The Adaptive Strategies Improving Design in Internet of Things

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Abstract The Internet of Things can bring a lot of economic, social and technical benefits, but it also raises essential challenges that could stand in the way. Issues like lack of privacy and security need to be controlled to ensure societal acceptance of IOT services, otherwise, it can undermine the user's confidence to fully enjoy the technology and result in a smaller than expected adoption. This paper has only presented an overview of few issues that come with IOT and a lot more is still needs to be researched in more details. There are issues that people and companies are still not comfortable with or do not know how to properly address. For instance, even after the product is developed, besides meeting the needs of the user, products will also have to provide seamless integration with other enterprise data, applications and environment. And how to monitor something you no longer own? Yet however, the company is still responsible for their performance. Besides all that there is also the need to meet the needs of the user and designed products will have to provide seamless integration with other enterprise data, applications and environment. Also overcome battery challenges that limit computation, display resolution and connectivity. The

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term Internet of Things might have been present for a long time now, but still there are plenty of work ahead to be done to transform this "term" into this success that everybody has been expecting.

Keywords Internet of Things · Digital twin · Recommendation system · Virtual and health care

1 Introduction

The idea of the Internet of Things is that, rather than having few very powerful devices such as laptops and smartphones, the user will possess a large number of devices, sometimes less powerful, but they will enable them to always stay connected and informed. (Saddik 2018; Steinbach et al. 2018) discussed that products are now composed of physical, smart and connectivity components. They have become complex systems composed by hardware, software, sensors, data storage, microprocessors and connectivity. Subsequent paragraphs, however, are indented.

Design is changing the focus from only physical products to data-centric physical products. The role of designers is also changing. Now, they have to advance human experience, design for user's experiences. For example, connected products will communicate to companies when something is not working properly, so they can start acting instantly when they receive the information and address before it becomes a bigger problem. And in the process, by knowing how the product is being used, companies can also start working proactively and start preventing failures before they happen, creating a more loyal customer base. "Listening" to the product will change perception of what constitutes a product and how to improve it. Information can be used to modify the company's own products to meet customer needs or combine it with other shared data enabling a new level for the next generation of products and services (Fig. 1).

A key component of the digital twin vision is the optimization of multi-modal communication/interaction from the user perspective, which did not get any attention from industrial and academic stakeholders until so far. As a result, the demands to

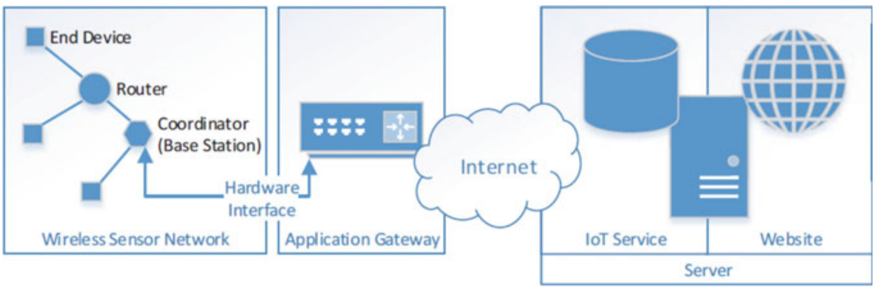

Fig. 1 Internet of things structure

conduct extensive researches and developments in this domain are still growing and infancy stages.

2 Problem Statement

Design for easy replacement of outdated hardware: Some components may have a replacement cycle longer than others may, for example, Bluetooth components have longer cycle life than the battery. Therefore, companies should consider ways to facilitate the upgrade or replacement of individual components without having to upgrade the entire product (Saddik 2018). Design for interoperability: Sharing hardware components between different devices and operational systems. Interfaces should not be limited to one single screen—or even a single device. Modular systems must be able to work in slightly different environments, infrastructures and regions. It is extremely important to utilize a software that can interact with several devices and platforms in different places and devices (Steinbach et al. 2018). Add-on connectivity to attach to "old" products: retrofitting add-on. It may cost more, but it is a great way to transform a "regular" product into a smart one, get to market faster and stay competitive (Arima et al. 2017). Build data-integration layers into existing modules facilitating flow of common data: Older systems may not be able to support gigantic data transfer from networked products, but there are several integration models that can be explored (Hassen and Steinbach 2018). Design products so that the user can customize features according with their values and willingness to pay: Customers have different needs and those needs might change many times during a short period of time or occasion. Being able to customize products either in level of engagement or technical feasibility in different scenarios is probably the future with IOT products. Design parts to be multi-functional, invest in smart algorithms that can identify required functionality from a single hardware: Look for alternatives and sophisticated algorithms that can make one unique sensor to provide different. Design parts for multiuse, create custom algorithms to explore older generation of products: Although an older product might not be able to take advantage of IOT applications, it still can provide useful systems data for the creation of new functions and features. Software applications develop agile software: Devices are always connected; huge amounts of data will be generated, and response should be instantaneous. Pursue a continuous delivery model: Companies should design for easy and continuous delivery of software updates focusing on supporting the customer. Applications must be quickly and frequently updated ensuring stability and security. Open-sourced software: Explore and develop open-sourced software to expand number of partners and accelerate the process. Consider developing open-source software for components that can stand alone. Create an open-source-based platform that can be further developed by different systems integrators.

Offloading data: Develop smart algorithms that can manage to identify the optimal point in time where data will be compressed, saved, or transmitted; and at the same time, it will reduce bandwidth requirements. Sending only the most relevant data to cloud-based servers can be an alternative to reduce cost of transmission and increase battery life. Adaptable software system: Systems must be able to deploy in different countries, with specific settings, in multiple regions and infrastructures, so flexibility is essential.

Power efficiency, always-on technology: An always-on technology can be delivered to IOT products to support context awareness, gesture recognition and indoor navigation. Users will expect to have an all-seeing awareness of the environment, ready for every change of context that needs to be informed. Developers must limit the time that components such as the display and application processor are in an inactive state. At the same time, the system must allow specific sensors to remain in an always-on state. Moreover, the challenge is that the product must do all of it without draining too much battery.

Minimize power consumption: Combining sensors with a sensor fusion algorithm can reduce power consumption. Sensors and processors are always on, but with a sensor fusion device, the main processor can go to sleep and the sensor fusion device will be on but with a very low power processor. When there is a change of context, the sensor fusion takes action and activate the main processor. Privacy and Security: Be transparent: Allow users to customize their permitted uses and allow them to opt-in and opt-out at any time. Interoperability creates space for breaches and risks increases exponentially; therefore, customers need to see a strong value proposition in the product to feel safe in sharing personal information. It will be critical that companies are transparent about the collection and usage of data, providing the highest possible levels of data security.

Create methods of protecting critical information: Information must be shared freely among companies, customers, departments and functions. New security schemes may be required and tight integration between software developers and IT operations will be needed.

3 Proposed Work

Metrics need to be aligned to companies' goals and objectives. With traditional goods, manufacturing metrics should improve quality, efficiency and reduce costs. Traditionally, metrics are determined and evaluated prior to product launch, but with a connected device, it becomes possible to monitor performance remotely even after the product is in the market. By doing so, it is possible to better understand and address a defect or a bad experience through collection and analysis of data and improve not only the current product but also the next generation. Next, are a few metrics that address some of IOT issues and can help designers to improve the smart components in cost and operational efficiency.

Cost efficiency in embedded communication is essential for the product to collect data and transmit information, interacting with other objects, people and environment. Applications1 show the data gathered from sensors in a friendlier way for the user. It would be impossible to get information and make decisions if it was not for the applications.

We can use sensors to sense any type of phenomenon in the environment. For example, we can use microphones to sense types of sound signals, a gyroscope to tell us about position and angles or a thermometer to detect temperature and humidity. As we can see from Fig. 2, sensor's cost is dropping every year and consequently, the number of sensors installed in products keeps getting bigger every day. To maintain businesses competitive, it will be necessary to have a differentiator, deliver the expected experience the user desires and also have low operating costs.

For example, a Smartphone has at least twenty sensors: gesture sensor, accelerometer, proximity sensor, gyro sensor, temperature sensor and geomagnetic sensor, to name a few. Individually, each one of them has a function such as detect the rotation or movement based on axes and change the image accordingly or display temperature and humidity levels for the user, but the sensors can also be combined to provide more valuable information. By combining a few sensors and an array of recognition technologies, Samsung can better understand users' behavior and deliver effortless user experience. Experiences like having an all-in-one companion that offers positive support during your work out by calculating how many calories are burned accurately or, understanding behavior by stopping and resuming a video when the user looks away. Therefore, when evaluating a Smartphone by its sensors and applications, this

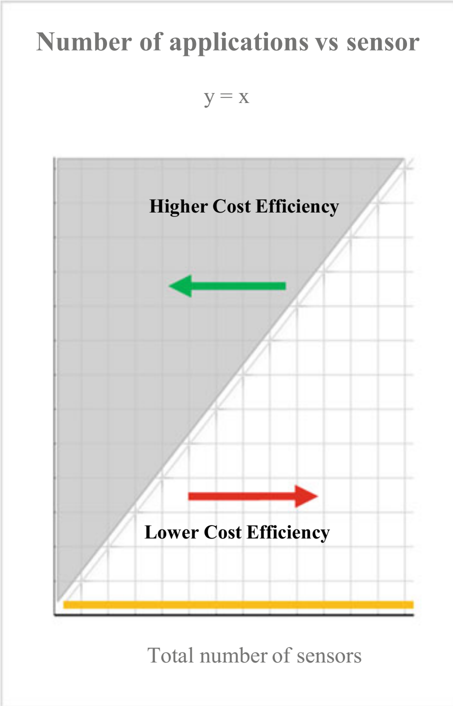

Fig. 2 Number of applications versus number of sensors

product would be positioned above the linear line on Fig. 4 and it would probably be mosre distant from the *x*-axis and closer to the *y*-axis. So, even though a Smartphone is considered a high-cost product, it would be considered highly efficient in terms of cost of sensor and applications.

Critical sensors are demonstrated that individual sensor readings are valuable, but its value increases exponentially when integrated with other data such as inventory locations, commodities prices, service histories and traffic patterns. This ability of achieving full value of data becomes a key source of competitive advantage. However, with that comes an issue of scale, and that is where one of the IOT problems begins. The volume of data produced on a device-by-device basis does not warrant concern, but once considered in aggregate, this data poses a significant threat for systems and networks. For example, according to Stephen (Hassen and Steinbach 2018, 3D systems 2021), a Boeing jet generates 10 terabytes of data per engine every 30 min of flight. Therefore, for a single six-hour flight, the total amount of data generated would be 240 terabytes. Multiply this number by the number of flights in the sky, by weeks, months and years, and the scale of sensor data gets massive, and it becomes a huge concern.

To collect all of the necessary data, manufacturers will have to equip products with faster processors and sophisticated and complex algorithms. Additionally, advanced analytics models and tools will be needed to enable data-driven optimization or predictions. Especially because part of the critical information will reside outside companies and it will probably be in an unstructured format such as social-network conversations, videos and audios, companies will have to integrate internal and external data. Making data useful will require a large investment in data capabilities (Narumi et al. 2011).

Even though there are solutions already in the market like SAP HANA that allows filtering, aggregating and enriching raw data before storing into your database, the less amount of data is there to clean, less time will be needed for the information to be delivered, less space for storage will be needed and consequently less money will be spent. For all that, minimizing the number of critical2 sensors that provides information that needs to be periodically collected will be essential.

Critical Ratio (CR) is the ratio of the number of critical sensors over the total3 number of sensors installed in a product. The Critical Ratio indicates how complex the infrastructure will need to be to support the required amount of data. The more critical sensors a product has, more information will need to be collected, cleaned, stored, protected and analyzed and more software and architecture complexity will need to be handled. Reducing the number of critical sensors can propagate into the whole process drastically. The smaller is the quantity of critical sensors deployed in a product, the less complexity in infrastructure for storage, security, analytics and so on will be needed. The closer CR is to 100% the more data will have to be gathered, analyzed and stored and the harder will be to get important information out of it. To manage all this data, more investment of analytical models and tools, data architecture, commitment and money will be required. In addition, if CR is closer to zero, it indicates that the product is more efficient regarding its sensors and the related information.

Max=X/Y

Subject Y > X; X >0

Where: X= Number of applications
Y= Number of sensors

Fig. 3 Number of applications versus number of sensors

Critical Ratio (CR) = Number of Critical sensors/Number of Total sensors.

Although most of the data produced is being thrown away, or when kept, companies do not know what to do with it, manufacturers should not be limited when deciding what data to collect and store. The costs and risks for not collecting certain types of data just because there is no clear use or application are too high. Companies should think about their stakeholders and what type of data will be valuable for them. With that in mind, companies can decide not to collect data at all, collect only the fields of data necessary to the product or service being offered, collect data that is less sensitive or identify the data they collect.

For example, (3D systems 2021) from Rapid7 tested 9 baby monitors and exposed that all of them had critical vulnerabilities. They all fail in all and exhibited several common vulnerabilities and exposures like easy guessed passwords. For this product, "*X*"-number of vulnerabilities would be 10. And the baby monitor deals with casual and personal data, so, the constant "*A*" is equal 0.3. With this numbers, the probability of the product to be hacked "*P*" is equal 90% (Fig. 4).

From Fig. 3, it is possible to see that the probability of a product to be hacked increases as the number of vulnerabilities varies. The baby monitor is definitely in the red line zone. Probability also increases considerable when dealing with more attractive data, if a product offers the opportunity to access long shelf life information, hackers will prefer to have the trouble to attack this one and gain more money out of it. Therefore, reducing the number of vulnerabilities in a product is the best guarantee that the product is safe from being hacked. However, manufactures cannot only depend on reducing vulnerabilities.

4 Conclusion

With the design for manufacturability and assembly principles, designers can improve the manufacturing process reducing time and cost for the physical product. With IOT product, manufacturers need to think not just about the technical details, but also of

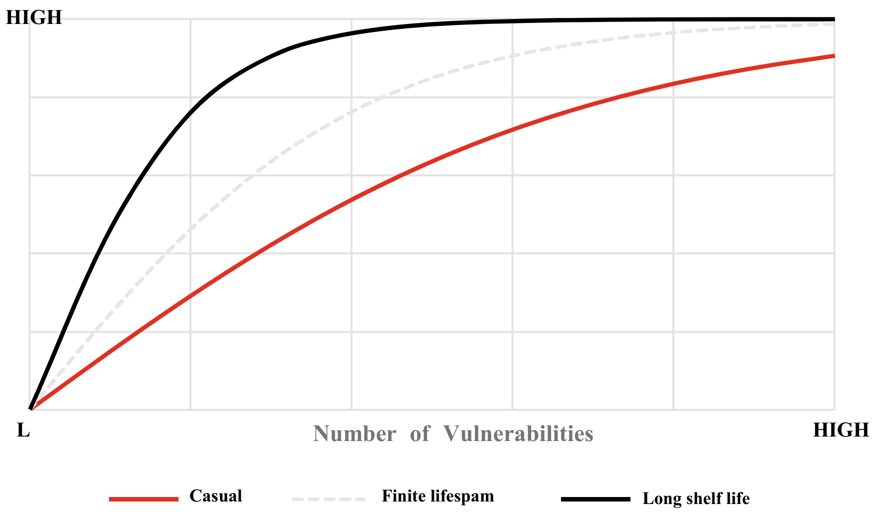

Fig. 4 Probability of an IOT product be hacked

how it will fit into the broader context of the user's life. The main components in a IOT product are its smart components such as connectivity and sensors, and these are the ones that need attention since they are usually the most expensive and complex.

The guidelines presented in this paper are going to be useful in helping designers to better understand how technologies work and how they are being used. It will be a valuable tool to identify the best way technology can work in our benefit, what are the alternatives for the smart components to deliver the same function and help the designer to decide what is the best fit for the product. These guidelines help manufactures to optimize and adapt product design to reduce resources, time and cost during mass production.

References

R. Arima, M. Sithu, Y. Ishibashi et al., Qoe assessment of fairness between players in networked virtual 3d objects identification game using haptic, olfactory, and auditory senses. Int. J. Commun. Netw. Syst. Sci. **10**(07), 129 (2017)

A. El Saddik, Digital twins: the convergence of multimedia technologies. IEEE Multimedia **25**(2), 87–92 (2018)

R. Hassen, E. Steinbach, Hssim: an objective haptic quality assessment measure for force-feedback signals. in *2018 Tenth International Conference on Quality of Multimedia Experience (QoMEX)*, (IEEE, 2018), pp. 1–6

T. Narumi, T. Kajinami, S. Nishizaka, T. Tanikawa, M. Hirose, Pseudo-gustatory display system based on cross-modal integration of vision, olfaction, and gustation. in *Virtual Reality Conference (VR)*, (IEEE, 2011), pp. 127–130

E. Steinbach, M. Strese, M. Eid, X. Liu, A. Bhardwaj, Q. Liu, M. Al-Ja'afreh, T. Mahmoodi, R. Hassen, A. El Saddik et al., Haptic codecs for the tactile internet. Proc. IEEE **107**(2), 447–470 (2018)

3D systems. Touch haptic device 2021. Online accessed: 6 May 2021