WEB OF THINGS - CORE DESIGN PRINCIPLES OF WEB ARCHITECTURE

SR. JAINY JACOB M

Abstract: Probably the most pervasive trend is the Web of Things, where just about everything we interact with becomes a computable entity. Our homes, our cars and even objects on the street will interact with our smart phones and with each other, seamlessly. What will drive the trend in the years to come are two complementary technologies: Near Field Communication (NFC), which allows for two-way data communication with nearby devices and ultra-low power chips that can harvest energy in the environment, which will put computable entities just about everywhere you can think of. While the Web of Things is already underway, it's difficult to see where it will lead us. Some applications, such as mobile payments and IBM's Smarter Planet initiative, will become widespread in just a few years. Marketing will also be transformed, as consumers will be able to seamless access digital products from advertisements in the physical world. Still, as computing ceases to be something we do seated at a desk and becomes a natural, normal way of interacting with our environment, there's really no telling what the impact will be.Building the Web of Things is a hands-on guide that teaches how to design and implement scalable, flexible, and industry-ready IoT solutions on the Web.

Keywords:- Hacking, Digital Divide, RFID,IOT, Big Data

Introduction: Media is changing at such a frenetic pace that even the most jaded veterans of the industry are uncertain about what it all means. We're told the old days are gone, but it's still not clear what the future will bring. It seems that as soon as the next "big thing" comes along, a bigger one arrives to take its place. All of the dissonance and chatter is extremely confusing and that makes it hard to plot strategy going forward. However, hidden in the commotion, there are some principles that are constant and they can help guide our way. "Build a better mousetrap and the world will beat a path to your door." That notion inspired generations of tinkerers, innovators and entrepreneurs.

Of course, then some whip-smart MBA got hold of it and it became "build a proprietary supply chain and a captive distribution channel and you can earn superior returns on your cost of capital." Scale, rather than inspiration, became the path to competitive advantage.

As digital technology pervades the physical world, the principles of scale are changing in a profound way. Ordinary people armed with smartphones are becoming hackers, co-creating their experiences with marketers. Products themselves are becoming services. Supply chains are giving way to demand chains. Marketing has changed forever.

The Internet and the Web: The Internet is essentially hardware – a patchwork of fibre, frequencies and protocols that link together the world's computers. The Web, on the other hand, is software that lays on top of the Internet and presents information on a unified standard. In other words, the Internet delivers connectivity and the Web provides universality. The Internet gave us "walled gardens" like AOL and the Web broke the walls down. The Internet, originally an obscure platform for scientists to share information, tends to be closed. The Web is an open platform.

The short history of digital technology has been an ongoing interplay between these two architectures. Technology usually appears on the scene proprietary and closed, then after some time becomes open and universal. Up till now, these distinctions have been somewhat academic, because they applied mostly to data and media. The phase we're entering now promises to be much more exciting.

Digital Invades the Physical World: As computer chips became smaller, cheaper and less power hungry, it became possible to incorporate them into just about anything. In 1999, a young assistant brand manager at Procter and Gamble named Kevin Ashton realized that by implanting RFID chips into products they could revolutionize the supply chain. The Internet of Things was born. Ashton's insight that having humans input data is incredibly clumsy and inefficient. It's much better to get information from objects themselves. With cheap sensors, they know where they are, what happens to them, how much energy they use and they can tell us about it. However, in a very real sense, the Internet of Things falls short, much like the Internet itself fell short. While it works well for proprietary systems, it needs an open environment to become ubiquitous. For it to have maximum impact, consumers need to be able to use it in an easy and seamless way. That's the essence of the Web of Things.

The Four Pillars of the Web of Things: Over the years, I have noticed a fundamental dissonance between visions of the future and the reality that unfolds. We are presented visions of conformists walking orderly, antiseptic halls in silver spandex and end up with piercings, tattoos and Foosball at the office. As technology advances, people seek more control over it to express their individuality. That's exactly what's happening now. While the virtual Web made documents universal, the Web of Things is making machines interoperable and allowing consumers to tap into the Internet of Things. The technology centres on four pillars:

Smartphone's: At the center of the Web of Things is our smartphones. We carry around more processing power than the Apollo program employed to put a man on the moon and we are increasingly using it as a universal remote control for our environment.

The phone itself is a sensor platform. Apps like Shazam and Viggle are able to recognize the media you are watching or listening to and serve related content to your smartphone or tablet. Cameras are able to recognize faces and objects and then search for related information while GPS notes our location and that of objects around us. Most of all, we are using our smartphones to interact with other elements of the Web of Things, like Smart Homes, Smart Cars and Smart Retail.

Smart Homes: New super-efficient chips are putting connectivity everywhere and our home appliances will be as much a part of the Web of Things as our tablets or smartphones. This isn't a new idea, we've been hearing about "refrigerators that order your milk" for years now. However, what's emerging is profoundly different. At CES 2012, Motorola showed of their 4Home system, which can sync any device with your Smartphone. You can monitor your home through video feeds, control your home security, manage your energy output and preheat the oven from the car. Again, the vision was of technology running everything itself, the reality will be more control for consumers.

The smart home concept is still in its infancy, but with a little imagination we can see the possibility for a multitude of Web of Things mashups for the home. Food packaging that interacts with ovens to set time and temperature, clothing that interacts with washing machines to alert us when we're about to ruin that new silk blouse and so on.

Smart Cars: Our cars are becoming an integral part of the new Web of Things as well. Ford's Sync and Toyota's entune, which are already installed in production units, connect with both the web and smartphones.

Much of the capabilities are what you would expect: navigation, roadside assistance, Pandora, and other standard fare. However, some early apps are showing the true potential once outside developers get involved in a big way.In Japan, McDonald's is experimenting with a system that will allow for downloading menus and in-car ordering. Ford is reaching out to medical device makers to collaborate on apps that help diabetics monitor glucose levels (a serious problem behind the wheel) and monitor allergens in the air for asthmatics.

Smart Retail: I've written before about the future of retail and it's clear that the Web of Things is already transforming the shopping experience. Major retailers like Wal-Mart and Target already have apps to help consumers navigate the store. Nieman Marcus just releasedone that alerts salespeople when a regular customer enters the store and gives them an account history. My Best Fit does full body scans to suggest the optimal size in various brands. Kraft is experimenting with technology that can suggest what you might want to buy for dinner based on information gleaned from a facial scan. Disney has a mirror that lets kids try on virtual outfits.

Another hotbed of innovation is payments. Check out this overview of five mobile payment options that are already in market. Cash registers will soon be the exception rather than the rule. Wherever you look, the Web of Things is turning everyday experiences into a mash-up of data and physical objects.

A Tale of Two Systems: In the former Soviet Union, heating is often centralized. The idea is that, much like the "central nervous system" vision of the Internet of things, heating is something that is best automated. So when it gets colder a thermostat automatically turns up the heat for the whole city, without anybody having to do anything. It's a good idea in theory, but in practice it leaves something to be desired. Different buildings trap heat differently, people's preferences are not the same and it takes a while for a system to generate heat throughout a whole city at once. The result is that when it gets cold, the heat doesn't really ratchet up for a few days, by which time the weather has often warmed up. So people are often freezing for a few days and then sweating in 90 degree apartments once the heat ratchets up.

The automated system is somewhat counteracted by the second "central nervous system." When it gets colder, thousands of people use electric heaters, which are dangerous and inefficient, and when the temperature drops but the heat goes on they open the windows to cool their apartments to a reasonable level.

The moral: People will hack. That's the beauty of the new Web of Things.

From Push Marketing to Hack Marketing: It used to be that you would research the market to find needs, build a product to address them and then blast out 30 second ads on TV to build demand. Much like Soviet planners, corporate planners would determine what got produced, at what price and for what purpose.

Compare that to what Microsoft did with their Kinect game system. When hackers started taking apart the game system in order to build new things with it, they didn't call their lawyers, they released a software development kit (SDK) to help them along and offered funding for the best ideas.

Marketers will have to think in terms of SDK's and API's as much as GRP's and CTR's. Platforms like Sync and entune will be powerful not for the ideas that Ford and Toyota dream up, but for what outside developers and consumers hack together. What used to be the exclusive domain of white coats in research labs is now giving way to an era of open innovation. Everybody from LEGO to Nike to cosmetics and financial services companies are getting into the act as well, using the Web of Things to co-create products and services with their consumers. A revolution, albeit a quiet one, is at hand.

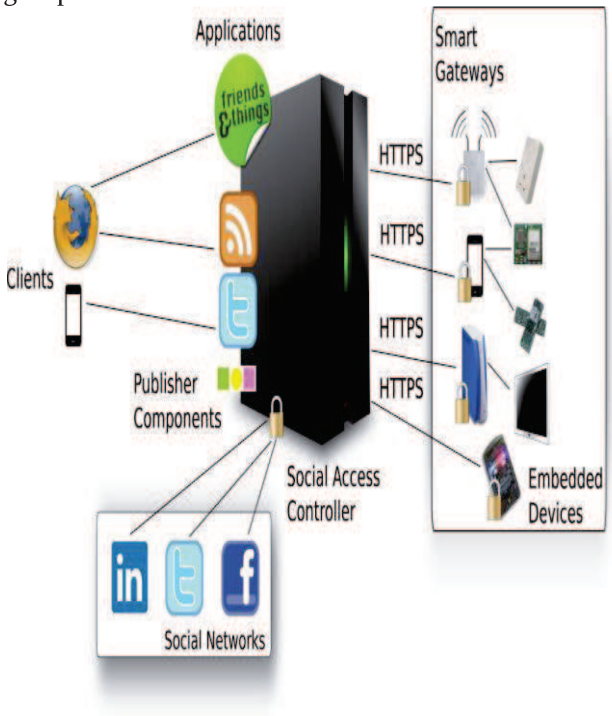
In the new era of the Web of Things, if you want to build a better mousetrap, you'll need to ask the mouse.

Sharing Smart Things: The success of Web 2.0 Mashups depends on the trend for Web 2.0 service providers (e.g., Google, Twitter, Wordpress, etc.) to provide access to some of their services through relatively simple, often RESTful, open APIs on the Web. Mashup developers often share their Mashups on the Web and expose them through open APIs as well, making the service ecosystem grow with each application and Mashup. The simplified component architecture of a Social Access Controller (SAC) serves as authentication proxy between clients and smart things.

To ensure the success of physical Mashups, they need to replicate the same level of openness. However, enabling such an open model for a Web of Things requires a sharing mechanism for physical things supporting access control to the RESTful services provided by devices. For example, one could share the energy consumption sensors in one's house with the community. However, this is a potentially risky process, given that these devices are part of our everyday life and their public sharing might result in serious privacy implications (if almost no energy has been used recently, the home owners may be on vacation and burglars might look for these kinds of patterns). HTTP already provides authentication mechanisms(e.g., HTTP Authentication24) based on credentials and server-managed user groups. While this solution is already available for free on most (embedded) Web servers, it still presents a number of drawbacks in the WoT context. First, for a large number of smart things it becomes quite unmanageable to share credentials for each of them. Then, as the shared resources are not advertised anywhere, sharing also requires the use of secondary channels, such as sending emails containing credentials to people. Several platforms, such as Sense Web or Pachube25 propose to overcome these limitations by providing a central platform for people to share their sensor data. However, these approaches are based on a centralised data repository and are not designed to support decentralisation and direct interaction with smart things.

A promising solution is to leverage existing social structures of social networks(e.g., Face book, Linkedin, Twitter, etc.) and their (open) APIs to share things. Using social networks enables users to share things with people they know and trust (e.g., relatives, friends, colleagues, fellow researchers, etc.), without the need to recreate yet another social network or user database from scratch on a new online service. Additionally, this enables advertising and sharing through a unique channel: you can use various well-known social networks to inform your friends about the sensors you shared with them by automatically posting messages to their profile or newsfeed.

The SAC platform is an implementation of this idea. SAC is an authentication proxy between clients (e.g., Web browsers) and smart things. Rather than maintaining its own database or list of trusted connections and credentials – as it would be done with simple HTTP authentication – SAC connects to a number of social networks (e.g., Twitter, Facebook, LinkedIn, etc.) to extract all potential users and groups one could share with.



Simplified Component Architecture of the SAC

This is possible as most social networks offer a Web API (e.g., Facebook Connect26). Providing an open Web API is one of the success factors of social networks themselves. Indeed, these APIs allow third-party Web applications to be built using partial data extracted from the social networks and thus to enhance the functionality of the social networks.

The sharing process occurs in three phases. First, the smart things owner accesses SAC by logging in, using at least one of his social networks credentials. SAC then uses delegated authentication with the social network to identify the owner. Afterwards, the smart thing to be shared has to be crawled in order to identify the re-sources and capabilities of its RESTful services, i.e., which functionalities can be shared for that thing. Finally, the user generates the access control list of the smart thing by selecting which friends can interact with what resource.

When an owner shares resources with a trusted connection, the latter is informed about it directly on their social network. In case of Facebook, it publishes a message to the news feed of the friend. In case of Twitter it simply tweets a message to the trusted connection (e.g., “Rachel shared her Ploggs Energy sensors with you”). The posted message also contains a link that redirects to the shared resource. The link does not point to the smart thing directly but to an instance of SAC that acts as the authentication proxy. When a trusted connection uses the provided link, SAC will verify its identity. If the friend is logged in successfully with one of their social networks, SAC will internally check whether this person also has access to the requested resource. If it is the case, SAC logs on the shared resource using the credentials provided by the owner when registering the resource. It then redirects the HTTP request of the trusted connection to the shared resource. Finally, it redirects the result directly to the HTTP client of the trusted connection, for example to a Web browser.5.6

Discussing the Future Web of Things: Thanks to the wide availability of HTTP libraries and clients, and to the loose coupling, simplicity, and scalability properties of RESTful architectures, RESTful applications have rapidly become one of the most practical integration architectures. This makes it desirable to use Web standards for interacting with smart things. Although HTTP introduces a communication overhead and increases average response latency, it is still sufficient for many pervasive scenarios where longer delays do not affect user experience. The performance of using HTTP as a data exchange protocol is largely sufficient for common pervasive scenarios, especially when only a few concurrent users are accessing the same resource simultaneously (200 ms mean response time with 100 concurrent users on a 1.1 GHz server running a Smart Gateway). We have also shown that caching techniques can significantly improve the performance of concurrent sensor data reading by using tools used for massively scalable Web sites. These techniques can be directly applied to Web devices, given that devices have on-board HTTP support.

Web 2.0 Mashups have significantly lowered the entry barrier for the development of Web applications, which is now accessible to non-programmers. It should be noted that a resource-oriented approach should not be universally considered as the miracle solution for every problem. In particular, scenarios with very specific requirements, such as high performance real-time communications, might benefit 30 from tightly coupled systems based on different system architectures. However, for less constrained applications, where massive scalability, ad-hoc interaction, and serendipitous re-use are necessary, Web standards allow any device to speak the same language as other services on the Web. This makes the integration of the real-world with any other Web content much easier, so that physical things can be bookmarked, browsed, searched for, and used just like any other Web resource.

Based on our personal experience, the drawbacks of Web architectures are easily offset by a notable simplification of the application design, integration, and deployment processes , in particular when comparing RESTful devices with other systems for embedded devices, such as WS-* Web services. As an example, the Plogg RESTful Gateway and the Sun SPOTs have been used by external development teams. In the first case, the idea was to build a mobile energy monitoring application based on the iPhone that communicates with the Ploggs.

In the second case, the goal was to demonstrate the use of a browser-based JavaScript Mashup editor with real-world services. According to interviews we conducted with these developers, their experience confirmed ours. They enjoyed using the RESTful smart things, in particular the ease of use of a RESTful Web API versus a different kind of API. For the iPhone application, a native API to Bluetooth did not exist at that time. However, like for almost any platform an HTTP (and JSON) library was available. One of the developers mentioned a learning curve for REST but emphasised the fact that it was still rather simple and that once it was learnt, the same principles could be used to interact with a large number of services. They finally noted the direct integration to HTML and Web browsers as one of the most prevalent benefits.

Conclusion: This paper, suggested that Web technologies are – contrary to popular belief – a suitable protocol for building applications on top of services offered by smart things. After summarising the core design principles of Web architecture, we proposed an architecture for the Web of Things based on the concepts of REST, syndication for smart things, Web Hooks, and Smart Gateways. We demonstrate the idea with several prototypes. Thanks to the loose-coupling, simplicity and scalability of

RESTful architectures, and the wide availability of HTTP libraries and clients, RESTful architectures are becoming one of the most ubiquitous and lightweight integration platforms. Because of this, using Web standards to interact with smart things seems to be increasingly adequate. Although HTTP introduces a communication overhead and increases average latency, it is sufficient for many pervasive scenarios where such longer delays do not affect user experience.

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Sr. Jainy Jacob M
Department of Computer Applications, Mercy College, Palakkad, Kerala.678004.