note: the elements must be in the document to read `offsetHeight` and other properties. A hidden (`display:none`) or out of the document element has no size.

Open the solution in a sandbox.

To formulation

Show a note near the element (absolute)

The solution is actually pretty simple:

- Use `position:absolute` in CSS instead of `position:fixed` for `.note`.
- Use the function getCoords() from the chapter Coordinates to get document-relative coordinates.

Open the solution in a sandbox.

To formulation

Position the note inside (absolute)

Open the solution in a sandbox.

To formulation

Hide on click

Open the solution in a sandbox.

To formulation

Hide self

Can use `this` in the handler to reference “the element itself” here:

```
<input type="button" onclick="this.hidden=true" value="Click to
hide">
```

To formulation

Which handlers run?

The answer: `1` and `2`.

The first handler triggers, because it’s not removed by `removeEventListener`. To remove the handler we need to pass exactly the function that was assigned. And in the code a new function is passed, that looks the same, but is still another function.

To remove a function object, we need to store a reference to it, like this:

```
function handler() {
  alert(1);
}

button.addEventListener("click", handler);
button.removeEventListener("click", handler);
```

The handler `button.onclick` works independently and in addition to `addEventListener`.

To formulation

Move the ball across the field

First we need to choose a method of positioning the ball.

We can't use `position:fixed` for it, because scrolling the page would move the ball from the field.

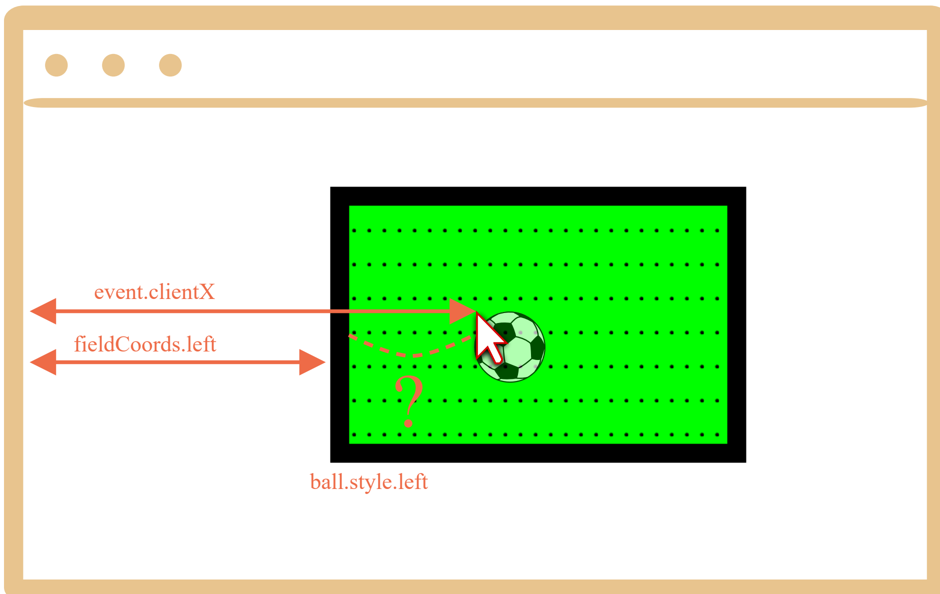
So we should use `position:absolute` and, to make the positioning really solid, make `field` itself positioned.

Then the ball will be positioned relatively to the field:

```
#field {
  width: 200px;
  height: 150px;
  position: relative;
}

#ball {
  position: absolute;
  left: 0; /* relative to the closest positioned ancestor (field) */
  top: 0;
  transition: 1s all; /* CSS animation for left/top makes the ball
fly */
}
```

Next we need to assign the correct `ball.style.left/top`. They contain field-relative coordinates now.

Here's the picture:



We have `event.clientX/clientY` – window-relative coordinates of the click.

To get field-relative `left` coordinate of the click, we can substract the field left edge and the border width:

```
let left = event.clientX - fieldCoords.left - field.clientLeft;
```

Normally, `ball.style.left` means the "left edge of the element" (the ball). So if we assign that `left`, then the ball edge, not center, would be under the mouse cursor.

We need to move the ball half-width left and half-height up to make it center.

So the final `left` would be:

```
let left = event.clientX - fieldCoords.left - field.clientLeft -
ball.offsetWidth/2;
```

The vertical coordinate is calculated using the same logic.

Please note that the ball width/height must be known at the time we access `ball.offsetWidth`. Should be specified in HTML or CSS.

Open the solution in a sandbox.

To formulation

Create a sliding menu

HTML/CSS

First let's create HTML/CSS.

A menu is a standalone graphical component on the page, so it's better to put it into a single DOM element.

A list of menu items can be laid out as a list `ul/li`.

Here's the example structure:

```
<div class="menu">
  <span class="title">Sweeties (click me)!</span>
  <ul>
    <li>Cake</li>
    <li>Donut</li>
    <li>Honey</li>
  </ul>
</div>
```

We use `<span>` for the title, because `<div>` has an implicit `display:block` on it, and it will occupy 100% of the horizontal width.

Like this:

```html
<div style="border: solid red 1px"
onclick="alert(1)">Sweeties (click me)!</div>
```

Sweeties (click me)!

So if we set `onclick` on it, then it will catch clicks to the right of the text.

As `<span>` has an implicit `display: inline`, it occupies exactly enough place to fit all the text:

```html
<span style="border: solid red 1px"
onclick="alert(1)">Sweeties (click me)!</span>
```

Sweeties (click me)!

Toggling the menu

Toggling the menu should change the arrow and show/hide the menu list.

All these changes are perfectly handled by CSS. In JavaScript we should label the current state of the menu by adding/removing the class `.open`.

Without it, the menu will be closed:

```css
.menu ul {
  margin: 0;
  list-style: none;
  padding-left: 20px;
  display: none;
}

.menu .title::before {
  content: '▶ ';
  font-size: 80%;
  color: green;
}
```

…And with `.open` the arrow changes and the list shows up:

```css
.menu.open .title::before {
  content: '▼ ';
}

.menu.open ul {
  display: block;
}
```

Open the solution in a sandbox.

To formulation

Add a closing button

To add the button we can use either `position:absolute` (and make the pane `position:relative`) or `float:right`. The `float:right` has the benefit that the button never overlaps the text, but `position:absolute` gives more freedom. So the choice is yours.

Then for each pane the code can be like:

```
pane.insertAdjacentHTML("afterbegin", '<button class="remove-
button">[x]</button>');
```

Then the `<button>` becomes `pane.firstChild`, so we can add a handler to it like this:

```
pane.firstChild.onclick = () => pane.remove();
```

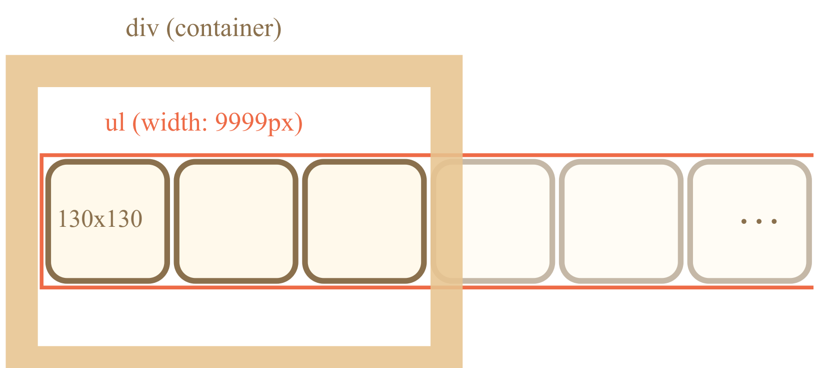
Open the solution in a sandbox.

To formulation

Carousel

The images ribbon can be represented as `ul/li` list of images `<img>`.

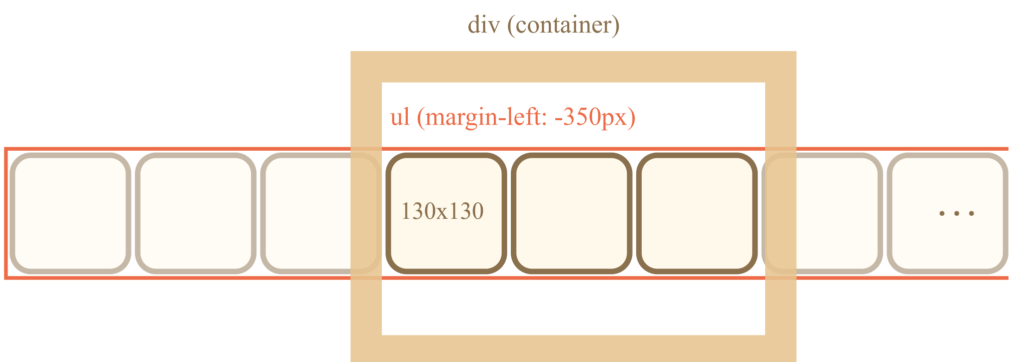
Normally, such a ribbon is wide, but we put a fixed-size `<div>` around to “cut” it, so that only a part of the ribbon is visible:



To make the list show horizontally we need to apply correct CSS properties for `<li>`, like `display: inline-block`.

For `<img>` we should also adjust `display`, because by default it's `inline`. There's extra space reserved under `inline` elements for "letter tails", so we can use `display:block` to remove it.

To do the scrolling, we can shift `<ul>`. There are many ways to do it, for instance by changing `margin-left` or (better performance) use `transform: translateX()`:



The outer `<div>` has a fixed width, so "extra" images are cut.

The whole carousel is a self-contained "graphical component" on the page, so we'd better wrap it into a single `<div class="carousel">` and style things inside it.

Open the solution in a sandbox.

To formulation

Event delegation

Hide messages with delegation

Open the solution in a sandbox.

To formulation

Tree menu

The solution has two parts.

1. Wrap every tree node title into `<span>`. Then we can CSS-style them on `:hover` and handle clicks exactly on text, because `<span>` width is exactly the text width (unlike without it).
2. Set a handler to the `tree` root node and handle clicks on that `<span>` titles.

Open the solution in a sandbox.

To formulation

Sortable table

Open the solution in a sandbox.

To formulation

Tooltip behavior

Open the solution in a sandbox.

To formulation

Why "return false" doesn't work?

When the browser reads the `on*` attribute like `onclick`, it creates the handler from its content.

For `onclick="handler()"` the function will be:

```
function(event) {
  handler() // the content of onclick
}
```

Now we can see that the value returned by `handler()` is not used and does not affect the result.

The fix is simple:

```
<script>
  function handler() {
    alert("...");
    return false;
  }
</script>

<a href="https://w3.org" onclick="return handler()">w3.org</a>
```

Also we can use `event.preventDefault()`, like this:

```
<script>
  function handler(event) {
    alert("...");
    event.preventDefault();
  }
```

```
</script>

<a href="https://w3.org" onclick="handler(event)">w3.org</a>
```

To formulation

Catch links in the element

That’s a great use of the event delegation pattern.

In real life instead of asking we can send a “logging” request to the server that saves the information about where the visitor left. Or we can load the content and show it right in the page (if allowable).

All we need is to catch the `contents.onclick` and use `confirm` to ask the user. A good idea would be to use `link.getAttribute('href')` instead of `link.href` for the URL. See the solution for details.

Open the solution in a sandbox.

To formulation

Image gallery

The solution is to assign the handler to the container and track clicks. If a click is on the `<a>` link, then change `src` of `#largeImg` to the `href` of the thumbnail.

Open the solution in a sandbox.

To formulation

Mouse events basics

Selectable list

Open the solution in a sandbox.

To formulation

Moving the mouse: mouseover/out, mouseenter/leave

Improved tooltip behavior

Open the solution in a sandbox.

To formulation

"Smart" tooltip

The algorithm looks simple:

1. Put `onmouseover/out` handlers on the element. Also can use `onmouseenter/leave` here, but they are less universal, won't work if we introduce delegation.
2. When a mouse cursor entered the element, start measuring the speed on `mousemove`.
3. If the speed is slow, then run `over`.
4. When we're going out of the element, and `over` was executed, run `out`.

But how to measure the speed?

The first idea can be: run a function every `100ms` and measure the distance between previous and new coordinates. If it's small, then the speed is small.

Unfortunately, there's no way to get "current mouse coordinates" in JavaScript. There's no function like `getCurrentMouseCoordinates()`.

The only way to get coordinates is to listen for mouse events, like `mousemove`, and take coordinates from the event object.

So let's set a handler on `mousemove` to track coordinates and remember them. And then compare them, once per `100ms`.

P.S. Please note: the solution tests use `dispatchEvent` to see if the tooltip works right.

Open the solution with tests in a sandbox.

To formulation

Drag'n'Drop with mouse events

Slider

As we can see from HTML/CSS, the slider is a `<div>` with a colored background, that contains a runner – another `<div>` with `position:relative`.

To position the runner we use `position:relative`, to provide the coordinates relative to its parent, here it's more convenient here than `position:absolute`.

Then we implement horizontal-only Drag'n'Drop with limitation by width.

Open the solution in a sandbox.

To formulation

Drag superheroes around the field

To drag the element we can use `position:fixed`, it makes coordinates easier to manage. At the end we should switch it back to `position:absolute` to lay the element into the document.

When coordinates are at window top/bottom, we use `window.scrollTo` to scroll it.

More details in the code, in comments.

Open the solution in a sandbox.

To formulation

Keyboard: keydown and keyup

Extended hotkeys

We should use two handlers: `document.onkeydown` and `document.onkeyup`.

Let's create a set `pressed = new Set()` to keep currently pressed keys.

The first handler adds to it, while the second one removes from it. Every time on `keydown` we check if we have enough keys pressed, and run the function if it is so.

Open the solution in a sandbox.

To formulation

Scrolling

Endless page

The core of the solution is a function that adds more dates to the page (or loads more stuff in real-life) while we're at the page end.

We can call it immediately and add as a `window.onscroll` handler.

The most important question is: "How do we detect that the page is scrolled to bottom?"

Let's use window-relative coordinates.

The document is represented (and contained) within `<html>` tag, that is `document.documentElement`.

We can get window-relative coordinates of the whole document as `document.documentElement.getBoundingClientRect()`, the `bottom` property will be window-relative coordinate of the document bottom.

For instance, if the height of the whole HTML document is `2000px`, then:

```
// when we're on the top of the page
// window-relative top = 0
document.documentElement.getBoundingClientRect().top = 0

// window-relative bottom = 2000
// the document is long, so that is probably far beyond the window
bottom
document.documentElement.getBoundingClientRect().bottom = 2000
```

If we scroll `500px` below, then:

```
// document top is above the window 500px
document.documentElement.getBoundingClientRect().top = -500
// document bottom is 500px closer
document.documentElement.getBoundingClientRect().bottom = 1500
```

When we scroll till the end, assuming that the window height is `600px`:

```
// document top is above the window 1400px
document.documentElement.getBoundingClientRect().top = -1400
// document bottom is below the window 600px
document.documentElement.getBoundingClientRect().bottom = 600
```

Please note that the `bottom` can't be `0`, because it never reaches the window top. The lowest limit of the `bottom` coordinate is the window height (we assumed it to be `600`), we can't scroll it any more up.

We can obtain the window height as `document.documentElement.clientHeight`.

For our task, we need to know when the document bottom is not no more than `100px` away from it (that is: `600-700px`, if the height is `600`).

So here's the function:

```
function populate() {
  while(true) {
    // document bottom
    let windowRelativeBottom =
document.documentElement.getBoundingClientRect().bottom;

    // if the user scrolled far enough (<100px to the end)
    if (windowRelativeBottom < document.documentElement.clientHeight
+ 100) {
      // let's add more data
      document.body.insertAdjacentHTML("beforeend", `<p>Date: ${new
Date()}</p>`);
    }
  }
}
```

Open the solution in a sandbox.

To formulation

Up/down button

Open the solution in a sandbox.

To formulation

Load visible images

The `onscroll` handler should check which images are visible and show them.

We also want to run it when the page loads, to detect immediately visible images and load them.

The code should execute when the document is loaded, so that it has access to its content.

Or put it at the `<body>` bottom:

```
// ...the page content is above...

function isVisible(elem) {

  let coords = elem.getBoundingClientRect();

  let windowHeight = document.documentElement.clientHeight;

  // top elem edge is visible?
  let topVisible = coords.top > 0 && coords.top < windowHeight;

  // bottom elem edge is visible?
  let bottomVisible = coords.bottom < windowHeight && coords.bottom
> 0;

  return topVisible || bottomVisible;
}
```

The `showVisible()` function uses the visibility check, implemented by `isVisible()`, to load visible images:

```
function showVisible() {
  for (let img of document.querySelectorAll('img')) {
    let realSrc = img.dataset.src;
    if (!realSrc) continue;

    if (isVisible(img)) {
      img.src = realSrc;
      img.dataset.src = '';
    }
  }
}

showVisible();
window.onscroll = showVisible;
```

P.S. The solution also has a variant of `isVisible` that “preloads” images that are within 1 page above/below the current document scroll.

Open the solution in a sandbox.

To formulation

Form properties and methods

Add an option to select

The solution, step by step:

```
<select id="genres">
  <option value="rock">Rock</option>
  <option value="blues" selected>Blues</option>
</select>

<script>
  // 1)
  let selectedOption =
genres.options[genres.selectedIndex];
  alert( selectedOption.value );

  // 2)
  let newOption = new Option("Classic",
"classic");
  genres.append(newOption);

  // 3)
  newOption.selected = true;
</script>
```

[To formulation](#)

Focusing: focus/blur

Editable div

Open the solution in a sandbox.

[To formulation](#)

Edit TD on click

1. On click – replace `innerHTML` of the cell by `<textarea>` with same sizes and no border. Can use JavaScript or CSS to set the right size.
2. Set `textarea.value` to `td.innerHTML`.
3. Focus on the textarea.
4. Show buttons OK/CANCEL under the cell, handle clicks on them.

Open the solution in a sandbox.

[To formulation](#)

Keyboard-driven mouse

We can use `mouse.onclick` to handle the click and make the mouse “moveable” with `position:fixed`, then `mouse.onkeydown` to handle arrow keys.

The only pitfall is that `keydown` only triggers on elements with focus. So we need to add `tabindex` to the element. As we're forbidden to change HTML, we can use `mouse.tabIndex` property for that.

P.S. We also can replace `mouse.onclick` with `mouse.onfocus`.

Open the solution in a sandbox.

To formulation

Events: change, input, cut, copy, paste

Deposit calculator

Open the solution in a sandbox.

To formulation

Forms: event and method submit

Modal form

A modal window can be implemented using a half-transparent `<div id="cover-div">` that covers the whole window, like this:

```
#cover-div {
  position: fixed;
  top: 0;
  left: 0;
  z-index: 9000;
```

```
  width: 100%;
  height: 100%;
  background-color: gray;
  opacity: 0.3;
}
```

Because the `<div>` covers everything, it gets all clicks, not the page below it.

Also we can prevent page scroll by setting `body.style.overflowY='hidden'`.

The form should be not in the `<div>`, but next to it, because we don’t want it to have `opacity`.

Open the solution in a sandbox.

To formulation

Resource loading: onload and onerror

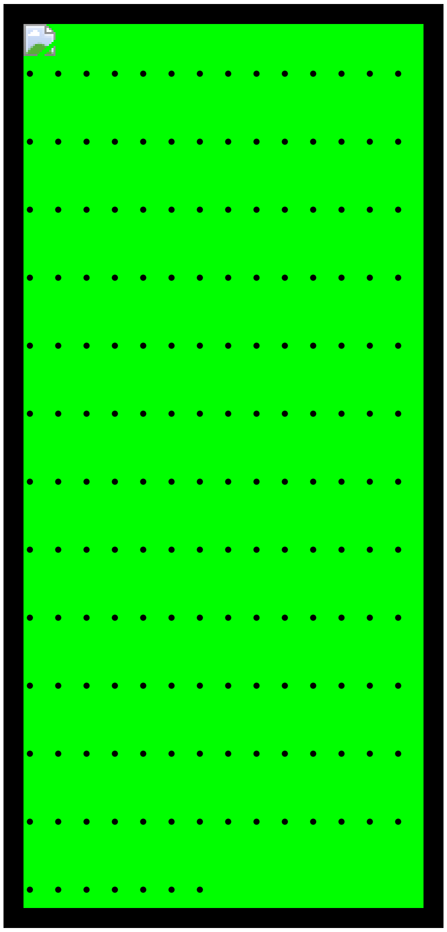
Load images with a callback

The algorithm:

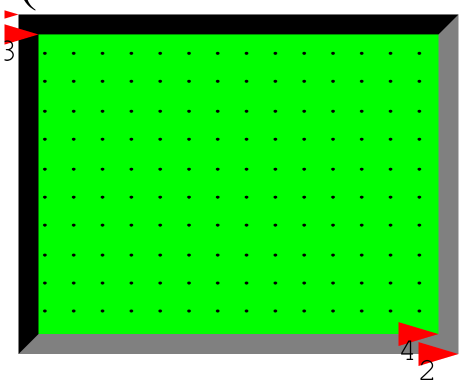
1. Make `img` for every source.
2. Add `onload/onerror` for every image.
3. Increase the counter when either `onload` or `onerror` triggers.
4. When the counter value equals to the sources count – we’re done: `callback()`.

Open the solution in a sandbox.

To formulation



Click anywhere to get window coordinates.
That's for testing, to check the result you get by JavaScript.
(click coordinates show up here)



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> “
>
> Teacher: Why are you late?
> Student: There was a man who lost a hundred dollar bill.
> Teacher: That's nice. Were you helping him look for it?
> Student: No. I was standing on it.

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note top-out

note top-in

note right-out

note bottom-in

> Teacher: Why are you late?
>
> Student: There was a man who lost a hundred dollar bill.
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> Teacher: That's nice. Were you helping him look for it?
>
> Student: No. I was standing on it.

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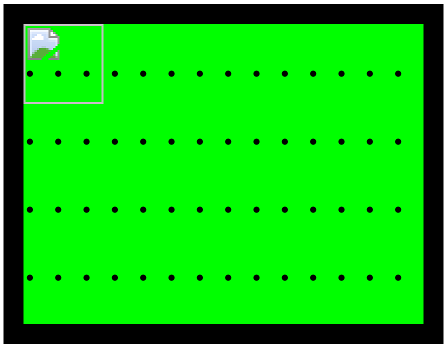
Click on a field to move the ball there.



Bagua Chart: Direction, Element, Color, Meaning

Northwest Metal Silver Elders	**North** Water Blue Change	**Northeast** Earth Yellow Direction
West Metal Gold Youth	**Center** All Purple Harmony	**East** Wood Blue Future
Southwest Earth Brown Tranquility	**South** Fire Orange Fame	**Southeast** Wood Green Romance


HTML
JavaScript
CSS

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