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The Internet of Things

Internet of Things in Energy Efficiency[1]

By Francois Jammes

Editors' Introduction

This paper aims to provide the view of what means IoT (Internet of Things) in energy efficiency applications, of its technical and business impacts, of its opportunities and risks for the different market players. It is concluded by the author's long term vision about the use of IoT in energy efficiency applications.

[1] *Disclaimer: This paper is the own personal view of the author and does not represent in any way the view of his employer. The use of corporate logos in this article is for the purpose of identification only; it does not signify an endorsement of or by these companies.*

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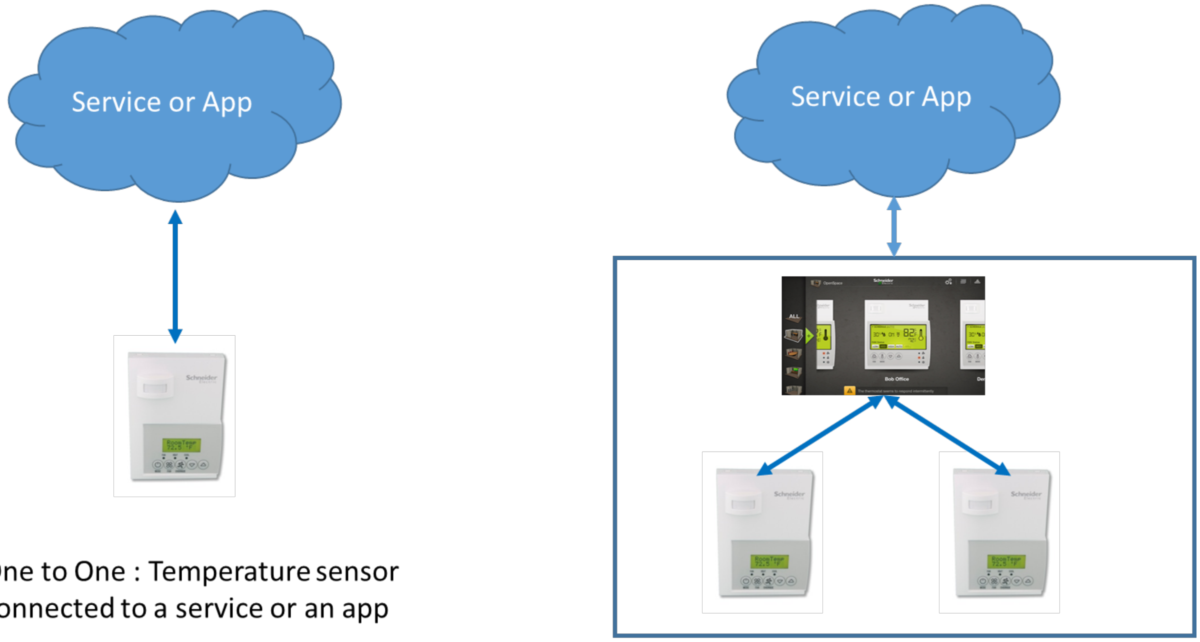
How does energy efficiency relate to the Internet of Things (IoT)? We must first define what we mean by "things." It could be very simple objects or complex objects. Things do not need to be connected directly to the public Internet, but they must be connectable via a network (which could be a LAN, PAN, body area network, etc.). The IoT is the network of physical objects that contain embedded technology to communicate and interact with the external environment. The IoT encompasses hardware (the "things" themselves), embedded software (software running on, and enabling, the connected capabilities of the things), connectivity/communications services, and information services associated with the things (including services based on analysis of usage patterns and sensor or actuator data). An IoT solution is a product (or set of products) combined with a service either a one-to-one or a one-to many relation. Meaning one service is combined with one (set of) product(s), or one service is combined with multiple (sets of) products (see Figure 1).

Examples of energy efficient IoT are abundant: Things may be simple sensors (e.g. temperature sensor in a room), more complex sensors (e.g. electrical power measuring device), actuators (e.g. HVAC room controller, motor), or complex devices (e.g. industrial circuit-breaker, PLC providing home, building or industrial automation). The IoT application may range from a simple monitoring application such as gauging the temperature in a building, to a complex application such as providing complete energy automation of a campus. IoT communications may be required offline, where information is exchanged every day or on demand, or online allowing for real-time control. Building control applications can provide efficient use of the energy in a building while insuring comfort (heat, electricity, etc.) to building occupants. Traditional solutions are using complex building management systems (BMS) interconnected with PLCs (programmable logical controllers) that send orders to actuators based on sensor data. The system must take into account multiple parameters such as weather forecasts or real-time energy costs.



One to One : Temperature sensor connected to a service or an app

One to Many : Several temperature sensors communicating with a local automation device, connected to a service or an app

Figure 1

Alternate, emerging IoT solutions are based on sensors and actuators interacting together in an autonomous manner. In order to provide the real-time building control locally (e.g. in a room, in a zone etc.), this local group of devices exchanges non real-time information (e.g. temperature set points) with other groups and with higher level services or apps to build the global building control application. This requires more intelligent devices (e.g. more intelligence in local actuators), but provides the same application without the complex structure of BMS and PLCs, interconnected with real-time constraints. Moreover, the local autonomy ensures the system is more resilient and reliable, while releasing the communication constraints.

Impact of IoT in Energy Efficiency

The IoT is not just an evolution from present situations where devices can be remotely controlled, it is a major disruption for energy efficiency applications by many aspects:

- The number of connected objects: It is estimated by 2020, 26 billion units[2] will be installed, although some of them will not be usable for energy efficiency applications.
- The business opportunity: $300 billion in extra business by 2020.
- The nature of objects: Not only smart devices, but also very simple objects down to a LED light bulb.
- The technologies and architectures involved, based on technical ecosystems: The vertical integration in a single supplier environment will be less common.
- The sensors revolution: IP camera, geo-location, personal contextual information from devices such as wearable sensors.
- The "Big Data" disruption: The ability to collect large amounts of unstructured data, analyze, and then predict future behavior.
- Smart-phones and apps are becoming the main user interface to IoT.

IoT has a major impact for energy efficiency, confirming the mega trend to connected objects. Everything must be connected, even if services are not defined at the beginning. But IoT will dramatically speed up this evolution and raise questions in the energy efficiency domain?

Present architectures and technologies for connecting objects must adapt. But the relevant consortia are very numerous and diverse. The selection of one of them is highly important, but very difficult to make. The business models will be application and services, where analytics (Big Data) will be key. This is a dramatic change from today's applications, where the value is in devices (sensors/actuators). The ecosystem is moving very fast. It is impossible to anticipate the many IoT solutions to come; as user communities will build the applications, startups will be where the most valuable IoT applications will be created; and giant IT players in the energy efficiency world—such as Apple, Google, Samsung and LG—will enter this new business field.

IoT Market in Energy Efficiency

The IoT addresses the consumer electronics market as well as the B2B industry. Depending on analysts, the value of IoT is estimated to be from $300 B to close to $2000 B in 2020 (depending

[2] Excluding PCs, smart-phones and tablets.

on what is accounted for in IoT market). Gartner has a defined focus on IoT added value. Ten billion IoT object shipments are expected each year starting in 2020, which will be used in a wide variety of applications [1]. Connected LED lamps are expected to be the largest by far. In term of technologies, Gartner states sensors will play a critical role within IoT architecture. However IoT architecture remains uncertain; there will not be one single architecture for all markets segments. More than 80 percent of the $300 B incremental revenue estimated for 2020 will be derived from services.

The incremental cost of hardware and embedded software is relatively small, whereas the service and analytics opportunity is much larger. Initially, much of the supplier focus in the IoT market(s) will be on hardware and software, as companies try different approaches and feature sets in an effort to build awareness of their products. As business models mature, however, the market will increasingly be driven by services (including data analytics services). There will be service opportunities associated with coordinating and managing the multiple things that typical consumers will interact with in an average day, both in their home and in their daily travels. Indeed, the value chain for IoT devices and services will be multilayered, with usage data leveraged using analytics software that is designed to pull out trends useful for further product and service marketing initiatives. IoT generates “Big Data” that analytics must address to transform huge volumes of data into a small (readily synthesized by a human mind) quantity of usable/actionable information.

Standardization and Consortia

In such an embryonic, moving, and competing context, selecting the most relevant consortia and standards they must contribute to is key in order to orient as far as possible the decisions, with the objective to identify the most relevant partners that will provide the expected features, and focus their own developments on what is specific to its businesses: go faster, avoid proprietary solutions, etc.

Figure 2 presents the consortia landscape, relevant for energy efficiency applications:

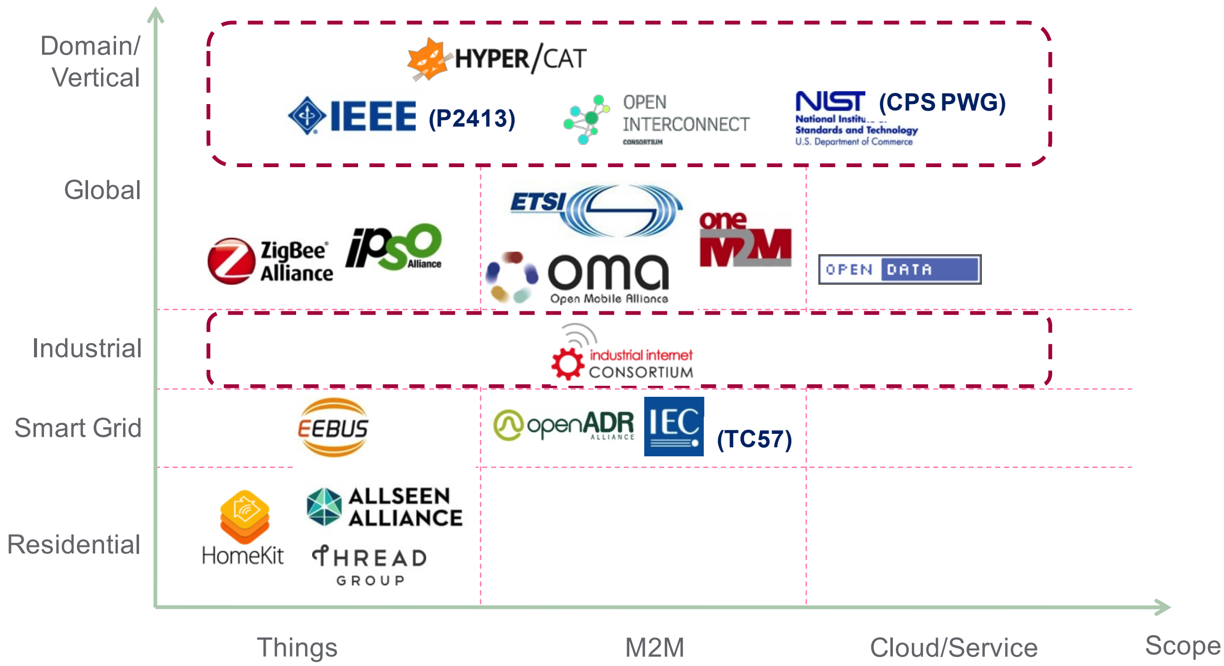


Figure 2

Over the past few years, standardization bodies and industry consortia (IETF, IEEE, Bluetooth SIG, Zigbee Alliance, etc.), start-ups (ArchRock, Sensinode, Gainspan, to name a few), silicon vendors, and some leading companies have specified and developed a number of technical bricks and protocols needed to empower the Internet of Things. They focused particularly on optimization of "access" technologies (802.15.4 radio, Bluetooth low energy, Wi-Fi low power, narrow band Power Line Carrier, etc.), on adaptation of IP protocols (6LoWPAN, CoAP, and RPL) to extend the web architecture down to the most constrained sensors and actuators, and on developing light-weight protocols enabling the connection of almost everything to the cloud (MQTT, LWM2M, etc.). While most of the technology is available today, interoperability between vendors and between "verticals" remains one of the biggest challenges and roadblocks for mass adoption.

Potential Benefits and Risks

The potential benefits of the IoT in the energy efficiency market are huge, especially for end-users and integrators. IoT will allow end users to measure, check, and adapt quickly their installation according to the expectations of the market, the cost of the raw materials or the energy prices. For energy efficiency system integrators, IoT will improve their capability to address customer needs, rapidly reducing the time for integration and commissioning. Integrators will improve the maintainability of their systems using remote diagnostic and fix capability of products.

However, this market is dominated by large players (e.g. Schneider Electric, Siemens, ABB, etc.) who have historically protected this highly beneficial market by maintaining an extremely high level of required investment to develop complete and complex solutions and implementing specific standardization (e.g. through domain specific protocols such as IEC61850).

The IoT promises to break these two entry barriers by offering low cost flexible solutions and using new communication solutions coming from the Internet world. As a consequence, new players are being attracted to this market. SMEs and start-ups may offer low cost solutions, at least for a full set of niche applications, while large players from the Internet world may also enter as direct competitors of the traditional large players (e.g. using their big data analysis capabilities.) The main risk is then for traditional large players: The opportunity provided by a large, new potential market is counterbalanced by the risk of these new players entering their traditional market. However, this risk may be balanced by the opportunity to partner with these new players, creating a complete new open ecosystem.

Discussion

In order to profit from IoT opportunities, and to overcome the identified risks, in an approach where all parties may be beneficial, the long-term vision of the use of IoT in the energy efficiency market is broad.

At the higher level of the architecture, traditional players will offer to the market free, open solutions—free apps or free open source server software—in order to create a community. In this community, SMEs, start-ups, and large IT players will offer complementary solutions to core energy efficiency applications.

More intelligent sensors and actors will be developed, with downloadable embedded firmware, in order to provide autonomous, resilient ,and flexible subsystems that are capable of executing unforeseeable applications. They will be completed by a range of new low cost sensors, developed by new players and interoperable inside the community.

Interoperability will be provided inside each community by choosing from a set of standardized protocols provided by one consortium. Interoperability between communities will also be made, thanks to ontologies provided for each application domains and semantic rule engines deployed in servers.

New integrators will take profit of these new offers, by building ad-hoc flexible solutions in a very time manner, thanks to the variety and interoperability of the offers.

As a conclusion, IoT in energy efficiency provides huge opportunities, both for traditional players—if they are able to create and animate open communities—and for new players and integrators taking advantages of these communities.

References

[1] Middleton, P. et al. *Forecast: Internet of Things, Endpoints and Associated Services, Worldwide, 2014* (G00270264). Retrieved from Gartner database. Oct. 20, 2014.

About the Author

Francois Jammes is now retired from Schneider Electric since January 1, 2016. He was before a Schneider Electric group senior expert. Since 1987, he has worked in the field of embedded software, communication networks and software applications, for several business units in Schneider Electric (Electrical Distribution, Industrial automation and Buildings), as well as for the corporate R&D department. He was coordinator of several awarded European collaborative projects. He is an expert for the European Commission evaluating proposals and reviewing projects in the field of Cyber-Physical Systems and Internet of Things.

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