

Data Interoperability and Semantics

< Part 2. Data Formats >

ICM – Toolbox Engineering and Interoperability of Software Systems – Course unit on Data Interoperability and Semantics
M1 Cyber Physical and Social Systems – Course unit on Data Interoperability and Semantics
Maxime Lefrançois <https://maxime-lefrancois.info>
Course unit URL: <https://ci.mines-stetienne.fr/cps2/course/data>

Data Interoperability and Semantics Outline

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 - Part 2.2. Delimiter-separated values
 - Part 2.3. Extensible Markup Language (XML)
 - Part 2.4. JavaScript Object Notation (JSON)
 - Part 2.5. Configuration file formats
 - Part 2.6. YAML Ain't Markup Language (YAML)
 - Part 2.7. Lightweight markup languages
 - Part 2.8. Compressed formats
 - Part 2.9 Multimedia formats
 - Part 2.10 3D models

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Data Interoperability and Semantics

Part 2. Data Formats

Part 2.1 Generalities

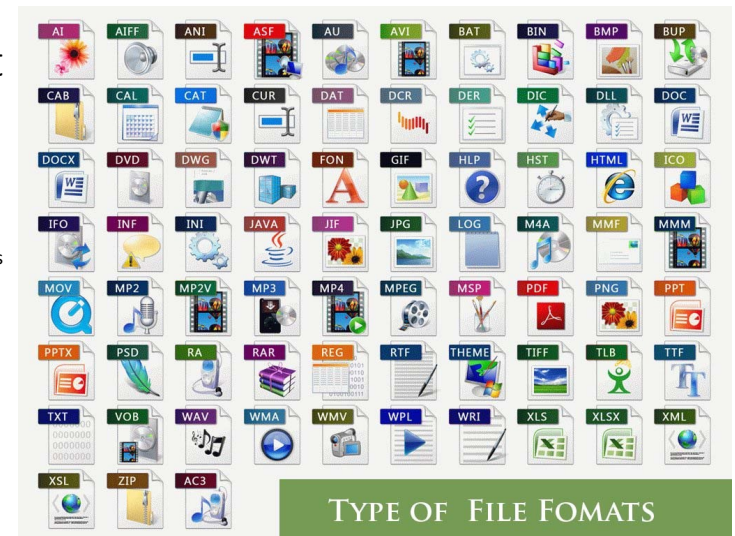
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File format

standard way that information is encoded for transfer or storage in a computer file

A format is what enables an application to interpret the raw data contained in a file. It is the mode of representation of these data

File formats are marked in the extension of the file name



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ToC of https://en.wikipedia.org/wiki/List_of_file_formats

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Proprietary file formats vs free file formats

Proprietary file format

Data encoding, s.t. one needs the company's software to decode and interpret it. Either the data encoding specification is secret, or restricted through license.

Examples of proprietary file formats

- **mp3**: open standard, but subject to patents in some countries
- **dwg**: non documented, AutoCAD
- **psd**: documented, Adobe Photoshop's native image format
- **rar**: partially documented, archive and compression file format owned by Alexander L. Roshal
- **zip** (newest versions have patented features)
- **gif**: CompuServe's Graphics Interchange Format, **patent expired** in 2004
- **pdf**: open since 2008 ISO 32000-1. Still some features proprietary by Adobe (forms, scripts)
- **doc, xls, ppt**: formerly closed/undocumented, now Microsoft Open Specification Promise

https://en.wikipedia.org/wiki/Proprietary_format

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Open vs unpublished file formats

Open file format

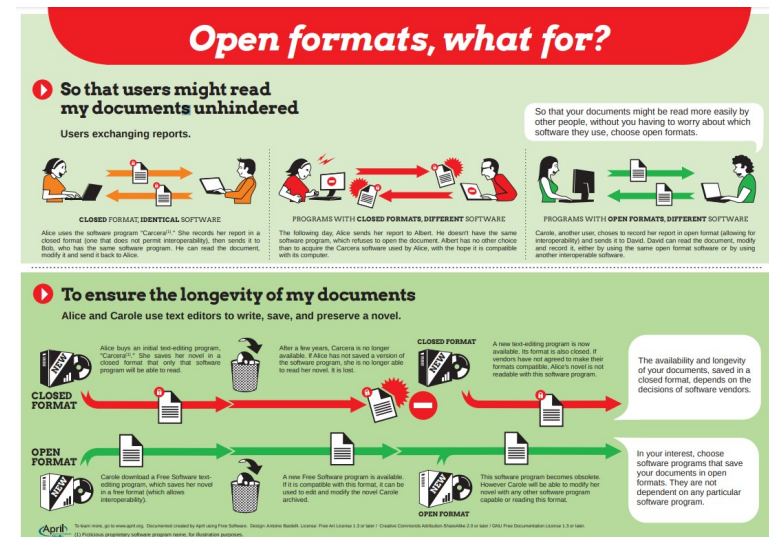
published specification usually maintained by a standards organization.

Linux Information Project: "any format that is published for anyone to read and study but which may or may not be encumbered by patents, copyrights or other restrictions on use"

US government: "An open format is one that is platform independent, machine readable, and made available to the public without restrictions that would impede the re-use of that information"

FR government: loi n° 2004-575 du 21 juin 2004 pour « la confiance dans l'économie numérique »: « On entend par standard ouvert tout protocole de communication, d'interconnexion ou d'échange et tout format de données interopérable et dont les spécifications techniques sont publiques et sans restriction d'accès ni de mise en œuvre. »

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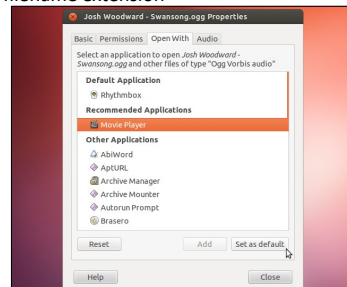
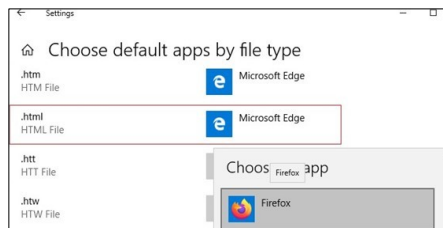
<https://www.april.org/en/open-formats>

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How to identify a file type ?

Filename extensions

- See https://en.wikipedia.org/wiki/List_of_filename_extensions
- Look up or browse categories <https://www.file-extension.info/>
- Windows / linux desktops: applications association to filename extension



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How to identify a file type ?

Filename extensions

- See https://en.wikipedia.org/wiki/List_of_filename_extensions
- Look up or browse categories <https://www.file-extension.info/>
- Windows / linux desktops: applications association to filename extension
- reason why .htm vs .html ? the 8.3 filename format
- OS hide the extensions + associate applications = creates security issues



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How to identify a file type ?

File header

may contain metadata about the file and its content

- ex., Exif metadata: image format, size, resolution color space, ...
- ex., AVI header format: <https://www.filefox.org/format/avi.html#header>

Camera manufacturer	Canon
Camera model	Canon EOS 1200D
Author	Praveen. P
Exposure time	1/60 sec (0.016666666666667)
F-number	f11
ISO speed rating	200
Date and time of data generation	22:29, 22 November 2018
Lens focal length	41 mm

ex., Exif metadata
<https://en.wikipedia.org/wiki/Exif>

Character-based documents may be opened in text editors, and their header interpreted

ex., head of a XML file

```
<?xml version="1.0" encoding="UTF-8"?>
<!DOCTYPE html
PUBLIC "-//W3C//DTD XHTML 1.0 Strict//EN"
"http://www.w3.org/TR/xhtml1/DTD/xhtml1-strict.dtd">
```

ex., head of a iCalendar file

```
BEGIN:VCALENDAR
VERSION:2.0
PRODID:-//hacksw/handcal//NONSGML v1.0//EN
BEGIN:VEVENT
```

ex., head of a ISO 10303-21 STEP file

```
ISO-10303-21;
HEADER;
FILE_DESCRIPTION(
/* description */ ('A minimal AP214 example wit
/* implementation_level */ ('2;1'));
FILE_NAME(
/* name */ ('demo',
/* time_stamp */ ('2003-12-27T11:57:53',
/* author */ ('Lothar Klein'),
/* organization */ ('LSoft'));
```

How to identify a file type ?

File's first bytes: Magic numbers

the first few bytes may be distinctive enough

Hex signature	ISO 8859-1	Offset	Extension	Description
23 21	#!	0		Script or data to be passed to the program following the shebang (#!)
52 49 46 46 ?? ?? ?? ??	RIF???	0	avi	Audio Video Interleave video format
41 56 49 20				
FF F8	y0			
FF F3	y6			
FF F2	y0	0	mp3	MPEG-1 Layer 3 file without an ID3 tag or with an ID3v1 tag (which is appended at the end of the file)
49 44 33	ID3	0	mp3	MP3 file with an ID3v2 container
21 3C 61 72 63 68 3E 0A	!<arch>..	0	deb	linux deb file
37 7A BC AF 27 1C	7zK" "s	0	7z	7-Zip File Format
1F 8B	us "	0	gz	GZIP compressed file ^[1]
			tar.gz	
FD 37 7A 58 5A 00	7zXZ...	0	xz	XZ compression utility
			tar.xz	using LZMA2 compression
4E 45 53 1A	NES...	0	nes	Nintendo Entertainment System ROM file ^[2]

Example of file signatures - https://en.wikipedia.org/wiki/List_of_file_signatures

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How to identify a file type ?

File's first bytes: Magic numbers

the first few bytes may be distinctive enough

ex., a file that starts with a Byte Order Mark (BOM) tells the system:

- Highly probable that the text stream is Unicode
- Describes the byte order, or endianness, of the text stream: Big-endian (BE) vs Little-endian (LE)
- Distinguish between Unicode character encoding (UTF-8, UTF-16, UTF-32, ...)

Encoding	Representation (hexadecimal)	Representation (decimal)	Bytes as CP1252 characters
UTF-8 ^[a]	EF BB BF	239 187 191	ÿ
UTF-16 (BE)	FE FF	254 255	by
UTF-16 (LE)	FF FE	255 254	yb
UTF-32 (BE)	00 00 FE FF	0 0 254 255	^@^@by (^@ is the null character)
UTF-32 (LE)	FF FE 00 00	255 254 0 0	yb^@^@ (^@ is the null character)

https://en.wikipedia.org/wiki/Byte_order_mark

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How to identify a file type ?

Example: the gzip file format starts with:

- a 10-byte header, containing:
 - magic number (0x1f8b),
 - the compression method (0x08 for DEFLATE),
 - 1-byte of header flags,
 - a 4-byte timestamp,
 - compression flags and
 - the operating system ID.
- optional extra headers as allowed by the header flags, including the original filename, and a comment field,

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How to identify a file type ?

MIME type = Media types

- managed by Internet Assigned Numbers Authority (IANA)
- example: text/html, image/gif, font/woff2, ...
- used by many internet protocols
- demo with your browser: with the Network tab of the developer tools open, see HTTP response headers of requests when accessing <https://fonts.google.com/>

Media Types

Last Updated: 2021-11-15

Registration Procedure(s): Expert Review for Vendor and Personal Trees.

Expert(s): Ned Freed, Alexey Melnikov, Murray Kucherawy (Backup)

Reference: [RFC4880][RFC4855]

Note: Per Section 3.1.1 of [RFC4880], Standards Tree requests made through IETF documents will be reviewed and approved by the IESG, while requests made by other recognized standards organizations will be reviewed by the Designated Expert in accordance with the Specification Required policy. IANA will verify that this organization is recognized as a standards organization by the IESG.

Note: [RFC4880] specifies that Media Types (formerly known as MIME types) and Media Subtypes will be assigned and listed by the IANA.

Note: Procedures for registering Media Types can be found in [RFC4880], [RFC4881], and [RFC4882]. Additional procedures for registering media types for transfer via Mail-List Transport Protocol (MTP) can be found in [RFC4881].

Note: The following is the list of Directories of Content Types and Subtypes. If you wish to register a Media Type with the IANA, please see the following for the online application: [Application for registration of Media Types]

Note: Other Media Type Parameters: [IANA registry: media-types:parameters]

Note: Media Type Sub-Parameters: [IANA registry: media-types:sub-parameters]

Note: Provisional Standard Media Type Registry: [IANA registry: provisional-standard-media-types]

Note: Per Section 3.2.1.1 of [RFC4881-Internet-Semantics-1], use of the "q" parameter name to control content negotiation would interfere with any media type parameter having the same name. Hence, the media type registry disallows parameters named "q".

Available Formats:

Registries included below:

- application
- audio
- font
- image
- message
- model
- multipart
- text
- video

<https://www.iana.org/assignments/media-types/media-types.xhtml>

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← → ↻ 📄 iana.org/assignments/media-types/font/woff2

Type name: font

Subtype name: woff2

Required parameters: None

Optional parameters: None

Encoding considerations: Binary

Interoperability considerations: WOFF 2.0 is an improvement on WOFF 1.0. The two formats have different Internet Media Types and different @font-face formats, and they may be used in parallel.

Published specification: This media type registration is extracted from the WOFF 2.0 specification [W3C.CR-WOFF2-20150414] at W3C.

Applications that use this media type: WOFF 2.0 is used by web browsers, often in conjunction with HTML and CSS.

Additional information:

Magic number(s): The signature field in the WOFF header MUST contain the "magic number" 0x774F4632 ("woff2")

File extension(s): woff2

Macintosh file type code(s): (no code specified)

Macintosh Universal Type Identifier code: "org.w3.woff2"

@font-face Format: woff2

Fragment Identifiers: See Section 4.2.

Person & email address to contact for further information: Chris Lilley (www-font@w3.org).

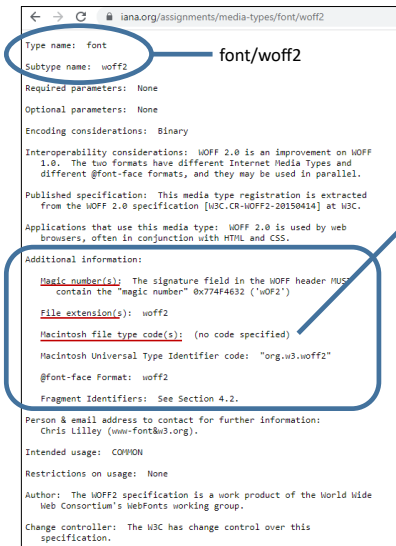
Intended usage: COMMON

Restrictions on usage: None

Author: The WOFF2 specification is a work product of the World Wide Web Consortium's WebFonts working group.

Change controller: The W3C has change control over this specification.

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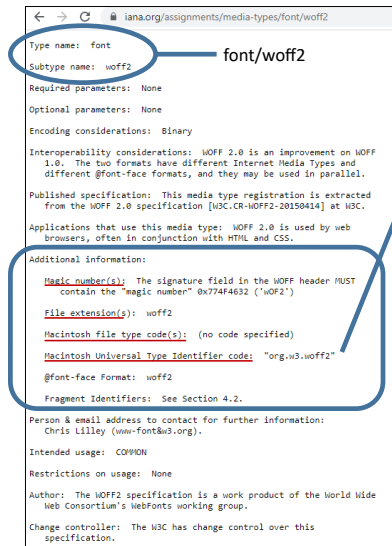


Macintosh file type code(s)

Apple Computer, Inc., "Mac OS: File Type and Creator Codes, and File Formats", Apple Knowledge Article 55381, June 1993, last accessed 17/05/2008
<https://web.archive.org/web/20080517021842/http://www.info.apple.com/kbnum/n55381>

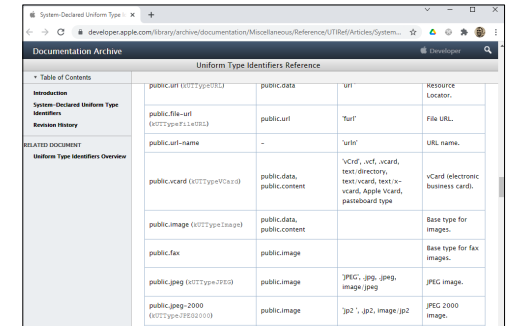
PICT	picture	Stores a PICT image contained in the file
PREF	preference	Stores the environment settings for an application
snd	sound	Stores a sound used in the file
STR	string	Stores a string or hexadecimal data used in the file
STR#	string list	Stores multiple strings used in the file
styl	style	Defines style information, such as the font, color and size of text
TEXT	text	Stores text

https://en.wikipedia.org/wiki/Resource_fork#Major_resource_types



Macintosh Universal Type Identifier code

- reverse-DNS naming structure
- public UTIs, and organization-specific UTIs
- multi-heritance



<https://developer.apple.com/library/archive/documentation/Miscellaneous/Reference/UTIRef/18>

Data Interoperability and Semantics

Part 2. Data Formats

Part 2.2. Delimiter-separated values

Delimiter-separated values

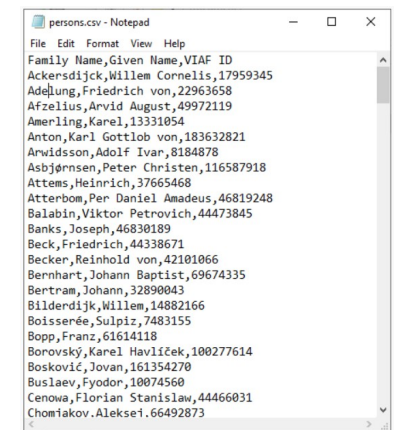
separator character

- comma
Comma-separated values (CSV)
ex: Microsoft Excel csv export¹
- semicolon
ex: Microsoft Excel csv export²
- tab
Tab-separated values (TSV)
- colon
ex: Linux \$ cat /etc/passwd

```
File: /etc/passwd
root:x:0:0::/root:/bin/zsh
bin:x:1:1::/usr/bin/nologin
daemon:x:2:2::/usr/bin/nologin
mail:x:8:12::/var/spool/mail:/usr/bin/nologin
ftp:x:14:11::/srv/ftp:/usr/bin/nologin
http:x:33:33::/srv/http:/usr/bin/nologin
```

¹ unless the decimal point of the locale is a comma (ex., France)

² when the decimal point of the locale is a comma



Delimiter-separated values

RFC 4180

separator character

records separated by CRLF

aaa,bbb,ccc CRLF
zzz,yyy,xxx CRLF or aaa,bbb,ccc CRLF
zzz,yyy,xxx CRLF

optional header file

field_name,field_name,field_name CRLF
aaa,bbb,ccc CRLF
zzz,yyy,xxx CRLF

fields enclosed in double quote

"aaa","b" CRLF
bb","ccc" CRLF
zzz,yyy,xxx CRLF

escaping cell character

"aaa","b","bb","ccc"

```
persons.csv - Notepad
File Edit Format View Help
Family Name,Given Name,VIAF ID
Ackersdijck,Willem Cornelis,17959345
AdeJung,Friedrich von,22963658
Afzelius,Arvid August,49972119
Amerling,Karel,13331854
Anton,Karl Gottlob von,183632821
Arwidsson,Adolf Ivar,8184878
Asbjørnsen,Peter Christen,116587918
Attens,Heinrich,37665468
Atterbom,Per Daniel Amadeus,46819248
Balabin,Viktor Petrovich,44473845
Banks,Joseph,46830189
Beck,Friedrich,44338671
Becker,Reinhold von,42101066
Bernhart,Johann Baptist,69674335
Bertram,Johann,32890043
Bilderdijk,Willem,14882166
Boisserée,Sulpiz,7483155
Bopp,Franz,61614118
Borovský,Karel Havlíček,100277614
Bosković,Jovan,161354270
Buslaev,Fyodor,10074560
Cenowa,Florian Stanisław,44466031
Chomiakov,Aleksej,66492873
```

Delimiter-separated values

Comparison Java libraries:

<https://github.com/univocity/csv-parsers-comparison>

- CPU: AMD Ryzen 7 1700 Eight-Core Processor @ 4.0 GHz
- RAM: 32 GB
- Storage: 1TB SSD drive
- OS: Arch Linux 64-bit
- JDK: 9.0.4 64-bit (Linux)
- JDK: 1.8.0_144 64-bit (Linux)
- JDK: 1.7.0_80 64-bit (Linux)
- JDK: 1.6.0_45 64-bit (Linux)

Processing 3,173,958 rows of non RFC 4180 compliant input. No quoted values.

JDK 9

Parser	Average time	% Slower than best	Best time	Worst time
univocity CSV parser	739 ms	Best time!	707 ms	768 ms
SimpleFlatMapper CSV parser	861 ms	16%	848 ms	901 ms
Jackson CSV parser	1212 ms	64%	1169 ms	1238 ms
Product Collections parser	1409 ms	90%	1389 ms	1451 ms
Java CSV Parser	1498 ms	102%	1490 ms	1508 ms
JCSV Parser	1681 ms	127%	1660 ms	1710 ms
Oster Miller CSV parser	1772 ms	139%	1762 ms	1780 ms
Gen-Java CSV	1799 ms	143%	1790 ms	1805 ms
Simple CSV parser	1861 ms	151%	1832 ms	1900 ms
SuperCSV	1893 ms	156%	1858 ms	1964 ms
OpenCSV	2022 ms	173%	2007 ms	2037 ms
Apache Commons CSV	2424 ms	228%	2409 ms	2442 ms
Way IO Parser	2577 ms	248%	2532 ms	2638 ms

Data Interoperability and Semantics

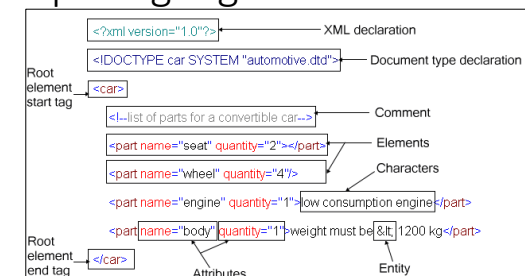
Part 2. Data Formats

Part 2.3. Extensible Markup Language (XML)

Extensible Markup Language

XML (file format)

Filename extension	.xml
Internet media type	application/xml text/xml [1]
Uniform Type Identifier (UTI)	public.xml
UTI conformation	public text
Magic number	<?xml
Developed by	World Wide Web Consortium
Type of format	Markup language
Extended from	SGML
Extended to	Numerous languages, including XHTML · RSS · Atom · KML
Standard	1.0 (Fifth Edition) [2] (November 26, 2008; 12 years ago) 1.1 (Second Edition) [2] (August 16, 2006; 15 years ago)
Open format?	Yes



- v1.0 in 1998, still extensively used in many verticals
- numerous formats based on XML (418 registered on IANA) https://en.wikipedia.org/wiki/List_of_XML_markup_languages
application/atom+xml application/rdf+xml ...
- verbosity, complexity and redundancy

Extensible Markup Language

XML (file format)	
Filename extension	.xml
Internet media type	application/xml text/xml [1]
Uniform Type Identifier (UTI)	public.xml
UTI conformation	public.text
Magic number	<?xml
Developed by	World Wide Web Consortium
Type of format	Markup language
Extended from	SGML
Extended to	Numerous languages, including XHTML · RSS · Atom · KML
Standard	1.0 (Fifth Edition) [2] (November 26, 2008, 12 years ago) 1.1 (Second Edition) [2] (August 16, 2006, 15 years ago)
Open format?	Yes

Characters and escaping

- unicode implementations: `<?xml version="1.0" encoding="UTF-8"?>`
- escaping characters: `<` - `<`; `&` - `&`; `❤` - `♥` - etc.

Syntactical correctness

- *well formed vs ill-formed*
- one root tag
- correct nesting
- tag names (approx) start with letter, then alphanumeric or `'`

Schemas and validation

- *valid vs invalid*
- DTD, or XML Schema

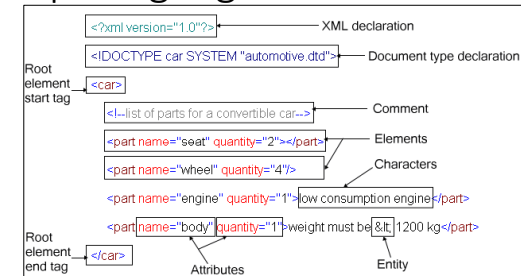
Namespaces

- `xmlns:ns1="http://example.org/ns1"`
- `xmlns:ns2="http://example.org/ns2"`
- allows to use different schemas together: `<ns1:Tag>` `<ns2:Tag>`

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Extensible Markup Language

XML (file format)	
Filename extension	.xml
Internet media type	application/xml text/xml [1]
Uniform Type Identifier (UTI)	public.xml
UTI conformation	public.text
Magic number	<?xml
Developed by	World Wide Web Consortium
Type of format	Markup language
Extended from	SGML
Extended to	Numerous languages, including XHTML · RSS · Atom · KML
Standard	1.0 (Fifth Edition) [2] (November 26, 2008, 12 years ago) 1.1 (Second Edition) [2] (August 16, 2006, 15 years ago)
Open format?	Yes



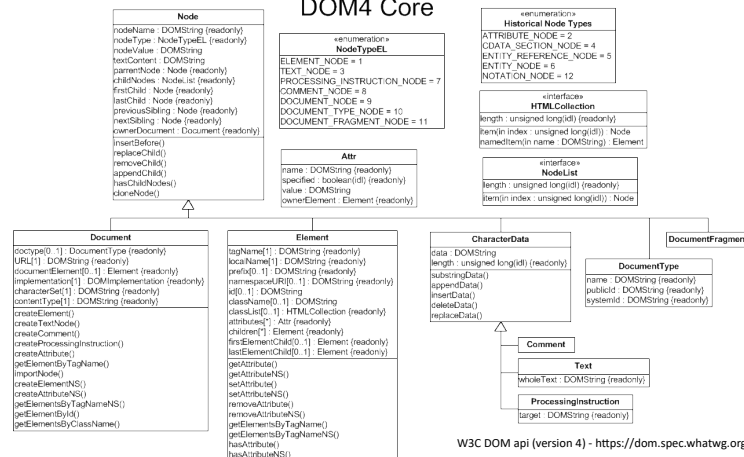
Rules of thumb for modelling with XML:

- limit the number of tag types and attribute types!
- use attributes for simple datatypes only
- order of elements is important
- group elements when appropriate
- anticipate how you are going to write XPath queries

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XML manipulation: Document Object Model (DOM)

DOM4 Core

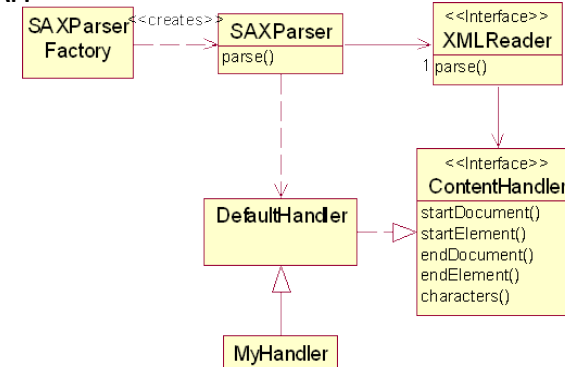


W3C DOM api (version 4) - <https://dom.spec.whatwg.org/>

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SAX (Simple API for XML)

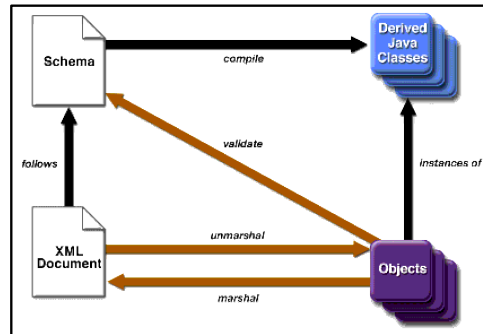
XML traversal API



Java API for XML Processing (JAXP) - <https://docs.oracle.com/javase/8/docs/api/javax/xml/parsing/package-summary.html>

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XML – OOP data binding



XML-OOP data binding

ex Java: <https://zetcode.com/java/jaxb/>

```

Employee.java
@XmlRootElement(name = "employee")
@XmlAccessorType(XmlAccessType.FIELD)
public class Employee implements Serializable {
    private Integer id;
    private String firstName;
    private String lastName;
}
  
```

```

employee.xml
<?xml version="1.0" encoding="UTF-8" standalone="yes"?>
<employee>
  <firstName>Lokesh</firstName>
  <id>1</id>
  <lastName>Gupta</lastName>
</employee>
  
```

Java Architecture for XML Binding (JAXB) example

<https://howtodoinjava.com/jaxb/jaxb-annotations/>

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XPath: Declarative tree-traversal language

XPATH locators

You can test all locator examples using Firebug and Firepath on the following page: <https://vpl.bibliocommons.com/search?q=java&key=word>
See more articles about XPATH on my blog: <http://test-able.blogspot.co>

/input
finds all INPUT elements that are included in the web page

/input[@aria-label='Search Catalogue']
finds all INPUT elements that have an ARIA-LABEL attribute with the "Search Catalogue" value

/button[@data-id='sortSelector']/span
1. finds all BUTTON elements that have a DATA-ID attribute with the "sortSelector" value
2. for each element from the BUTTON list, find the SPAN elements that are direct children

/div[@class='listitem clearfix']/span
1. finds the DIV elements that have the CLASS attribute's value equal to "listitem clearfix"
2. gets the second element from the DIV elements list
3. finds all SPAN elements (direct children or not) that are inside of the second DIV

/input[@id='globalQuery' and @name='q']
finds all INPUT elements that:
1. have an ID attribute with the "globalQuery" value
2. have a NAME attribute with the "q" value

More XPATH locators

You can test all locator examples using Firebug and Firepath on the following page: <https://vpl.bibliocommons.com/search?q=java&key=word>

//div[@class='listitem clearfix']/[3]
1. finds all DIV elements that have the CLASS attribute's value equal to "listitem clearfix"
2. selects the 3rd DIV element from the list of DIV elements

/input[@id='globalQuery' and @name='q']
finds all INPUT elements that:
1. have an ID attribute with the "globalQuery" value
2. have a NAME attribute with the "q" value

/div[contains(@href, 'show_circulation')]
finds all A elements that have "show_circulation" included in the value of the HREF attribute

/div[starts-with(@href, 'item/show_circulation')]
finds all A elements that have the HREF attribute's value starting with "item/show_circulation"

/input[not(@name='q')]
finds all INPUT elements that have the NAME attribute's value different than "q"

<https://www.w3.org/TR/xpath/>
<https://cheatography.com/alexsiminiuc/cheat-sheets/xpath/pdf/>
<https://devhints.io/xpath>

(/div[@class='listitem clearfix']/last())
1. finds all DIV elements that have the CLASS attribute's value equal to "listitem clearfix"
2. select the last DIV element from the list of DIV elements

count(/div[@class='listitem clearfix'])
provides the count of all DIV elements that have the CLASS attribute's value equal to "listitem clearfix"

/x[@class='extendSearch']/testid
1. finds the A elements that have the CLASS attribute's value equal to "extendSearch"
2. gets the value of the TESTID attribute for the A elements

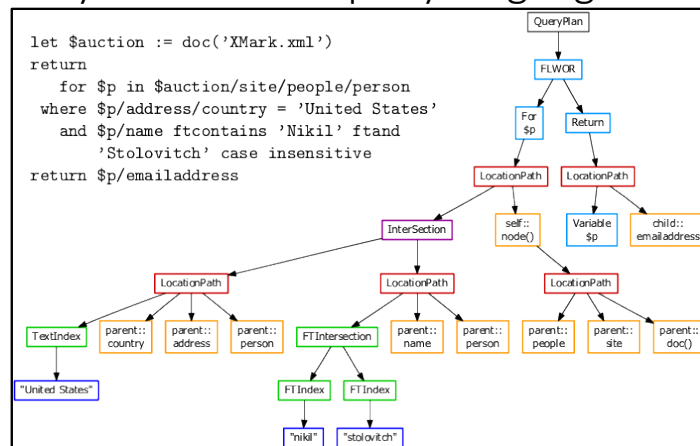
/x[@class='extendSearch']/text()
1. finds the A elements that have the CLASS attribute's value equal to "extendSearch"
2. get the value of the A elements

/div[normalize-space(@class)='listitem clearfix']
1. finds the DIV elements that have a CLASS attribute
2. removes all spaces from the value of the CLASS attribute
3. finds the DIV elements that have the value of the CLASS attribute (excluding spaces) equal to "listitem clearfix"

/x[string-length(@href) > 70]
finds all A elements that have the HREF attribute value length greater than 70 characters

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XQuery: Declarative query language



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XSLT: Declarative transformation language

XSLT

Paradigm Declarative

Developer World Wide Web Consortium (W3C)

First appeared 1998

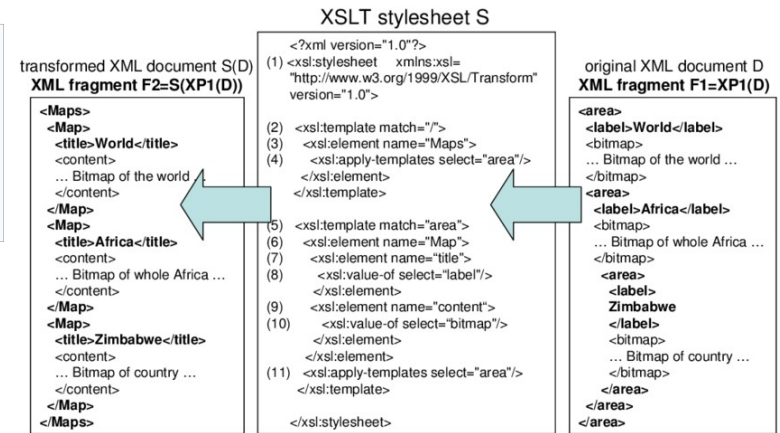
Stable release 3.0 / June 8, 2017; 4 years ago

Filename extensions .xsl

Website www.w3.org/TR/xslt-30/

Major implementations libxslt, Saxon, Xalan

Influenced by DSSSL



Data Interoperability and Semantics

Part 2. Data Formats

Part 2.4. JavaScript Object Notation (JSON)

ICM – Toolbox Engineering and Interoperability of Software Systems – Course unit on Data Interoperability and Semantics
M1 Cyber Physical and Social Systems – Course unit on Data Interoperability and Semantics
Maxime Lefrançois <https://maxime-lefrancois.info>
Course unit URL: <https://ci.mines-st-etienne.fr/cps2/course/data>

JavaScript Object Notation

JavaScript Object Notation

Filename extension	.json
Internet media type	application/json
Type code	TEXT
Uniform Type Identifier (UTI)	public.json
Type of format	Data interchange
Extended from	JavaScript
Standard	STD 90 (RFC 8259), ECMA-404, ISO/IEC 21778:2017
Open format?	Yes
Website	json.org

- since early 2000s. Now used a lot in software development
- many mediatypes based on JSON (118 registered on IANA)
application/geo+json application/ld+json ...
- simple, human-readable
- attribute–value pairs and arrays (or other serializable values)

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JavaScript Object Notation

Filename extension	.json
Internet media type	application/json
Type code	TEXT
Uniform Type Identifier (UTI)	public.json
Type of format	Data interchange
Extended from	JavaScript
Standard	STD 90 (RFC 8259), ECMA-404, ISO/IEC 21778:2017
Open format?	Yes
Website	json.org

```
JSON Object → {  
  "company": "mycompany",  
  "companycontacts": { ← Object Inside Object  
    "phone": "123-123-1234",  
    "email": "myemail@domain.com"  
  },  
  "employees": [ ← JSON Array  
    {  
      "id": 101, ← Number Value  
      "name": "John",  
      "contacts": [ ← Array Inside Array  
        {  
          "email@employee1.com",  
          "email2@employee1.com"  
        },  
        {  
          "id": 102, ← Number Value  
          "name": "William",  
          "contacts": null ← Null Value  
        }  
      ]  
    },  
    {  
      "id": 103, ← Number Value  
      "name": "Mary",  
      "contacts": null ← Null Value  
    }  
  ]  
}
```

- since early 2000s. Now used a lot in software development
- many mediatypes based on JSON (118 registered on IANA)
application/geo+json application/ld+json ...
- simple, human-readable
- attribute–value pairs and arrays (or other serializable values)

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JavaScript Object Notation

JavaScript Object Notation

Filename extension	.json
Internet media type	application/json
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Uniform Type Identifier (UTI)	public.json
Type of format	Data interchange
Extended from	JavaScript
Standard	STD 90 (RFC 8259), ECMA-404, ISO/IEC 21778:2017
Open format?	Yes
Website	json.org

Characters and escaping

- full Unicode character set
- escaping characters `\b \f \n \r \t \" \\`

Data types

- number
- string
- boolean
- array
- object
- null

Semantics

While JSON provides a syntactic framework for data interchange, unambiguous data interchange also requires agreement between producer and consumer on the semantics of specific use of the JSON syntax. One example of where such an agreement is necessary is the serialization of data types defined by the JavaScript syntax that are not part of the JSON standard, e.g., Date, Function, Regular Expression, and "undefined"

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JSON Schema

JSON Schema Validator newtonsoft.com

An online, interactive JSON Schema validator. Supports JSON Schema Draft 3, Draft 4, Draft 6 and Draft 7. [View source code](#)

Select schema:

```

1 {
2   "$schema": "http://json-schema.org/draft-07/schema#",
3   "definitions": {
4     "person": {
5       "type": "object",
6       "properties": {
7         "name": { "type": "string" },
8         "children": {
9           "type": "array",
10          "items": { "$ref": "#/definitions/person" },
11          "default": []
12        }
13      }
14    },
15    "type": "object",
16    "properties": {
17      "person": { "$ref": "#/definitions/person" }
18    }
19  }
20 }

```

Input JSON:

```

1 {
2   "personsdad": {
3     "nameilk": "Elizabeth",
4     "childrenss": {
5       "names": "Charles",
6       "childrens": {
7         "names": "William",
8         "children": {
9           "names": "George",
10          "name": "Charlotte"
11        }
12      }
13    },
14    "names": "Harry"
15  }
16 }

```

✓ No errors found. JSON validates against the schema

JSONPath: Declarative tree-traversal language

XPath	JSONPath	Description
/	\$	the root object/element
.	@	the current object/element
/	. or []	child operator
..	n/a	parent operator
//	..	recursive descent. JSONPath borrows this syntax from E4X.
*	*	wildcard. All objects/elements regardless their names.
@	n/a	attribute access. JSON structures don't have attributes.
[]	[]	subscript operator. XPath uses it to iterate over element collections and for predicates . In Javascript and JSON it is the native array operator.
	[.]	Union operator in XPath results in a combination of node sets. JSONPath allows alternate names or array indices as a set.
n/a	[start:end:step]	array slice operator borrowed from ES4.
[]	?()	applies a filter (script) expression.
n/a	()	script expression, using the underlying script engine.
()	n/a	grouping in XPath

Examples:

```

$.store.book[0].title
$['store']['book'][0]['title']
$.store.book[(@.length-1)].title
$.store.book[?(@.price < 10)].title

```

<https://goessner.net/articles/jsonPath/>

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JSONPath: Declarative tree-traversal language

```

{ "store": {
  "book": [
    { "category": "reference",
      "author": "Nigel Rees",
      "title": "Savings of the Century",
      "price": 8.95
    },
    { "category": "fiction",
      "author": "Evelyn Waugh",
      "title": "Sword of Honour",
      "price": 12.99
    },
    { "category": "fiction",
      "author": "Herman Melville",
      "title": "Moby Dick",
      "isbn": "0-553-21311-3",
      "price": 8.99
    },
    { "category": "fiction",
      "author": "J. R. R. Tolkien",
      "title": "The Lord of the Rings",
      "isbn": "0-395-19395-8",
      "price": 22.99
    }
  ],
  "bicycle": {
    "color": "red",
    "price": 19.95
  }
}

```

XPath	JSONPath	Result
/store/book/author	\$.store.book[*].author	the authors of all books in the store
//author	\$.author	all authors
/store/*	\$.store.*	all things in store, which are some books and a red bicycle.
/store//price	\$.store..price	the price of everything in the store.
//book[3]	\$.book[2]	the third book
//book[last()]	\$.book[(0.length-1)] \$.book[-1:]	the last book in order.
//book[position() < 3]	\$.book[0,1] \$.book[:2]	the first two books
//book[isbn]	\$.book[?(@.isbn)]	filter all books with isbn number
//book[price<10]	\$.book[?(@.price<10)]	filter all books cheaper than 10
//*	\$.*	all Elements in XML document. All members of JSON structure.

<https://goessner.net/articles/jsonPath/>

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APIs for JSON Processing

example for java: <https://javaee.github.io/jsonp/>

{ "JSON": "P" }

Documentation -> Contribute -> Download



Java API for JSON Processing

JSR 374 Specification

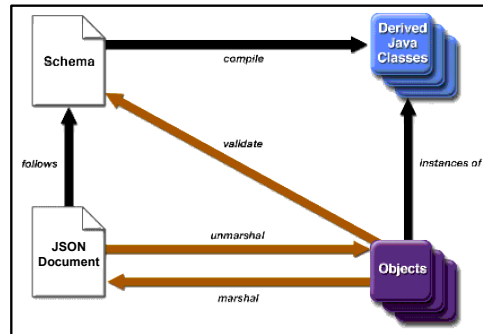
[GETTING STARTED](#) [DOWNLOAD](#)

What is JSON-P?

JSON Processing (JSON-P) is a Java API to process (for e.g. parse, generate, transform and query) JSON messages. It produces and consumes JSON text in a streaming fashion (similar to StAX API for XML) and allows to build a Java object model for JSON text using API classes (similar to DOM API for XML).

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JSON – OOP data binding



JSON-OOP data binding



Parsing Speed	Speed MB/MS	Parsing Time
GSON	100%	0%
Jackson	58%	70.87%
JSON simple	79%	126.58%
JSONP	44%	25.49%

Comparison of Java JSON libraries: Jackson vs. Gson vs. JSON-B vs. JSON-P vs. org.json vs. Jsonpath
<https://itsallbinary.com/jackson-vs-gson-vs-json-b-vs-json-p-vs-org-json-vs-jsonpath-java-json-libraries-features-comparison/>

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Data Interoperability and Semantics

Part 2. Data Formats

Part 2.5. Configuration file formats

ICM – Toolbox Engineering and Interoperability of Software Systems – Course unit on Data Interoperability and Semantics
 M1 Cyber Physical and Social Systems – Course unit on Data Interoperability and Semantics
 Maxime Lefrançois <https://maxime-lefrancois.info>
 Course unit URL: <https://ci.mines-stetienne.fr/cps2/course/data>

.properties files

Filename extension	.properties
--------------------	-------------

Mainly for Java-related conf files

Ex: i18n¹ and l10n²

- key=value,
- key = value,
- key:value,
- key value

¹i18n: internationalization
²l10n: localization

```

1 # You are reading a comment in ".properties" file.
2 ! The exclamation mark can also be used for comments.
3 # Lines with "properties" contain a key and a value separated by a delimiting character.
4 # There are 3 delimiting characters: "-" (equal), ":" (colon) and whitespace (space, \t and \f).
5 website = https://en.wikipedia.org/
6 language = English
7 topic .properties files
8 # A word on a line will just create a key with no value.
9 empty
10 # White space that appears between the key, the value and the delimiter is ignored.
11 # This means that the following are equivalent (other than for readability).
12 hello=hello
13 hello = hello
14 # Keys with the same name will be overwritten by the key that is the furthest in a file.
15 # For example the final value for "duplicateKey" will be "second".
16 duplicateKey = first
17 duplicateKey = second
18 # To use the delimiter characters inside a key, you need to escape them with a \.
19 # However, there is no need to do this in the value.
20 delimiterCharacters\\ = This is the value for the key "delimiterCharacters:\\".
21 # Adding a \ at the end of a line means that the value continues to the next line.
22 multiline = This line \
23 continues
24 # If you want your value to include a \, it should be escaped by another \.
25 path = c:\wiki\templates
26 # This means that if the number of \ at the end of the line is even, the next line is not included in the value.
27 # In the following example, the value for "evenKey" is "This is on one line!".
28 evenKey = This is on one line\\
29 # This line is a normal comment and is not included in the value for "evenKey"
30 # If the number of \ is odd, then the next line is included in the value.
31 # In the following example, the value for "oddKey" is "This is line one and#This is line two".
32 oddKey = This is line one and\\
33 # This is line two
34 # White space characters are removed before each line.
35 # Make sure to add your spaces before your \ if you need them on the next line.
36 # In the following example, the value for "welcome" is "Welcome to Wikipedia!".
37 welcome = Welcome to \
38     Wikipedia!
39 # If you need to add newlines and carriage returns, they need to be escaped using \n and \r respectively.
40 # You can also optionally escape tabs with \t for readability purposes.
41 valueWithEscapes = This is a newline\n and a carriage return\r and a tab\t.
42 # You can also use Unicode escape characters (maximum of four hexadecimal digits).
43 # In the following example, the value for "encodedHelloInJapanese" is "こんにちは".
44 encodedHelloInJapanese = \u3053\u3093\u306b\u3061\u306f
45 # But with more modern file encodings like UTF-8, you can directly use supported characters.
46 helloInJapanese = こんにちは
  
```

INI files

Filename extension	.ini
Internet media type	text/plain, application/textedit, application/zz-winassoc-ini
Type of format	Initialization/Configuration File

https://en.wikipedia.org/wiki/INI_file

- Developed for Windows for initialization: BOOT.INI, SYSTEM.INI, WIN.INI, ...
- Similar in Linux systems with .conf, .cfg, ...
- Syntax used by many programs
 - php.ini
 - ssh.conf
 - git.conf
 - ...

```

; Last modified 1 April 2001 by John Doe
[owner]
name = John Doe
organization = Acme Widgets Inc.

[database]
; use IP address in case network name resolution is not working
server = 192.0.2.62
port = 143
file = "payroll.dat"
  
```

```

[section]
domain = wikipedia.org

[section.subsection]
foo = bar
  
```

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TOML files

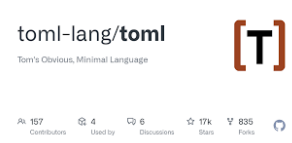
TOML



Filename extension	.toml
Internet media type	Not registered ¹⁾
Developed by	Tom Preston-Werner
Initial release	23 February 2013; 9 years ago
Latest release	v1.0.0 January 11, 2021; 18 months ago
Type of format	Data interchange
Open format?	Yes
Website	toml.io

<https://en.wikipedia.org/wiki/TOML>

Tom's Obvious, Minimal Language.
<https://toml.io/en/>



- key = "value" pairs
- [section names],
- # comments
- Datatypes:
 - String,
 - Integer,
 - Float,
 - Boolean,
 - Datetime,
 - Array,
 - and Table

```
# This is a TOML document.

title = "TOML Example"

[owner]
name = "Tom Preston-Werner"
dob = 1979-05-27T07:32:00-08:00 # First class dates

[database]
server = "192.168.1.1"
ports = [ 8000, 8001, 8002 ]
connection_max = 5000
enabled = true

[servers]

# Indentation (tabs and/or spaces) is allowed but not required
[servers.alpha]
ip = "10.0.0.1"
dc = "eqdc10"

[servers.beta]
ip = "10.0.0.2"
dc = "eqdc10"

[clients]
data = [ ["gamma", "delta"], [1, 2] ]

# Line breaks are OK when inside arrays
hosts = [
  "alpha",
  "omega"
]
```

TOML files

TOML



Filename extension	.toml
Internet media type	Not registered ¹⁾
Developed by	Tom Preston-Werner
Initial release	23 February 2013; 9 years ago
Latest release	v1.0.0 January 11, 2021; 18 months ago
Type of format	Data interchange
Open format?	Yes
Website	toml.io

<https://en.wikipedia.org/wiki/TOML>

Example:
Python packaging and dependency management with Poetry

python-poetry/poetry

Python dependency management and packaging made easy.

334 Contributors · 1k Issues · 133 Discussions · 19k Stars · 2k Forks

```
[project]
name = "infer_pyproject"
version = "0.1.0"
description = "Create a pyproject.toml file for an existing project."
authors = [
  "Martin Thoma <info@martin-thoma.de>"
]
license = "MIT"
readme = "README.md"
python = "3.6"
homepage = "https://github.com/MartinThoma/infer_pyproject"
repository = "https://github.com/MartinThoma/infer_pyproject"
documentation = "https://github.com/MartinThoma/infer_pyproject"

keywords = ["packaging", "dependency", "infer", "pyproject.toml"]

classifiers = [
  "Topic :: Software Development"
]

# Requirements
[dependencies]
Click = ">7.0"

[dev-dependencies]
black = { version = ">18.3-alpha.0", python = ">3.6" }

[scripts]
poetry = "infer_pyproject.cli:main"

[build-system]
requires = [
  "setuptools >= 35.0.2",
  "setuptools_scm >= 2.0.0, <3"
]
build-backend = "setuptools.build_meta"

https://martin-thoma.com/pyprojecttoml/
```

Data Interoperability and Semantics

Part 2. Data Formats

Part 2.6. YAML Ain't Markup Language (YAML)

YAML



Filename extensions	.yaml, .yml
Internet media type	Not registered
Initial release	11 May 2001; 20 years ago
Latest release	1.2 (Third Edition) (1 October 2009; 12 years ago)
Type of format	Data interchange
Open format?	Yes
Website	yaml.org

- since early 2000s
- used a lot for software configuration
- human-readable, superset of JSON

YAML Ain't Markup Language (YAML)

```
--- !clarkevans.com/^invoice
invoice: 34843
date : 2001-01-23
bill-to: &id001
  given : Chris
  family : Dumas
  address:
    lines: |
      458 Walkman Dr.
      Suite #292
    city : Royal Oak
    state : MI
    postal : 48046
ship-to: *id001
product:
  - sku      : BL394D
    quantity : 4
    description: Basketball
    price    : 450.00
  - sku      : BL4438H
    quantity : 1
    description: Super Hoop
    price    : 2392.00
tax : 251.42
total: 4443.52
comments: >
  Late afternoon is best.
  Backup contact is Nancy
  Billsmer @ 338-4338.
```

Annotations in the image:

- SCALAR: points to `invoice: 34843`
- COLLECTIONS: points to `bill-to: &id001`
- MULTI-LINE COLLECTIONS: points to the `address` block
- LISTS/DICTIONARIES: points to the `product` list
- MULTI-LINE FORMATTING: points to the `comments: >` block

YAML Ain't Markup Language (YAML)

YAML	
	
Filename extensions	.yaml, .yml
Internet media type	Not registered
Initial release	11 May 2001; 20 years ago
Latest release	1.2 (Third Edition) (1 October 2009; 12 years ago)
Type of format	Data interchange
Open format?	Yes
Website	yaml.org

- Whitespace indentation, tabs forbidden
- end-of-line comments (#)
- lists

```
--- # Favorite movies
- Casablanca
- North by Northwest
- The Man Who Wasn't There
```

or

```
--- # Shopping list
[milk, pumpkin pie, eggs, juice]
```

- associative arrays

```
--- # Indented Block
name: John Smith
age: 33
--- # Inline Block
{name: John Smith, age: 33}
```

YAML Ain't Markup Language (YAML)

YAML	
	
Filename extensions	.yaml, .yml
Internet media type	Not registered
Initial release	11 May 2001; 20 years ago
Latest release	1.2 (Third Edition) (1 October 2009; 12 years ago)
Type of format	Data interchange
Open format?	Yes
Website	yaml.org

- strings

```
data: |
  There once was a tall man from Ealing
  Who got on a bus to Darjeeling
  It said on the door
  "Please don't sit on the floor"
  So he carefully sat on the ceiling
```

or

```
data: >
  Wrapped text
  will be folded
  into a single
  paragraph

Blank lines denote
paragraph breaks
```

- datatypes

```
---
a: 123                # an integer
b: "123"              # a string, disambiguated by quotes
c: 123.0              # a float
d: !!float 123        # also a float via explicit data type prefixed by (!! )
e: !!str 123          # a string, disambiguated by explicit type
f: !!str Yes          # a string via explicit type
g: Yes                # a boolean True (yaml1.1), string "Yes" (yaml1.2)
h: Yes we have No bananas # a string, "Yes" and "No" disambiguated by context.
```

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YAML Ain't Markup Language (YAML)

YAML	
	
Filename extensions	.yaml, .yml
Internet media type	Not registered
Initial release	11 May 2001; 20 years ago
Latest release	1.2 (Third Edition) (1 October 2009; 12 years ago)
Type of format	Data interchange
Open format?	Yes
Website	yaml.org

- anchors and references

```
--- # Sequencer protocols for Laser eye surgery
- step: &id001          # defines anchor label &id001
  instrument: Lasik 2000
  pulseEnergy: 5.4
  pulseDuration: 12
  repetition: 1000
  spotSize: 1mm
- step: &id002
  instrument: Lasik 2000
  pulseEnergy: 5.0
  pulseDuration: 10
  repetition: 500
  spotSize: 2mm
- step: *id001           # refers to the first step (with anchor &id001)
- step: *id002           # refers to the second step
- step: *id002
```

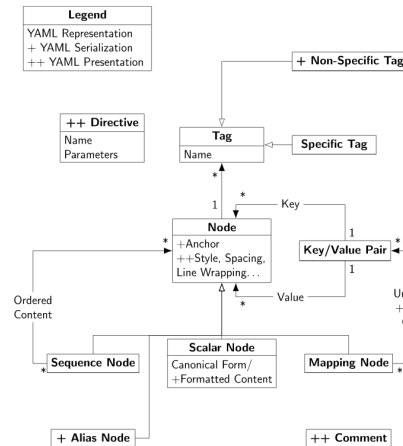
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YAML Ain't Markup Language (YAML)

<https://yaml.org/refcard.html>

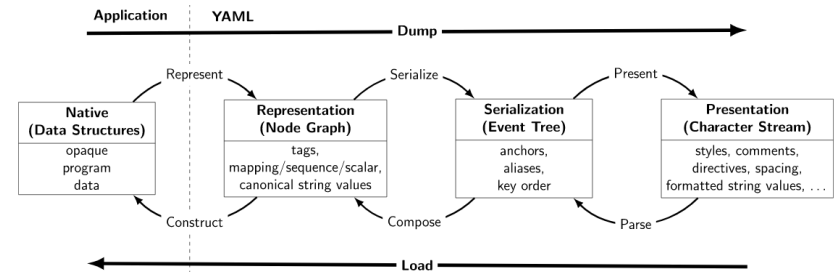
```
%YAML 1.1 # Reference card
---
Collection indicators:
'?' : Key indicator.
':' : Value indicator.
'-' : Nested series entry indicator.
',' : Separate in-line branch entries.
'[]' : Surround in-line series branch.
'{' : Surround in-line keyed branch.
Scalar indicators:
'''' : Surround in-line unescaped scalar ('' escaped ').
''' : Surround in-line escaped scalar (see escape codes below).
'|' : Block scalar indicator.
'>' : Folded scalar indicator.
'-' : Strip chomp modifier ('|- ' or '>- ').
'+' : Keep chomp modifier ('|+ ' or '>+ ').
1-9 : Explicit indentation modifier ('|1' or '>2').
# Modifiers can be combined ('|2-', '>+1').
Alias indicators:
'&' : Anchor property.
'*' : Alias indicator.
Tag property: # Usually unspecified.
none : Unspecified tag (automatically resolved by application).
'!' : Non-specific tag (by default, "!!map"/"!!seq"/"!!str").
'!foo' : Primary (by convention, means a local "foo" tag).
'!|foo' : Secondary (by convention, means "tag:yaml.org,2002:foo").
'!|foo' : Requires "!!TAG !|!" (prefix) (and then means "<prefix>foo").
'!<foo' : Verbatim tag (always means "foo").
Document indicators:
'%' : Directive indicator.
'---' : Document header.
'...' : Document terminator.
Misc indicators:
'#' : Throwaway comment indicator.
'@' : Both reserved for future use.
Special keys:
'=' : Default "value" mapping key.
'<<' : Merge keys from another mapping.
Core types: # Default automatic tags.
'!!map' : { Hash table, dictionary, mapping }
'!!seq' : { List, array, tuple, vector, sequence }
'!!str' : Unicode string
More types:
'!!set' : { cherries, plums, apples }
'!!omap' : [ one: 1, two: 2 ]
Language Independent Scalar types:
{ ~, null } : Null (no value).
[ 1234, 0x4D2, 02333 ] : [ Decimal int, Hexadecimal int, Octal int ]
[ 1_230.15, 12.3015e+02 ] : [ Fixed float, Exponential float ]
[ .inf, -.inf, .NaN ] : [ Infinity (float), Negative, Not a number ]
{ Y, true, Yes, ON } : Boolean true
{ n, FALSE, No, off } : Boolean false
? !!binary >
  R0LG...BADS=
  : >- Base 64 binary value.
Escape codes:
Numeric : { "\x12": 8-bit, "\u1234": 16-bit, "\U00102030": 32-bit }
Protective: { "\\\": '\\', "\\n": '\n', "\\>": '>', "\\<TAB>": '\t' }
C : { "\0": NUL, "\\a": BEL, "\\b": BS, "\\f": FF, "\\n": LF, "\\r": CR, "\\t": TAB, "\\v": VTAB }
Additional: { "\\e": ESC, "\\_": NBS, "\\N": NEL, "\\L": LS, "\\P": PS }
```

YAML Ain't Markup Language (YAML)



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APIs for YAML Processing



- Tutorial for Java: <https://www.baeldung.com/java-snake-yaml>
- Package for JavaScript: <https://www.npmjs.com/package/yaml>
- Module for Python: <https://pyyaml.org/wiki/PyYAMLDocumentation>

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Data Interoperability and Semantics

Part 2. Data Formats

Part 2.7. Lightweight markup languages

Lightweight markup languages

Comparing language features							
Language	HTML export tool	HTML import tool	Tables	Link titles	class attribute	id attribute	Release date
AsciiDoc	Yes	Yes	Yes	Yes	Yes	Yes	2002-11-25 ^[1]
BBCode	No	No	Yes	No	No	No	1998
Creole	No	No	Yes	No	No	No	2007-07-04 ^[2]
Gemtext	Yes	?	No	Yes	No	No	2020
GitHub Flavored Markdown	Yes	No	Yes	Yes	No	No	2011-04-28+
Jira Formatting Notation	Yes	No	Yes	Yes	No	No	2002 ^[3]
Markdown	Yes	Yes	No	Yes	Yes/No	Yes/No	2004-03-19 ^{[4][5]}
Markdown Extra	Yes	Yes	Yes ^[6]	Yes	Yes	Yes	2013-04-11 ^[7]
MarkedText ^[8]	Yes	No	Yes	No	No	No	2021-01
MediaWiki	Yes	Yes	Yes	Yes	Yes	Yes	2002 ^[8]
MultiMarkdown	Yes	No	Yes	Yes	No	No	2009-07-13
Org-mode	Yes	Yes ^[9]	Yes	Yes	Yes	Yes	2003 ^[10]
PmWiki	Yes ^[11]	Yes	Yes	Yes	Yes	Yes	2002-01
POD	Yes	?	No	Yes	?	?	1994
reStructuredText	Yes	Yes ^[9]	Yes	Yes	Yes	auto	2002-04-02 ^[12]
Slack	No	No	No	Yes	No	No	2013+ ^{[13][14]}
TiddlyWiki	Yes	No	Yes	Yes	Yes	No	2004-09 ^[15]
Textile	Yes	No	Yes	Yes	Yes	Yes	2002-12-26 ^[16]
Texy	Yes	Yes	Yes	Yes	Yes	Yes	2004 ^[17]
txt2tags	Yes	Yes ^[18]	Yes ^[19]	Yes	Yes/No	Yes/No	2001-07-26 ^[20]
WhatsApp	No	No	No	No	No	No	2016-03-16 ^[21]

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HTML output	<code>strongly emphasized</code> <code>bold text</code>	<code>emphasized text</code> <code><i>italic text</i></code>	<code><code>code</code></code> <code><tt>monospace text</tt></code>	semantic presentational
AsciiDoc	*bold text*	_italic text_	+monospace text+	Can double operators to apply formatting where there is no word bound example **b*old t**ex**t yields bold text .
ATX	*bold text*	_italic text_	[monospace text]	email style
BBCode	[b]bold text[/b]	[i]italic text[/i]	[code]monospace text[/code]	Formatting works across line breaks.
Creole	**bold text**	//italic text//	{{(monospace text)}}	Triple curly braces are for nowiki which is optionally monospace.
Gemtext	N/A	N/A	'''alt text monospace text ...	Text immediately following the first three backticks is alt-text.
Jira Formatting Notation	*bold text*	_italic text_	{{(monospace text)}}	
Markdown ^[42]	**bold text**	*italic text*	'monospace text'	semantic HTML tags
MarkadText ⁴³	**bold text**	//italic text//	;monospace text;;	semantic HTML tags
MediaWiki	'''bold text'''	''italic text''	<code>monospace text</code>	mostly resorts to inline HTML
Org-mode	*bold text*	/italic text/	<code>	
PmWiki	'''bold text'''	''italic text''	@monospace text@	
reST	**bold text**	*italic text*	'monospace text'	
Setext	**bold text**	~italic text~	N/A	
Textile ^[43]	*strong*	_emphasis_	@monospace text@	semantic HTML tags presentational HTML tags
Textyl	**bold text**	*italic text*	'monospace text'	semantic HTML tags by default, optional support for presentational tags
TidlyWiki	'''bold text'''	//italic text//	'monospace text'	
txt2tags	**bold text**	//italic text//	'monospace text'	
POD	=bold text=	italic text	Comonospace text	Indented text is also shown as monospaced code.
Slack	*bold text*	_italic text_	'monospace text'	'''block of monospaced text'''
WhatsApp	*bold text*	_italic text_	'''monospace text'''	

Paragraphs and Line Breaks * Para – one or more consecutive lines * Empty lines – end of paragraph * > 2 spaces at Eol. – HTML line break Headers * # This is an H1 * ## This is an H2 * ##### This is an H6 - Alternative: =s for H1, --s for H2 Emphasis * *This is an * and _so is this_. * **This is a ** and ___so is this___. * Use same closing marker as opening * Emphasis possible in middle of word * !^ or !_ for a literal ^ or _ Blockquotes * Prefix > for each blockquote line... or even hard-wrapped paragraph * Additional > for nested blockquotes * Blockquotes can contain Markdown Images * ![Alt text](URL "Title") * ![:text:]([id]) [id]: URL "Title" * See syntax for Links	Links Inline * This is [an example](http://example.com/) link * This is [example](http://example.com/ "Title") with a title Reference * This is a [reference link][id] with an id [id]: http://example.com/ "Title" * This is a [reference link] without an id [reference link]: http://example.com/ (Title) * Link id can be letters, numbers, spaces, and punctuation * Link id is case-insensitive * In ref links, link definition can be indented up to 3 spaces * In ref links, use parentheses, single or double quotes for title * In ref links, link URL can be surrounded by < > * In ref links, title can be on separate line with indentation * In ref links, link definitions can appear anywhere in document Lists <table> <tr> <td>Unordered</td><td>Asterisks, pluses & hyphens interchangeably</td><td>+ Red - Green - Blue</td></tr> <tr> <td>Ordered</td><td>Numbers, not necessarily sequential. Always start with 1.</td><td>1. Red 1. Green 1. Blue</td></tr> </table> * List marker must be followed by 1/more spaces or a tab * List marker can be indented upto 3 spaces * Hanging indent supported but not required * Blank lines between list items implies paragraph * Paragraph start must be indented by 4 spaces or a tab * To avoid unintended list numbering (e.g. 1986. What a great season) backslash the period (1986. What a great season). Markdown ➔ http://daringfireball.net/projects/markdown/ Cheat sheet from Ahren Code ➔ http://Ahren.org/code	Unordered	Asterisks, pluses & hyphens interchangeably	+ Red - Green - Blue	Ordered	Numbers, not necessarily sequential. Always start with 1.	1. Red 1. Green 1. Blue	Code Block * Indent code by 4 spaces or 1 tab * One level indentation will be removed * & and <_> are automatically HTML'ised * Markdown not usable in code blocks Code Spans * Use backticks around code: <code>printf()</code> * Use multiple backticks for literal backtick: <code>Is 'date+sh' [wc -l ']</code> * Use space if literal backtick is at start of code span: <code>`</code> Miscellaneous Horizontal Rule / Line 3 or more asterisks, hyphens or underscores List with embedded Blockquote Indent > delimiters: * A list item with a blockquote: > This is a blockquote List with embedded Code block Indent code block 8 spaces or two tabs: * A list item with a code block: ... some code ... Automatic Links * Use <_> for auto-linking URLs * Use <_> for auto-linking email addrs * Email text is auto obscured (somewhat) For all else use HTML markup * blank lines around block level elements * no indentation for tags * no Markdown inside HTML blocks
Unordered	Asterisks, pluses & hyphens interchangeably	+ Red - Green - Blue						
Ordered	Numbers, not necessarily sequential. Always start with 1.	1. Red 1. Green 1. Blue						

Data Interoperability and Semantics

Part 2. Data Formats

Part 2.8. Compressed formats

Compression

A compressed file is an archive that contains one or more file that have been reduced in size.

many different file compression types: **zip**, **arc**, **arj**, **rar**, **cab**, **tar.gz**, ...

lossless file compression

reduce redundancy without losing data

ex. AAABBBBCC -> A3B5C2

lossy file compression

ok to loose some data

ex. video, audio, images

How compression works



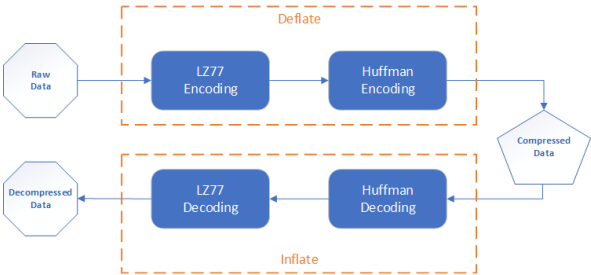
Compression - Computerphile
Computerphile • 384K views • 8 years ago
Most of us deal with data compression on a daily basis, but what is it and how does it work? Professor David Brailsford introduces compression with regards to text and pictures. <http://www.facebook.com/computerphile>...
CC



Elegant Compression in Text (The LZ 77 Method) - Computerphile
Computerphile • 436K views • 8 years ago
Text compression methods such as LZ can reduce file sizes by up to 80%. Professor Brailsford explains the nuts and bolts of how it is done. Original Compression film: <http://youtu.be/Lto-ajuqW3w...>
CC



How Huffman Trees Work - Computerphile
Computerphile • 225K views • 8 years ago
How do we derive the most compact codes for a situation? Huffman Trees can help. Professor Brailsford explains how computer scientists like their trees to be upside down. "Entropy in Compression..."
CC

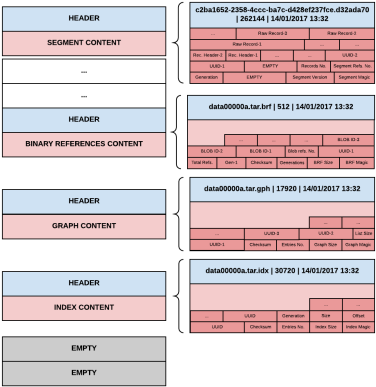


gzip	
Filename extension	.gz
Internet media type	application/gzip ^[2]
Uniform Type Identifier (UTI)	org.gnu.gzip-archive
Magic number	1f 8b
Developed by	Jean-loup Gailly and Mark Adler
Type of format	Data compression
Open format?	Yes
Website	gzip.org (obsolete)

ZIP file format	
Filename extension	.zip .zipx
Internet media type	application/zip ^[1]
Uniform Type Identifier (UTI)	com.pkware.zip-archive
Magic number	none PK\x03\x04 PK\x05\x06 (empty) PK\x07\x08 (spanned)
Developed by	PKWARE, Inc.
Initial release	14 February 1989; 32 years ago
Latest release	6.3.9 (15 July 2020; 15 months ago)
Type of format	Data compression
Extended to	JAR (EAR, RAR (Java), WAR) (Microsoft) Office Open XML (Microsoft) Open Packaging Conventions OpenDocument (ODF) XPI (Mozilla extensions)
Standard	APPNOTE from PKWARE ISO/IEC 21320-1:2015 (a subset of ZIP file format 6.3.3) ^[3]
Open format?	Yes

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tar	
Filename extension	.tar
Internet media type	application/x-tar
Uniform Type Identifier (UTI)	public.tar-archive
Magic number	ustar\000 at byte offset 257 (for POSIX versions) ustar\040\040\0 (for old GNU tar format) ^[1] absent in pre-POSIX versions
Latest release	various (various)
Type of format	File archiver
Standard	POSIX since POSIX.1, presently in the definition of pax ^[1]
Open format?	Yes



+

gzip	
Filename extension	.gz
Internet media type	application/gzip ^[2]
Uniform Type Identifier (UTI)	org.gnu.gzip-archive
Magic number	1f 8b
Developed by	Jean-loup Gailly and Mark Adler
Type of format	Data compression
Open format?	Yes
Website	gzip.org (obsolete)

Data Interoperability and Semantics

Part 2. Data Formats
Part 2.9 Multimedia formats

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Portable Network Graphics



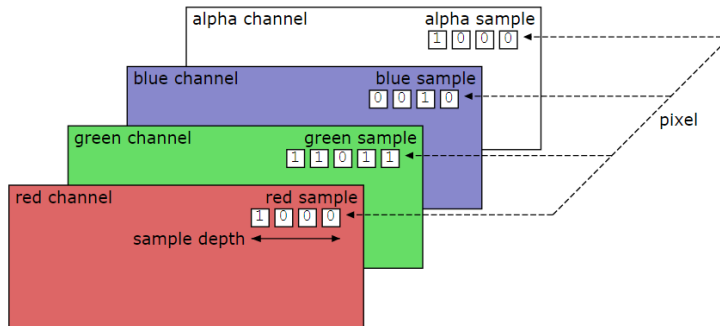
A PNG image with an 8-bit transparency channel, overlaid onto a checkered background, typically used in graphics software to indicate transparency

Filename extension .png
Internet media type image/png
Type code PNGF
Uniform Type Identifier (UTI) public.png
UTI conformation public image
Magic number 89 50 4e 47 0d 0a 1a 0a
Developed by PNG Development Group (donated to W3C)
Initial release 1 October 1996; 25 years ago
Type of format Lossless bitmap image format
Extended to Standard APNG, JNG and MNG
ISO/IEC 15948,^[1] IETF RFC 2083
Open format? Yes

PNG

W3C REC and ISO/IEC 15948:2003

<http://www.w3.org/TR/PNG>



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Portable Network Graphics



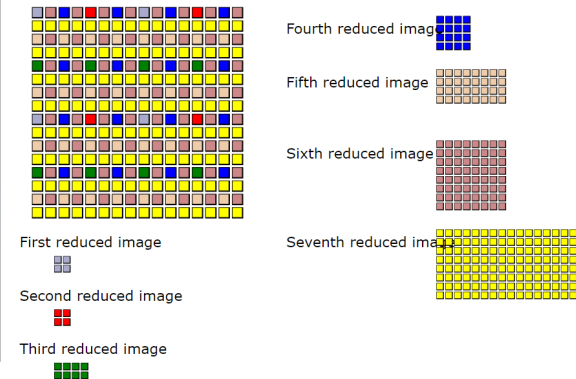
A PNG image with an 8-bit transparency channel, overlaid onto a checkered background, typically used in graphics software to indicate transparency

Filename extension .png
Internet media type image/png
Type code PNGF
Uniform Type Identifier (UTI) public.png
UTI conformation public image
Magic number 89 50 4e 47 0d 0a 1a 0a
Developed by PNG Development Group (donated to W3C)
Initial release 1 October 1996; 25 years ago
Type of format Lossless bitmap image format
Extended to Standard APNG, JNG and MNG
ISO/IEC 15948,^[1] IETF RFC 2083
Open format? Yes

PNG

W3C REC and ISO/IEC 15948:2003

<http://www.w3.org/TR/PNG>



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WebP



An example WebP image

Filename extension .webp^[1]
Internet media type image/webp
Magic number 52 49 46 46 xx xx xx xx 57 45 42 50
Developed by Google
Initial release 30 September 2010; 11 years ago^[2]
Type of format Image format
 Lossless/lossy compression algorithm
Contained by Resource Interchange File Format (RIFF)^[3]
Open format? Yes^[4]
Website developers.google.com/speed/webp^[5]

Modern image file formats: WebP

- WebP lossless images are 26% smaller in size compared to PNGs.
- WebP lossy images are 25-34% smaller than comparable JPEG images at equivalent structural similarity index measure quality index.

Image	File Name	Original Size	Compressed JPG	WebP Format
	jpg-to-webp-1.jpg	480 KB	407 KB	43 KB
	jpg-to-webp-2.jpg	659 KB	578 KB	113 KB
	jpg-to-webp-3.jpg	787 KB	715 KB	127 KB
	jpg-to-webp-4.jpg	617 KB	543 KB	61 KB

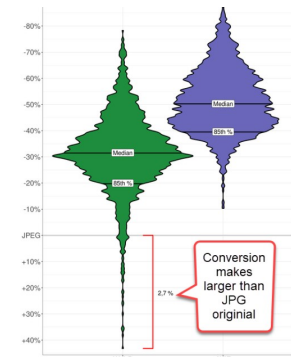
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Modern image file formats: AVIF

AV1 Image File Format (AVIF)

Filename extension .avif, .avifs; .heif, .heifs; .hif
Internet media type image/avif, image/avif-sequence
Developed by Alliance for Open Media
Initial release v1.0.0, 19 February 2019
Type of format Image format
 Lossless/lossy compression algorithm
Contained by HEIF
Extended from HEIF, ISO/BMFF, AV1
Open format? Yes
Website aomedia.com; github.io/av1-avif/

- In most cases, AVIF generates a smaller image payload than WebP.
- In a few cases, WebP generates a larger version than the original JPEG.
- ImageEngine will recognize and deliver the most format with the smallest possible payload.



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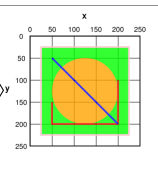
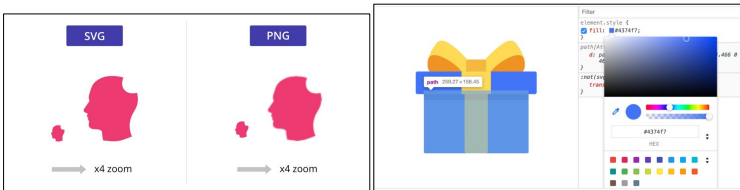
<https://imageengine.io/blog/how-efficient-is-avif/>

Scalable Vector Graphics



Internet media type	image/svg+xml [1][2]
Uniform Type Identifier (UTI)	public.svg-image
Developed by	W3C
Initial release	4 September 2001 (20 years ago)
Latest release	1.1 (Second Edition) (16 August 2011; 10 years ago)
Type of format	Vector graphics
Extended from	XML
Standard	W3C SVG [3]
Open format?	Yes
Website	www.w3.org/Graphics/ SVG [4]

```
<?xml version="1.0" encoding="UTF-8" standalone="no"?>
<!DOCTYPE svg PUBLIC "-//W3C//DTD SVG 1.1//EN" "http://www.w3.org/Graphics/SVG/1.1/DTD/svg11.dtd">
<svg width="391" height="391" viewBox="-70.5 -70.5 391 391" xmlns:xlink="http://www.w3.org/1999/xlink">
  <rect fill="#fff" stroke="#000" x="-70" y="-70" width="390" height="390"/>
  <g opacity="0.8">
    <rect x="25" y="25" width="200" height="200" fill="lime" stroke-width="4" stroke="pink" />
    <circle cx="125" cy="125" r="75" fill="orange" />
    <polyline points="50,150 50,200 200,200 200,100" stroke="red" stroke-width="4" fill="none" />
    <line x1="50" y1="50" x2="200" y2="200" stroke="blue" stroke-width="4" />
  </g>
</svg>
```

What is an SVG File Used For and Why Developers Should be Using Them
 # Published Jan 19, 2021 - <https://deliciousbrains.com/svg-advantages-developers/>

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Recommendations for images in the browser

<https://developer.mozilla.org/en-US/docs/Web/Media/Formats>

Photographs

- AVIF*, WebP, or JPEG

Icons

- SVG, Lossless WebP, or PNG

Screenshots

- Lossless WebP or PNG

Diagrams, drawings, and charts

- SVG, PNG

AVIF as a Progressive Enhancement

```
<picture>
  <source srcset="photo.avif" type="image/avif">
  <source srcset="photo.webp" type="image/webp">
  
</picture>
```

Annotations: AVIF (pointing to the first source), WebP (pointing to the second source), Fallback JPEG (pointing to the img tag).

* I added AVIF here

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Audio file formats

https://en.wikipedia.org/wiki/Audio_file_format

Waveform Audio File Format (WAVE/WAV)



Filename extension	.wav, .wave
Internet media type	audio/vnd.wave, ^[1] audio/wav, audio/wave, audio/x-wav ^[2]
Type code	WAVE
Uniform Type Identifier (UTI)	com.microsoft.waveform-audio
Developed by	IBM & Microsoft
Initial release	August 1991; 30 years ago ^[3]
Latest release	Multiple Channel Audio Data and WAVE Files (7 March 2007; 14 years ago (update) ^{[4][5]}
Type of format	audio file format, container format
Extended from	RIFF
Extended to	BWF, RF64

MP3



Filename extension	.mp3
Internet media type	.bit (before 1995) ^[1] audio/mpeg ^[2] audio/mp4 ^[3] audio/mpa-robust ^[4] audio/mpeg4-generic
Developed by	Karlheinz Brandenburg, Ernst Eberlein, Heinz Gerhäuser, Bernhard Grill, Jürgen Herre and Harald Popp (all of Fraunhofer Society), ^[5] and others
Initial release	1991; 30 years ago
Type of format	Digital audio
Contained by	MPEG-ES
Standards	ISO/IEC 11172-3 ^[6] ISO/IEC 13818-3 ^[7]
Open format?	Yes ^[8]

Advanced Audio Coding

Filename extension	MPEG/3GPP container • .m4a, .mp4, .3gp
Internet media type	Apple container • .m4a, .m4b, .m4p, .m4r, .m4v ADTS stream • .aac
Developed by	Bell, Fraunhofer, Dolby, Sony, Nokia, LG Electronics, NEC, NTT Docomo, Panasonic ^[1]
Initial release	1997; 24 years ago ^[2]
Type of format	Audio compression format, lossy compression
Contained by	MPEG-4 Part 14, 3GP and 3G2, ISO base media file format and Audio Data Interchange Format (ADIF)
Standard	ISO/IEC 13818-7, ISO/IEC 14496-3

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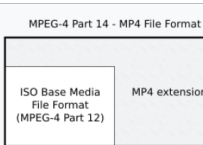
Video file formats

Audio Video Interleave

Filename extension	.avi
Internet media type	video/vnd.avi ^[1] video/avi video/msvideo video/x-msvideo "vfw"
Type code	public.avi
Developed by	Microsoft
Initial release	November 10, 1992; 29 years ago
Container for	Audio, Video
Extended from	Resource Interchange File Format
Open format?	No
Website	https://docs.microsoft.com/en-us/windows/win32/directshow/avi-file-format

MPEG-4 Part 14

MPEG-4 Part 14 - MP4 File Format



Filename extension	.mp4, .m4a, .m4p, .m4b, .m4r and .m4v ^[note 1]
Internet media type	video/mp4 audio/mp4
Type code	mp4
Developed by	International Organization for Standardization
Initial release	2001; 20 years ago
Type of format	Media container
Container for	Audio, video and text
Extended from	QuickTime File Format and MPEG-4 Part 12
Standard	ISO/IEC 14496-14
Open format?	Yes

3GP

Filename extension	.3gp
Internet media type	Video/3gpp, audio/3gpp public.3gpp
Uniform Type Identifier (UTI)	3GPP
Developed by	media container
Type of format	audio, video, text
Container for	MPEG-4 Part 12

3G2

Filename extension	.3g2
Internet media type	video/3gpp2, audio/3gpp2 public.3gpp2
Uniform Type Identifier (UTI)	3GPP2
Developed by	media container
Type of format	audio, video, text
Container for	MPEG-4 Part 12

WebM



Filename extension	.webm
Internet media type	video/webm, audio/webm
Developed by	Initially On2, Xiph, and Matroska; later Google
Initial release	May 18, 2010; 11 years ago ^[1]
Latest release	v1.9.0 ^[2] (December 19, 2019; 22 months ago)
Type of format	Video file format
Container for	VP8/VP9/AV1 (video) Vorbis/Opus (audio)
Extended from	Limited subset of Matroska
Open format?	Yes ^[3]
Website	www.webmproject.org

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Recommendations for audio and video files

<https://developer.mozilla.org/en-US/docs/Web/Media/Formats>

Audio-only files

If you need...	Consider using this container format
Compressed files for general-purpose playback	MP3 (MPEG-1 Audio Layer III)
Losslessly compressed files	FLAC with ALAC fallback
Uncompressed files	WAV

Video files

If you need...	Consider using this container format
General purpose video, preferably in an open format	WebM (ideally with MP4 fallback)
General purpose video	MP4 (ideally with WebM or Ogg fallback)
High compression optimized for slow connections	3GP (ideally with MP4 fallback)
Compatibility with older devices/browsers	QuickTime (ideally with AVI and/or MPEG-2 fallback)

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Data Interoperability and Semantics

Part 2. Data Formats

Part 2.10 3D models

(focusing on Web and Cyber-Physical Systems application domains)

ICM – Toolbox Engineering and Interoperability of Software Systems – Course unit on Data Interoperability and Semantics
M1 Cyber Physical and Social Systems – Course unit on Data Interoperability and Semantics
Maxime Lefrançois <https://maxime-lefrancois.info>
Course unit URL: <https://ci.mines-stetienne.fr/cps2/course/data>



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3D models

Many file formats



Key features of a 3D file:

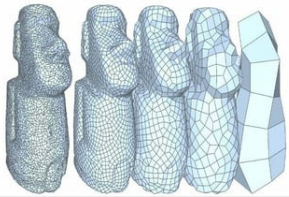
- geometry,
- surface texture,
- scene details,
- animation of the model
- element properties,

<https://all3dp.com/2/most-common-3d-file-formats-model/>

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Shape Geometry

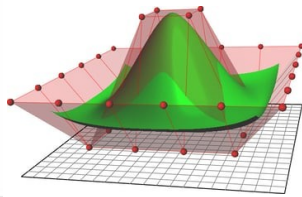
a) Approximate Mesh Encoding
« tessellations »: decompose a surface in polygons (usually triangles)
Good for 3D printing
Files may be huge.



<https://www.digitalpatterning.net/doblog/how-do-i-know-the-pattern-is-right>

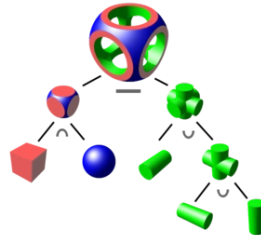
<https://all3dp.com/2/most-common-3d-file-formats-model/>

b) Precise Mesh Encoding
Parametric surfaces made of control points and knots. Example: non-uniform rational basis spline (NURBS)
Exact at any resolution
Slow rendering



https://en.wikipedia.org/wiki/Non-uniform_rational_B-spline

c) Constructive Solid Geometry
Primitive shapes that are combined using Boolean operations
Good for CAD

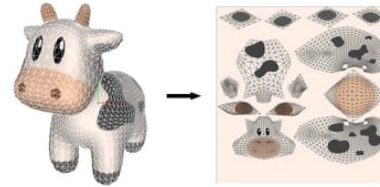


https://en.wikipedia.org/wiki/Constructive_solid_geometry

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Surface Textures

a) Texture Mapping
every point in the 3D model's surface (or the polygonal mesh) is mapped to a two-dimensional image.

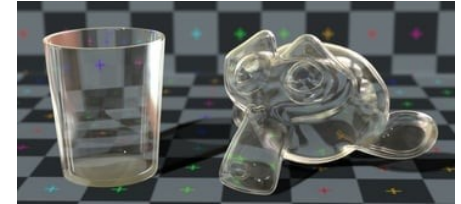


<https://metalbyexample.com/textures-and-samplers/>



<https://www.creativeblog.com/3d-tips/find-high-res-textures-1232646>

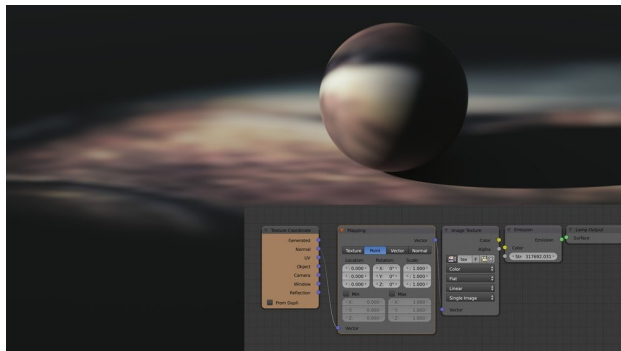
b) Face Attributes
each face of the mesh has a set of attributes
Color, texture, material type, reflection, refraction,...



<https://www.blendernation.com/2021/11/05/realistic-glass-shader-in-blender-eevee-tutorial/>

Scene detail

- layout of the 3D model in terms of cameras, light sources, and other nearby 3D models

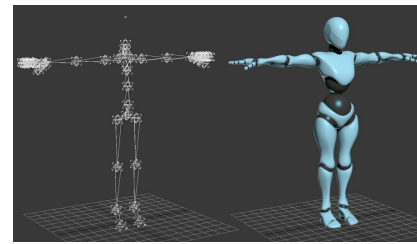


<https://www.creativevrmp.com/light-texture-tutorial-1-lighting-book.html>

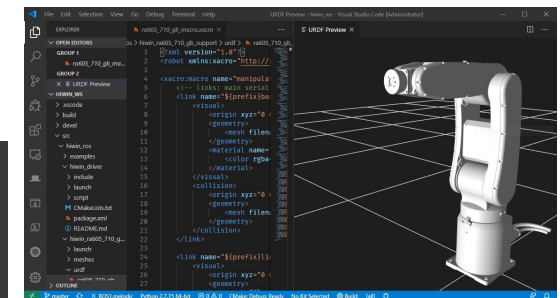
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Animation

- skeletal animation: skeleton + joints



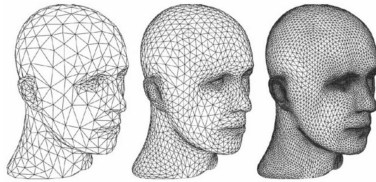
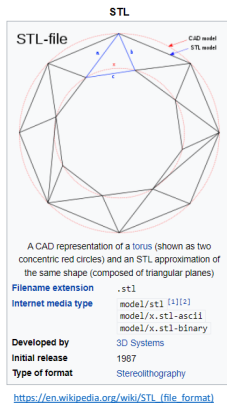
http://www.downloads.redway3d.com/downloads/public/documentation/wf_skeletal_animation.html



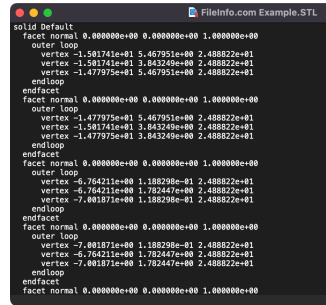
Unified Robot Description Format (URDF) in Visual Studio Code
https://microsoft.github.io/Win-RoS-Landing-Page/hiwin_case_study.html

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Popular 3D file formats: STL (“stereolithography”)



- Popular for 3D printing
- Triangular mesh,
- No color information
- ASCII or Binary representation
- Superseded by OBJ, 3MF, AMF, ...



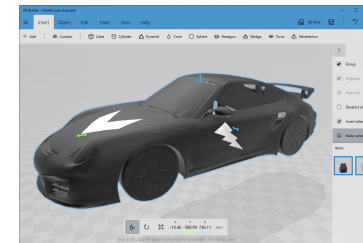
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Popular 3D file formats: Wavefront OBJ file format

OBJ geometry format	
Filename extension	.obj
Internet media type	model/obj [1]
Developed by	Wavefront Technologies
Type of format	3D model format

MTL material format	
Filename extension	.mtl
Internet media type	model/mtl [1]
Magic number	ASCII: newmtl Hex: 6E65776D746C [4]
Developed by	Wavefront Technologies
Type of format	3D texture format

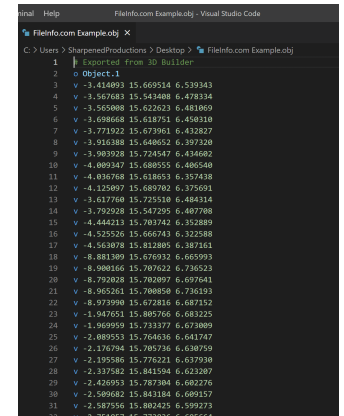
https://en.wikipedia.org/wiki/Wavefront_.obj_file



OBJ file open in Microsoft 3D Builder

- Popular for 3D printing and 3D graphics
- Triangular mesh
- + other kinds of interpolation: Taylor, B-splines...
- No animation, no deformation
- Reference to companion file MTL (Material Template Library)

<https://people.sc.fsu.edu/~jburkardt/data/mtl/mtl.html>

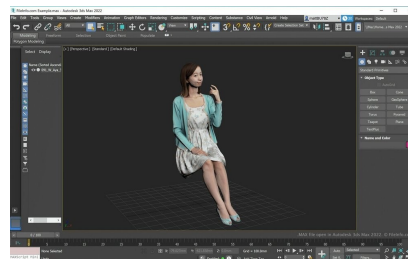


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Popular 3D file formats: Autodesk 3DS Max file format

3DS Max File	
Filename extension	.3ds
Internet media type	application/x-3ds, image/x-3ds
Magic number	4D 4D (hex), MM (ASCII)
Developed by	Autodesk Inc.
Type of format	3D file formats

<https://en.wikipedia.org/wiki/3ds>



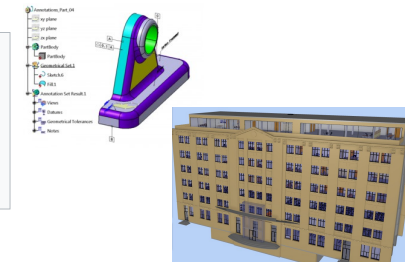
Reference: <http://paulbourke.net/dataformats/3ds/>
Tree structure made of chunks
In binary :
- 6 byte Chunk header:
 - 1-2 = chunk ID
 - 3-6 = little-endian length of the chunk
- Next bytes: chunk's data, including sub-chunks

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Popular 3D file formats: ISO 10303-21 STEP-files

STEP	
Filename extension	.stp, .step, .stpnc, .p21, .210
Internet media type	model/step, model/step+xml, model/step+zip, model/step+xml+zip
Magic number	ISO-10303-21
Developed by	ISO
Initial release	1994
Website	Specification@

https://en.wikipedia.org/wiki/ISO_10303-21



- Popular for in many engineering domains that rely on CAD
 - Mechanical engineering
 - AECOO industry (Architecture, Engineering, Construction, Owner Operator)
- ASCII, not storage-efficient
- Schema defined separately in the EXPRESS data modeling language ISO 10303-11

```
ISO-10303-21;
HEADER;
FILE_DESCRIPTION(
  /* description */ ('A minimal AP214 example with a single part'),
  /* implementation_level */ '2;1;');
FILE_NAME(
  /* name */ 'demo',
  /* time_stamp */ '2003-12-27T11:57:53',
  /* author */ ('Lothar Klein'),
  /* organization */ ('LKSoft'),
  /* preprocessor_version */ '',
  /* originating_system */ 'IDA-STEP',
  /* authorization */ '');
FILE_SCHEMA (('AUTOMOTIVE_DESIGN (1 0 ISO 10303 21 1 1)'));
ENDSEC;
DATA;
#10=ORGANIZATION('00001', 'LKSoft', 'company');
#11=PRODUCT_DEFINITION_CONTEXT('part_definition', #12, 'manufacturing');
#12=APPLICATION_CONTEXT('mechanical design');
#13=APPLICATION_PROTOCOL_DEFINITION('', 'automotive_design', 2003, #12);
#14=PRODUCT_DEFINITION('0', #15, #11);
#15=PRODUCT_DEFINITION_FORMATION('', #16);
#16=PRODUCT('00001', 'Test Part 1', '', (#18));
#17=PRODUCT_RELATED_PRODUCT_CATEGORY('part', #19, (#16));
#18=PRODUCT_CONTEXT('', #12, '1');
#19=APPLIED_ORGANIZATION_ASSIGNMENT(#10, #20, #16);
#20=ORGANIZATION_ROLE('id owner');
ENDSEC;
END-ISO-10303-21;
```

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Data Interoperability and Semantics

</ Part 2. Data Formats >

ICM – Toolbox Engineering and Interoperability of Software Systems – Course unit on Data Interoperability and Semantics

M1 Cyber Physical and Social Systems – Course unit on Data Interoperability and Semantics

Maxime Lefrançois <https://maxime-lefrancois.info>

Course unit URL: <https://ci.mines-stetienne.fr/cps2/course/data>