Cascading Style Sheets (CSS)

Péter Jeszenszky

Faculty of Informatics, University of Debrecen

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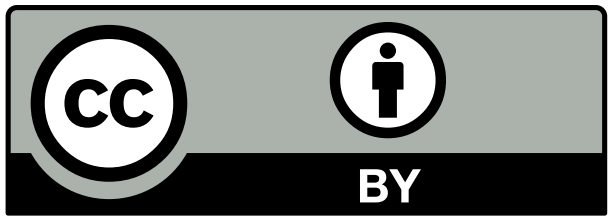
Terms of Use



What is CSS?

- A style sheet language for describing the rendering of structured documents (such as HTML and XML).
  - Supports rendering on different devices, such as screens, printers, and Braille devices.
- It separates the presentation style of documents from the content of documents.
  - Thus, it simplifies web authoring and site maintenance.
- Website: https://www.w3.org/Style/CSS/

History

- Originally, CSS was proposed by Håkon Wium Lie, a Norwegian researcher in 1994 while he was working with Tim Berners-Lee at CERN.
  - Website: https://www.wiumlie.no/
- For more information, see: 20 Years of CSS (W3C)
  - A brief history of CSS until 2016

Development

Developed by the CSS Working Group of W3C.

Levels

- CSS does not have versions in the traditional sense; instead, it has levels:
  - CSS Level 1
  - CSS Level 2
  - CSS Level 3
- Each level of CSS builds on the previous one, refining definitions and adding features.
  - See: Levels, snapshots, modules... (W3C)

CSS Level 1

- Specification: Cascading Style Sheets, level 1 (Superseded W3C Recommendation)
- It is now obsolete.

CSS Level 2

- Defined by the CSS2.1 specification (i.e., a single document):
  - Cascading Style Sheets Level 2 Revision 1 (CSS 2.1) Specification (W3C Recommendation, 7 June 2011)
- Its revision is currently under development:
  - Cascading Style Sheets Level 2 Revision 2 (CSS 2.2) Specification (W3C First Public Working Draft, 12 April 2016)

CSS Level 3 (1)

- Currently under development.
- Has a modular structure:
  - Broken into modules, where each module defines a part of CSS.
  - Each module adds functionality and/or replaces part of the CSS2.1 specification.
- Modules also have levels.
  - Modules with no CSS Level 2 equivalent start at Level 1.
  - Modules that update features that existed in CSS Level 2 start at Level 3.

CSS Level 3 (2)

- Different CSS modules are at varying levels of stability.
- The list of all CSS specifications:
  http://www.w3.org/Style/CSS/current-work.en.html
- A few modules are the following:
  - Selectors Level 3 (W3C Recommendation, 6 November 2018)
  - CSS Values and Units Module Level 3 (W3C Candidate Recommendation Draft, 22 March 2024)
  - CSS Transforms Module Level 1 (W3C Candidate Recommendation, 14 February 2019)
  - CSS Transforms Module Level 2 (W3C Working Draft, 9 November 2021)
  - ...

CSS Level 3 (3)

CSS Snapshot 2025 (W3C Group Note, 18 September 2025)

- Collects together all specifications that together form the current state of CSS.
- The primary audience is CSS implementers.
- See the section titled Cascading Style Sheets (CSS) – The Official Definition.

CSS Level 4 and Beyond

- There is no CSS Level 4.
- Independent modules can reach level 4 or beyond, but CSS the language no longer has levels.
- “CSS Level 3” as a term is used only to differentiate it from the previous monolithic versions.

Browser Support

- Modern web browsers support most of the features of CSS 2.1.
- They support some features of CSS3:
  - https://caniuse.com/?search=CSS3
  - Browser Score
    - Repository: https://github.com/LeaVerou/css3test

Coding Styles

- Google HTML/CSS Style Guide
- Nicolas Gallagher. Principles of writing consistent, idiomatic CSS.

Editors (1)

Free and open source software:

- Visual Studio Code (platform: Linux, macOS, Windows; license: MIT License) https://code.visualstudio.com/ https://github.com/Microsoft/vscode
  - See: https://code.visualstudio.com/docs/languages/css

Editors (2)

Non-free software:

- WebStorm (platform: Linux, macOS, Windows)
  https://www.jetbrains.com/webstorm/
  - See: Style Sheets (WebStorm Documentation)

Editors (3)

Emmet (written in: JavaScript; license: MIT License) https://emmet.io/ https://github.com/emmetio/emmet

- A set of text editor plugins for boosting HTML and CSS code writing.
- Available for many text editors, such as Eclipse, NetBeans, Notepad++, Visual Studio Code, or WebStorm.
- See: https://emmet.io/download/
- Documentation: https://docs.emmet.io/
  - Customization: https://docs.emmet.io/customization/
- See also: Emmet in Visual Studio Code

Editors (4)

Examples of Emmet abbreviations:

Abbreviation	Expanded to
`bd`	`border: 1px solid #000;`
`bdt`	`border-top: 1px solid #000;`
`bgc`	`background-color: #fff;`
`fwb`	`font-weight: bold;`
`p10`	`padding: 10px;`
`p1e`	`padding: 1em;`
`mla`	`margin-left: auto;`
`mra`	`margin-right: auto;`
`pt.5e`	`padding-top: 0.5em;`
`tac`	`text-align: center;`
`tar`	`text-align: right;`
`df`	`display: flex;`
`w50%`	`width: 50%;`

CSS Frameworks

Minimalistic CSS frameworks:

- Milligram (license: MIT License) https://milligram.io/ https://github.com/milligram/milligram
  - Examples: https://milligram.io/#examples
- Pico CSS (license: MIT License) https://picocss.com/ https://github.com/picocss/pico
  - Examples: https://picocss.com/examples
- Simple.css (license: MIT License) https://simplecss.org/ https://github.com/kevquirk/simple.css
  - Examples: https://simplecss.org/demo

For more, see: https://github.com/troxler/awesome-css-frameworks

Other Tools

Minifier tools:

- cssnano (written in: CSS/JavaScript; license: MIT License)
  https://cssnano.github.io/cssnano/
  https://github.com/cssnano/cssnano
- CSSO (written in: CSS/JavaScript; license: License MIT)
  https://css.github.io/csso/ https://github.com/css/csso
- Visual Studio Code:
  - MinifyAll (written in: TypeScript; license: GPLv3) https://marketplace.visualstudio.com/items?itemName=josee9988.minifyall
    https://minifyall.jgracia.es/ https://github.com/Josee9988/MinifyAll

Online CSS Sandboxes

- CodePen
- JSFiddle
- Liveweave

File Properties

- File extension: `.css`
- IANA media type: `text/css`

Characters

- CSS uses the Unicode character set.

Escape Sequences (1)

- Unicode characters can be specified with escape sequences of the form *hhhhhh* where *hhhhhh* is a sequence of one to six hexadecimal digits representing the code point of the Unicode character.
  - If the number of hex digits is less than six, and a character in the range `[0-9a-fA-F]` follows the hexadecimal number, then a whitespace character must end the escape sequence.
  - A whitespace character that immediately follows an escape sequence will be ignored.
- Examples:
  - `\9`, `\09`, ..., `\000009` denote the vertical tab character.
  - `\A9`, `\0A9`, ..., `\0000A9` denote the copyright symbol (©).

Escape Sequences (2)

- Special characters can be escaped with a `'\'` character.
- For example, it is required when a selector contains an element name that contains `'.'` characters.
  - For example, an element named `given.name` matches the selector `given\.name` and does not match the selector `given.name`.

Character Encoding

- Character encoding is determined by the following:
  - A byte order mark (BOM).
  - Otherwise, the value of the `charset` parameter in the `Content-Type` HTTP header field.
  - Otherwise, the `@charset "encoding";` at-rule at the very beginning of the stylesheet.
    - Example: @charset “UTF-16”;
  - Otherwise, UTF-8 is the default character encoding.
- See: Declaring character encodings in CSS (W3C)

Comments

- Comments can be placed between the `/*` and `*/` delimiters.
  - Example: `/* Style sheet for index.html */`
- They can occur anywhere but in tokens.
- They cannot be nested.

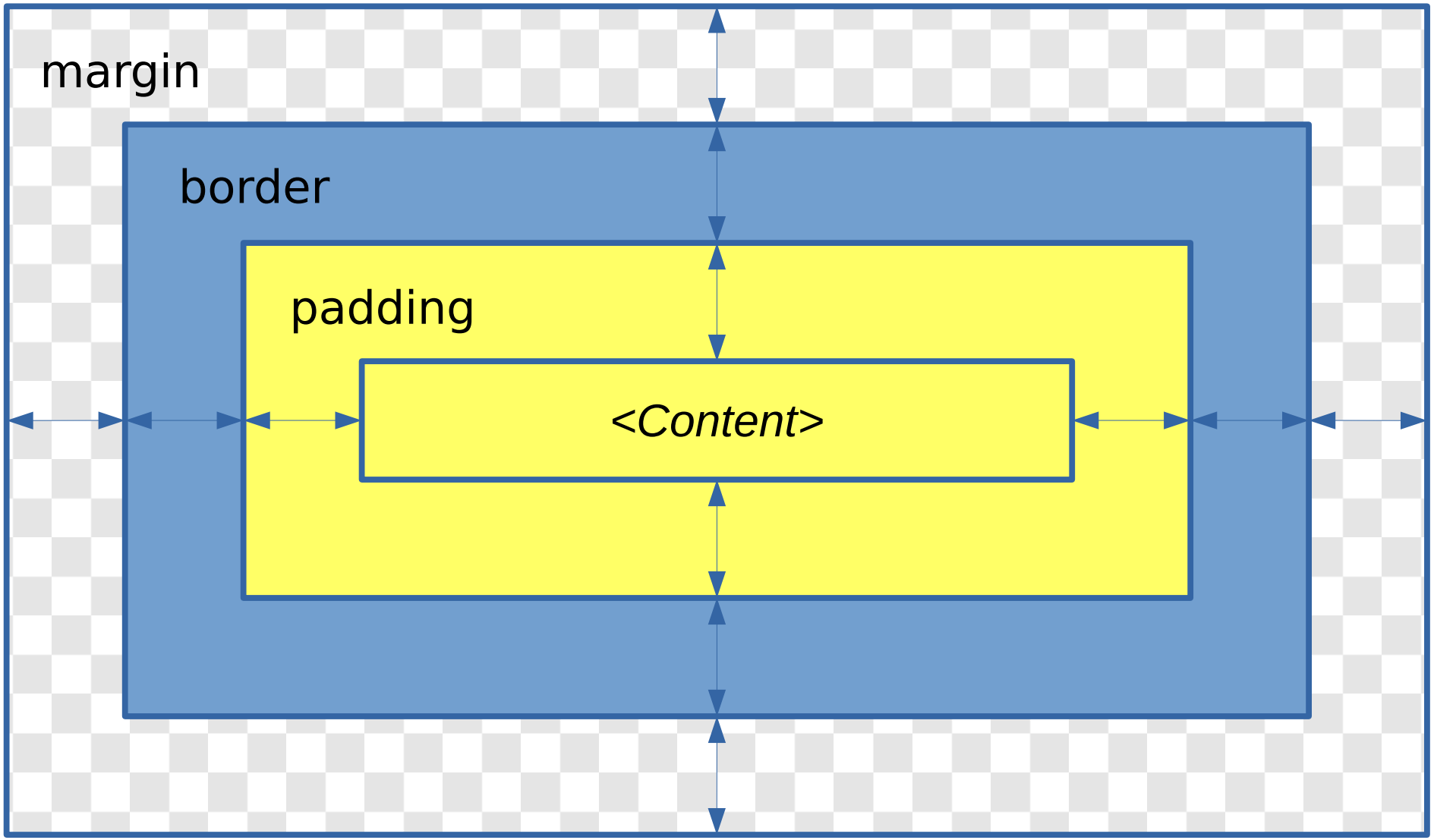
Box Model (1)

- Relevant specification: CSS Display Module Level 3 (W3C Candidate Recommendation Snapshot, 30 March 2023)

Box Model (2)

- CSS takes a source document, organized as a tree, and renders it onto a canvas (such as the screen) generating an intermediary structure, the **box tree**, which represents the formatting structure of the rendered document.
- Each box in the box tree represents a corresponding element (or pseudo-element) from the document in space and/or time on the canvas.
- For each element, CSS generates zero or more boxes as specified by that element's `display` property.
    - Typically, an element generates a single box.

Box Model (3)



Properties (1)

- Parameters defined by CSS to control the rendering of documents.
- Properties have names and values.
- The list of CSS properties: List of CSS properties (W3C)
  - The total number of distinct property names is 705.

Properties (2)

Shorthand property:

- A property that allows authors to specify the values of several properties simultaneously.
- For example, the `margin` property is a shorthand property for setting the value of the `margin-top`, `margin-right`, `margin-bottom`, and `margin-left` properties.

Declaration Blocks

- They start with a `'{'` character and end with a `'}'` character, in between which must be a list of zero or more declarations.
- Declarations are of the form *name*`:`*value*, where whitespace characters are allowed before and after tokens.
- In a declaration *name* is an identifier.
- Declarations must end with a `';'` character.
- The `';'` character after the last declaration can be omitted.

Rule Sets (Style Rules)

- They consist of a selector (or a list of selectors separated with a `','` character) followed by a declaration block.

At-rules

- They define special processing rules or values.
- They start with a `'@'` character, followed by an identifier, and include everything up to the next `';'` character, or the next declaration block.
- Examples: `@charset`, `@import`, `@namespace`, `@media`
- See: At-rules (MDN)

Values (1)

- Relevant specification: CSS Values and Units Module Level 3 (W3C Candidate Recommendation Draft, 22 March 2024)
- See also: CSS values and units (MDN)

Values (2)

A property value can have one or more components:

- Identifiers (e.g., `none`, `inherit`)
- Strings (e.g., `'Hello, world!'`)
- URLs (e.g., `url(images/item.png)`)
- Numbers (e.g., `123`, `3.141593`)
- Percentages (e.g., `150%`)
- Dimensions (e.g., `10px`, `0.5em`, `45deg`)
- Colors (e.g., `fuchsia`, `#f0f`, `#ff00ff`, `rgb(255,0,255)`)
- Functional notations (e.g., `attr(name)`, `calc(100% - 50px)`, `counter(chapter-number)`)
- ...

Values (3)

- For each property, CSS specifications define the type, number, and ordering of components allowed in property values.
  - Examples:
    - `text-transform: none | capitalize | uppercase | lowercase | full-width`
    - `letter-spacing: normal | <length>`
    - `border-color: <color>{1,4}`
    - `border-top: <line-width> || <line-style> || <color>`

Identifiers

- Keywords: are ASCII case-insensitive (i.e., the `[a-z]` and `[A-Z]` characters are equivalent).
- Author-defined identifiers:
  - Used, for example, for names of counters.
  - Are case-sensitive.
- Syntax:
  - See: https://www.w3.org/TR/css-syntax-3/#ident-token-diagram

Strings

- Sequences of characters delimited by `'''` or `'"'` characters.
- Cannot contain the delimiter character directly.
  - Delimiters in strings must be escaped with a `'\'` character.
    - Example: `'It\'s So Cool', "\"Good morning, Frank,\" said Hal."`
- Newlines can be specified only with the `\A` escape sequence.

URL-s

- Examples:
  - `list-style-image: url("http://eg.com/images/item.png")`
  - `list-style-image: url('http://eg.com/images/item.png')`
  - `list-style-image: url(http://eg.com/images/item.png)`
- Relative references can be used and are resolved against the URL of the stylesheet.
  - Example: `list-style-image: url("images/item.png")`
- In some contexts, e.g., in `@import` at-rules, the `url()` function can be omitted and a bare string can be used in its place.
  - Example: `@import "default.css";`

Numbers

- CSS uses two types of numbers:
  - **Integers**: consist of an optional sign and one or more decimal digits.
    - Examples: 0, 255, -1, +10946
  - **Real numbers**: consist of an optional sign, one or more decimal digits, an optional dot, optionally followed by an `'e'` or `'E'` character and an integer.
    - At least one digit is required after the dot.
    - Integers are special cases of real numbers.
    - Examples: `1.5`, `-100.0`, `+.25`, `1E-10`
- Properties may restrict numeric values to some range.
  - For example, they can exclude negative numbers.

Percentages (1)

- They consist of an integer or a real number immediately followed by a '%' character.
- Percentage values are always relative to another quantity.
  - Each property that allows percentages also defines the quantity to which the percentage refers.
  - This quantity can be a value of another property for the same element, the value of a property for an ancestor element, or something else.

Percentages (2)

Examples:

```
sup {
  font-size: 75%;
}

nav {
  width: 40%;
}
```

Dimensions

- They consist of an integer or a real number immediately followed by a unit.
  - Units are ASCII case-insensitive identifiers.
- Each dimension represents a quantity, such as length or angle.
- For zero lengths, the unit can be omitted.

Lengths (1)

- There are two types of length units:
  - **Relative**: specify a length relative to another length.
    - `em`, `ex`, `ch`, `rem`, `vw`, `vh`, `vmin`, `vmax`
  - **Absolute**: fixed in relation to each other and anchored to some physical measurement.
    - `cm`, `mm`, `Q`, `in`, `pc`, `pt`, `px`
- Examples: `0.5em`, `1.5cm`, `0px`, `0`, `-1in`
- See: <length> (MDN)

Lengths (2)

Relative units:

- `ch`: equals the width of the `0` (zero) glyph in the element's font.
- `em`: equals the computed value of the `font-size` property of the element on which it is used (in case of the `font-size` property itself, it refers to the computed `font-size` of the parent element).
- `ex`: equals the x-height of the element's font (in case of the `font-size` property itself, it refers to the x-height of the parent element).
  - It is so called because it is often equal to the height of the lowercase *x* character.

Colors (1)

- Relevant specification: CSS Color Module Level 3 (W3C Recommendation, 18 January 2022)

Colors (2)

- The 16 basic color keywords: `aqua`, `black`, `blue`, `fuchsia`, `gray`, `green`, `lime`, `maroon`, `navy`, `olive`, `purple`, `red`, `silver`, `teal`, `white`, `yellow`.
- Modern web browsers generally support several other color keywords, see:
  - https://www.w3.org/TR/css-color-3/#svg-color
  - <named-color> (MDN)

Colors (3)

RGB color model:

- For example, all of the following specify the same color:
  - `lightslategrey`
  - `#778899`
  - `#789` (each hexadecimal digit is doubled)
  - `rgb(119,136,153)`

Colors (4)

RGB color model:

- The `rgb()` functional notation also accepts three percentages as arguments, where the integer value 255 corresponds to 100%.
- For example, the following colors are equivalent:
  - `#ffffff`
  - `#fff`
  - `rgb(255,255,255)`
  - `rgb(100%,100%,100%)`
  - `white`

Selectors (1)

- Relevant specification: Selectors Level 3 (W3C Recommendation, 6 November 2018)
- Selectors express pattern matching rules.
- They determine which style rules apply to elements.

Selectors (2)

- Selectors are case-insensitive within the ASCII range (i.e., the characters `[a-z]` and `[A-Z]` are equivalent), except for parts that are not under the control of CSS (element names, attribute names and values).
  - The case sensitivity of document language element names, attribute names, and attribute values in selectors depend on the document language
- For example, element names are case-sensitive in XHTML and XML.

Selectors (3)

- Simple selector: either a type selector, universal selector, attribute selector, class selector, ID selector, or pseudo-class.
- Examples:
  - `div`
  - `[rel=stylesheet]`
  - `.copyright`
  - `#logo`
  - `:lang(hu)`

Selectors (4)

Combinator: any of the following characters:

- *whitespace*
- '>'
- '+'
- '~'

Selectors (5)

Sequence of simple selectors:

- A chain of simple selectors that are not separated by a combinator.
- Begins with a type selector or a universal selector. No other type selector or universal selector is allowed in the sequence.
- Examples:
  - `div`
  - `h2#status`
  - `link[rel=stylesheet][type=text/css]`
  - `p.copyright`
  - `*:lang(hu)`
  - `tr:nth-child(odd)`
  - `li:not(:last-child)`

Selectors (6)

Selector:

- A chain of one or more sequences of simple selectors separated by combinators.
- One pseudo-element may be appended to the last sequence of simple selectors.
- Examples:
  - `p`
  - `a img`
  - `h1 ~ table`
  - `div#main > h1`
  - `div > h1 + p`
  - `q::before`

Type Selector

- Written as a CSS qualified name, generally, an identifier.
- Matches the elements of that name.
- Examples:

```
p {
  color: red;
}
h1 {
  text-decoration: underline;
}
```

Universal Selector

- Written as `*`.
- Matches all elements.
- May be omitted from a simple selector if it is not the only component.
  - Thus, for example, the following selectors are equivalent:
    - `*#nav` and `#nav`
    - `*.important` and `.important`
    - `*[title]` and `[title]`
  - It is recommended not to omit the `*` because it improves readability.
    - For example, the selector `div *:first-child` is more readable than the selector `div :first-child`, because it is less likely to be confused with the selector `div:first-child`.

Attribute Selectors (1)

- `[att]`: matches elements with the `att` attribute.
- `[att=val]`: matches elements with the `att` attribute whose value is exactly *val*.
- `[att~=val]`: matches elements with the `att` attribute whose value is a whitespace-separated list of words, one of which is exactly *val*.

Attribute Selectors (2)

`[att|=val]`:

- Matches elements with the `att` attribute, its value either being exactly *val* or beginning with *val*`-`.
- Primarily intended to be used for attributes whose value is a language tag, for example, `en-US`, `en-GB`.
- For the `xml:lang` attribute and the HTML `lang` attribute, the `:lang(C)` pseudo-class should be used.

Attribute Selectors (3)

Additional attribute selectors introduced by CSS3:

- `[att^=val]`: matches elements with the `att` attribute whose value begins with the prefix *val*.
- `[att$=val]`: matches elements with the `att` attribute whose value ends with the suffix *val*.
- `[att*=val]`: matches elements with the `att` attribute whose value contains the substring *val*.

Attribute Selectors (4)

- In each attribute selector, *val* must be a CSS identifier or a string.
- Thus, for example, the `[dir=rtl]`, `[dir='rtl']`, and `[dir="rtl"]` selectors are equivalent.

Attribute Selectors (5)

Examples:

```
text[type=italic] {
  font-style: italic;
}

text[type=bold] {
  font-weight: bold;
}

text[type=normal] {
  font-style: normal;
  font-weight: normal;
}

a[hreflang|=en] {
  text-decoration: line-through;
}
```

Class Selector

- For HTML documents, the attribute selector `[class~=val]` is equivalent with the selector `.val`.
- Examples:

```
div.centered {
  margin-left: auto;
  margin-right: auto;
}

.important {
  color: red;
  text-decoration: underline;
}
```

ID Selector (1)

- A selector of the form #*identifier* matches the element with that identifier.
- The identifier must be provided by an attribute of type `ID` in the document.
  - The name of such an attribute depends on the document language; for example, in HTML, the attribute is named `id`.

ID Selector (2)

- Examples:

```
div#main {
  margin-left: auto;
  margin-right: auto;
  width: 50%;
}

#footer {
  text-align: center;
}
```

Pseudo-classes (1)

- Selectors of the form `:identifier` or `:identifier(value)`.
- Pseudo-class names are case-insensitive.
- Permit selection based on information that lies outside the document or that cannot be expressed using the other simple selectors.
- Some pseudo-classes are mutually exclusive (e.g., `:link` and `:visited`).
- Some pseudo-classes are dynamic: an element may acquire or lose a dynamic pseudo-class while a user interacts with the document.
  - The two types of dynamic pseudo-classes: link pseudo-classes and user action pseudo-classes.

Pseudo-classes (2)

Link pseudo-classes:

- `:link`: applies to links that have not been visited yet.
- `:visited`: applies to links that have been visited.
  - For privacy reasons, a minimal set of CSS properties can be set via the `:visited` pseudo-class.
  - Moreover, for the same reasons, modern web browsers lie about the values of the CSS properties of visited links when queried from JavaScript via the `Window.getComputedStyle()` method.
  - See:
    - `:visited` (MDN)
    - Privacy and the :visited selector (MDN)
    - Window: getComputedStyle() method (MDN)

Pseudo-classes (3)

User action pseudo-classes:

- `:hover`: applies while the user designates an element with a pointing device, but does not necessarily activate it.
- `:active`: applies while the user is activating an element.
  - For example, between the times the user presses and releases the mouse button.
- `:focus`: applies while an element has the focus (accepts keyboard or mouse events or other forms of input).

Pseudo-classes (4)

Example for using dynamic pseudo-classes:

```
a:link {
  color: indigo;
  text-decoration: none;
}

a:visited {
  color: gray;
  text-decoration: line-through; /* Won't work */
}

a:hover {
  border-width: medium;
  border-style: solid;
}

a:active {
  font-weight: bolder;
}
```

Pseudo-classes (5)

The `:target` pseudo-class:

- When the URI of the document contains a fragment identifier, `:target` represents the element referred by the fragment.
- For example, if `index.html#copyright` is the URI of the document, then the selector `div:target` represents the `div` element with the ID `copyright`.

Pseudo-classes (6)

The `:lang(C)` pseudo-class:

- Represents elements that are in language *C*, where *C* is a CSS identifier (language code).
- Examples:
  - `:lang(en)`, `:lang(en-GB)`, `:lang(en-US)`
  - `:lang(hu)`
- In XML documents, the language used is defined by the `xml:lang` attribute. In HTML documents, the language can be specified with both the `lang` and the `xml:lang` attributes.
  - The `lang` and `xml:lang` attributes do not necessarily occur directly on an element.

Pseudo-classes (7)

Example for using the `:lang(C)` pseudo-class: using Hungarian quotation marks for quotations in Hungarian

```
q:lang(hu) {
  quotes: "„" "”" "»" "«";
}
```

Pseudo-classes (8)

UI element states pseudo-classes:

- `:enabled`: represents user interface elements that are enabled.
- `:disabled`: represents user interface elements that are disabled.
- `:checked`: represents user interface elements that are in a “checked” state (for example, radio buttons, checkboxes).

Pseudo-classes (9)

Structural pseudo-classes:

- Only elements are counted when calculating the position of an element in its list of siblings.
  - For example, text, comments, and processing instructions are ignored.
- Index numbering starts at 1.

Pseudo-classes (10)

Structural pseudo-classes:

- `:root`: represents the root element of the document.
- `:only-child`: represents elements with no siblings.
- `:only-of-type`: represents elements that have no siblings with the same element name.
- `:empty`: represents elements that have no children at all.
  - These elements do not contain any text or elements but may contain comments and processing instructions.

Pseudo-classes (11)

Structural pseudo-classes (continued): a and b are integers

- `:nth-child(an+b)`: represents elements with $an + b - 1$ siblings before it in the document for any non-negative integer value of n.
- `:nth-last-child(an+b)`: represents elements with $an + b - 1$ siblings after it in the document for any non-negative integer value of n.
- `:nth-of-type(an+b)`: represents elements that have $an + b - 1$ siblings with the same element name before it in the document for any non-negative integer value of n.
- `:nth-last-of-type(an+b)`: represents elements that have $an + b - 1$ siblings with the same element name after it in the document for any non-negative integer value of n.

Pseudo-classes (12)

Structural pseudo-classes (continued):

- `:nth-child()`, `:nth-last-child()`, `:nth-of-type()` és `:nth-last-of-type()`:
  - The argument `an+0` can be specified as `an` in short.
  - The argument `0n+b` can be specified as `b` in short.
  - For a negative *b*, the argument must be specified as `an-b`; the form `an+-b` is invalid.
  - The argument `2n` can be specified as `even` and `2n+1` as `odd`, respectively.

Pseudo-classes (13)

Structural pseudo-classes (continued):

Selector	Meaning
`tr:nth-child(2n+0)`	The even rows of a table
`tr:nth-child(2n)`	
`tr:nth-child(even)`	
`tr:nth-child(2n+1)`	The odd rows of a table
`tr:nth-child(2n-1)`	
`tr:nth-child(odd)`	
`tr:nth-child(5)`	The the fifth row of a table
`tr:nth-child(5n+1)`	The 1st, 6th, 11th, ... rows of a table
`tr:nth-child(5n-4)`	
`tr:nth-child(-n+5)`	The first five rows of a table
`tr:nth-last-child(-n+5)`	The last five rows of a table

Pseudo-classes (14)

Structural pseudo-classes (continued):

- `:first-child`: has the same meaning as `:nth-child(1)`
- `:last-child`: has the same meaning as `:nth-last-child(1)`
- `:first-of-type`: has the same meaning as `:nth-of-type(1)`
- `:last-of-type`: has the same meaning as `:nth-last-of-type(1)`

Pseudo-classes (15)

The negation pseudo-class:

- A selector of the form `:not(X)` , where the argument is a simple selector (excluding the negation pseudo-class itself).
- Matches elements that do not match the argument.
- Examples:
  - `:not(.important)`
  - `:not([title])`
  - `li:not(:last-child)`
  - `a:not(:hover)`

Pseudo-classes (16)

The negation pseudo-class (continued):

- Only the argument is taken into account when calculating specificity!
- For example, the selector `h1:not(h2)` is practically equivalent to the selector `h1`, but it has a higher specificity: $(a = 0, b = 0, c = 2)$.

Pseudo-elements (1)

- Pseudo-elements allow authors to refer to content in the document that is otherwise inaccessible.
  - This includes content that originally did not exist in the document (i.e., generated content).
- Only one pseudo-element may appear per selector.
- The following pseudo-elements are available:
  - `::first-letter`
  - `::first-line`
  - `::before`, `::after`
- CSS3 uses `'::'` instead of `':'` for pseudo-elements to distinguish them from pseudo-classes.
- For compatibility `':'` can also be used.

Pseudo-elements (2)

`::first-line`: represents the first formatted line of an element.

- Example:

```
p::first-line {
  text-decoration: underline
}
```

Pseudo-elements (3)

`::first-letter`: represents the first letter or digit of an element if it is not preceded by any other content (such as images) on its line.

- Also applies to any punctuation character that precedes or follows the first letter.
- Example:

```
p::first-letter {
  font-size: 2em;
  font-weight: bold;
}
```

Pseudo-elements (4)

`::before` and `::after`: they can be used to describe generated content before or after an element's content.

- Example:

```
div.proof::before {
  content: "Proof: ";
  font-weight: bold;
}

div.proof::after {
  content: "\220E" /* End of proof */
}
```

Combinators (1)

Descendant combinator:

- Whitespace that separates two sequences of simple selectors.
- If `P` and `Q` are two sequences of simple selectors, the selector `P Q` represents elements matching `Q` that are descendants of elements matching `P`.
- Example:

```
thead th {
  background-color: darkgrey;
}
```

Combinators (2)

Child combinator:

- A `'>'` character that separates two sequences of simple selectors.
- If `P` and `Q` are two sequences of simple selectors, the selector `P > Q` represents elements matching `Q` that are children of elements matching `P`.
- Example:

```
nav > div {
  display: inline;
}

p > img:only-child {
  margin-left: 0;
}
```

Combinators (3)

Next-sibling combinator:

- A `'+'` character that separates two sequences of simple selectors.
- If `P` and `Q` are two sequences of simple selectors, the selector `P + Q` represents elements matching `Q` that immediately follow an element matching `P`.
  - The elements represented by the two sequences share the same parent in the document.
  - Non-element constructs (e.g., text and comments) are ignored when considering the adjacency of elements.
- Example:

```
h1 + p {
  text-indent: 0;
}
```

Combinators (4)

Subsequent-sibling combinator (CSS3):

- A `'~'` character that separates two sequences of simple selectors.
- If `P` and `Q` are two sequences of simple selectors, the selector `P ~ Q` represents elements matching `Q` that (not necessarily immediately) follow an element matching `P`.
- The elements represented by the two sequences share the same parent in the document.
- Example:

```
img ~ span {
  color: red;
}
```

Grouping Rules (1)

- Rules with the same declarations can be grouped.
- The selector of the grouped rule contains the selectors of the original rules separated by `','` characters.

Grouping Rules (2)

For example, the first three rules are equivalent to the fourth one:

```
h1 + p { text-indent: 0 }
h2 + p { text-indent: 0 }
h3 + p { text-indent: 0 }

h1 + p, h2 + p, h3 + p {
  text-indent: 0;
}
```

Selectors Level 4 (1)

- Specification: Selectors Level 4 (W3C Working Draft, 11 November 2022)
- Changes since Level 3: https://www.w3.org/TR/selectors-4/#changes-level-3
- New features:
  - `:any-link` and `:local-link` pseudo-classes
  - `:has()` pseudo-class
  - `:is()` pseudo-class
  - `:not()`: takes a selector list as an argument
  - ...

Selectors Level 4 (2)

`:is()` pseudo-class:

- A selector of the form `:is(X)` where the argument is a selector list.
- Also called the matches-any pseudo-class.
- Matches any element that can be matched by any of the selectors in the list argument.
- Useful for representing long selector lists in a more compact form.
- Pseudo-elements are not valid within `:is()`.
- The specificity of the `:is()` selector is the specificity of the selector with the highest specificity in the list argument.
- Browser support: https://caniuse.com/css-matches-pseudo

Selectors Level 4 (3)

`:is()` pseudo-class: for example, the following two style rules are equivalent:

```
div:is(.note, .warning, .hint)::before {
  /* ... */
}
```

```
div.note::before,
div.warning::before,
div.hint::before {
  /* ... */
}
```

Other Uses of CSS Selectors

Web scraping:

- Free and open source software:
  - Scrapy (written in: Python; license: New BSD License)
    https://scrapy.org/ https://github.com/scrapy/scrapy
  - Parsel (written in: Python; license: New BSD License)
    https://parsel.readthedocs.io/ https://github.com/scrapy/parsel

Specificity (1)

- For each selector and declaration, a specificity is calculated, which is a vector (a, b, c) of length 3, where a, b, and c are non-negative integers.
- The vectors are sorted in lexicographic order.

Specificity (2)

A selector's specificity is calculated as follows: the specificity of the selector is a vector (a, b, c), where:

- a is the number of ID selectors in the selector.
- b is the number of class selectors, attribute selectors, and pseudo-classes in the selector.
  - Selectors inside the negation pseudo-class are counted like any other, but the negation itself does not count as a pseudo-class!
- c is the number of type selectors and pseudo-elements in the selector.

Specificity (3)

Specificity of a declaration:

- Each declaration has the same specificity as the selector of the style rule in which it appears.
- Declarations that do not belong to a style rule (such as the contents of a `style` attribute in HTML) are considered to have a specificity higher than any selector.

Calculating a Selector's Specificity (1)

- The specificity of the selector `*` is $(a = 0, b = 0, c = 0)$.
  - Because it does not contain any ID selectors, class selectors, attribute selectors, pseudo-classes, type selectors, or pseudo-elements.
- The specificity of the selector `div` is $(a = 0, b = 0, c = 1)$.
- The specificity of the selector `p::first-letter`, `a img`, and `h1 + p` is $(a = 0, b = 0, c = 2)$.

Calculating a Selector's Specificity (2)

- The specificity of the selector `div[class=nav]` and the equivalent selector `div.nav` is $(a = 0, b = 1, c = 1)$.
- The specificity of the selector `#main *:lang(en)` is $(a = 1, b = 1, c = 0)$.

Calculating a Selector's Specificity (3)

The selectors from the examples in increasing order of specificity:

Selector	Specificity
`*`	$(a = 0, b = 0, c = 0)$
`div`	$(a = 0, b = 0, c = 1)$
`p::first-letter`	$(a = 0, b = 0, c = 2)$
`a img`	
`h1 + p`	
`div[class=nav]`	$(a = 0, b = 1, c = 1)$
`div.nav`	
`#main *:lang(en)`	$(a = 1, b = 1, c = 0)$

Stylesheets of Different Origins

- Multiple stylesheets of different origins may be associated with a document.
- Stylesheets may have three different origins:
  - User agent
  - User
  - Author
- Origins are listed in increasing order of precedence.

User agent stylesheets (1)

- User agents must apply a default stylesheet.
- For example, they provide a style rule specifying that the content of the HTML `em` element is presented using an italic font.

User agent stylesheets (2)

- **Firefox** : the default stylesheet can be accessed as follows:
  - Type the following in the address bar: resource://gre-resources/
  - As a result, a directory is presented, in which the `html.css` file is the default stylesheet.
  - See: https://searchfox.org/firefox-main/source/layout/style/res/html.css
- **Chromium**, **Google Chrome** : the default stylesheet to render HTML documents: https://chromium.googlesource.com/chromium/blink/+/master/Source/core/css/html.css

User Stylesheets

- The user may be able to specify style information for a particular document.
- This is important to people with disabilities.
- Related concept: web accessibility
- The Stylus extension for the Google Chrome, Firefox, and Opera browsers provide such functionality: https://add0n.com/stylus.html https://github.com/openstyles/stylus

Author Stylesheets (1)

- In HTML, the `link` element associates an external stylesheet with the document.
  - Example:

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

- In HTML, the `style` element allows the direct embedding of style rules in the document.
  - Example:

```
<style>
  h1, h2, h3, h4, h5, h6 {
    font-variant: small-caps
  }
</style>
```

Author Stylesheets (2)

- In XML, the `xml-stylesheet` processing instruction associates an external stylesheet with the document.
- The processing instruction should occur before the root element of the document.
- Example:

```
<?xml-stylesheet type="text/css" href="style.css"?>
```

- See: Associating Style Sheets with XML documents 1.0 (Second Edition) (W3C Recommendation, 28 October 2010)

Importing Stylesheets

- The `@import` at-rule allows users to import style rules from other stylesheets.
- The URL of the stylesheet can be specified with the `url()` function or as a string.
- If an `@import` at-rule refers to a valid stylesheet, user agents must treat the contents of the stylesheet as if they were written in place of the `@import` at-rule.
- Any `@import` at-rules must precede all other at-rules and style rules except the `@charset` at-rule.
- Example:

```
@import url(https://fonts.googleapis.com/css?family=Tangerine);
@import "default.css";
```

Important Declarations (1)

- A declaration can be followed by the token `'!'` token and keyword `important`.
- Example:

```
color: red !important
```

- Such a declaration overrides any other normal declarations.
- See: Specificity – The !important exception (MDN)

Important Declarations (2)

- By default, rules in author stylesheets have higher precedence than rules in user stylesheets.
- Both author and user stylesheets may contain `!important` declarations, and user `!important` rules override author `!important` rules.

Important Declarations (3)

Example:

```
<html lang="en">
  <head>
    <title>!important</title>
    <meta charset="UTF-8">
    <style>
      p {
        background-color: cornsilk;
        color: green !important;
      }
    </style>
  </head>
  <body>
    <p style="background-color: aliceblue; color: red">
      Hello, World!
    </p>
  </body>
</html>
```

Important Declarations (4)

Practical example:

```
table.chessboard > tbody > tr:nth-child(odd) > td:nth-of-type(odd) {
    background-color: white;
}

table.chessboard > tbody > tr:nth-child(odd) > td:nth-of-type(even) {
    background-color: lightgray;
}

table.chessboard > tbody > tr > td:hover {
    background-color: salmon !important;
}
```

Without `!important`, the third rule would never be used.

Calculating Property Values

The final value of a CSS property for a given element or box is the result of a multi-step calculation:

- **Cascaded value**: the result of the cascade.
- **Specified value**: the result of the defaulting.
- **Computed value**: the result of transforming a relative value to an absolute one.
- **Used value**: the result of formatting the document.
- **Actual value**: the result of transforming the used value to be suitable for a display environment.

Cascading, Inheritance, and Initialization

- **Cascading**: conflict resolution mechanism applied when different declarations set a value for the same element/property combination.
- **Inheritance**, **initialization**: mechanisms applied when no declarations try to set a value for an element/property combination.
- Relevant specification: CSS Cascading and Inheritance Level 3 (W3C Recommendation, 11 February 2021)

Cascade (1)

- Several different declarations can set the value of the same variable.
- These declarations can be of different origins.
- The cascade is the process of determining which declaration sets the value of a given property of a given element.

Cascade (2)

The cascade determines the cascaded value of a property for an element as follows:

- The declarations that set the value of a property for the element are identified and collected.
  - Remember that these declarations are provided by style rules or the `style` HTML attribute.
- These declarations are sorted by decreasing origin.
- Declarations of the same origin are sorted by decreasing specificity.
  - In the cases of equal specificity, the last declaration in document order wins.
- The property's value is set by the first declaration according to this order.

Rule Ordering (1)

- The ordering of style rules may be significant.
- The ordering is significant when more than one style rule with the same specificity applies to an element.
- In this case, the last declaration in document order wins.

Rule Ordering (2)

- For example, the first two rules will never be taken into account here:

```
a:active { color: red }     /* (a = 0, b = 1, c = 1) */
a:hover { color: green }    /* (a = 0, b = 1, c = 1) */
a:visited { color: black } /* (a = 0, b = 1, c = 1) */
a:link { color: blue }      /* (a = 0, b = 1, c = 1) */
```

- The correct order of these rules is the following (the first two rules are interchangeable):

```
a:visited { color: black }
a:link { color: blue }
a:hover { color: green }
a:active { color: red }
```

Specified Value

- The specified value is the value of a given property that the style sheet authors intended for that element.
- If the cascade results in a value, then that is the specified value.
- Otherwise, the specified value is determined by the defaulting process.

Defaulting

- When the cascade does not result in a value, the specified value must be found some other way.
  - Inherited properties draw their defaults from their parent element through inheritance.
  - All other properties take their initial value.
- Authors can explicitly request inheritance or initialization via the `inherit` and `initial` keywords.

Computed Value (1)

- In general, a relative value is transformed to an absolute one when the computed value is determined.
- However, the computed value can be a percentage!
  - The result of determining the computed value is a percentage, when the specified value is a percentage that is relative to a quantity that depends on the layout of the document.
    - Such percentages are transformed to absolute values when the used value is determined.
- The computed value is the value that is transferred from parent to child during inheritance.

Computed Value (2)

Example:

- CSS:

```
section { font-size: 12px }
h2 { font-size: 1.5em }
```

- HTML:

```
<section>
  <h2>Introduction</h1>
</section>
```

- The specified and the computed value of the `font-size` property of the `section` element is `12px`.
- The specified value of the `font-size` property of the `h2` element is `1.5em`, its computed value is $1.5 \times 12\text{px} = 18\text{px}$.

Used Value

- Computed values are determined without formatting the document.
- However, there are properties whose value may depend on the layout of the document (e.g., `height`, `width`).
  - For such properties, the used value is determined from the computed value based on the layout of the document.
  - For all other properties, the used value is the same as the computed value.

Actual Value

- The used value is transformed to the actual value based on constraints of the display environment.
- For example, the value of the `font-size` property may need adjustment based on the availability of fonts.

Inheritance (1)

- Inheritance propagates property values from parent elements to their children.
- Some properties are inherited; this means that unless the cascade results in a value, the value will be determined by inheritance.
- For each property, the relevant CSS specification defines whether it is inherited or not.
  - For example, the `font-family`, `font-style`, `font-variant`, `font-weight`, `font-size`, and `font` properties are inherited.
  - For example, the `margin-top`, `margin-bottom`, `margin-right`, `margin-left`, `margin`, and `width` properties are not inherited.
- If the cascaded value of a property is the `inherit` keyword, the inherited value becomes the property's specified and computed values.

Inheritance (2)

Example:

When no rules apply to the `em` HTML element below, setting the value of the `color` property, the element inherits the value of the property from the span element (i.e., `red`).

```
<span style="color: red">
  May the <em>force</em> be with you!
</span>
```

Inheritance (3)

Example:

When the style rule below applies, a hyperlink inherits the value of the `color` property from its parent. Thus, for example, the value of the `color` property of the `a` element in the `div` element is `green`.

```
a:visited, a:link {
  color: inherit;
}
```

```
<p style="color: green">
  Click here: <a href="https://www.w3.org/">W3C</a>
</p>
```

Initial Value

- Each property has an initial value, defined in the relevant CSS specification. The initial value can be defined to depend on the user agent.
  - For example, the initial value of the `background-color` property is the `transparent` keyword.
    - See: https://www.w3.org/TR/css-backgrounds-3/#the-background-color
  - For example, the initial value of the `color` property depends on the user agent.
    - See: https://www.w3.org/TR/css-color-3/#foreground
- If the property is not an inherited property, and the cascade does not result in a value, then the specified value of the property is its initial value.
- If the cascaded value of a property is the `initial` keyword, the property's initial value becomes its specified value.

Assignment (1)

- Consider the following style rules in an author stylesheet associated with a HTML document:

```
:lang(hu) { color: red }
div > p { color: blue }
#main > p.foo { color: yellow }
#main :lang(hu) { color: green }
div:lang(hu) p.foo:first-child { color: black }
```

- What is the color of the text in the p element?

```
<div id="main" lang="hu">
  <p class="foo">What is the color of this text?</p>
</div>
```

Assignment (2)

- Consider the following style rules in an author stylesheet associated with a HTML document:

```
.movies > ul > li:not(:first-child) { color: navy }
h1 + ul li:first-child { color: gold }
ul > :nth-child(2n + 1) { color: purple }
#ot li + :last-child { color: tomato }
*:not([class]) + ul:first-child > li:first-child { color: silver }
```

- What is the color of the text in each `li` element?

```
<section id="ot" class="movies">
  <h1>The Original Trilogy</h1>
  <ul>
    <li>A New Hope</li>
    <li>The Empire Strikes Back</li>
    <li>Return of the Jedi</li>
  </ul>
</section>
```

Error Handling (1)

See:

- CSS Syntax Module Level 3 (W3C Candidate Recommendation Draft, 24 December 2021)
  - For a high-level overview of error handling, see subsection 2.2. Error Handling.
- CSS error handling (MDN)

Error Handling (2)

- When errors occur in CSS, the parser attempts to recover gracefully, throwing away only the minimum amount of content before returning to parsing as normal.
  - This is because new syntax looks like an error to an old parser.

Error Handling (3)

- Each invalid construct (i.e., declaration, style rule, at-rule) is ignored by the user agent, and parsing is continued.
  - When the selector list of a style rule contains an invalid selector, the entire style rule is ignored by the UA.
    - An exception is when the invalid selector occurs within an `:is` pseudo-class; in this case, only the invalid selector is ignored.
- Invalid, thus ignored, declarations can be seen in DevTools.

Error Handling (4)

Example:

The style rule

```
p {
  color: white
  background color: navy;
  font-family: sans-serif;
  font-size: xxx;
  unknown: 0;
}
```

is effectively the same as the following style rule:

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

Error Handling (5)

Example:

- The following style rule is ignored because `:foobar` is not a valid pseudo-class:

```
a:hover, a:foobar {
  font-weight: bold;
}
```

- However, the following style rule is not ignored completely:

```
a:is(:hover, :foobar) {
  font-weight: bold;
}
```

Nesting of Style Rules (1)

- Specification: CSS Nesting Module (W3C Working Draft, 14 February 2023)

The content of this slide is communicated only orally in the lecture.

Nesting of Style Rules (2)

The content of this slide is communicated only orally in the lecture.

Nesting of Style Rules (3)

Example:

```
table.chessboard {
    border-collapse: collapse;
    margin: 1rem auto;
    & th {
        font-family: sans-serif;
        font-weight: normal;
    }
}
```

is equivalent to

```
table.chessboard {
    border-collapse: collapse;
    margin: 1rem auto;
}
table.chessboard th {
    font-family: sans-serif;
    font-weight: normal;
}
```

Nesting of Style Rules (4)

Example:

```
table.chessboard {
    & td, & th {
        font-size: 2rem;
        height: 4rem;
        text-align: center;
        vertical-align: middle;
        width: 4rem;
    }
}
```

is equivalent to

```
table.chessboard td, table.chessboard th {
    font-size: 2rem;
    height: 4rem;
    text-align: center;
    vertical-align: middle;
    width: 4rem;
}
```

Nesting of Style Rules (5)

Example:

```
table.chessboard > tbody {
    & > tr:nth-child(odd) > td:nth-of-type(even),
    > tr:nth-child(even) > td:nth-of-type(odd) {
        background-color: lightgray;
    }
}
```

is equivalent to

```
table.chessboard > tbody > tr:nth-child(odd) > td:nth-of-type(even),
table.chessboard > tbody > tr:nth-child(even) > td:nth-of-type(odd) {
    background-color: lightgray;
}
```

Nesting of Style Rules (6)

However, for example, the following is not allowed:

```
p {
    img {
        vertical-align: middle;
    }
}
```

Instead, it should be written as:

```
p {
    & img {
        vertical-align: middle;
    }
}
```

Nesting of Style Rules (7)

Example:

```
ol, ul {
  font-family: sans-serif;
  :is(h2) + & {
    border: medium solid green;
  }
  .highlight, + p {
    background-color: gold;
    text-decoration: underline;
  }
  &.details {
    background-color: powderblue;
  }
}
```

```
ol, ul {
  font-family: sans-serif;
}

h2 + :is(ol, ul) {
  border: medium solid green;
}

:is(ol, ul) .highlight, :is(ol, ul) + p {
  background-color: gold;
  text-decoration: underline;
}

:is(ol, ul).details {
  background-color: powderblue;
}
```

Vendor Prefix (1)

- The CSS2.1 specification reserves a prefixed syntax for proprietary and experimental extensions to CSS.
  - A CSS feature is a proprietary extension if it is meant for use in a closed environment accessible only to a single vendor's user agent(s).
  - A CSS feature is considered unstable until its specification has reached the Candidate Recommendation (CR) stage in the W3C process.
- See:
  - CSS Snapshot 2025 – Implementations of Unstable and Proprietary Features (W3C)
  - Glossary of web terms – Vendor prefix (MDN)

Vendor Prefix (2)

- Keywords and property names beginning with `'-'` or `'_'` are reserved for vendor-specific extensions.
  - An initial dash or underscore is guaranteed never to be used in a property or keyword by any current or future level of CSS.
- See: CSS 2.1 Specification – Syntax and basic data types – Vendor-specific extensions

Vendor Prefix (3)

- Once an unstable feature has stabilized (i.e., its specification reaches the Candidate Recommendation stage), support for the vendor-prefixed syntax should be removed from implementations.

Vendor Prefix (4)

Notable vendor prefixes include the following:

- Mozilla (Firefox): `-moz-`
- Microsoft (Internet Explorer, Microsoft Edge): `-ms-`
- Apple (Safari): `-webkit-`

Vendor Prefix (5)

Vendor prefix trend:

- Today, the use of vendor prefixes is considered to be a bad practice, and browser vendors are moving away from using them.
- Instead, the recommended practice for unstable features is to put them behind a flag.

Vendor Prefix (6)

- Chromium does not use vendor prefixes.
- Instead, a browser setting (i.e., `chrome://flags/#enable-experimentalweb-platform-features`) is provided to turn experimental features on/off.
- See: https://www.chromium.org/blink/developer-faq/#will-we-see-a-chrome-vendor-prefix-now

Vendor Prefix (7)

Proprietary extensions to CSS:

- Mozilla CSS extensions (MDN)
- WebKit CSS extensions (MDN)

Vendor Prefix (8)

An example for a proprietary extension: `::-moz-list-number` (MDN)

- Example of use:

```
li::-moz-list-number {
  font-style: italic;
  font-weight: bold;
}
```

Vendor Prefix (9)

An example for a once unstable feature: `fit-content` (MDN)

- Relevant CSS specification: CSS Box Sizing Module Level 4 (W3C Working Draft, 20 May 2021)
- Browser support: https://caniuse.com/mdn-css_properties_width_fit-content
  - Firefox supports the unprefixed standard form since version 94 released in 2021.

Vendor Prefix (10)

An example for a once unstable feature: `fit-content` (MDN)

- A style rule that also works with earlier versions of Firefox:

```
.fit-content {
  width: -moz-fit-content;
  width: fit-content;
}
```

CSS Object Model (CSSOM)

- Specification: CSS Object Model (CSSOM) (W3C Working Draft, 26 August 2021)
- A set of APIs that allows access to and manipulation of style related state information and processes from JavaScript.
- Defines an object model is similar to the DOM.
- Further information: CSS Object Model (CSSOM) (MDN)

Working with the CSSOM

Example:

Suppose that the

```
body {
  font-size: 16px;
}
```

style rule applies to the body element that has no style attribute.

```
console.log(document.body.style.fontSize); // ''
console.log(window.getComputedStyle(document.body).fontSize); // '16px'
document.body.style.padding = '1.5em';
console.log(document.body.style.padding); // '1.5em'
console.log(window.getComputedStyle(document.body).padding); // '24px'
```

CSS Houdini (1)

- Houdini is a set of low-level APIs that exposes parts of the CSS engine, giving developers the power to extend CSS by hooking into the styling and the layout process of a browser's rendering engine.
- See: Houdini APIs (MDN)

CSS Houdini (2)

- Specifications:
  - CSS-TAG Houdini Editor Drafts
- Status and support:
  - https://caniuse.com/?search=houdini
- Further useful links:
  - CSS Houdini Wiki

Further Resources (1)

References:

- MDN Web Docs – CSS
  - CSS Reference
- CSS Reference – A free visual guide to CSS (cssreference.io)
- CSS Reference (Codrops)
- DevDocs CSS Reference

Further Resources (2)

Surveys:

- The State of CSS Survey
  - State of CSS 2025
- HTTP Archive. Web Almanac – Part I Chapter 1: CSS. 2022.

Further Resources (3)

Demos and games:

- CSS Zen Garden
- CSSBattle
- CSS Diner
  - Repository: https://github.com/flukeout/css-diner
- Fun and Games with CSS
  - Repository: https://github.com/rupl/fun-games-css
- Unfolding the Box Model
  - Repository: https://github.com/rupl/unfold