Answer to the European Commission public consultation on the early challenges regarding the "Internet of Things"

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How the (World Wide) Web changes the way humans interact with information.

The invention

Tim Berners Lee invented the WorldWideWeb as an implementation of hypertext in a connected environment : the Internet.
Hypertext is a way to provide comprehensive browsing experience for an evolving set of documents, with minimum technical infrastructure and minimum technical overhead for the authors and readers.

This architecture was perfectly suited for a Web of Documents, and it has had tremendous success in all groups dealing with document publishing.

It is commonly admitted that the World Wide Web has provided an innovative answer to remote data access, information browsing and data sharing among humans.

The evolution

During the 90s, and even more in the 2000s, the Web of Document has become a major interest for Internet users, both for publishing information and consuming it.

Its technical architecture has evolved to manage a new broader scope: the Web Of Documents has evolved into a Web of Data (Web 2.0).
Nowadays, it is possible to mashup (i.e aggregate/filter/transform/link) information from various sources and documents, such as documents, databases, remote services or even other people.
The term Web 2.0 is common accepted to describe the evolution of systems and architecture towards a more user-centric Web.

The Web 2.0 is now fine to publish/consume both documents and data.

But in the near future, we must expect the scope of the Web to extend further to include, documents, users and Things.

So it is important to think about the next-gen Web architecture: what is not correct today? What could be done to imporve that? What are the goals of a Web of Things?

Towards a next-gen web.

The current state of the art

The (current state of the art) Web 2.0 provides a lot facilities to mashup data, manage user feedback into the system, and some very powerful interaction systems between users.

But several shortcomings are to be solved in the next years:

Data exchange is usually specific for each application by each vendor.
Data mediation and commonly agreed data formats and exchange formats are poorly developped on global-scale. That situation dramatically reduces the global dynamics of the system.

Because of that, no automatic systems has emerged from the web. The user is always involved with data treatment, filtering...

The problem of goal achievement on the Web

In the Web 2.0 technologies, it is quite difficult to mix several services or data sources together, especially if the systems are available on remote sites for which you have poor control or access rights, or each data sources do not know about each other.

This architecture makes it very difficult to build full-vertical applications,
that considers a user's need and try to get everything from the Web to help the user manage that need. Of course, everything is available on the Web, but each piece of data is not connected (or connectable) with the others to provider a correct set of information
To achieve the user's goal, only the user can interconnect those data, manage them in his or her own way in order to achieve the goal.

This makes goal achievement on the Web to become incredibly difficult, especially if you consider an environment where no efficient search engine is available.

The Semantic Web as the next step.

The Web as seen by Tim Berners Lee is a way to get more from your data by interconnecting it with other data in a global system.
But the Web 2.0 has reached a dead end in that perspective, standards are very difficult to impose among big players, and web applications and services are difficult to reuse and improve.

This situation will prohibit the Web to manage new paradigms in data interconnection, such as the Internet of Things.

So, for Tim Berners Lee, it is time to rethink the system and focus on the meaning of data.

For him, the system must become semantic-aware, ie. the semantic inside the data becomes the contract between systems instead of the data format and protocol.
Web servers, architectures, data formats, web services will become a commodity in this "Semantic Web", all providing the necessary tools to achieve the single most important goal: managing and providing semantic information.

Considering that only the semantics of data is important, we now can concentrate on the information, the concepts, the statements inside the data and how they relate to each other.
Then, the Web can evolve and manage new kind of data, in new innovative ways.

Typically, the Internet of Things cannot stand in the current Web 2.0 paradigm.
Concepts such as geolocated services, proximity services, services mashup cannot become general concepts in the Web 2.0, and trying to mimic them with the current paradigms will become a real mess.

Switching from the Web 2.0 to the Semantic Web

In the Semantic Web, the point is to build systems that manage *transparent* data and systems interconnection, mashup and manipulation in order to achieve a given goal. You no longer manage almost-immutable data structures; everything is a piece of a goal-driven process that will involved each needed piece of the system.

This infrastructure is much more adaptable but breaks some paradigms of the Web 2.0 such as client/server, text inside tags in HTML, databased-backuped web sites.
They are replaced by new concepts such as client/multiple servers, semantic information alongside their textual representation, semantic database exposed to the users directly and worldwide data interconnection.

How the (Semantic) Web will change the way humans interact with things.

Considering that we investigate a world of Interconnected Things (a Internet of Things), it is necessary to think about the paradigm shift that Tim Berners Lee promotes with the Semantic Web.
Let's keep the good things of the Web 2.0 but extend it to a broader scope and propose a next Web.
This is a fundamental and necessary step to achieve a Web of Interconnected Things. We, at Datao.net, consider it is very important to investigate the Semantic Web for the "Internet Of Things" initiative.

In the next part, we will discuss various central technologies of the Semantic Web and how they relate to the Internet of Things.

The need to rethink the web browser

All clients? All servers?

In a very interconnected Internet of Things, we cannot consider the publisher/subscriber model to be the most important paradigm. It becomes a subatomic operation in a chain of request/response.

Getting things done with all of the devices

When achieveing the goal of managing your next food shopping, you will need to get information from various sources (the fridge, the virtual cookbook, may be your bank account, your calendar, the supermarket calendar for promotions, etc). All those data may be known to you or yet unknown but still relevant, that is why it is important to consider data as several sets to be aggregated on the fly depending on the goal to be achieved.

From that perspective, the existing solutions based on statically-defined data models, pre-generated data aggregation programs or limited sets of goals is too limitative. The system should understand the questions of the user and search/retrieve/manage all the data available in order to answer it. The user should not be the mediator between all the devices and data, but the ultimate decision maker, after optimal data aggregation and processing by the system.

These use cases require to consider data with a new eye and define a next-gen preprocessing and discovery mechanism. So a given set of devices and systems can interact together in order to achieve a given goal.

In that perspective, the Semantic Web is well suited to modelize such data and systems, with all those constraints in mind.

A use case of the Web of Things.

Let's illustrate the Web of Things with a (very simple) example.

Dumb use case 1 (no tech):

You are just coming back from the supermarket with some food and other goods for your home. Some goods are to be stored in the fridge.
Let's consider the fridge as a smartItem, connected to the Internet, enabled with a webcam and an internal semantic web browser.

What the system must do is to understand how the human has just interacted with itself. For example, the user may have shown the bill to the webcam. What the user meant is "here are the good I have bought". With text reckognition or barcodes decoding, the semantic browser inside the smartItem can discover which goods are related to itself ("i

am a fridge, so i probably now contain the apples, the oranges, the milk that the user has mentionned) and act accordingly.
The system (ie the fridge) has been able to “understand” the user (and more generally the outside world) and it is now aware that it has been refilled the stock of food with apples, orange juice, meat, eggs, etc.

From that moment, the fridge can become a data provider for other services inside the kitchen, such as the virtual cookbook, the virtual expiry date reminder, etc.

Dumb use case 1 (tech):

The fridge is both a data consumers (from its sensors) and a data publisher.
It reads data from outside: the bill, the supermarket website, the user’s cellphone, the webcam, etc.
It reckognizes the useful concepts from its point of view (ie. a fridge will never bother with bank account information), processes them and interconnects those semantic data together. Then, it can initiate actions and also become a data publisher for other devices.

We now have a smart fridge that can help other devices with any goal related to food and cooking. Some other semantics could be added to this smartItem, for example electrical consumption. Then the fridge could interact with other applications and systems involved in the specific semantic (i.e domain) of electricity consumption.

DataO as a next-gen browser

A platform for the Semantic Web

Current architectures will have to be rethought in order to deal with the Internet of Things, for which the frontier between client and server does not exist any longer, where devices will be used together for an optimal goal resolution, where involved systems are to be dyn amically discovered based on the semantic of the goal.

In that perspective, we would like to introduce our semantic web browser technology called DataO, a technological platform to experiment the capabilities of the Semantic Web. This technology offers the current browsing capabilities of modern browsers, but provides advanced features both from a human-machine interaction point of view and from a data processing point of view.

Integrated semantic processor

Datao embeds a semantic engine. So it can extract meaning from the content of data. With this device, Datao is able to crawl data automatically, identify the relevant content, organize them and adapt its features accordingly. It is no longer up to the end user to read/filter/understand relevant content and links. The semantic processor can interlink

with other semantic processors inside devices, or retrieve relevant data from devices and process them locally.

Smart mashup

Datao proposes a different approach for searching the data in a Interconnected Web of Things. Thanks to semantic components (semantic data discovery, intention capturing Uis, internal semantic processor), Datao can crawl the Semantic Web surrounding you, identify data sets corresponding to your questions, organize them in a meaningful manner and display this answer with an optimal layout.

Plus it can extend this answer by proposing related Q&As. By affinity, you will browse your environment in a very interactive manner, by providing questions to the system and expecting relevant answers based on the devices available and the connectivity with remote information sources.

Optimized user interaction

To optimize the interaction of the user with its environment in the Internet of Things, DataO can adapts its User Interfaces based on the data available, to optimize the relationship between the user and its virtual environment.

Read *and write*

User interaction with things cannot rely solely on read access. It is quite clear that the user will want to interact with its envrionment in a read *and write* manner.
That is a problematic that DataO is proposing to solve with Uis specially dedicated to writing data back to where they are supposed to go.

Headless mode

DataO is not only meant to be used by human users. All the system is SOA based and each function can be managed locally or remotely by automatic systems. For that perspective, DataO can be seen as a powerful web middleware for smartItems in addition of being an interface for humans.

Conclusion

This document is a presentation of the Semantic Web, as imagined by Tim Berners Lee, and the product Datao that will ease the interaction between users and new kind of Webs such as the Semantic Web or the Internet of Things.
We consider the studies around the Semantic Web to find direct application in the Internet of Things and hope this point will be considered when defining the goals of future projects managed by the European commission.