Lecture 1: Web of Things (Web 3.0) and Semantic Web in a nutshell

TIES4520 Semantic Technologies for Developers
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Part 1

Web of Things (Web 3.0)

Avalanche of information

Weather forecast and disaster notification systems

Education

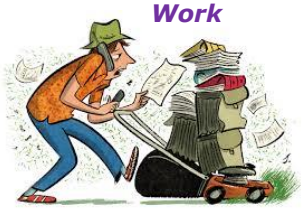
Road and city services

Events (art, cultural, sport), exhibitions, etc.

Social Networks

But!!! Information is not yet a data...

Work



Emergency service activities

Shopping Centers: sales, offers, etc.

Public transport scheduling system

Demands and Challenges

Demands of Society and Businesses

- *society requires **new innovative services and applications** that make the life much easier, comfortable and interactive;*
- *Industry and businesses require **new intelligent systems** to better perform maintenance and do better automation of service provisioning, product development and operation processes;*
- *markets are looking for **new opportunities** based on information/data co-creation and reuse.*

Challenges

Data

- ***unavailability of data** limits us to develop new useful services and whittles away context-awareness of applications and services;*
- ***complex accessibility and heterogeneity of data sources** limits consumption of data by applications and services;*
- ***human orientation of data formats** slows down the process of intelligent autonomous service creation and service integration;*
- ***passiveness of data sources**, **lack of handy channels to provide and manage data**, minimizes process of data reuse.*

Applications and Services

- *being **bounded to certain data source**, application is limited with possibility to access other data sources, to get more fresh and updated information;*
- *being based **on limited (closed) data model**, application is not able to utilize data produced by another application and be interoperable.*

Information sources (readiness to be consumed)

Digital sources of information:

- *huge variety of freely accessible digital sources of information available in human readable form;*
- *specific "closed" systems and databases with restricted access for limited number of applications and users;*
- *systems and services accessible through APIs;*
- *web sources with appropriate metadata descriptions.*

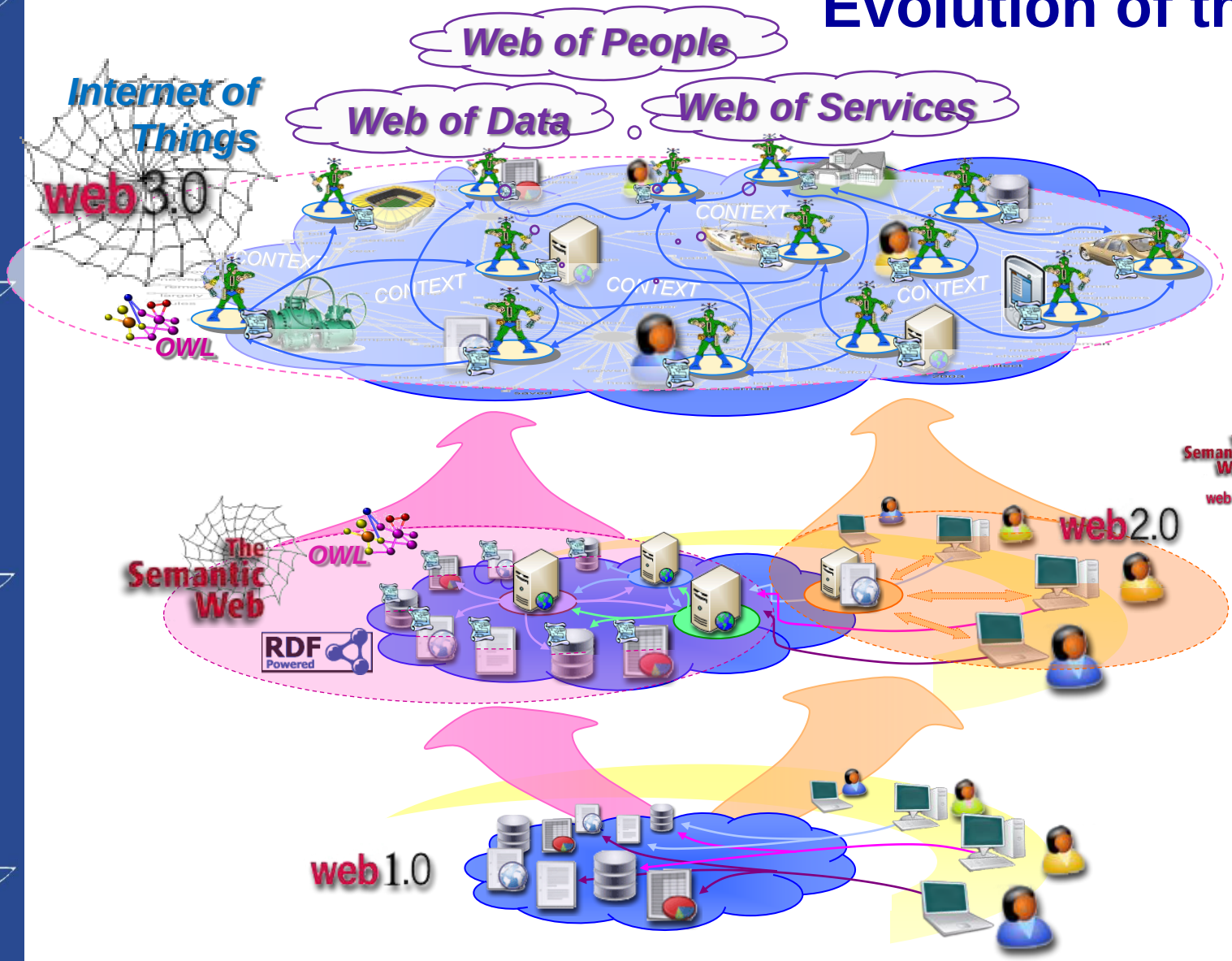
Non-digital information:

- *human oriented information in non-digitalized form;*
- *information that can be recognized only by human (visually, based on a sound or through other human sensors).*

Human as a very powerful data source:

- *various social networks, as human tools for content creation, become fast growing and rapidly updatable data sources;*
- *computational stations in human's pocket become ubiquitous sensor of the environment and intelligent provider of contextual information;*
- *As an expert, human might be used in knowledge and skill sharing process.*

Evolution of the Web



Context-aware Flexible Interoperable Dynamic Collaborative Environment

Proactive Goal-driven Resources:

data, services/software, processes, organizations, real world objects (human, device, machine, etc.)

Communication:

Resource-to-Resource *(Thing-to-Thing)*.

Flexible Interoperable Static Environment

Collaborative Environment

Resources:

Static Annotated Data, Ontology-driven Services/Software.

Communication:

Human-to-Data, Human-to-Service, Human-to-Human, Service-to-Data, Service-to-Service.

Static Environment

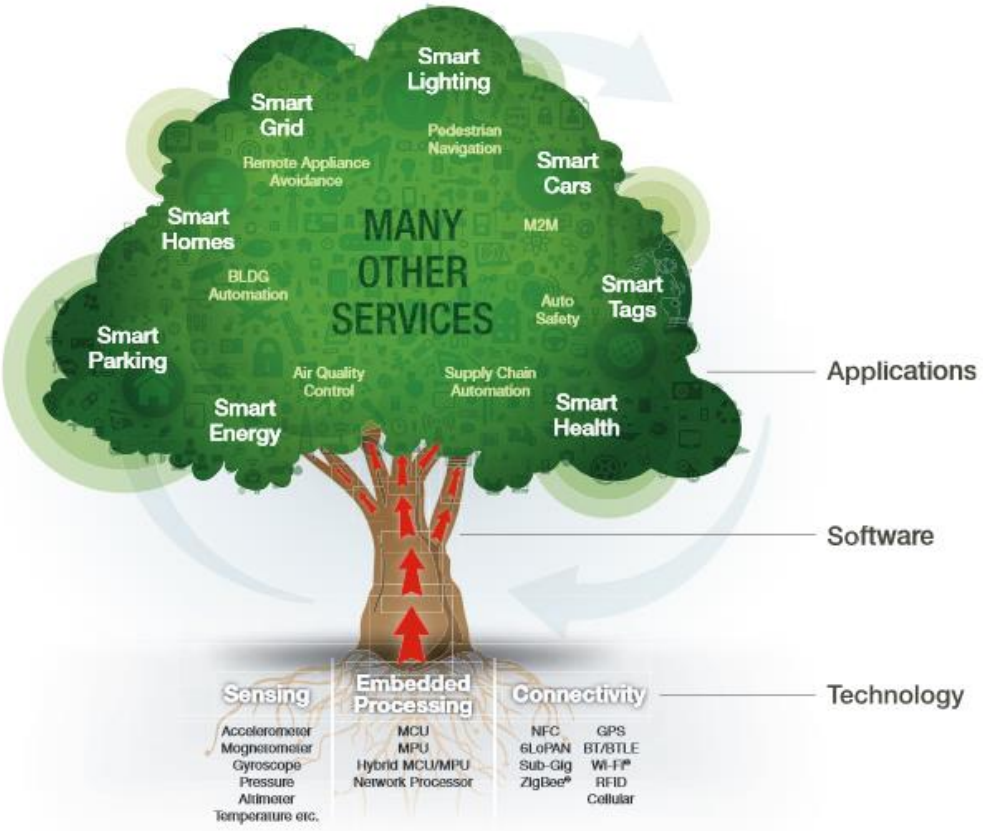
Resources:

Static Data, Static Services.

Communication:

Human-to-Data, Human-to-Service, Human-to-Human, Service-to-Data, Service-to-Service.

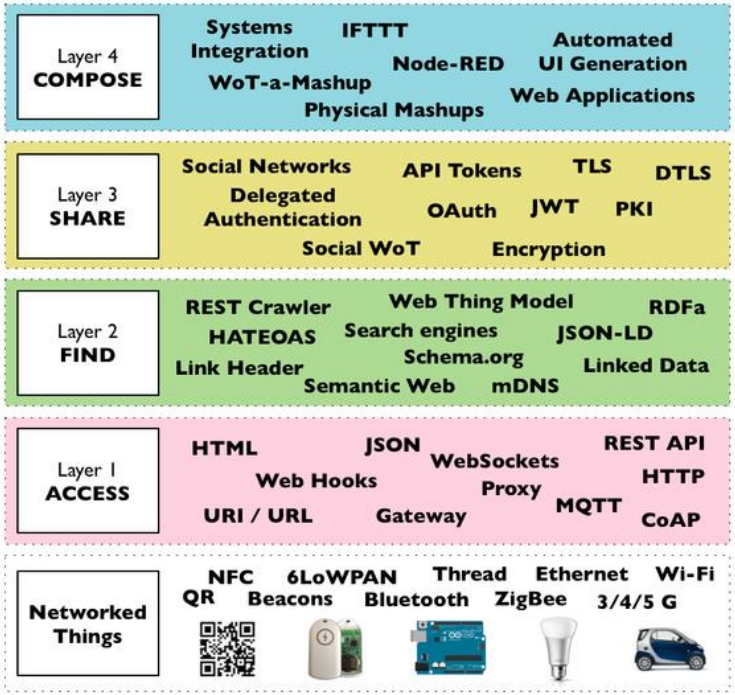
Towards Web of Things



IoT require thing-to-thing communication:

- *Transmit information (technical interoperability);*
- *Comprehend transmissions (semantic interoperability).*

Towards Web of Things



Source: Building the Web of Things: book.webofthings.io
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Web of Things (***WoT***) *is a term used to describe approaches, software architectural styles and programming patterns that allow real-world objects to be part of the World Wide Web. Similarly to what the Web (Application Layer) is to the Internet (Network Layer), the Web of Things provides an Application Layer that simplifies the creation of Internet of Things applications.*

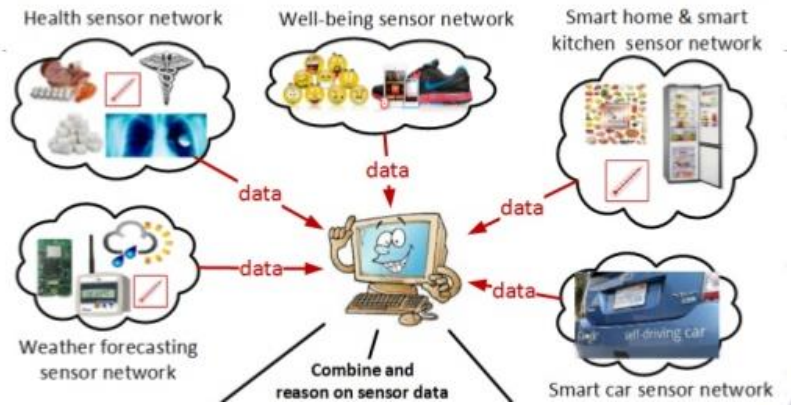
Rather than re-inventing completely new standards, the Web of Things reuses existing and well-known Web standards used in the ***Programmable Web*** *(e.g., REST, HTTP, JSON),* ***Semantic Web*** *(e.g., JSON-LD, Microdata, etc.), the* ***Real-time Web*** *(e.g., Websockets) and the* ***Social Web*** *(e.g., oauth or social networks).*

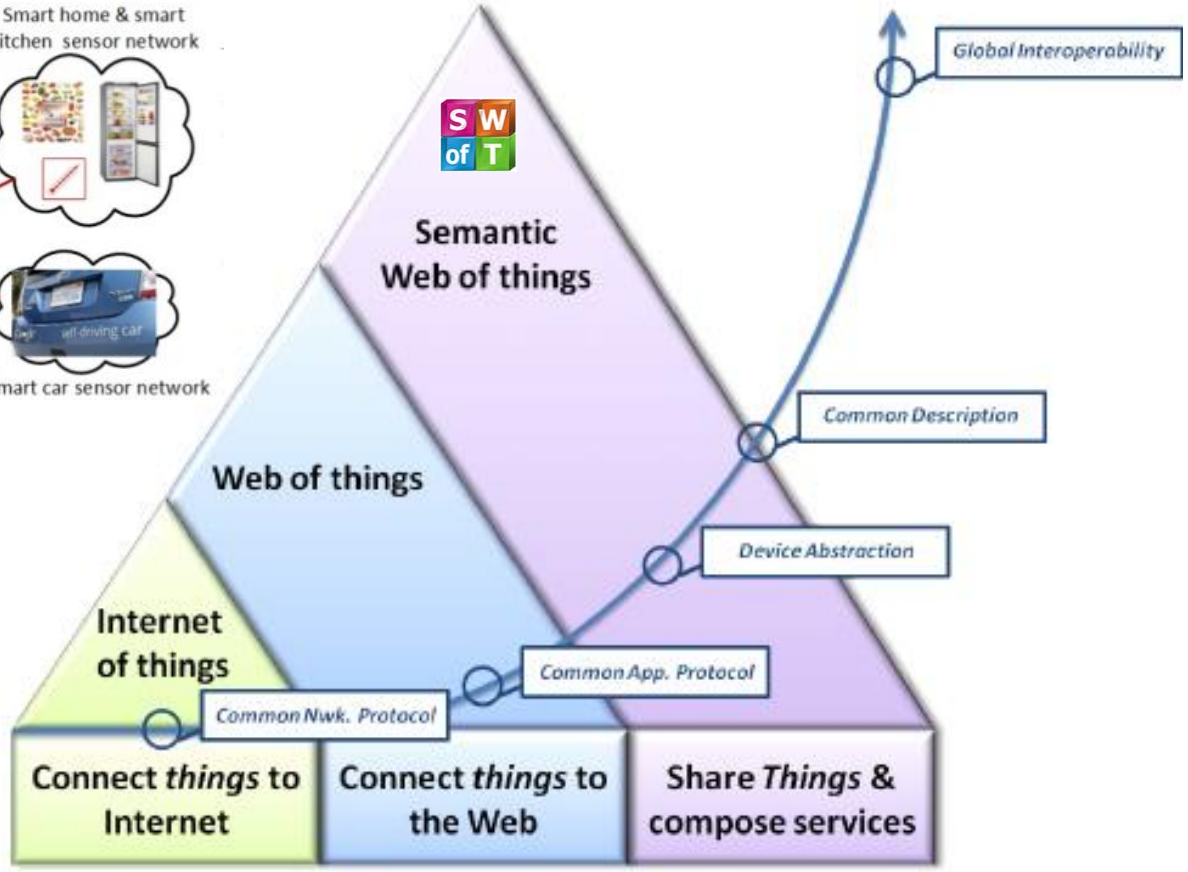
https://en.wikipedia.org/wiki/Web_of_Things

Examples

- *Samsung SmartThings: http://www.smartthings.com*
- *BOSCH IoT (Bosch ConnectedWorld Blog): http://blog.bosch-si.com/*
  https://blog.bosch-si.com/internetofthings/top-iot-success-stories-2017/
- *https://www.cio.com/article/3229671/10-internet-of-things-success-stories.html*
- *https://iot-analytics.com/iot-2018-in-review/*
- *…*

Towards Web of Things





Source *[1]*

Some Semantic Web of Things related materials:

- *https://www.researchgate.net/publication/314071541_Building_Interoperable_and_Cross-Domain_Semantic_Web_of_Things_Applications*
- *https://www.researchgate.net/publication/319284127_Towards_semantic_interoperability_in_an_open_IoT_ecosystem_for_connected_vehicle_services*
  https://www.researchgate.net/publication/309414146_Ontologies_and_Context_Modeling_for_the_Web_of_Things
- *https://www.researchgate.net/publication/318515502_A_Survey_of_IoT_Key_Enabling_and_Future_Technologies_5G_Mobile_IoT_Sematic_Web_and_Applications*
- *http://sisinflab.poliba.it/swottools/*

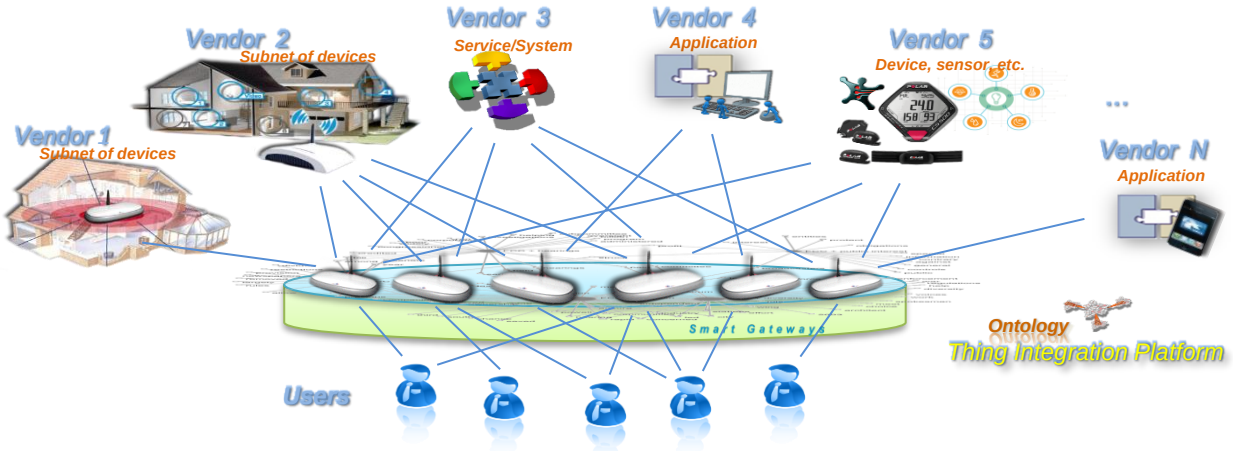
Towards Web of Things

Added value of Things

- *we are going to be surrounded by amazingly huge number of smart devices and entities that do a lot of invisible work for us and bring really useful added value;*
- *various sensors constantly produce huge amount of data measuring and logging various parameters of the environment, devices, systems, and of course people;*
- *having such variety of data and contextual information, intelligent systems are able to provide new innovative services that were impossible even to imagine before.*

Challenges of interoperable Web of Things

- *unwillingness of vendors to provide open, flexible and interoperable solutions;*
- *lack of open infrastructure for third party application and services development;*
- *unavailability of appropriate business model that brings benefits to end-users through fair open competitive environment of thing vendors.*

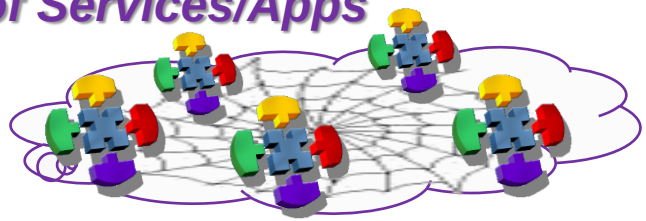


Evolution of the Web

Web of People

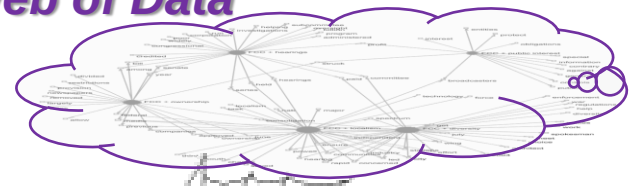
- *Human as a user (consumer of other Webs);*
- *Human as a service provider for other Things.*

Web of Services/Apps

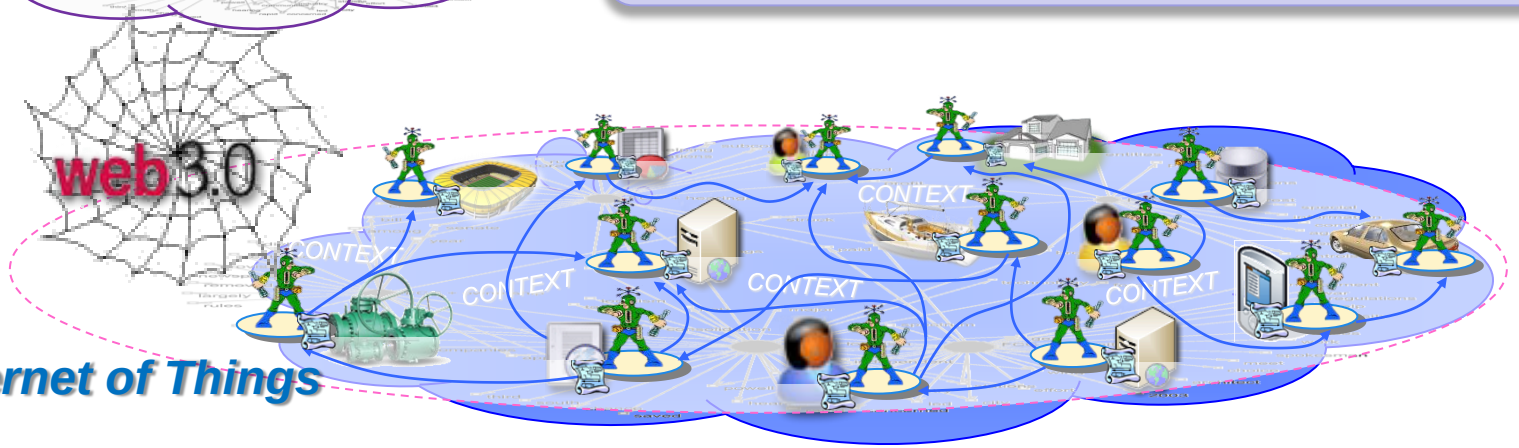


- *Thing representatives in the digital world (reflective/proactive);*
- *Apps and Services for Human;*
- *Services for non-Human Things.*

Web of Data

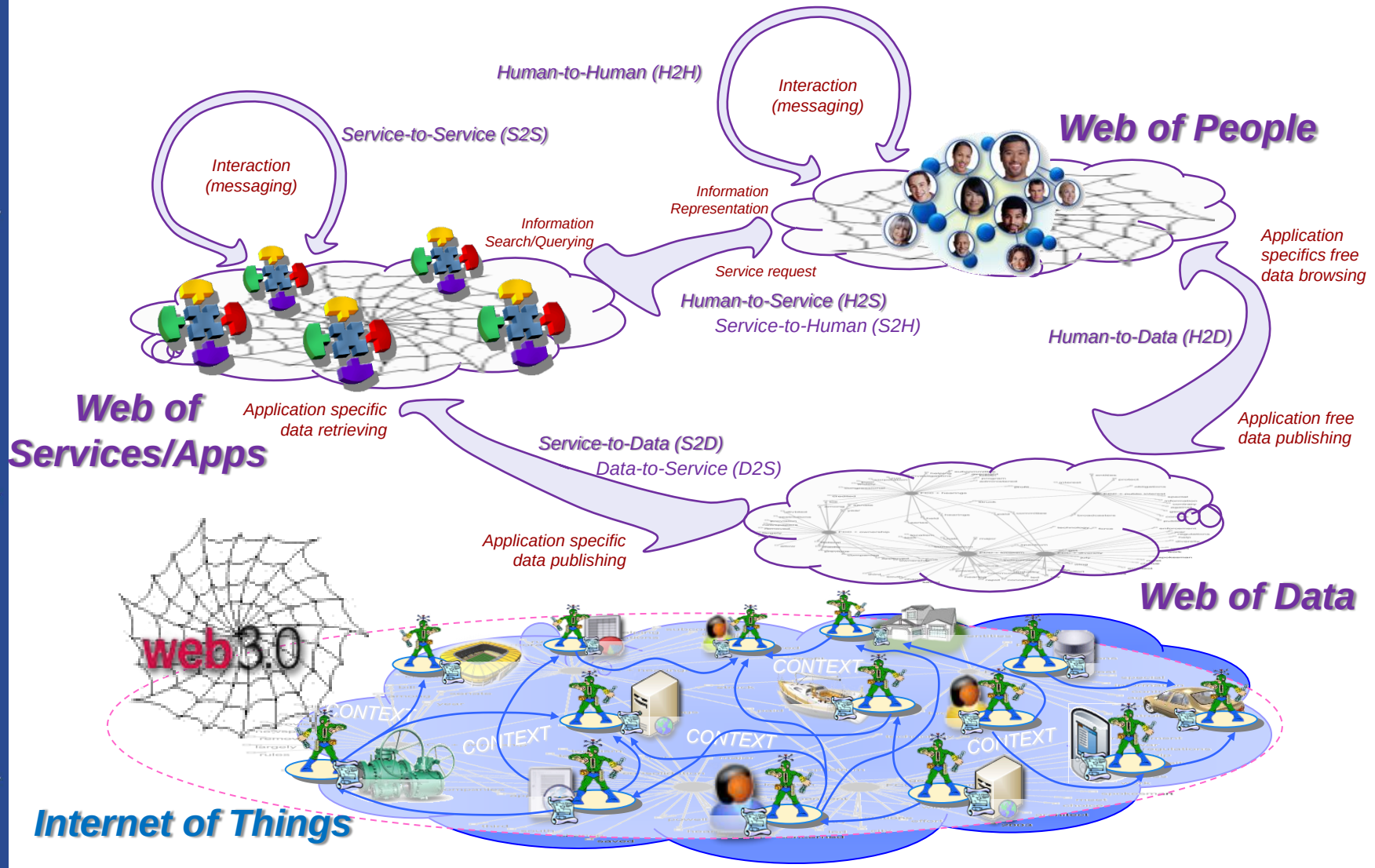


- *Unstructured data;*
- *Application dependent data;*
- *Semantically annotated and linked data.*

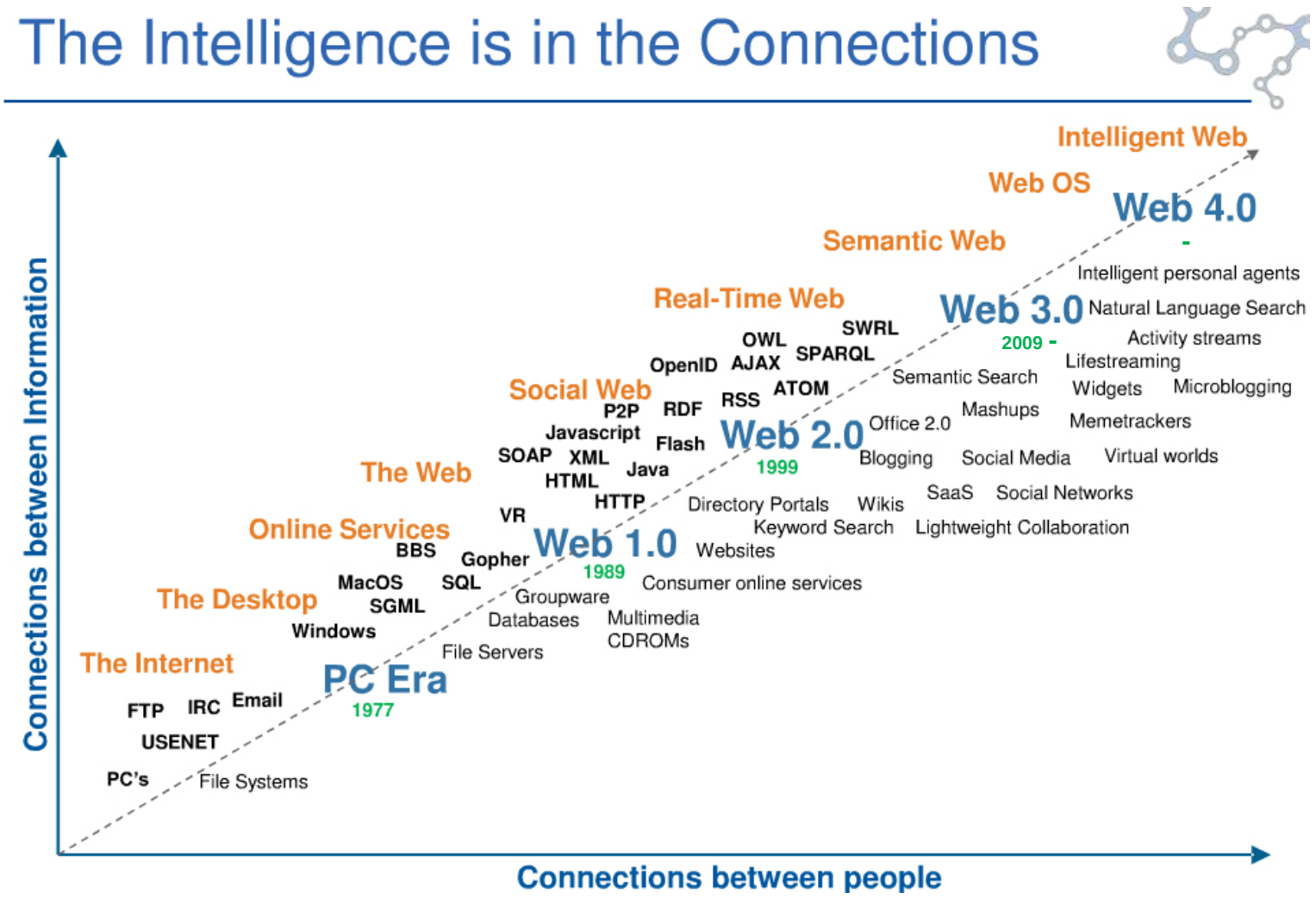


Internet of Things

Evolution of the Web



Web of Services and Apps



Source: *http://www.tryscribble.com/wikis/open-innovation/pages/creating-and-handling-metastability-of-the-web*

Web of Services and Apps

Service-to-Human (S2H) interaction:

People are great asset to be utilized in servicing, service support and service creation process. Human should not be considered only as a user (service consumer) anymore. Human should be involved into the process as an expert – valuable part of a service ecosystem that provides own knowledge and expertise, and adds value to technology evolution. Thus, to be accessible by any other Things in the Web, Human, as all the objects of the real world, needs a unified adapter to a digital world.

Personal Human Assistant *- is a distributed agent system that communicates with a human through various communication channels, manages user profile and behaves as a representative of the user in a digital world.*

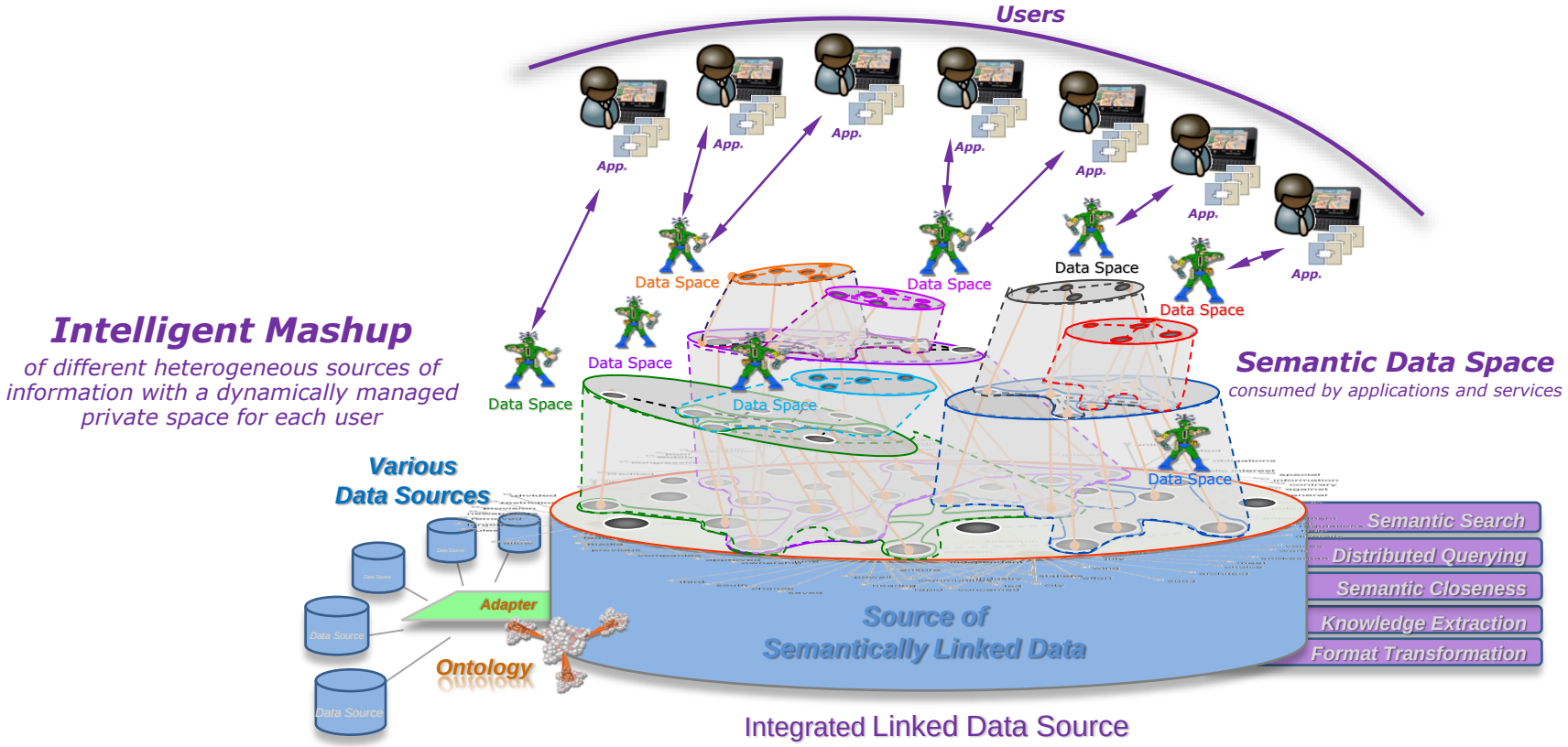
- *Collects all user-related and contextual data (from user's inputs, body and other sensors, massaging, utilized applications and services, etc.) constantly updating user profile;*
- *Constantly learns personal user's preferences and updates personal data model (ontology) for communication;*
- *Learns user's behavior model and automates (semi-automates) various processes of the user's life.*

Web of Services and Apps

Data-to-Service (D2S) interaction:

Semantic Data Space - *is intelligent data management ecosystem* [2][3]

- *contains virtual data spaces, personally created for every application/service willing to consume the data;*
- *is represented by agents-manager of personal data spaces, that is responsible for proper context-dependent data access control, for relevance of collected data and unambiguousness of it.*



Web of Services and Apps

Service-to-Service (S2S) interaction:

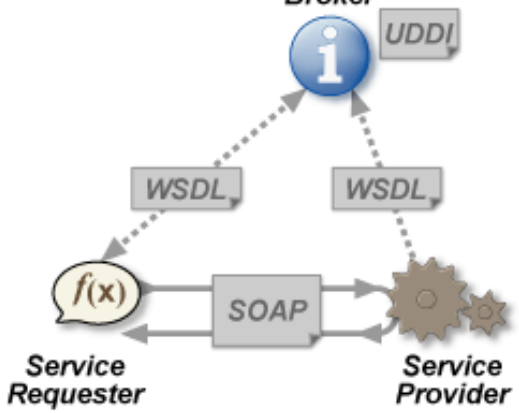
Web Services – are software systems offered over the Internet via platform and programming-language independent interfaces defined on the basis of a set of open standards such as XML, SOAP, and WSDL.

- *Web Services description/definition has been done with WSDL (http://www.tutorialspoint.com/wsdl/index.htm) that provides a machine-readable description of how the service can be called, what parameters it expects, and what data structures it returns. Specification of only syntactic interoperability without semantic meaning of data requires programmers to reach specific agreements on the interaction of web services and makes automatic composition very difficult;*
- *Web Services interaction has been implemented via XML-based SOAP (Simple Object Access Protocol) messaging;*
- *Web Service composition has been supported by several languages in order to combine services in a process-oriented way (e.g., BPEL4WS, WS-BPEL);*
- *Web Service publication has been performed via UDDI (Universal Description, Discovery, and Integration)registries that were relatively complex and do not support expressive queries.*

WSDL Document Structure

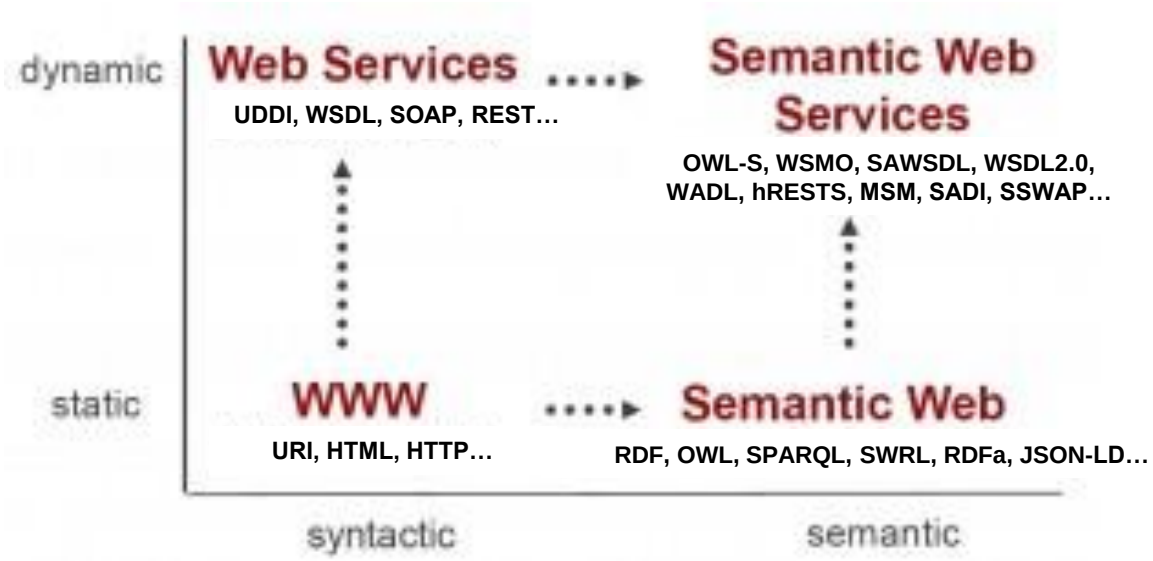
```
<definitions>
   <types>
    definition of types.......
   </types>
   <message>
    definition of a message....
   </message>
   <portType>
      <operation>
       definition of a operation.......
      </operation>
   </portType>
   <binding>
    definition of a binding....
   </binding>
   <service>
    definition of a service....
   </service>
</definitions>
```

Lack of semantics to automate the process…



Web of Services and Apps

- **Service-to-Service (S2S) interaction:**



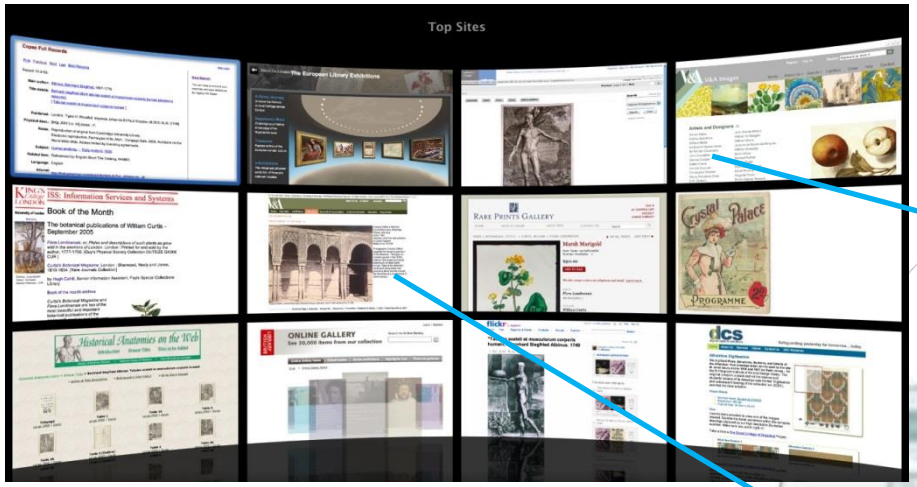
Part 2

Semantic Web in a nutshell

World Wide Web (WWW)

web page

(document with some information)

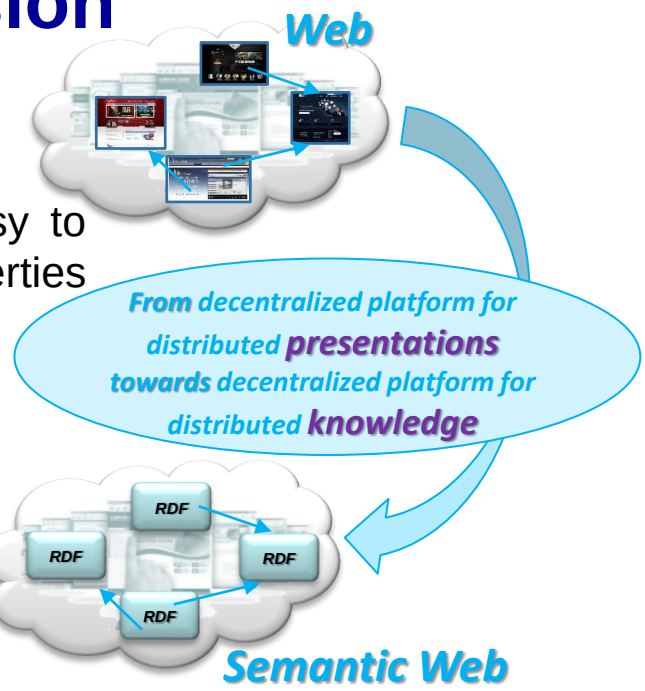


World Wide Web

- **AAA principle** = Anybody can write Anything about Any topic
- Basic building block is a web page
- Any web page can refer to any other web page freely
- No central point of control
- No central repository. Documents scattered across the whole Web…

- ***Problem***: Web page is a ***document for humans***. For computers (machines) web pages are too *difficult to understand*

Semantic Web vision



- Solution
  - Let's produce Web data in a form that is easy to "digest" by a machine without losing good properties of WWW
- How?
  - Switch: informal representation => formal model
  - Connect information, but stay consistent
  - Distribute information (no central repository)
- Semantics
  - Relation between signs, words, symbols and the *things* (documents, people, places, events, organizations, concepts, etc.) to which they refer.
  - Relation of the things to each other.

Syntax: *I love technology* *I ♡ technology*

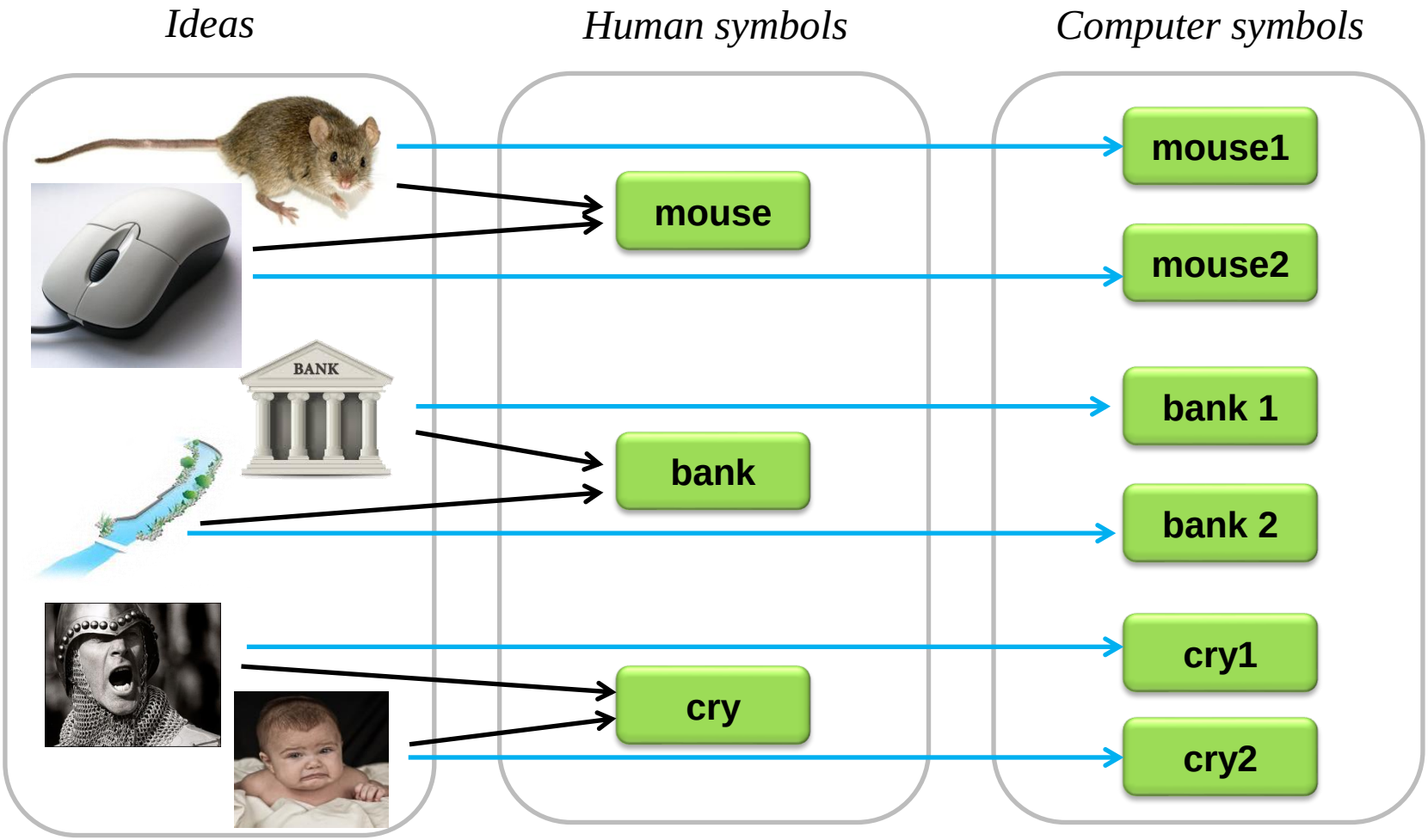
Semantics: *I am enjoying about learning and using new technology…*

Challenges of Semantic Web

- We want:
  - Anybody can express data/knowledge about anything and connect it to anything
  - Web of distributed knowledge where the logical pieces of meaning can be manipulated by machines in a smart way

- We face these main problems:
  - How can I express some data so that it is disambiguous?
  - How can I refer to data (= connect it)?

Disambiguity of data (1)



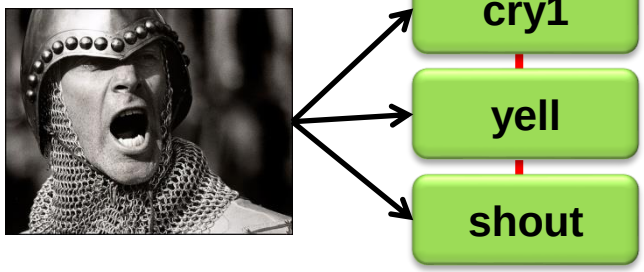
Disambiguity of data (2)

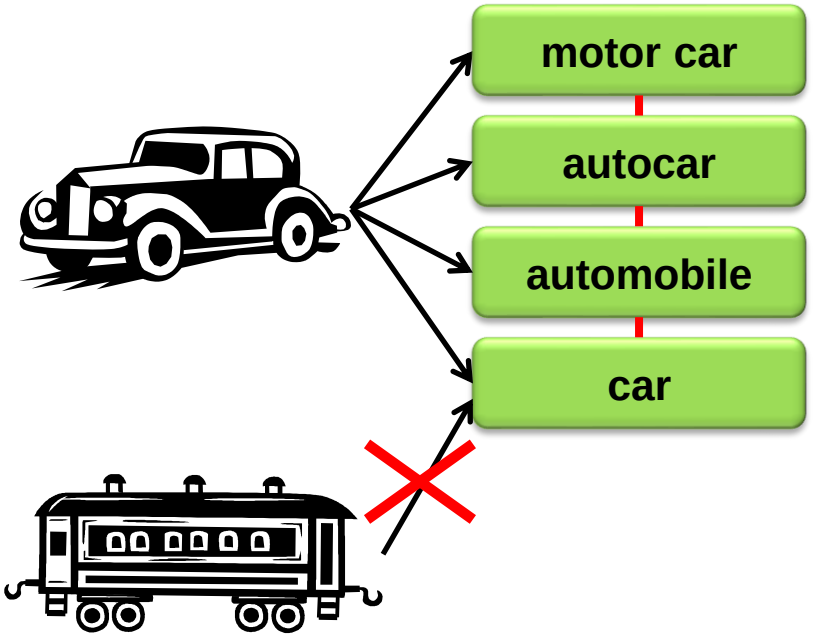
- Disambiguity of referencing to things:
  - Example: mouse, windows, cry, …
  - Every thing should have its ***unique*** name
  - Solution: URIs (Uniform Resource Identifiers)

- Disambiguity of concepts
  - Example:
    - John is *attracted to* Mary.
    - North pole is *attracted to* south pole.
  - There has to be some common understanding of the domain in question
  - Solution: ***Ontology*** – a precise explanation of terms and reasoning in a subject area.

Non-unique Naming Assumption

- Some resource (abstract idea or concrete thing) may have several names
- We have to ***explicitly*** tell the computer that these names mean the same thing





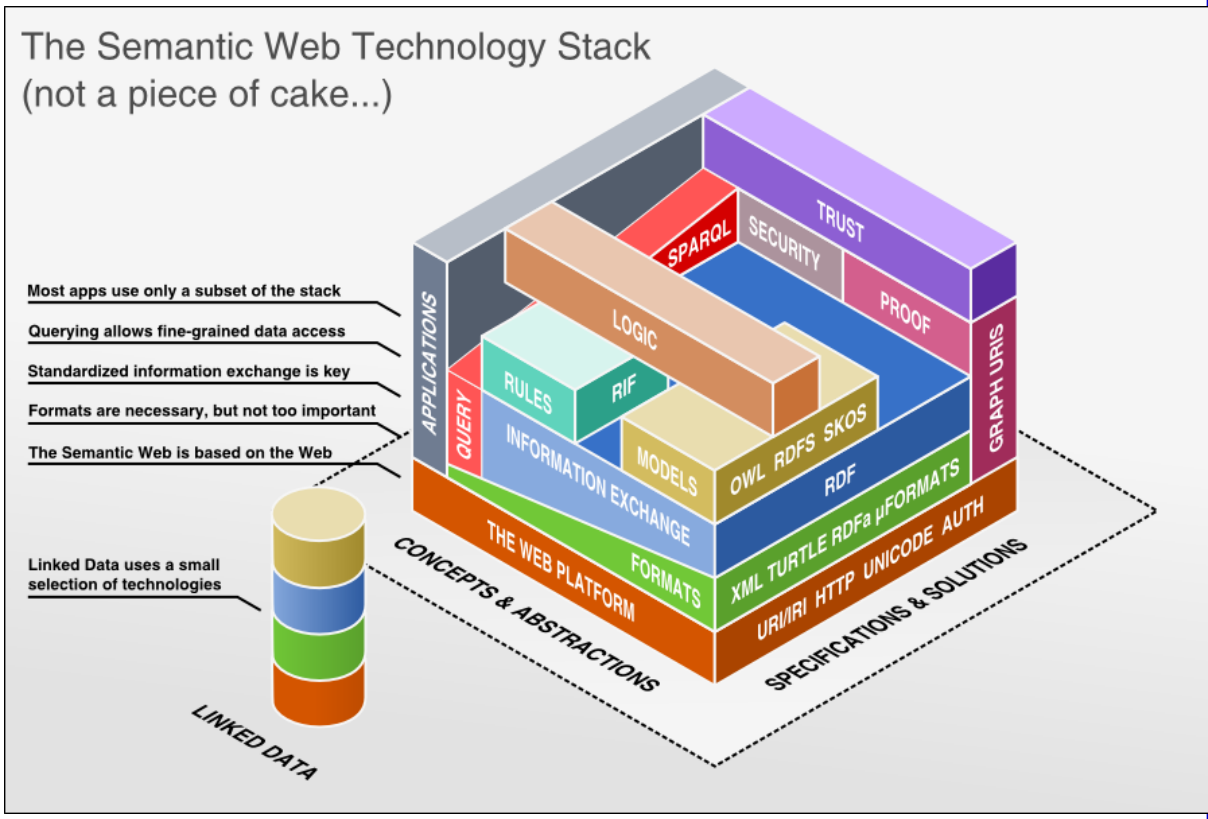
Open world assumption

- Any information can come at any point in the future
- We never know everything about the world. There can be true facts that are not contained in the knowledge base

	Open world	Closed world
Data	Helsinki and Tampere are in Finland. Paris is not in Finland.	
Q1	Is Helsinki in Finland?	
A1	YES	YES
Q2	Is Paris in Finland?	
A2	NO	NO
Q3	Is Jyväskylä in Finland?	
A3	I don’t know	NO

Half way summary

- Semantic Web
  - Anybody can express data about anything and connect it to anything
  - Data is readable and manipulated by machines
- Problems
  - Disambiguity of data => URIs + ontologies
- Properties
  - Non-unique Naming Assumption
  - Open World Assumption



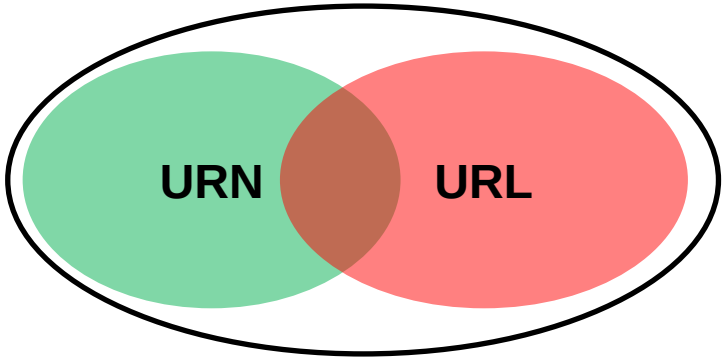
URI (Uniform Resource Identifier)

- **URI** globally identifies a certain entity (abstract or real)
- Special cases
  - ***URN*** (Uniform Resource Name)
    - Identifies the resource by naming it (URN is the name)
  - ***URL*** (Uniform Resource Locator)
    - Identifies the resource by locating it (URL is the address)
- Examples:

  http://bakery.com/breads/baguette

  isbn:0-12-385965-4

  http://users.jyu.fi/~olkhriye/ties4520/lectires/Lecture01.pdf



Namespaces

- Problem:
  - In one document you have these URIs:
    - *http://www.jyu.fi/people/students/john/assignments/assignment1*
    - *http://www.jyu.fi/people/students/john/assignments/assignment2*
    - *http://www.jyu.fi/people/students/john/assignments/assignment3*
  - Too long representation
- Solution:
  - Introduce a namespace as a prefix of the short (qualified name):

Full name: *http://www.jyu.fi/people/students/john/assignments/assignment1*

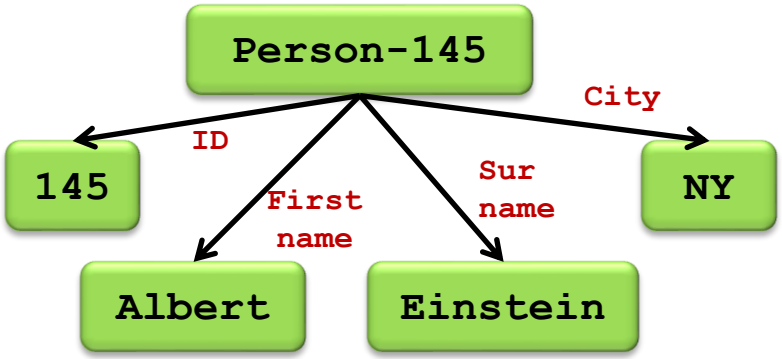
Prefix (for example as:) Rest of the name

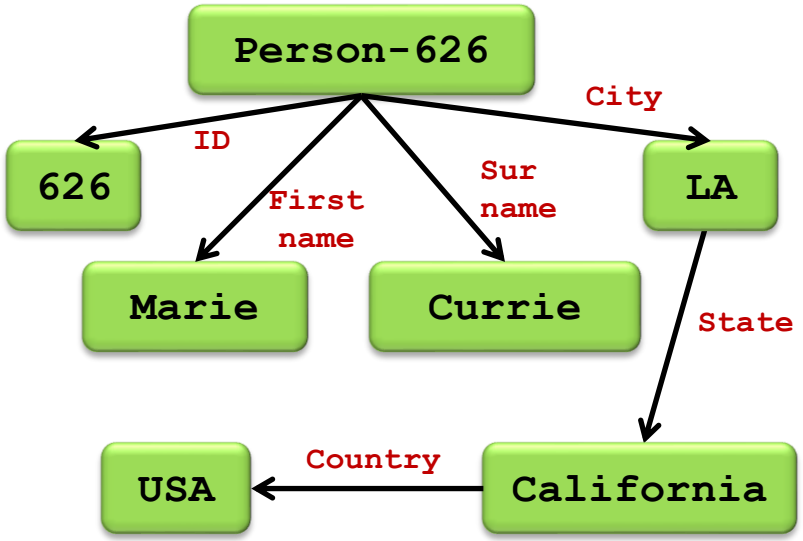
  - Use qualified names (qnames):
    - as:assignment1
    - as:assignment2
    - as:assignment3
- Benefits:
  - Improved readability
  - Saves space

RDF (Resource Description Framework)

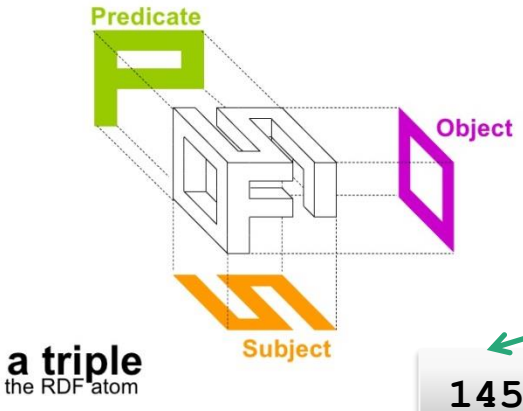
- RDF is a general method to decompose knowledge into small pieces with rules about the meaning of those pieces. It is a method to *describe facts in a short form*.
- Everything is a *Resource*
  - Anything that we can talk about and has identity in a form of URI.
  - Example: human, building, weather
- RDF represents graphs

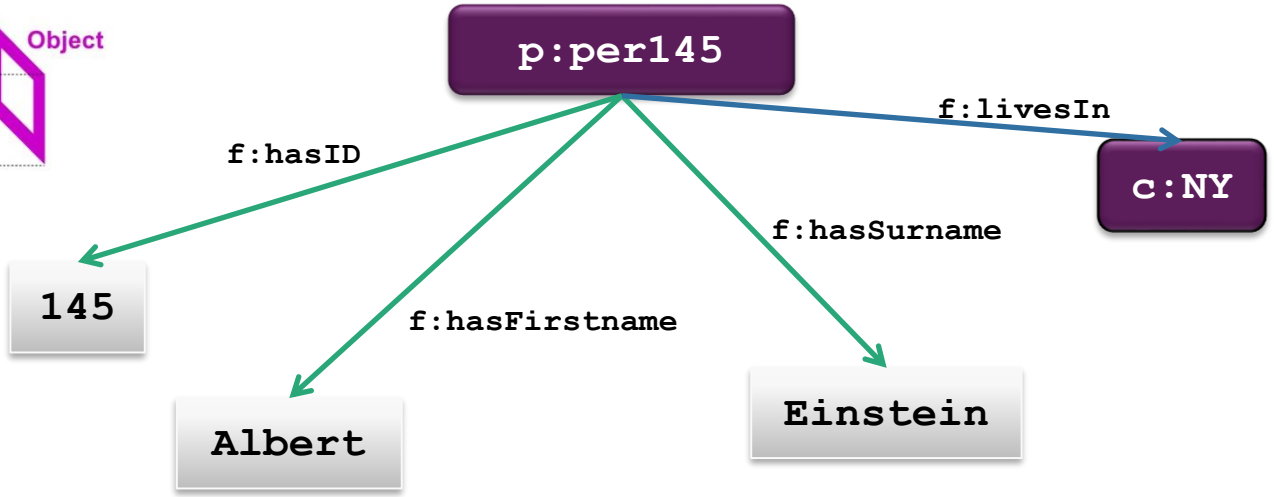
ID	Firstname	Surname	City
145	Albert	Einstein	NY
626	Marie	Currie	LA





RDF as graph, RDF as text

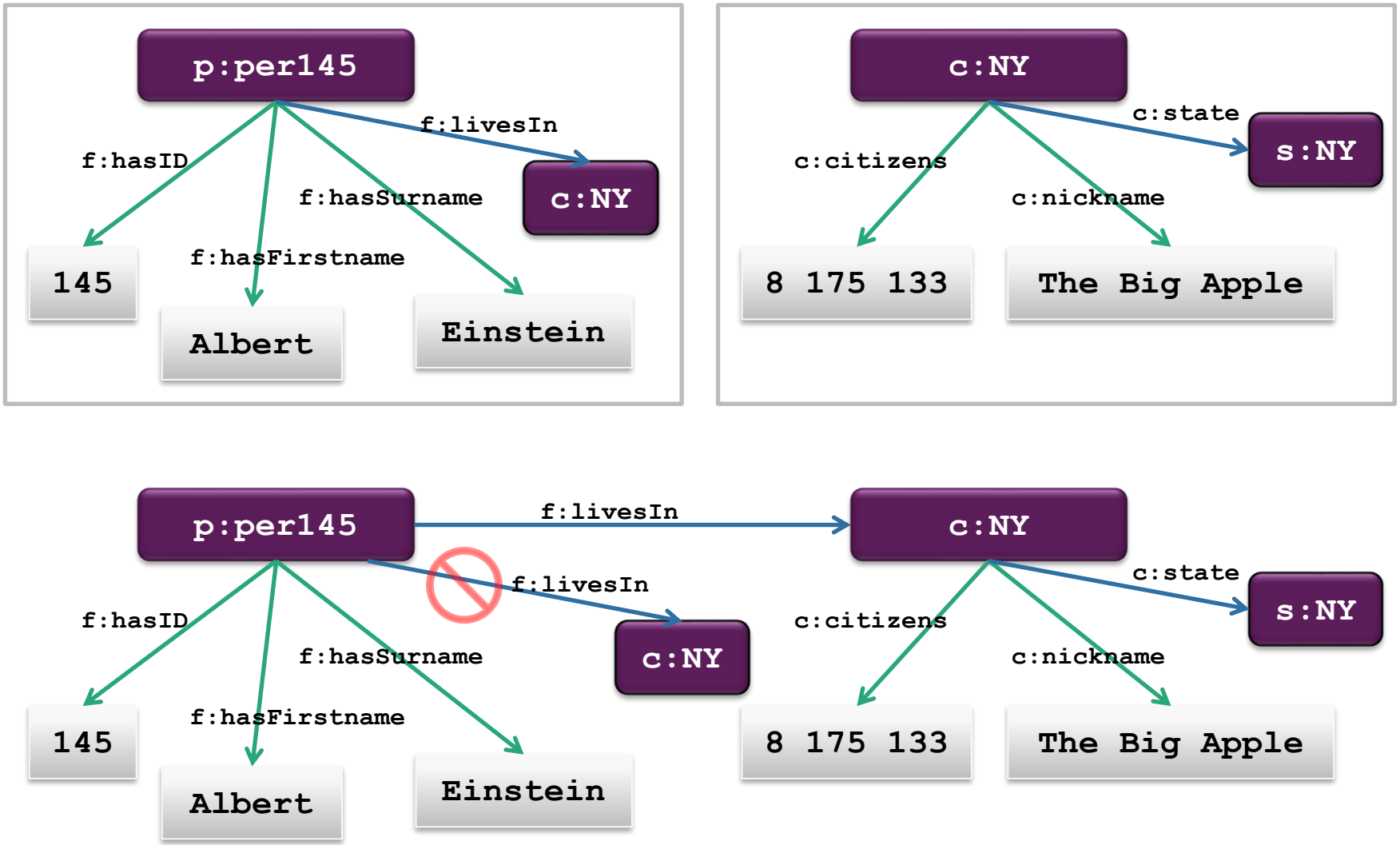




All the data in RDF is described in statements/triples:
subject – predicate – object

```
p:per145 f:hasID "145" .
p:per145 f:hasFirstName "Albert" .
p:per145 f:hasSurname "Einstein" .
p:per145 f:livesIn c:NY .
```

Graph matching and merging



References

All the links in the lecture materials

- [1] Jara A.J., Olivieri A.C., Bocchi Y., Jung M., Kastner W., Skarmeta A., Semantic Web of Things: an analysis of the application semantics for the IoT moving towards the IoT convergence, In: International Journal of Web and Grid Services 10(2/3):244-272, April, 2014.
- [2] Khriyenko O., Nagy M., Semantic Web-driven Agent-based Ecosystem for Linked Data and Services, In: Proceedings of the Third International Conferences on Advanced Service Computing (SERVICE COMPUTATION 2011), 25-30 September, 2011, Rome, Italy, 8 pp.
- [3] Khriyenko O., Collaborative service ecosystem: step towards the world of ubiquitous services, In: Proceedings of the IADIS Multi Conference on Computer Science and Information Systems 2012 (MCCSIS-2012): IADIS International Conference Collaborative Technologies 2012, 17-23 July, 2012, Lisbon, Portugal, pp. 185-190.

Relevant lecture materials

- RDF: What is RDF and what is it good for?: *https://github.com/JoshData/rdfabout/blob/gh-pages/intro-to-rdf.md#*
- Semantic web: *http://www.youtube.com/watch?v=OGg8A2zfWKg*
- Linked data: *http://www.youtube.com/watch?v=qMjkI4hJej0*
- Web 3.0: *https://www.youtube.com/watch?v=0tZFQs7qBfQ*