I/ The emergence of new demands

From IoT to IoE

With the emergence of new technologies, services and dynamics, there has been a discussion about the concepts of the Internet of Things (IoT) and the Internet of Everything (IoE).

IoT was a term created by Kevin Ashton back in 1999 used to reference physical devices that have the power to connect with each other and exchange data. Back then, Internet-connected devices were computers and large mobile devices. Nowadays, the list of these Internet-connected devices has drastically expanded with smartphones, connected earphones, robots, home assistants etc…

These IoT devices are assisted with AI and the data users provide. They are used to facilitate humans in their everyday life as IoT devices are now present in domains such as health with physical implants monitoring health conditions.

Studies have shown that in 2020 ‘‘that the IoT will consist of about 30 billion objects’’ and ‘’the global market value of IoT will reach $7.1 trillion’’.

As new technologies are emerging everyday, experts discuss that these objects are becoming the Internet of Everything (IoE) as things are almost all connected to the Internet. For instance, cars, earphones, gym devices are all connected to the Internet today.

Challenges

Whether One considers this global phenomenon as IoT or IoE, the stakes and challenges are similar. As all devices are connected between them and to the Internet, privacy and security remain an omnipresent challenge. Security protocols have to be adapted the kind of devices are Internet-connected and the way these entities use data.

To face these security challenges, new alternatives on how data is managed have surfaced such as distributed networks. This way, data isn’t destined to be handled by one central point but rather by multiple points to avoid leakage and security failures.

However, a significant problem is challenging the domains of IoT and IoE. Expert technology companies such a Gartner declare that ‘’more than half of major new business processes and systems will incorporate some element of the [IoT/IoE] by 2020’’. Although some devices use mainline power, a serious amount of these Internet-connected entities use a rechargeable battery. This evokes a serious energy problem if all IoT/IoE devices are taken into account. To face this energy problem, field experts must find appropriate ways to regulate the power that the radio powering the connection uses.

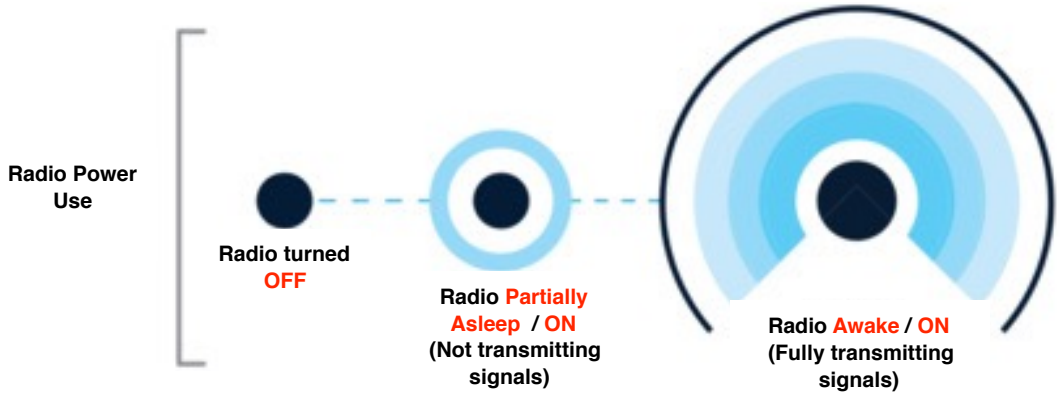
Regulating radio power will enable devices to have a longer lifespan, extend the time between each device battery charge and help the impact of IoT/IoE on the environment.

As a result, Low Energy Consumption Protocol is at the core of the challenges that the IoT/IoE industries are facing today. Above all, engineers must keep prices of components influencing on device energy consumption under control.

Current Technologies

Today, connected devices use radios. There are many kinds of radios, some are more adapted to specific entities than others. For instance, smartphones use Wi-Fi, the radio dedicated to this will be a Wi-Fi network and router. Smaller devices such as AirPods may only need the Bluetooth radio as they don’t need to directly communicate with Wi-Fi.

For IoT/ IoE devices using Wi-Fi, the best solution to save energy consumption is to activate the radio if the device is using Wi-Fi. However, in the case of smartphones, Wi-Fi is almost always turned on whether it is being used or not. To avoid the radio being fully turned on at all times, engineers have developed a way where the radio can be **partially asleep**, not transmitting any signals. Nonetheless, the radio will be totally **awake** when being actively used. This energy saving protocol helps devices not consume as much power and have a better life expectancy. Below is a graph inspired from Embedded Computing summarizing this energy saving protocol :



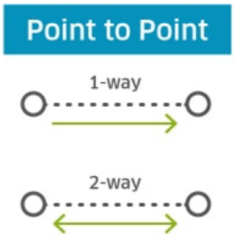
Cellular Networks such as 3G/ 4G have radios with similar ways of operating as Wi-Fi. To save energy consumption, it's important to use byte-efficient communication protocol purposely made for IoT/ IoE to the cloud. By using the cloud, data can be stocked and retrieved more easily. Consequently, less energy will be consumed by the radios.

One of the popular radios that is used today is the Bluetooth Low Energy (BLE) radio. It was launched in 2004. According to Wikipedia, BLE "is intended to provide considerably reduced power consumption and cost while maintaining a similar communication range" than Classic Bluetooth. BLE is a significant innovation in regards to the energy consumption protocol as its component is small. In fact, BLE operates on a single button cell requiring very small space on IoT/ IoE devices and increasing device life expectancy for multiple months. Above all, the BLE button cell is at a low cost making all smartphone manufacturers eager to use it. In 2011, Apple implemented the BLE in the iPhone 4S making a positive step towards energy saving.

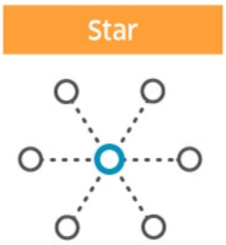
Now let's take a look at Microcontroller's (MCU), Wireless Sensor Node Architecture that exist today…

With the rise of IoT/IoE, tools, companies and engineers are concentrating their works on system energy usage. To face this energy consumption challenge, tools such as wireless interface and micro controller (MCU) are used today. The amount of energy an MCU uses depends on how quickly the Internet-connected entity is woken up or asked to perform an action. This amount of consumed energy can be regulated automatically by handling sensor interfaces and peripheral functions.

What affects power consumption today in wireless links and therefore IoT/ IoE devices are the network topology of these network links.



1) The first topology is the point-to-point architecture using sub-GHz protocol. This architecture enables a low-energy consumption for the devices and it relatively cheap. However, it limits the coverage area of the sensor which disables high node-count networks.



2) The second network topology is the star architecture using sub-GHz protocol (same as the point-to-point topology) as well as the 2.4 GHz protocol. This topology is more expensive but enables a better coverage and is more reliable. However, wireless links are more complex which means that the energy consumed by the sensor will be higher.

3) The third network topology that we will be looking at is the mesh. It uses the ZigBee protocol. This network allows the highest efficiency, sensor coverage. In addition, using the ZigBee protocol enables a low power and low cost solution.

Comparing protocols

As recently discussed, there exists a variety of protocols today. We will compare the protocols we have studied in a table below.

	Wi-Fi	**BLE** (Bluetooth Low Energy)	**Sub-GHz**	**ZigBee**
Purpose	Internet surfing, media content sharing, etc..	Sensors	Monitoring and Control	Monitoring and Control
Node Count	[10;250]	[0:10[	[10;100]	[10;1000]
Range	100 meters	70 meters	100 meters	7 kilometers
Network Topology	point-to-point, star	point-to-point, star	point-to-point, star and mesh	point-to-point, star
Properties	High power High process capacity	Low power Low cost	Low power Low cost Big scope	Low power Low cost

III/ Future stakes

With companies, services and organizations such as SigFox, LoRa and Amazon Sidewalk revolutionizing the world of IoT and IoE, more and more interconnectivity and network coverage problems are being solved. However, there are still a significant number of stakes.

First, energy consumption will remain a prominent stake. The fight for a near infinite battery life for all IoT/ IoE devices will remain omnipresent for a number of years. Even if the energy consumption problem is solved, this means that an astronomical number of IoT/ IoE devices will have to be thrown away by consumers creating a huge amount of waste for which most will not be recycle yet.

On an economical level, only a small population will be immediately able to afford these low-energy consuming IoT/ IoE devices. Plus, in order for cities to incorporate these new technological tools enabling high network coverage, these cities must invest a huge amount of public money coming from taxes on the human population.