Welcome

Summer School

Digital Tools for Humanists

Pisa – June 3-12 2024

Refresher

Refresher on Computer Fundamentals and Networking

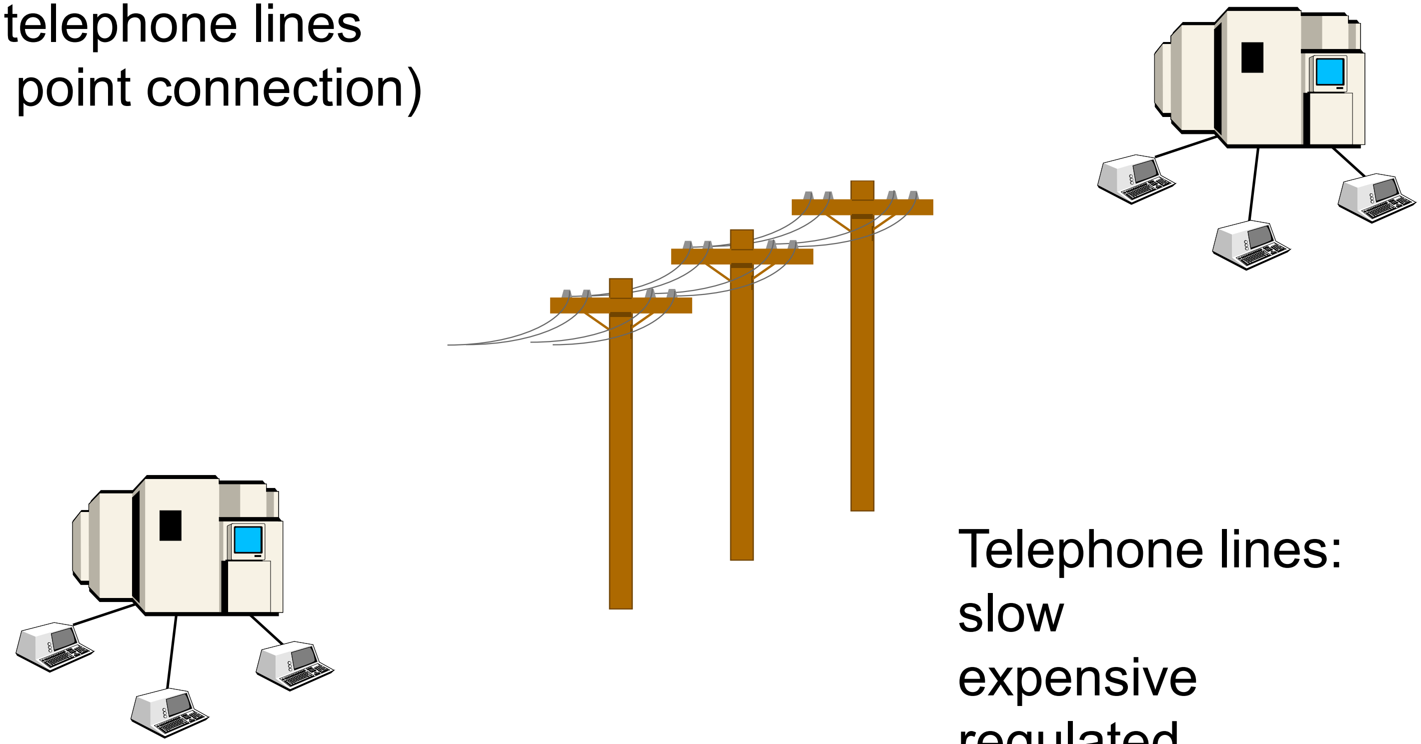
- History of computers
- Architecture of a computer
- Data representation within a computer
- Computer networks and the Internet
- The Semantic Web

Evolution of technology

- Computer technology
  - CPU and integrated chips
  - Random Access Memories
    - RAM – from KB to GB
  - External memories
    - Tapes, hard disks, floppy disks
    - Memory sticks
    - CDs
    - DVDs
    - from MB to GB to TB to PB to EB
- Communication technology (networks)
  - Telephone (low line speed)
  - Point to point (leased lines)
  - Local Area Networks
  - Inter-networking (TCP/IP)

Early computer communication

From mainframe to mainframe
through telephone lines
(point to point connection)



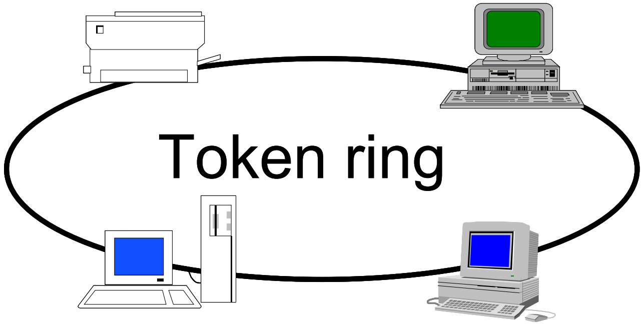
Telephone lines:
slow
expensive
regulated

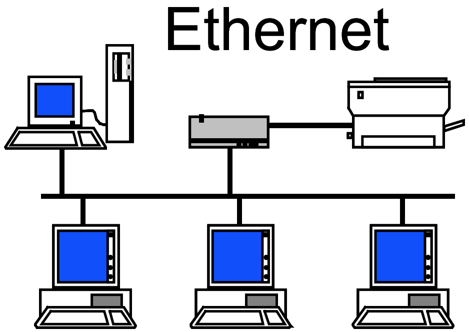
Networking

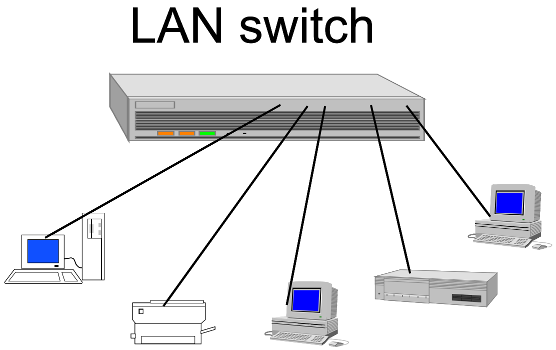
- In the sixties, first studies on “networking”
  - Networking means communication between node A and node B through one or more intermediate nodes
- In the seventies, fragmentation of the market with the arrival of “minicomputers” provided further motivation for research on networking
- At the same time (in the seventies), the arrival of the LANs (Local Area Networks) provided the final impulse for the development of networking

LAN - Local Area Networks

Private networks
Up to several kilometers
Speed up to 100 Mb/sec



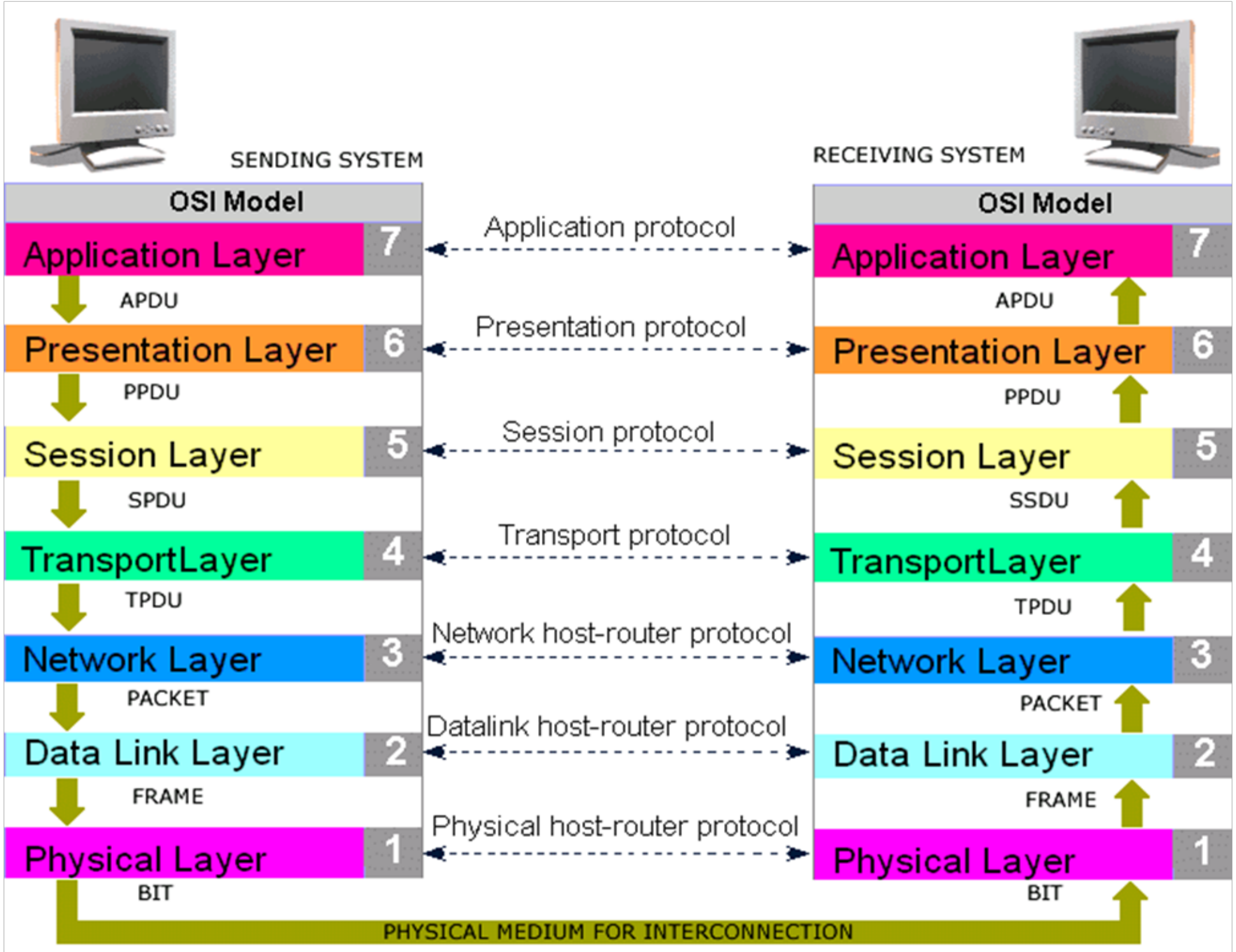




Research on networking

- Starting in the late sixties, many research projects on networking, both from universities and industry
  - Arpanet, Cyclades, SNA (IBM), DECnet
- In the late seventies ISO (International Standard Organization), under pressure of a group of computer manufacturer, started the work for the proposal of a “new” communication standard, called OSI: Open System Interconnection
- The OSI model, though no longer in use today, has established a number of networking concepts and is still used as a “reference model”
- The main concept introduced by OSI is the “communication layer”

The OSI model
1980-1990



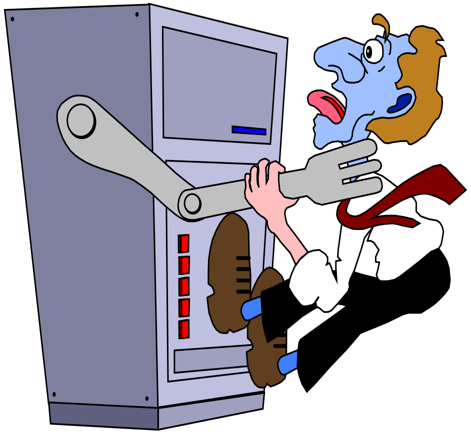
Protocol: formats and rules for exchanging messages between “partners” (e.g. computers)

Packet switching: messages are broken down into “packets”, and each packet gets to destination independently from the others.

OSI and Internet

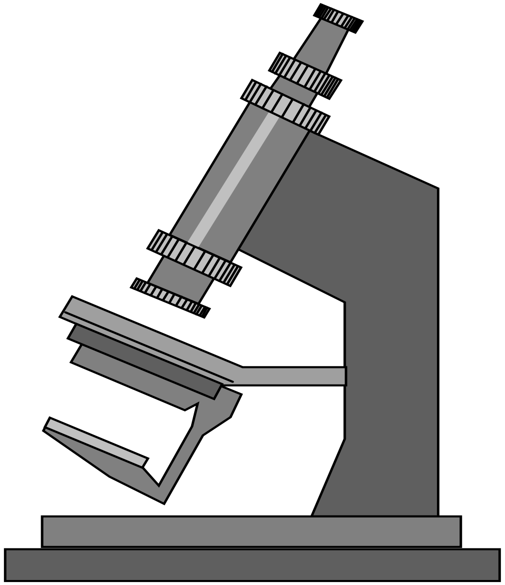
- The OSI effort provided a sound and durable foundation for networking, but never became a “market leader”
  - Slow development
    - Initial opposition from IBM
    - “Designed by a Committee”
    - Expensive development
  - Heavy and slow in operation
- In the same period the Internet was defining a number of “light weight” protocols
- Most of the market preferred them to OSI

Internet evolution 1960-1990



Experimental
Network
DARPA
Arpanet

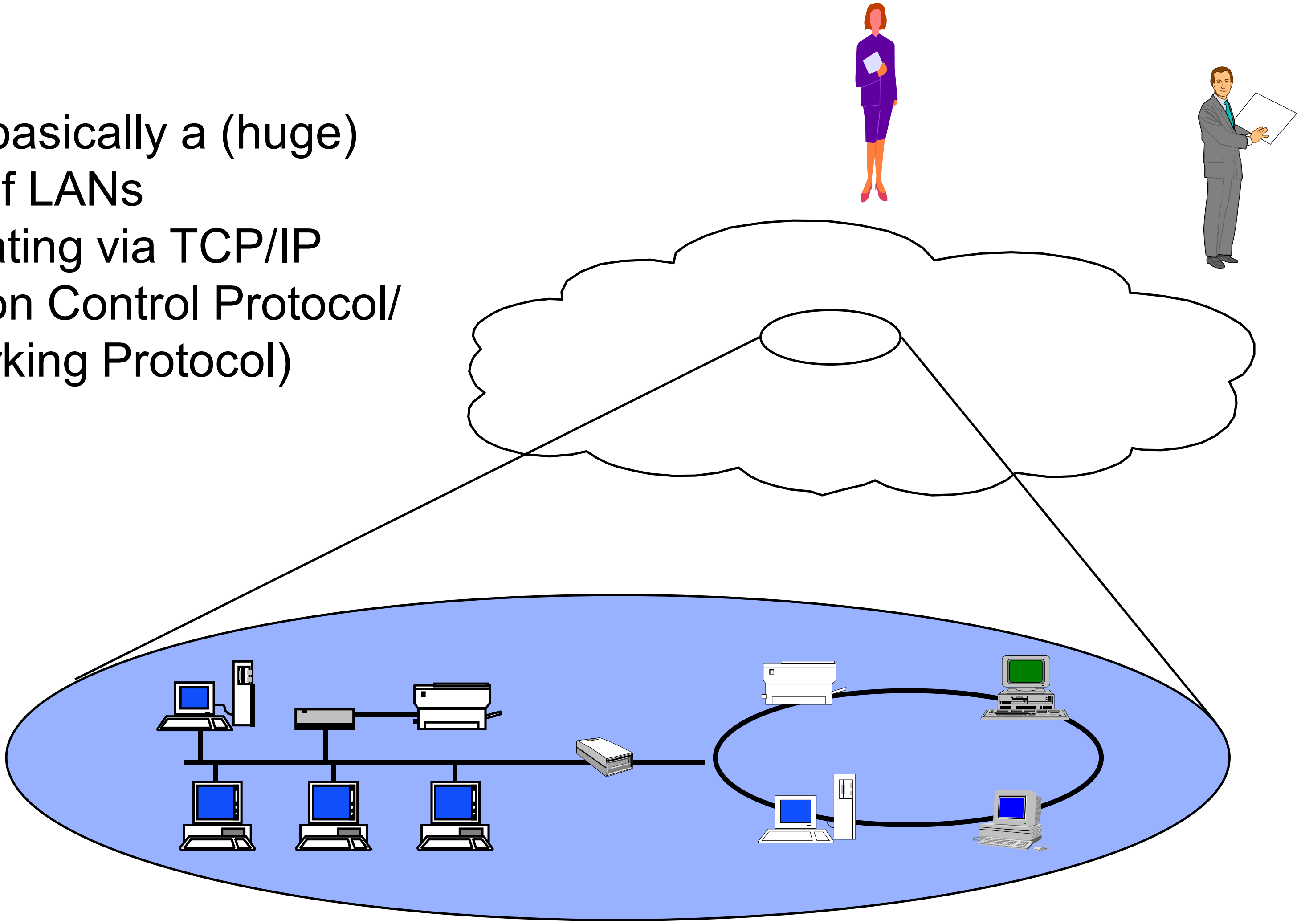
Research
Network
NSF
Internet



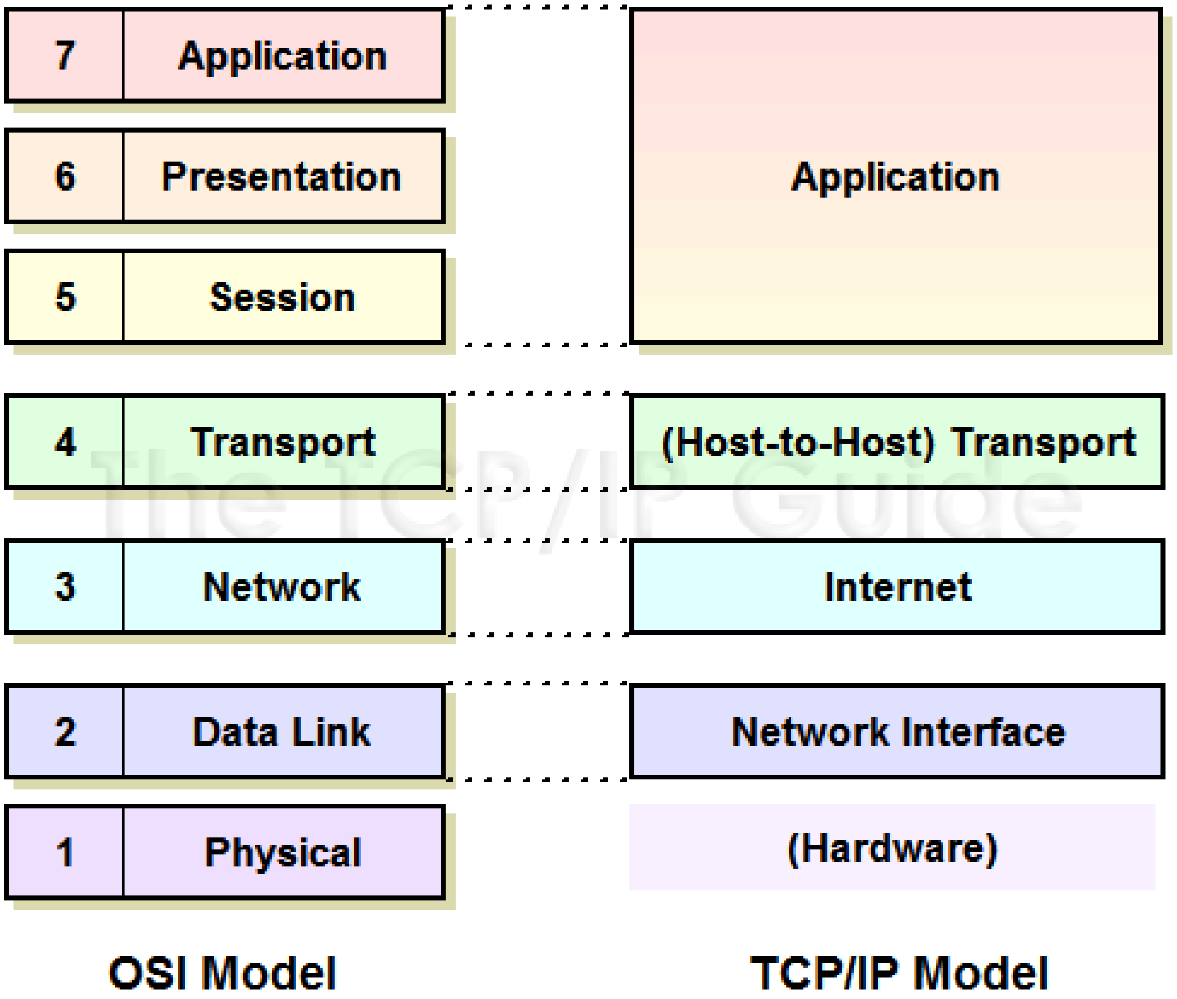
Communication
Infrastructure
Private and public
sectors
The Web

Inter-networking

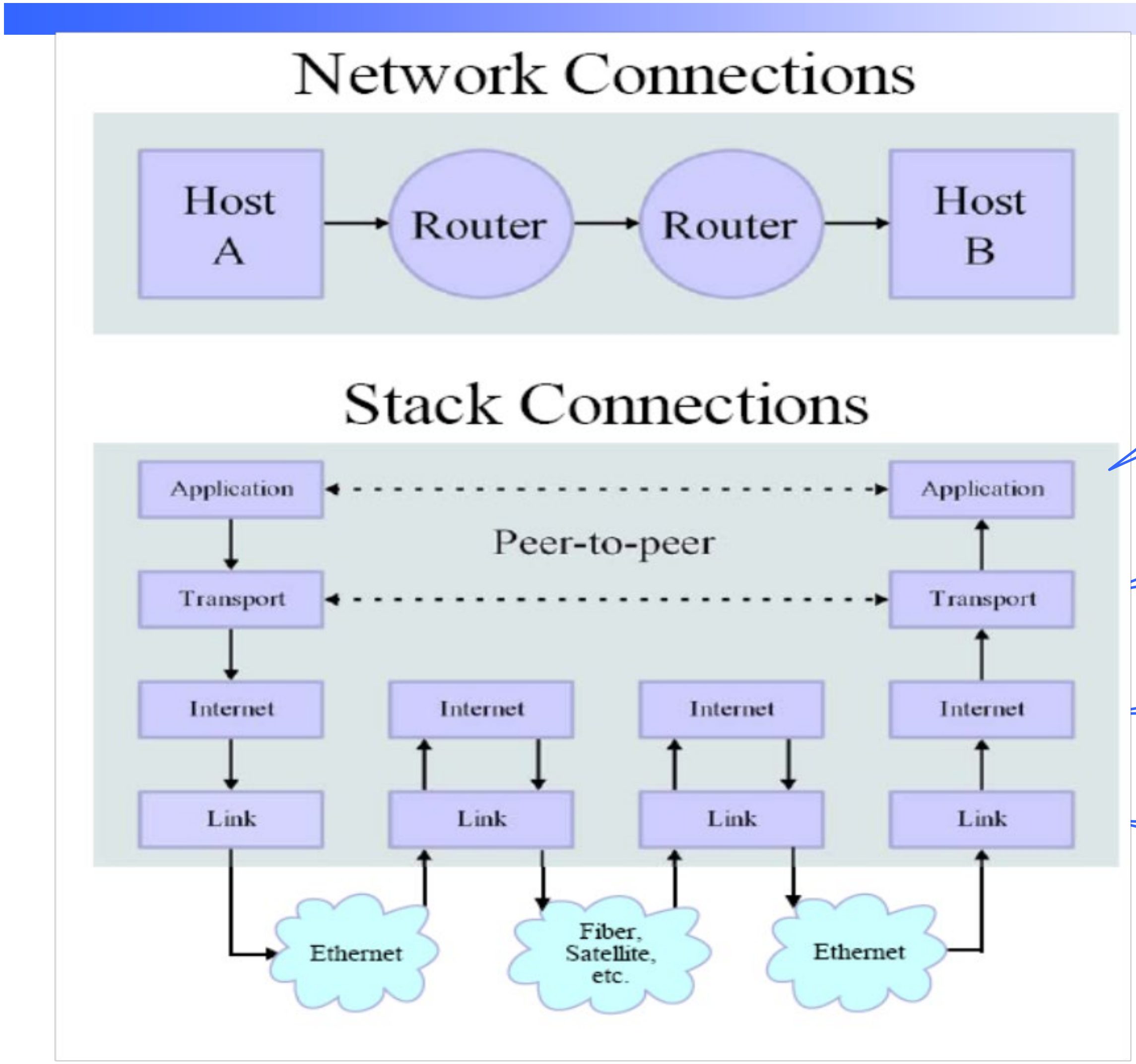
Internet is basically a (huge) collection of LANs communicating via TCP/IP (Trasmission Control Protocol/ Internetworking Protocol)



OSI and TCP/IP



Internet protocols



Application protocols

TCP/UDP

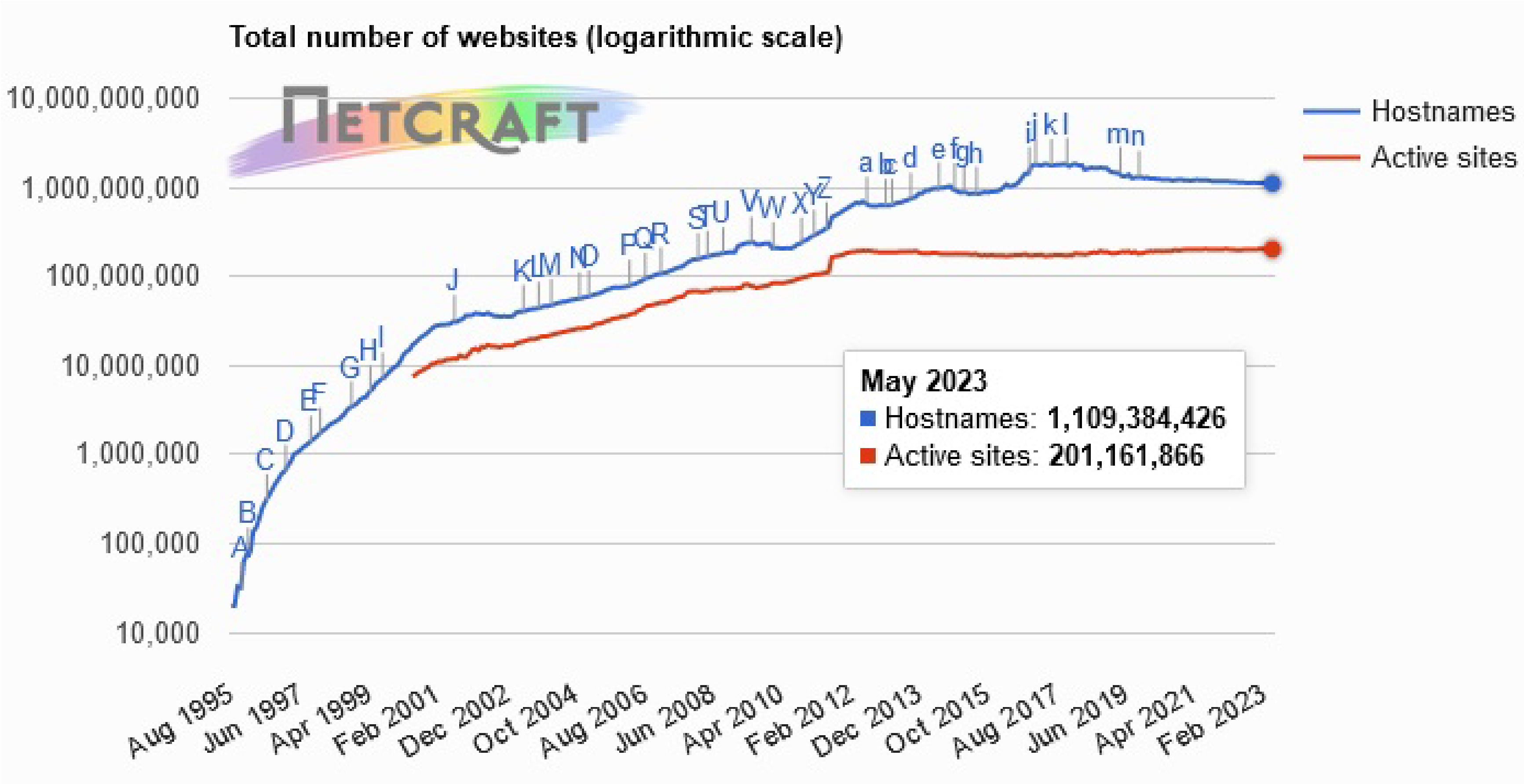
IP

ETHERNET

The Internet and the Web

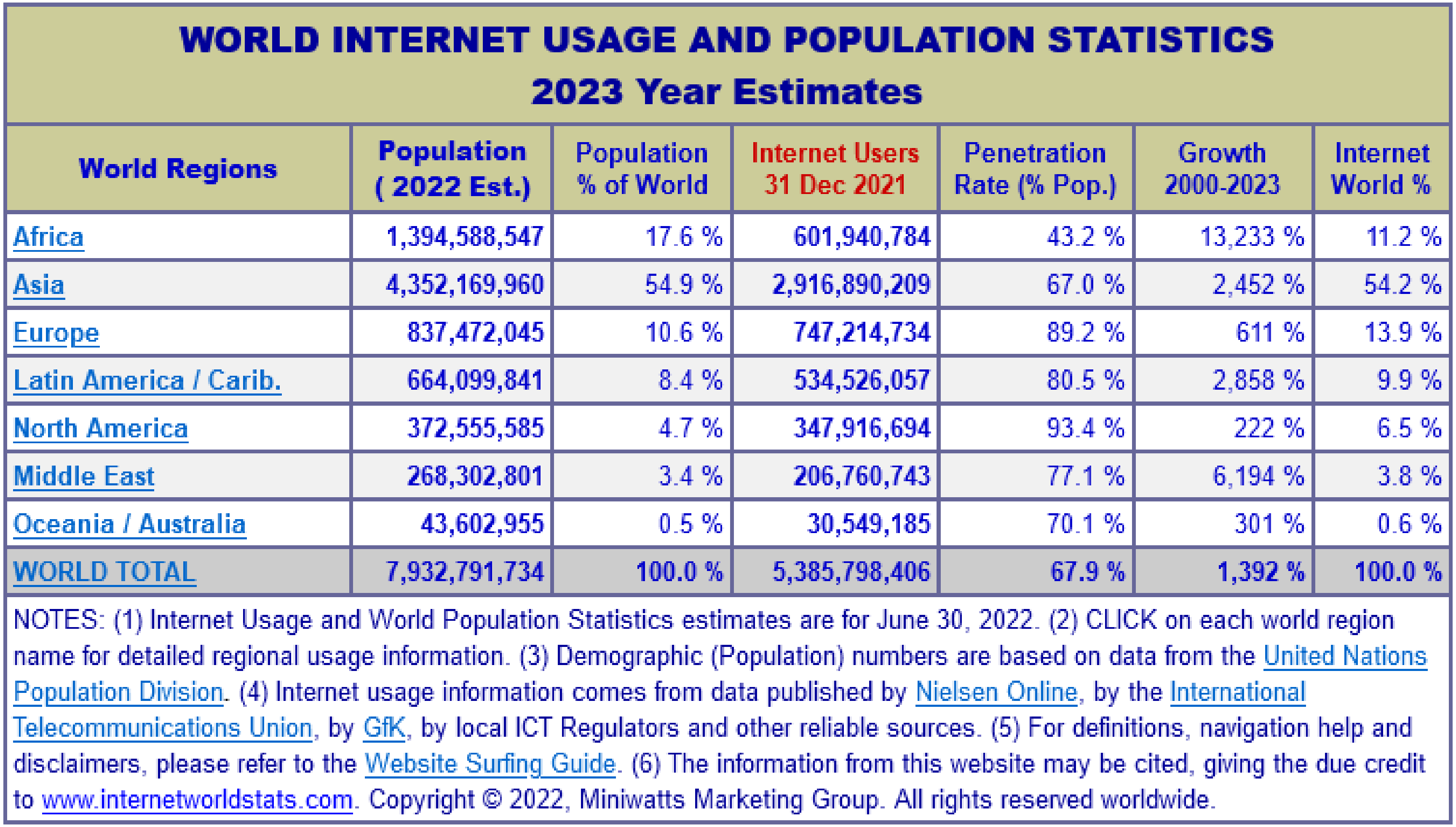
- Internet is a worldwide network of computers
  - It started in 1969 as a university research network (funded by DARPA) with 4 computers
  - By the end of the 80’s, when it was opened to “the world”, it had more than 20000 hosts in universities and research centers worldwide
  - As of May 2024, the total number of web servers is estimated to be in the order of 1100 millions hosts
  - As of June 2022, the total number of Internet users is estimated to be 5,39 billions users
- The Web is the information space accessible through the Internet
  - As of March 2021, the number of “visible” Web pages (indexed by Google) was estimated to be between 50 and 60 billions pages
  - There is also a Deep Web, whose content is not indexed by any search engine, and whose size is completely unknown
- The Web has been made possible by a combination of computer technology and communication technology

Internet Web servers



https://news.netcraft.com/archives/category/web-server-survey/

Internet users in the World



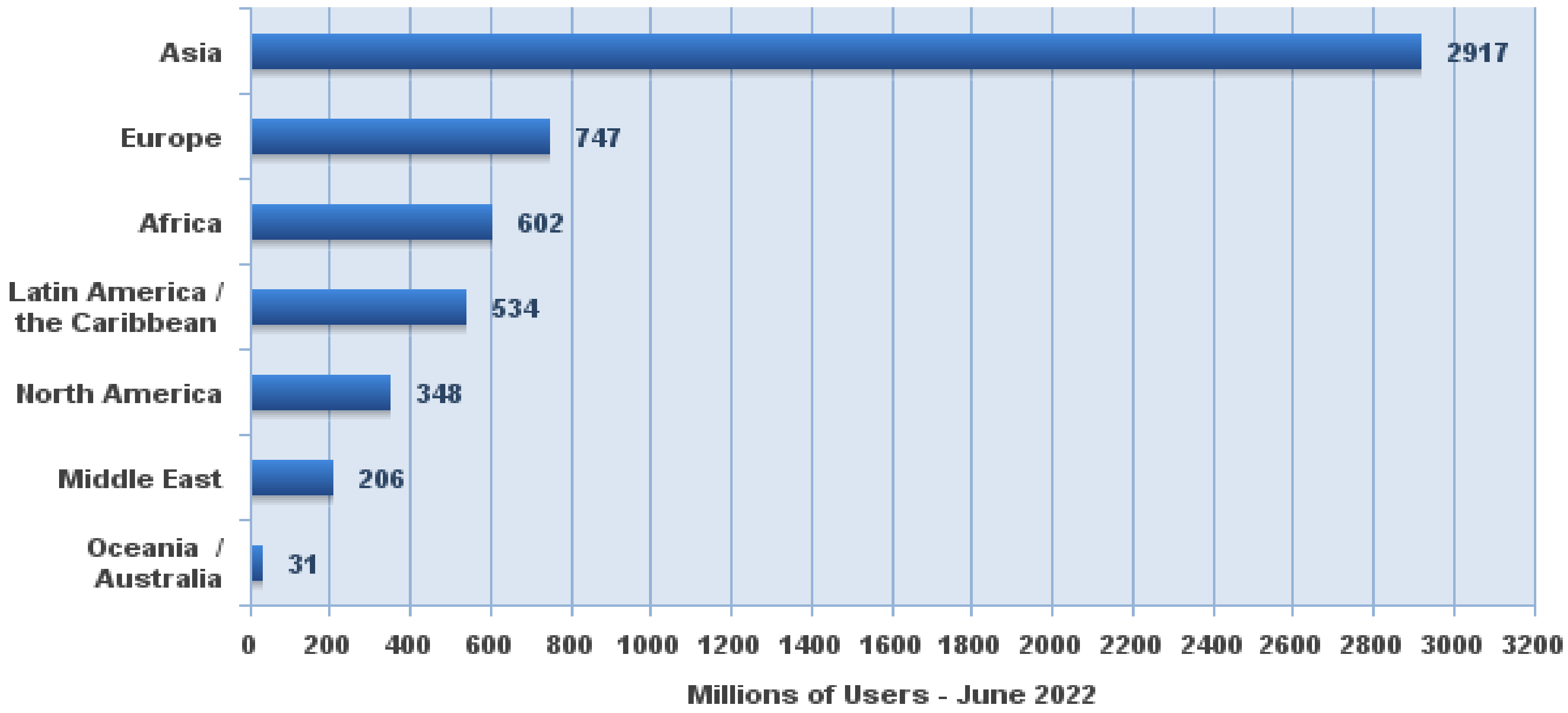
WORLD INTERNET USAGE AND POPULATION STATISTICS
2023 Year Estimates

World Regions	Population (2022 Est.)	Population % of World	Internet Users 31 Dec 2021	Penetration Rate (% Pop.)	Growth 2000-2023	Internet World %
Africa	1,394,588,547	17.6 %	601,940,784	43.2 %	13,233 %	11.2 %
Asia	4,352,169,960	54.9 %	2,916,890,209	67.0 %	2,452 %	54.2 %
Europe	837,472,045	10.6 %	747,214,734	89.2 %	611 %	13.9 %
Latin America / Carib.	664,099,841	8.4 %	534,526,057	80.5 %	2,858 %	9.9 %
North America	372,555,585	4.7 %	347,916,694	93.4 %	222 %	6.5 %
Middle East	268,302,801	3.4 %	206,760,743	77.1 %	6,194 %	3.8 %
Oceania / Australia	43,602,955	0.5 %	30,549,185	70.1 %	301 %	0.6 %
WORLD TOTAL	7,932,791,734	100.0 %	5,385,798,406	67.9 %	1,392 %	100.0 %

NOTES: (1) Internet Usage and World Population Statistics estimates are for June 30, 2022. (2) CLICK on each world region name for detailed regional usage information. (3) Demographic (Population) numbers are based on data from the United Nations Population Division. (4) Internet usage information comes from data published by Nielsen Online, by the International Telecommunications Union, by GfK, by local ICT Regulators and other reliable sources. (5) For definitions, navigation help and disclaimers, please refer to the Website Surfing Guide. (6) The information from this website may be cited, giving the due credit to www.internetworldstats.com. Copyright © 2022, Miniwatts Marketing Group. All rights reserved worldwide.

Internet users in the World

Internet Users in the World by Geographic Regions - 2022



Source: Internet World Stats - www.internetworldstats.com/stats.htm
Basis:5,385,798,406 Internet users estimated in June 30, 2022
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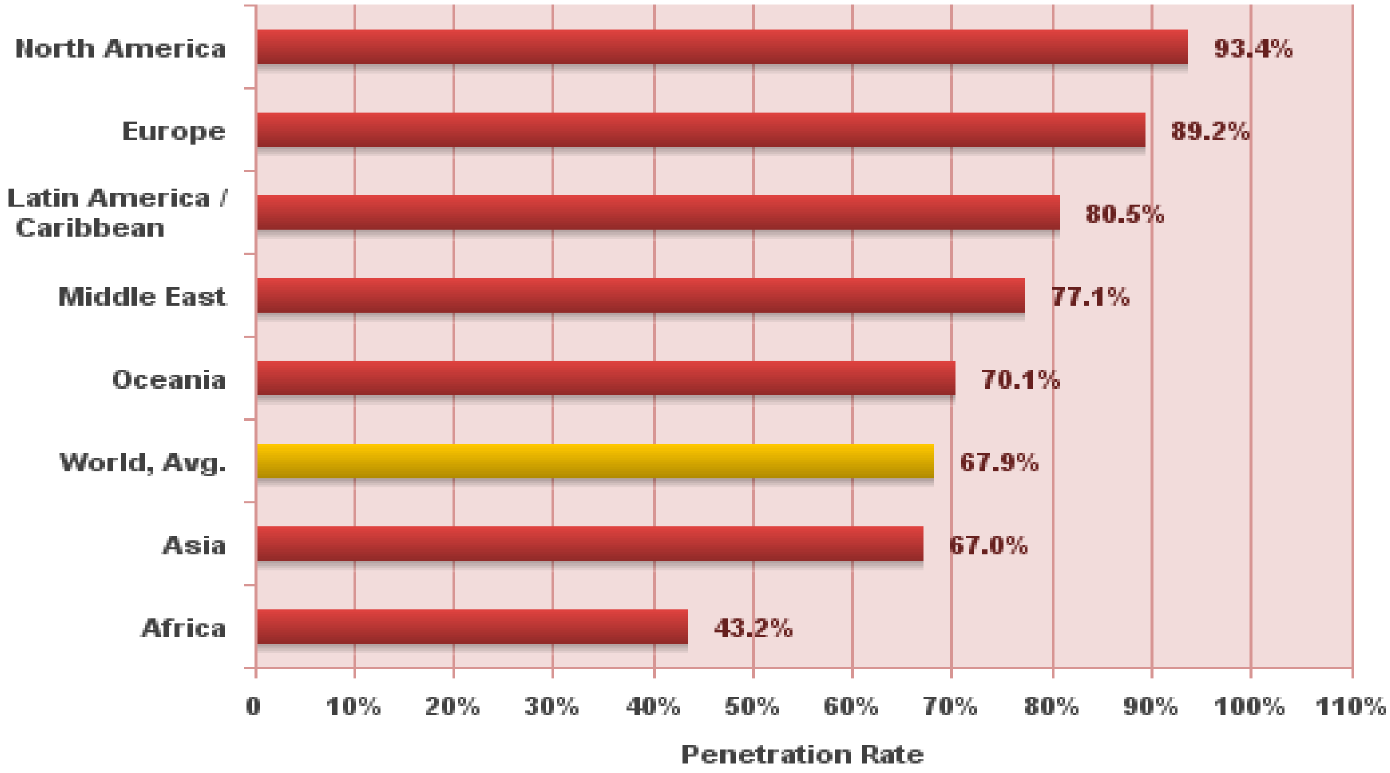
Internet World penetration rates

Internet World Penetration Rates
by Geographic Regions - 2022

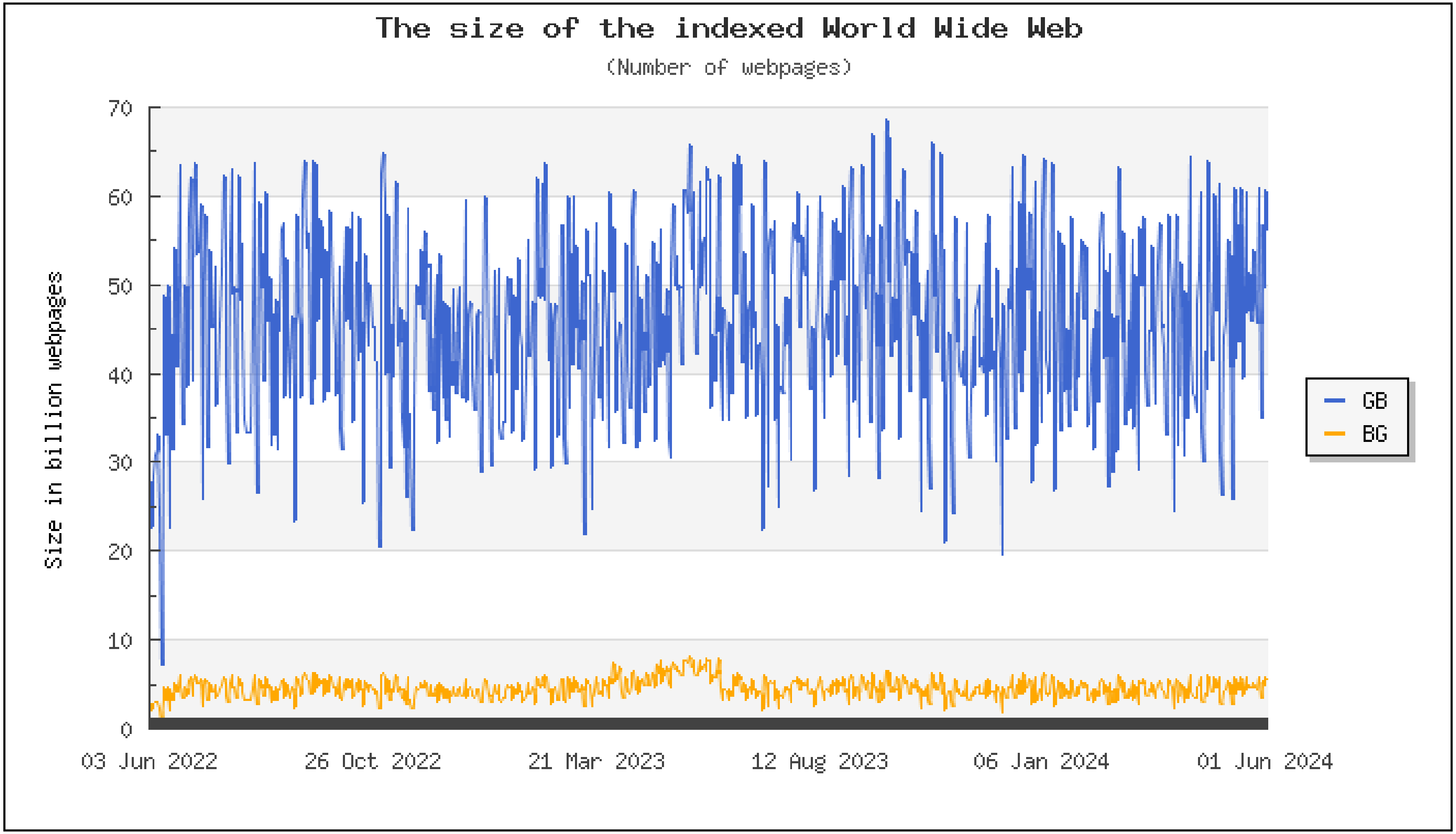


Source: Internet World Stats - www.internetworldstats.com/stats.htm
Penetration Rates are based on a world population of 7,932,791,734
and 5,385,798,406 estimated Internet users in June 30, 2022.

The Internet and the Web

- Internet is a worldwide network of computers
  - It started in 1969 as a university research network (funded by DARPA) with 4 computers
  - By the end of the 80's, when it was opened to "the world", it had more than 20000 hosts in universities and research centers worldwide
  - As of September 2021, the total number of web servers is estimated to be in the order of 1200 millions hosts
  - As of December 2021, the total number of Internet users is estimated to be 5,25 billions users
- The Web is the information space accessible through the Internet
  - As of May 2023, the number of "visible" Web pages (indexed by Google) is estimated to be between 40 and 50 billions pages
  - There is also a Deep Web, whose content is not indexed by any search engine, and whose size is completely unknown
- The Web has been made possible by a combination of computer technology and communication technology

The size of the indexed Web



https://www.worldwidewebsize.com/

The World Wide Web

- Combination of computer technology and communication technology
- It all started with the “hyperlink” (late eighties)
- Then came the “browser” (Mosaic) (early nineties)
- Then came the “information explosion” (mid-nineties)
- Then came the “dot come, dot gone” (late nineties)
- Then came the second wave (early 2000)
- Then came the Web 2.0 (around 2004)
- Then came the Web 3.0 (around 2010)
- Today we have:
  - An estimate of about 1200 million hosts
  - An estimate of 40 to 50 billion pages on line

The editors

- Text processing applications started already in the early days of the computers (sixties)
- A “text processor” (or editor) has two main functions:
  - processing the text (delete, replace, insert, etc.)
  - specifying the format (bold, center, new line, etc.)
- The first editors were using a “mark up” language (i.e. commands intermixed with the text) to provide formatting instructions (only limited interactivity available through typewriter-like terminals)
- The “second generation” editors (interactivity available with display and mouse) were using the WYSIWYG paradigm: What You See Is What You Get

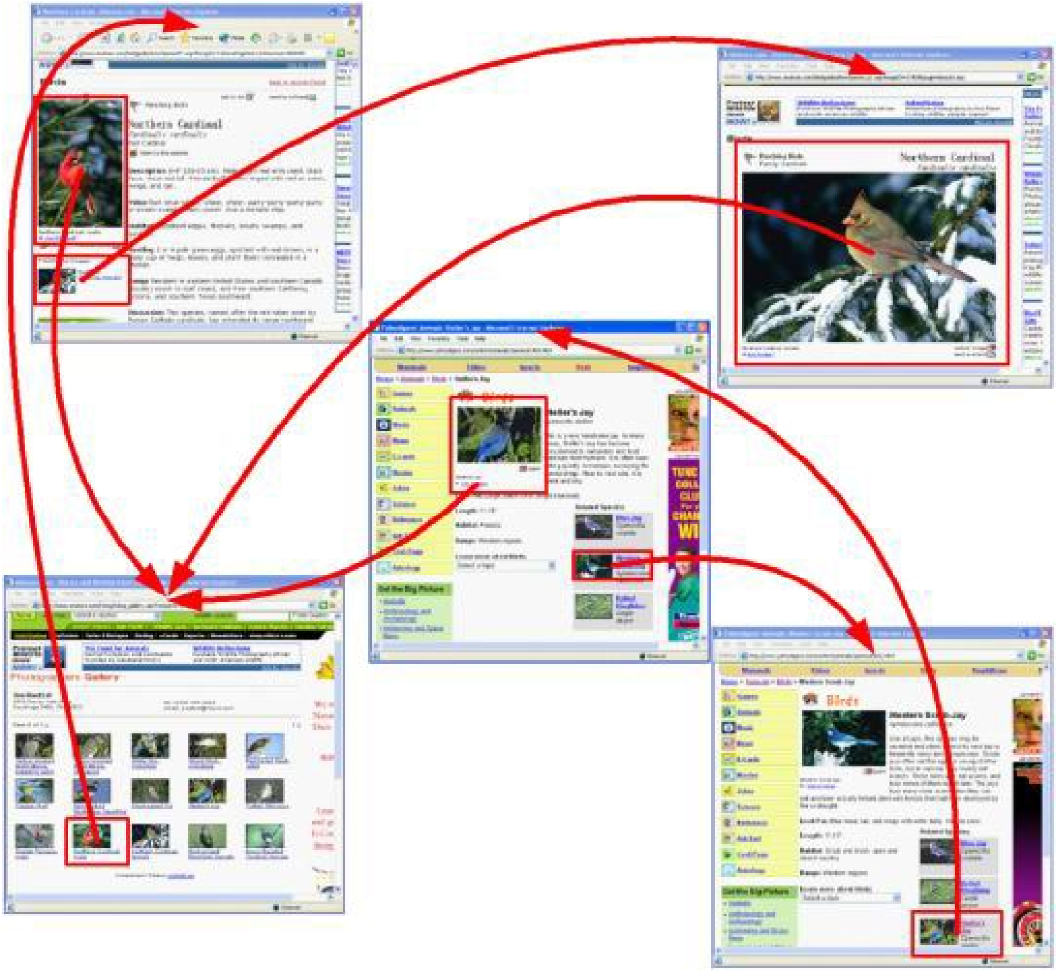
The hyperlink

- The idea of the “hyperlink” was (experimentally) proposed in the sixties, as a feature of a “smart editor”
  - selecting a portion of the text, it was possible to open a second document, in addition to the one being edited (very awkward to use on a typewriter-like terminal)
- With the arrival of display screens and the mouse (eighties) the hyperlink came back in “3D documents”
  - clicking on a portion of the text it was possible to open a second document, which was maintained as a second (virtual) screen behind the first one
- With the arrival of the (fast) internet, it became the “web hyperlink”
  - clicking on a portion of the text it was possible to open a second document, coming from a different computer

The browser

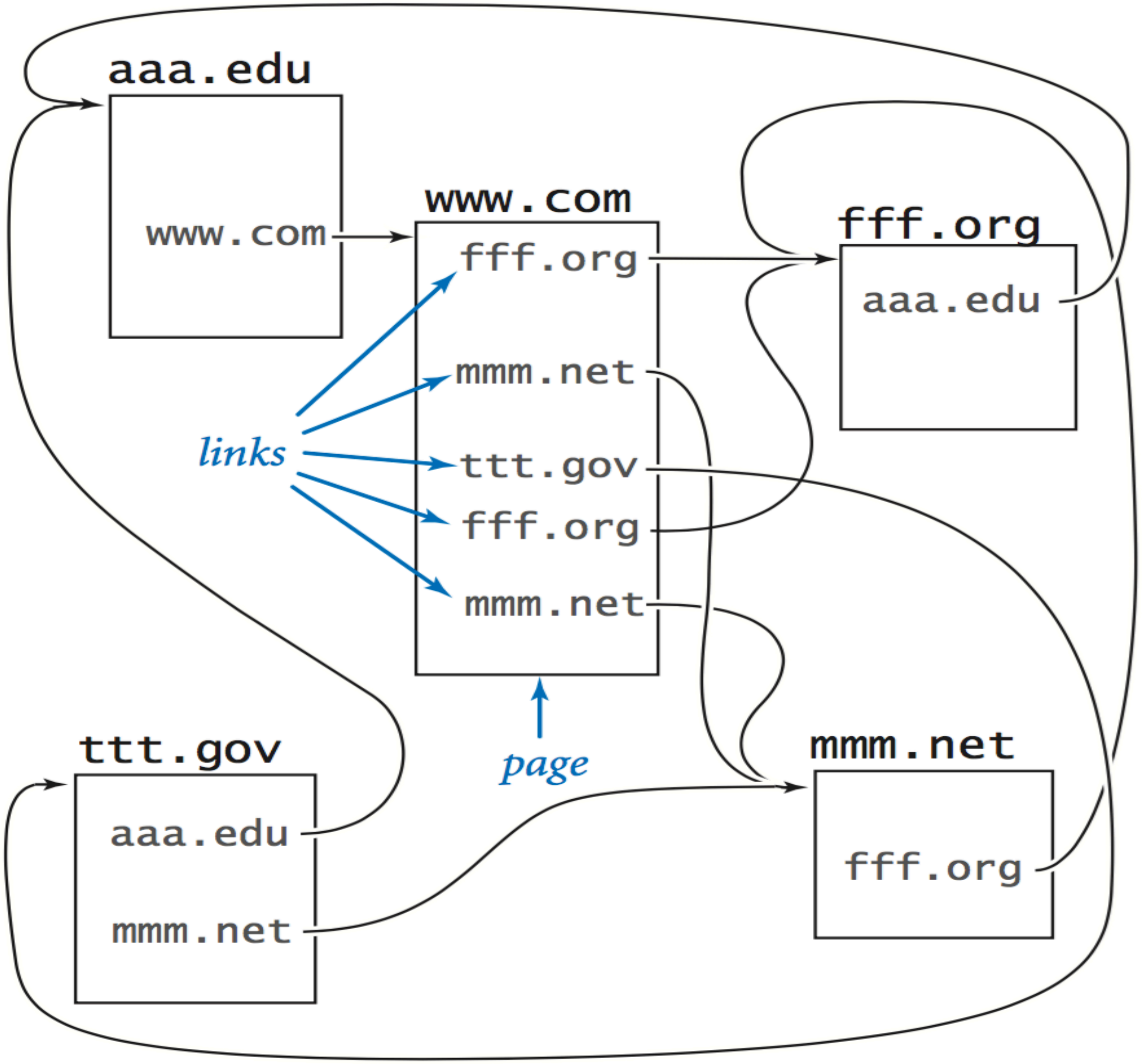
- With the arrival of the (web) hyperlink, the problem was then how to properly display a (web) page that had been generated on a different computer, possibly with a different (wysiwyg) editor
- The solution was the definition of HTML (Hyper Text Markup Language), i.e. a standard mark up language for formatting a page, and the implementation of smart editors (called browsers – the most popular was Mosaic, released in 1993) capable of correctly displaying pages formatted with HTML, regardless of where they were coming from
- At the same time it was defined the HTTP protocol (Hyper Text Transfer Protocol) for the exchange of information between the browser and the Web server

The World Wide Web

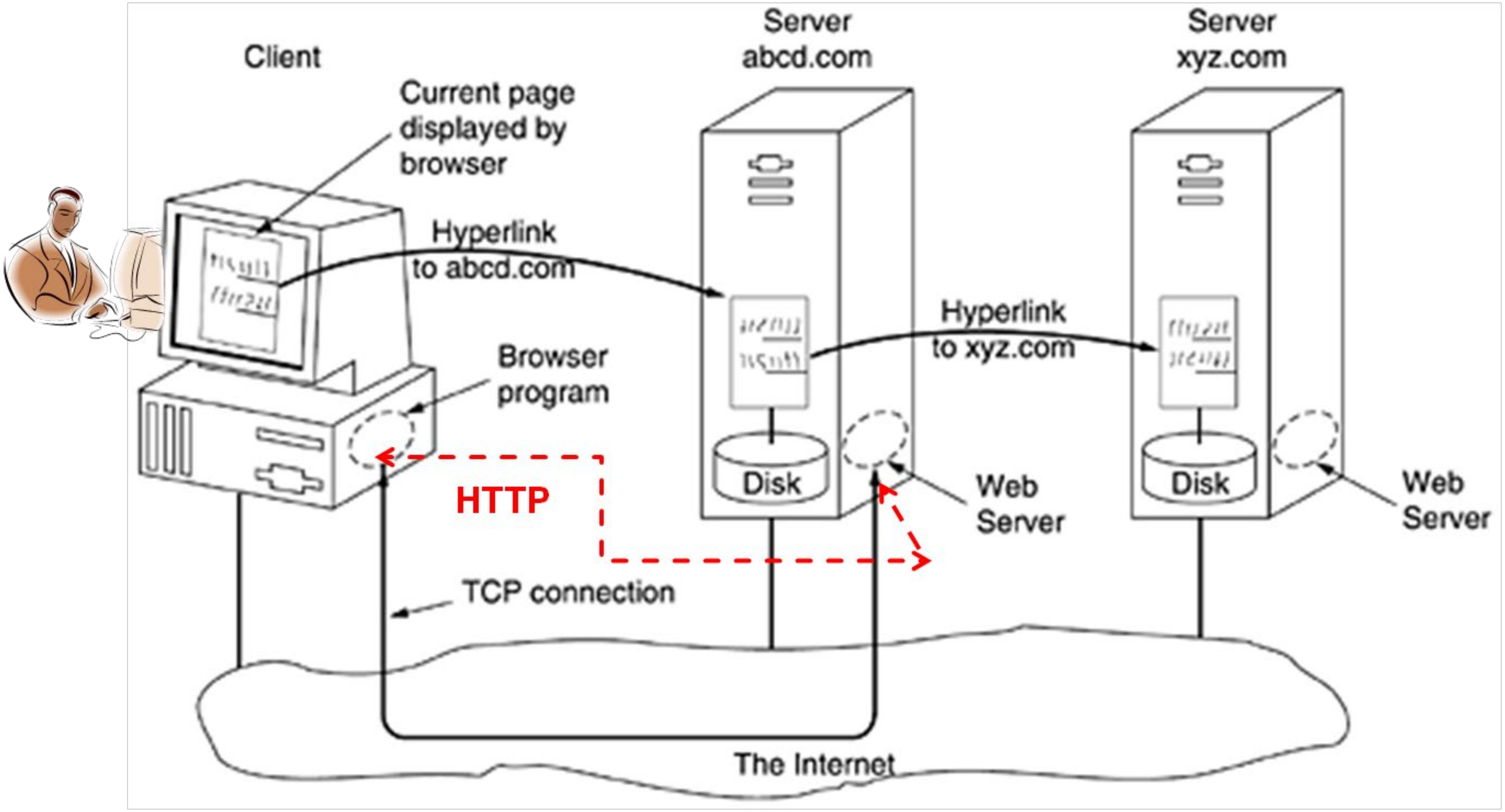


The hyperlinks

A link is made of two parts: the visible text (or image) and the link to the resource (typically a web page) to be looked for when clicking on the visible text or image



The Web architecture



Evolution of the Web

- Web 1.0 (1993-2003/4)
  - Web is a “publishing medium”
  - Users (humans) can only read
- Web 2.0 (2003/4-today)
  - Web is a “social medium”
  - Users (humans) can publish and interact (e.g. Youtube, Wiki, Flickr, Facebook, etc.)
- Web 3.0 (2010/1-today, more often called IoT - Internet of Things)
  - In addition to humans, users of the Web are “programs” that can interact
  - Users of the Web are “things”, whose programs interact with other things

Refresher

Refresher on Computer Fundamentals and Networking

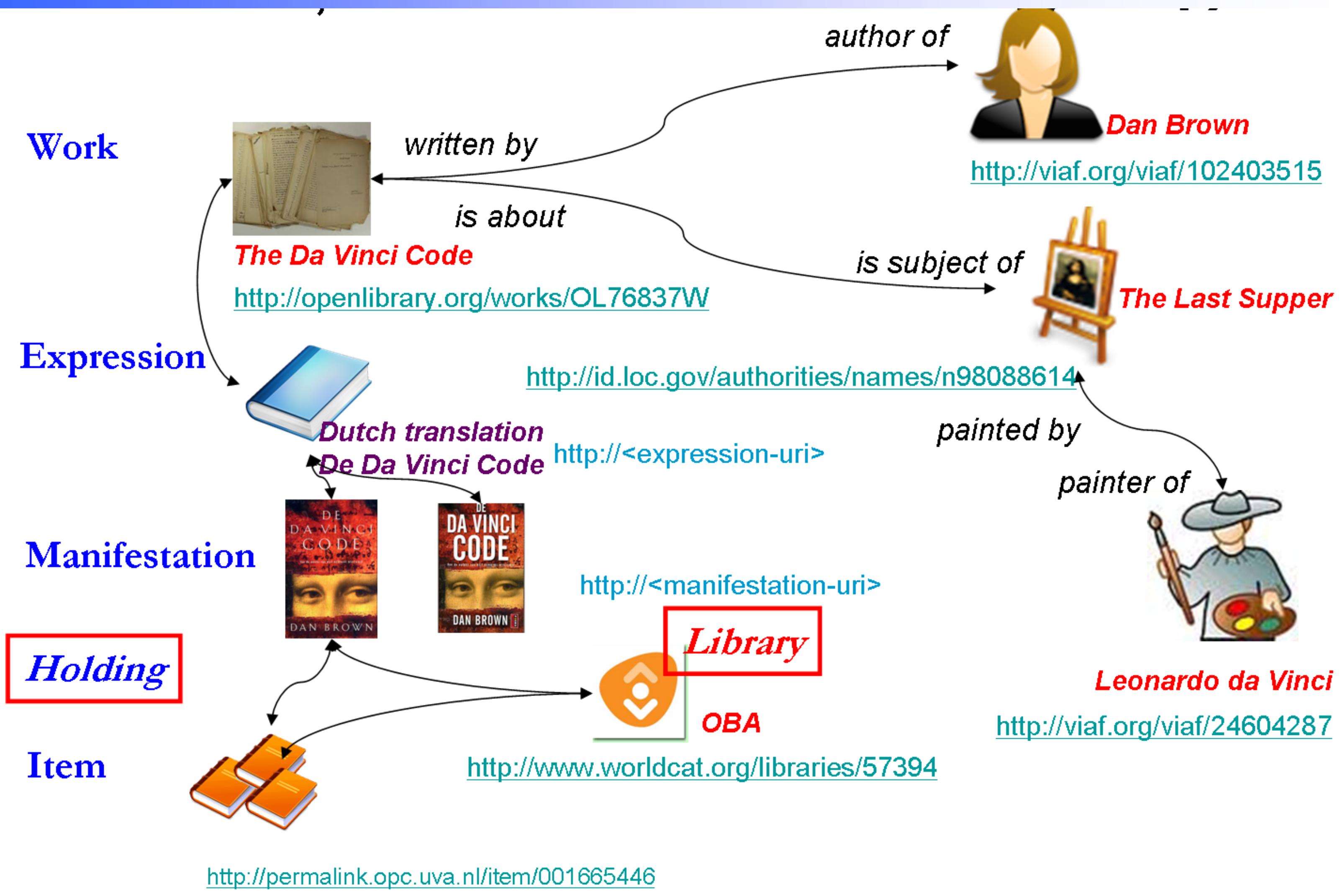
- History of computers
- Architecture of a computer
- Data representation within a computer
- Computer networks and the Internet
- The Semantic Web

“I have a dream”

“I have a dream for the Web [in which computers] become capable of analyzing all the data on the Web – the content, links, and transactions between people and computers. A ‘Semantic Web’, which should make this possible, has yet to emerge, but when it does, the day-to-day mechanisms of trade, bureaucracy and our daily lives will be handled by machines talking to machines. The ‘intelligent agents’ people have touted for ages will finally materialize”

Tim Berners-Lee, 1999

The Web of Linked Data



author of
Work
written by
Dan Brown
http://viaf.org/viaf/102403515
is about
The Da Vinci Code
is subject of
http://openlibrary.org/works/OL76837W
The Last Supper
Expression
http://id.loc.gov/authorities/names/n98088614
Dutch translation
De Da Vinci Code
http://<expression-uri>
painted by
painter of
Manifestation
http://<manifestation-uri>
Library
Holding
Leonardo da Vinci
OBA
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Item
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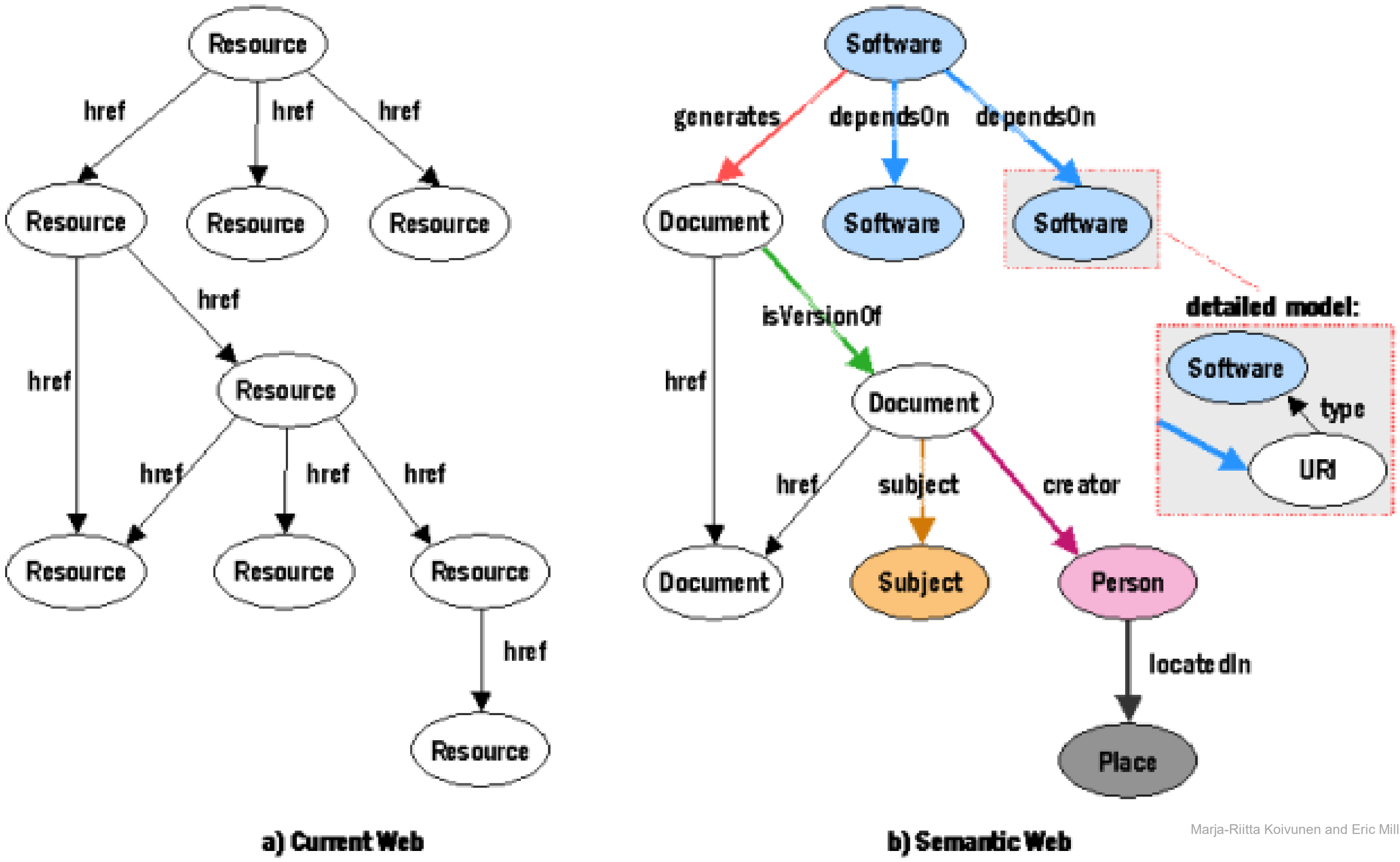
http://permalink.opc.uva.nl/item/001665446

The Semantic Web



a) Current Web

b) Semantic Web

Marja-Riitta Koivunen and Eric Miller w3.org

The Semantic Web

- The whole idea of the Semantic Web is to make available (for use in the Web) resources (or resource descriptions) whose “meaning” is understandable by a computer
- This is accomplished by providing descriptions of resources in a “formal way”, so that these descriptions can be “understood” by a computer (i.e. a program running in a computer)
- The first step in approaching this formal description is to define exactly the “portion of the universe” that we want to describe, and then define a “conceptual model” of it
- The conceptual model is then described in a formal notation that can be interpreted by a computer program

Resource Description Framework

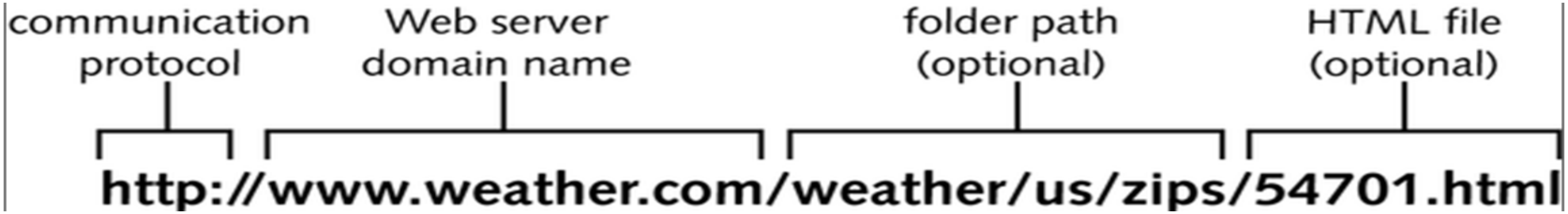
- Resource Description Framework (RDF) is a way to represent information about *resources* in the Web (in the World)
- A resource is anything that has identity. For example, a resource may be an electronic document, an image, a service (e.g., "today's weather report for Pisa"), or a collection of other resources. Not all resources are network "retrievable"; e.g., human beings, corporations, and bound books in a library can also be considered resources
- All resources are identified by a URI (Uniform Resource Identifier)
  - a string of characters that unambiguously identifies a particular resource
- *Resources* are described in terms of simple statements specifying properties and property values of resources

Several types of URIs
URI Syntax

<scheme name> : <hierarchical part> [? <query>] [# <fragment>]

```
any://example.com:8042/over/there?name=ferret#nose
\___/  \________________/   \_________/ \_________/  \__/
scheme    authority            path          query      fragment
```

- ftp://ftp.is.co.za/rfc/rfc1808.txt
- **http://www.ietf.org/rfc/rfc2396.txt**
- ldap://[2001:db8::7]/c=GB?objectClass?one
- mailto:John.Doe@example.com
- news:comp.infosystems.www.servers.unix
- tel:+1-816-555-1212
- telnet://192.0.2.16:80/
- urn:oasis:names:specification:docbook:dtd:xml:4.1.2bb



RDF statements

- Resources:
  - An object, an entity or anything we want to talk about (e.g. authors, books, publishers, places, people, facilities)
- Properties:
  - They codify relations (e.g. written-by, friend-of, located-in, …) and attributes (e.g. age, date of birth, length, …)
- Statements:
  - Statements assert the properties of resources in form of triples subject-property-value (subject-predicate-object)
- Every resource and property has a URI
- Values (the object) can be other resources (for relations) or literals, i.e. terminal values (for attributes)

Simple RDF statement

- A statements is composed of three parts: a subject, a predicate (about the subject), an object (the value of the predicate)
- Example
  - http://www.example.org/index.html has a creator whose value is John Smith
- the subject is the resource identified by this URI: **`http://www.example.org/index.html`**
- the predicate is the phrase “has a creator"
- the object is the phrase "John Smith“
- To avoid “misunderstandings”, the three components of this statement should be indicated by URIs
  - Subject http://www.example.org/index.html
  - Predicate http://purl.org/dc/elements/1.1/creator
  - Object http://www.example.org/staffid/85740

Additional RDF statements (in natural language)

- http://www.example.org/index.html
  has a creator
  whose value is John Smith

- http://www.example.org/index.html
  has a creation-date
  whose value is August 16, 1999

- http://www.example.org/index.html
  has a language
  whose value is English

RDF statements as triples

Each statement corresponds to a “triple“

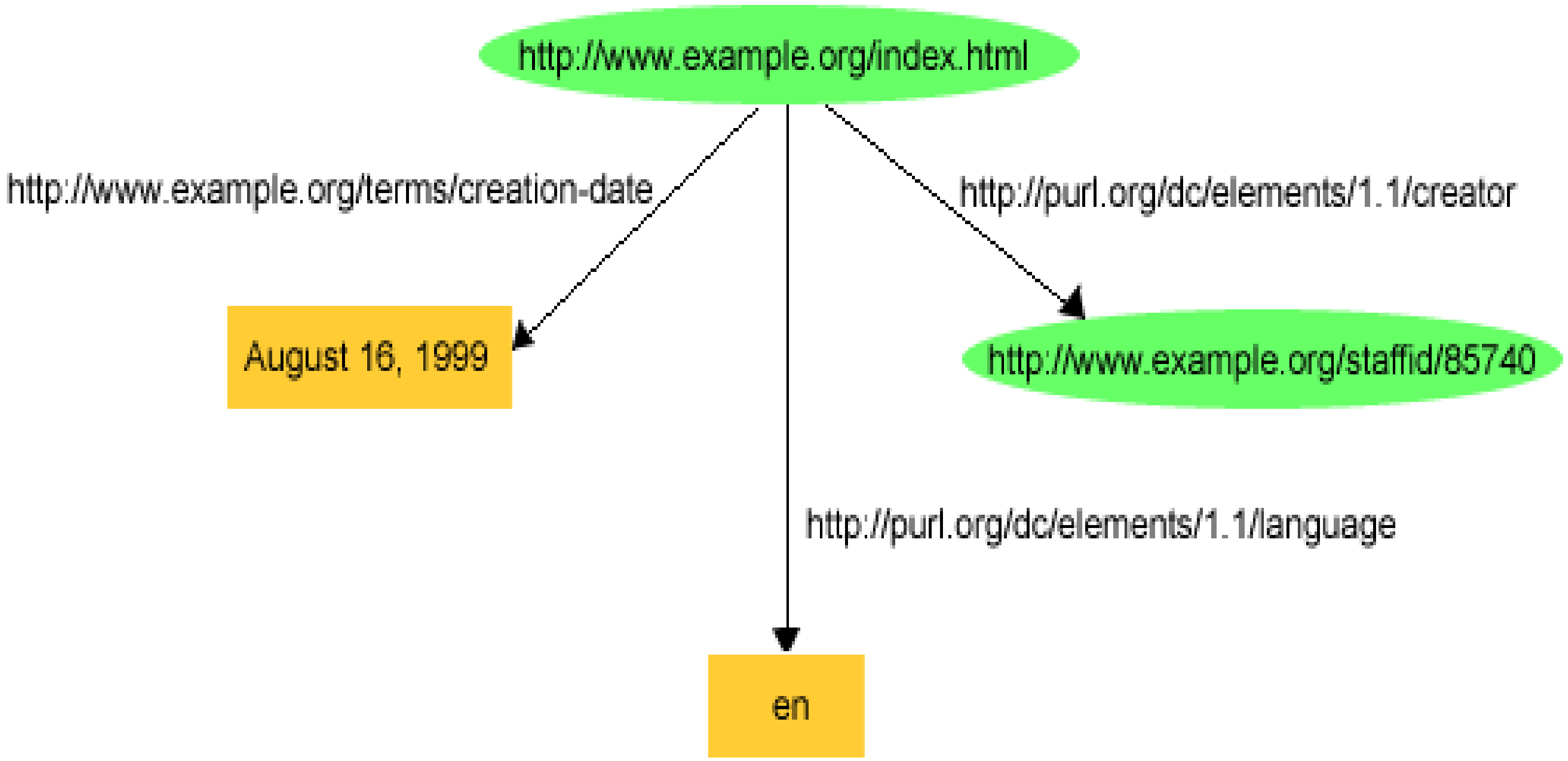
- <http://www.example.org/index.html>
- <http://purl.org/dc/elements/1.1/creator>
- <http://www.example.org/staffid/85740> .

- <http://www.example.org/index.html>
- <http://www.example.org/terms/creation-date>
- "August 16, 1999" .

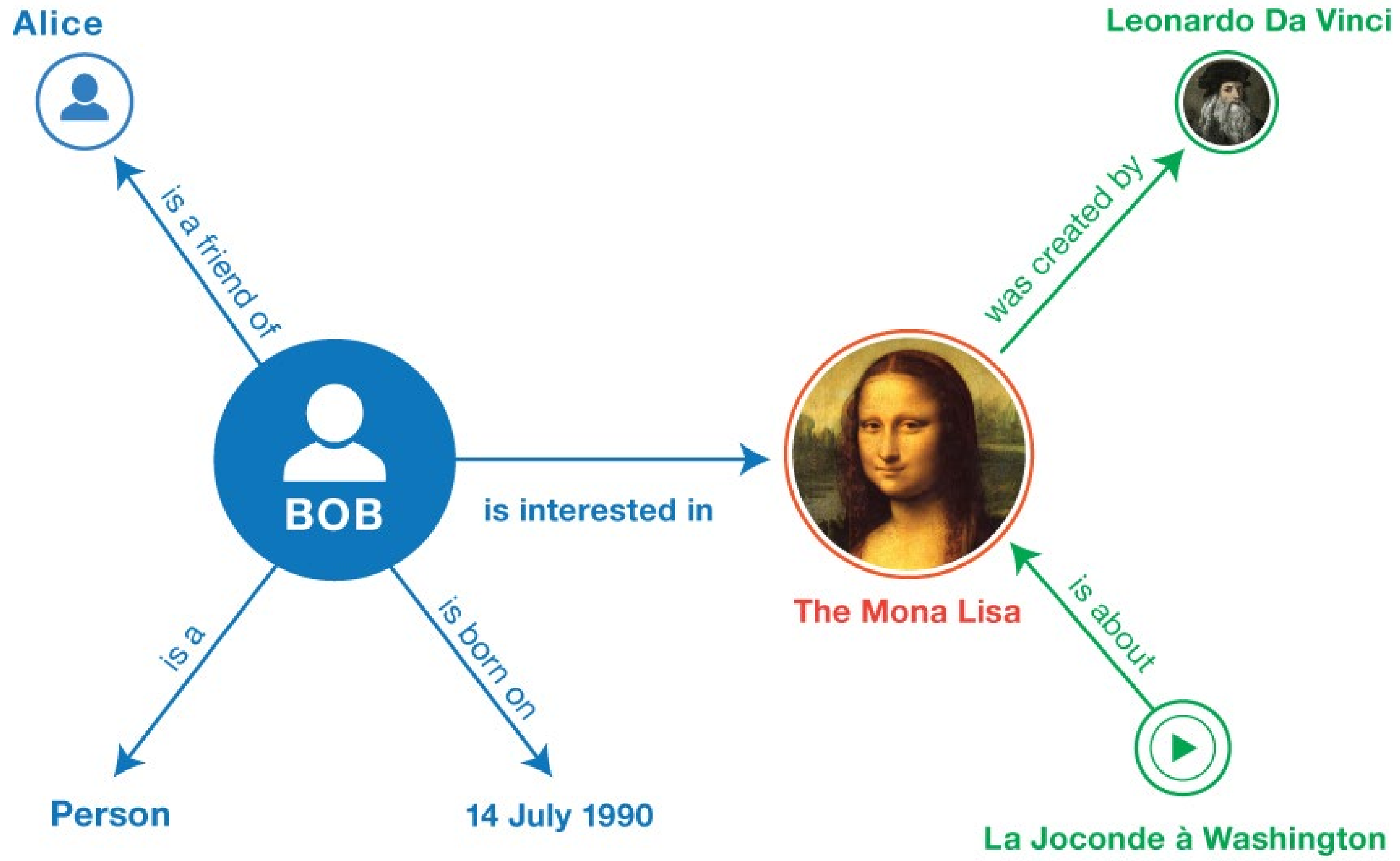
- <http://www.example.org/index.html>
- <http://purl.org/dc/elements/1.1/language>
- "en" .

RDF statements are graphs

Each triple corresponds to an arc in a graph


http://www.example.org/index.html
http://www.example.org/terms/creation-date
http://purl.org/dc/elements/1.1/creator
August 16, 1999
http://www.example.org/staffid/85740
http://purl.org/dc/elements/1.1/language
en

An RDF graph


Alice
Leonardo Da Vinci
is a friend of
was created by
BOB
is interested in
The Mona Lisa
is a
is born on
is about
Person
14 July 1990
La Joconde à Washington

The same graph represented with RDF-like triples

<Bob> <is a> <person>.
<Bob> <is a friend of> <Alice>.
<Bob> <is born on> <the 14th of July 1990>.
<Bob> <is interested in> <the Mona Lisa>.
<the Mona Lisa> <was created by> <Leonardo da Vinci>.
<the video 'La Joconde à Washington'> <is about>
<the Mona Lisa>

RDF summary

- A resource can be described by a set of RDF triples
- A set of RDF triples can be represented as a graph
- An RDF triple has three components
  - a **subject**, which is an RDF URI reference
  - **predicate**, which is an RDF URI reference
  - an **object**, which can be:
    - an RDF URI reference
    - an RDF literal

RDF Schema

- RDF provides a way to express simple statements about resources, using "named" properties and values
- It is convenient to define the *vocabularies* (terms) that are going to be used in those statements, to indicate that they are describing specific kinds or classes of resources, and will use specific properties in describing those resources
- For example, to describe bibliographic resources we could define classes such as "Book" or "Journal Article", and use properties such as "author", "title", "borrowedBy" to describe them
- **RDF Schema** defines the terms used in RDF descriptions by providing a **type system** to be used in the RDF descriptions
- In other words, it provides a way to represent a "conceptual model" of a (small) part of the world, by defining the main "concepts" (classes) in this part of the world, their properties and their relationships

Main notions of RDF Schema

- The main notions of the RDF Schema are:
  - Classes, which can be organized in sub-classes, to any level (defining a taxonomy)
  - Properties, which also can be organized in sub-properties, to any level (defining another taxonomy)
- Vocabulary descriptions (schemas) written in the RDF Schema language are valid RDF graphs
- There is a close analogy with XML documents and XML schemas

Basics of RDF Schema

- In RDF Schema we have a way to express:
  - that something (i.e. a term in a vocabulary) is a class or a property
  - that a class is a sub-class of another class
  - that a property is a sub-property of another property
  - that a class is the domain of a property
  - that a class is the range of a property

Summarizing the RDF Schema

- An RDF Schema is a simple “meta” vocabulary used to describe ontologies
  - Class, subClassOf, type
    - e.g., Person**,** Team
  - Property, subPropertyOf
    - e.g., playsFor
  - Domain (the **class for the subjects** of a particular *property*)
    - **Person** *playsFor* Team
  - Range (the **class for the values** of a particular *property*)
    - Person *playsFor* **Team**

Examples of Domain and Range

```
ex:Person     rdf:type     rdfs:Class
ex:Book       rdf:type     rdfs:Class

ex:hasAuthor  rdf:type     rdfs:Property
ex:hasAuthor  rdfs:domain  rdfs:Book
ex:hasAuthor  rdfs:range   rdfs:Person

ex:isAuthorOf rdf:type     rdfs:Property
ex:isAuthorOf rdfs:domain  rdfs:Person
ex:isAuthorOf rdfs:range   rdfs:Book
```

With these definitions of domain and range we are saying that in our (simple) "model of the world" books can only be written by a person, and a person can only write books (unless there are other triples in the schema defining other objects that can be written by a Person)

Inference for answering queries

```
ex:hasMother rdf:type    rdfs:Property
ex:hasMother rdfs:range  ex:Female
ex:hasMother rdfs:range  ex:Person

exstaff:Frank ex:hasMother  exstaff:Mary
```

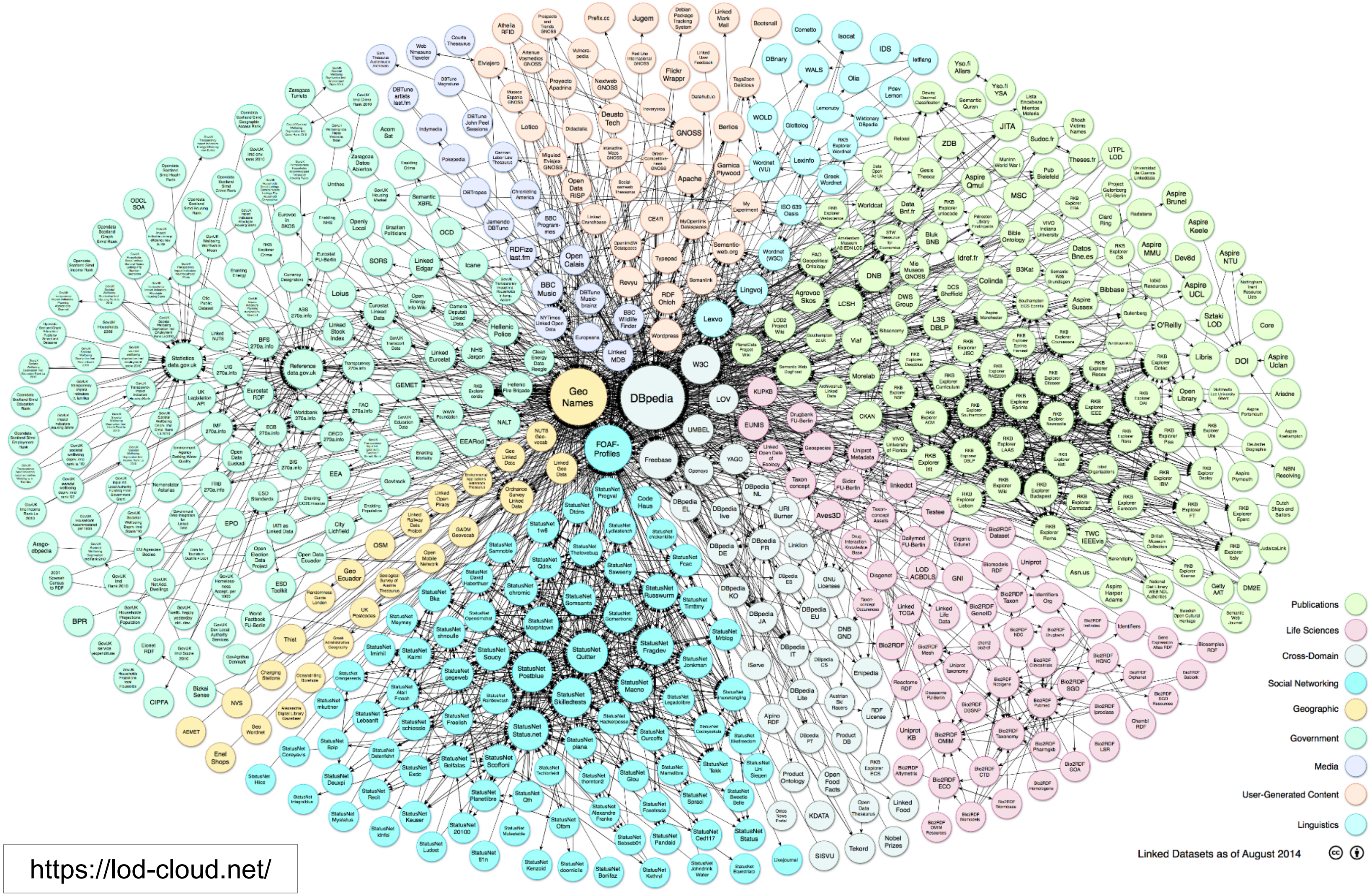
Mary (the mother of Frank) must be at the same time a person and a female

It is therefore possible to answer queries like: “List the names of all the females” and Mary will be in the list, without having ever provided the information that Mary is a female

LOD and the Semantic Web

- The main formalism used today for describing resources is RDF – Resource Description Framework
- The RDF descriptions are based on RDF schemas (often called vocabularies or ontologies), which are also described in RDF (they are the “conceptual models”)
- One of the main initiatives in the Semantic Web is “Linked Open Data” (LOD), where the resources (or their descriptions) to be made freely available on the Web must be described in RDF and must be linked one to another with “typed links” (i.e. RDF predicates)
- The term Linked Data refers to a set of best practices for publishing and connecting structured data on the Web
- An increasing number of data providers over the last years have contributed to the creation of a global data space containing billions of statements (RDF triples)

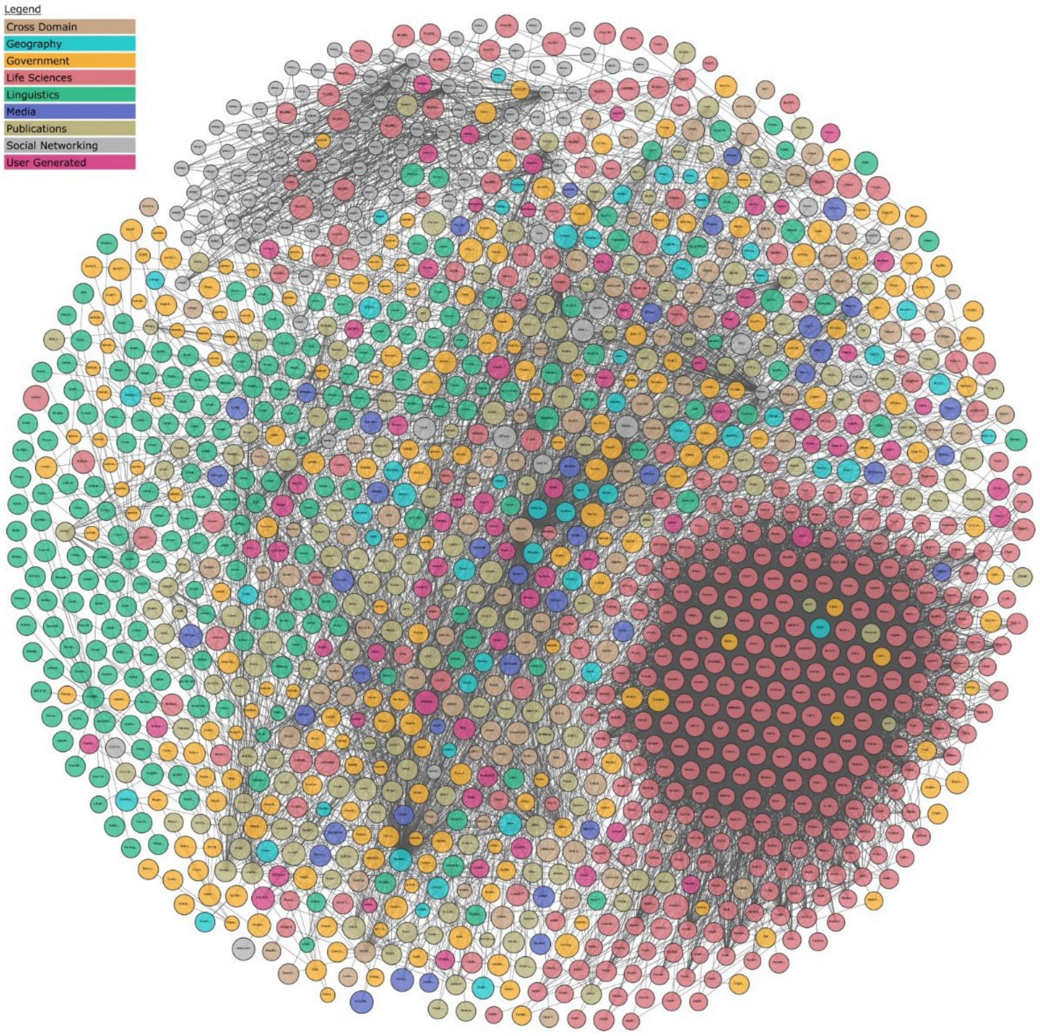
LOD in the Web (August 2014)



https://lod-cloud.net/

LOD in the Web (Nov 2023)

The LOD cloud contains 1314 datasets



The Linked Open Data Cloud from lod-cloud.net

https://lod-cloud.net/

Linked Data principles

- Use URIs as names for things
- Use HTTP URIs so that people can look up those names.
- When someone looks up a URI, provide useful information, using the standards (RDF*, SPARQL)
- Include links to other URIs, so that they can discover more things.

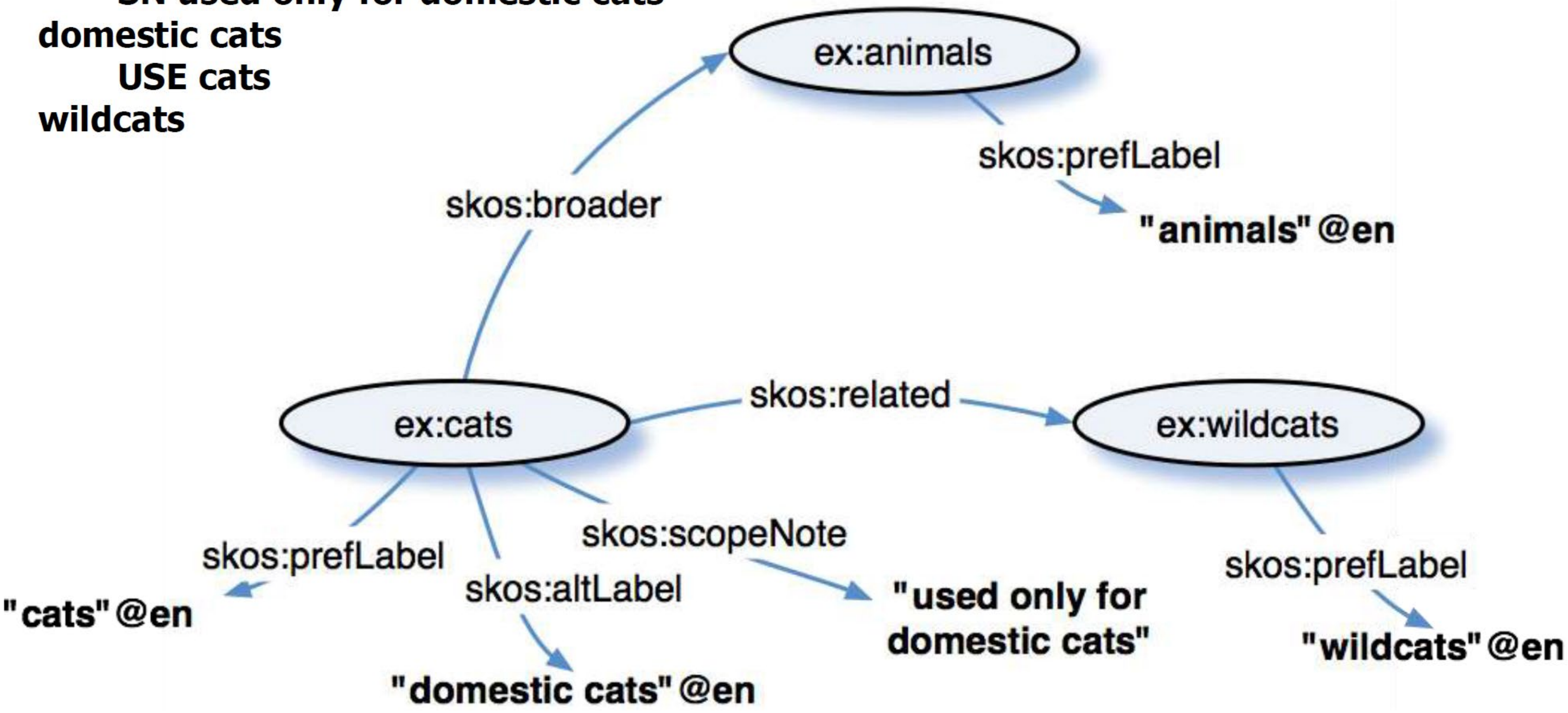
Using “de facto standards”

- Different communities have specific preferences on the vocabularies they prefer to use for publishing data on the Web.
- The Web of Data is therefore open to arbitrary vocabularies being used in parallel.
- Despite this general openness, it is considered good practice to reuse terms from well-known RDF vocabularies such as FOAF, SKOS, DOAP, vCard, Dublin Core, or Good Relations wherever possible in order to make it easier for client applications to process Linked Data.
- Only if these vocabularies do not provide the required terms should data publishers define new, data source-specific terminology

SKOS example

Simple Knowledge Organization System

animals
cats
    UF domestic cats
    RT wildcats
    BT animals
    SN used only for domestic cats
domestic cats
    USE cats
wildcats

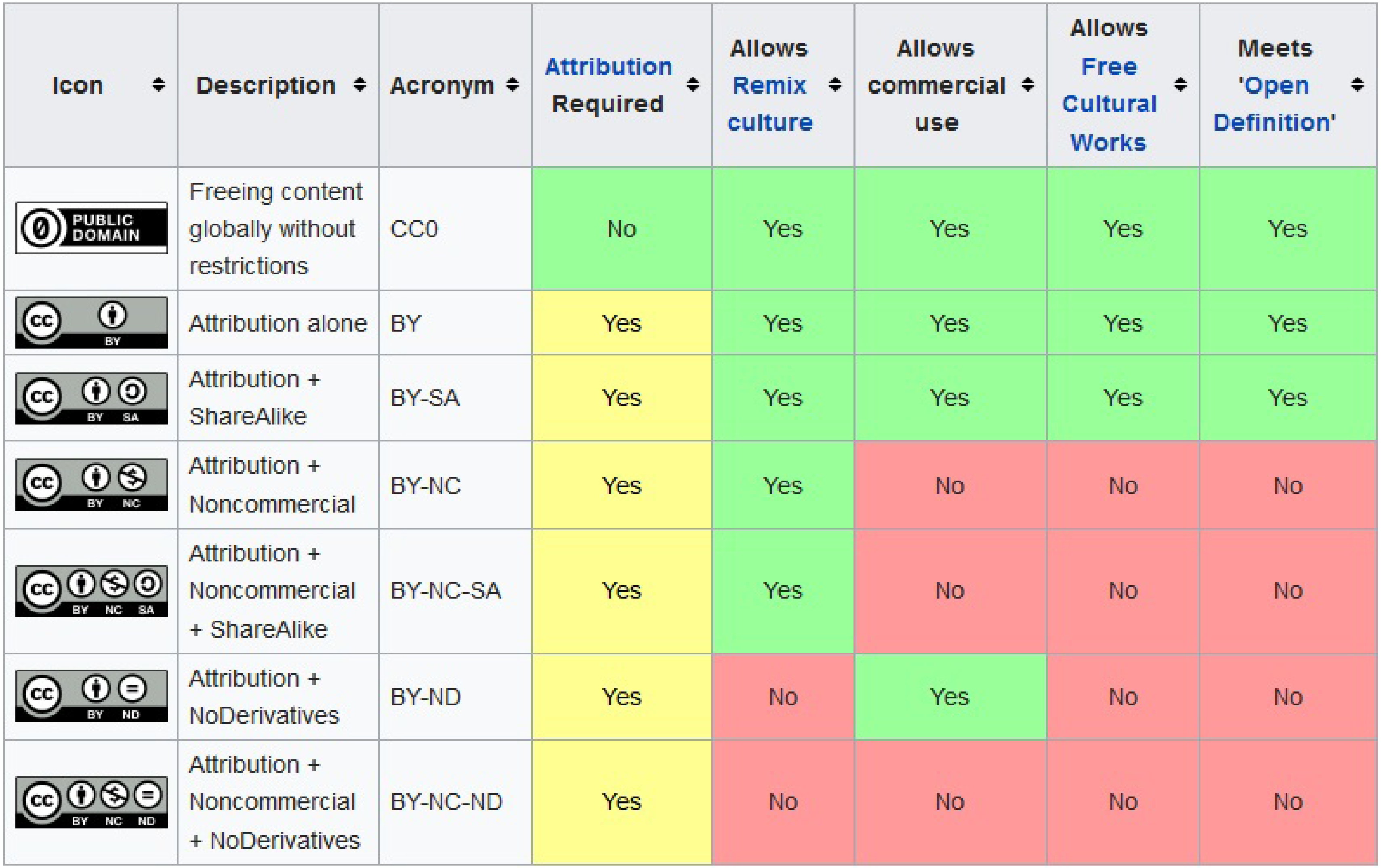


Five Star Open Data

- ★ make your stuff available on the Web (whatever format) under an open license
- ★★ make it available as structured data (e.g., Excel instead of image scan of a table)
- ★★★ use non-proprietary formats (e.g., CSV instead of Excel)
- ★★★★ use URIs to denote things, so that people can point at your stuff
- ★★★★★ link your data to other data to provide context

Usually Open Data is available under a **CC-BY-SA license**. This means you can include it in any other work (Creative Commons) under the condition that you give proper attribution (created BY). If you create derivative works (such as modified or extended versions of the Open Data), then you must also license them as CC-BY-SA (Share Alike).

Creative Commons



Icon	Description	Acronym	Attribution Required	Allows Remix culture	Allows commercial use	Allows Free Cultural Works	Meets 'Open Definition'
PUBLIC DOMAIN	Freeing content globally without restrictions	CC0	No	Yes	Yes	Yes	Yes
cc BY	Attribution alone	BY	Yes	Yes	Yes	Yes	Yes
cc BY SA	Attribution + ShareAlike	BY-SA	Yes	Yes	Yes	Yes	Yes
cc BY NC	Attribution + Noncommercial	BY-NC	Yes	Yes	No	No	No
cc BY NC SA	Attribution + Noncommercial + ShareAlike	BY-NC-SA	Yes	Yes	No	No	No
cc BY ND	Attribution + NoDerivatives	BY-ND	Yes	No	Yes	No	No
cc BY NC ND	Attribution + Noncommercial + NoDerivatives	BY-NC-ND	Yes	No	No	No	No