The Internet of Things:

The Merging of Goods and Services

and Its Impact on Business Models

by

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Abstract: The Internet of Things, and devices associated with the Internet of things are poorly defined in popular media. This paper attempts to come up with a useful definition for both, with a focus on that differentiates an Internet of Things device from a smart device by giving examples of devices in various stages of technological advancement. After establishing a working definition of an Internet of Things device the paper explores a way to view two broad categories relating to the sale of goods and services and then uses this framework to address potential shifts in traditional business models to accommodate changes in the value proposition presented by increasing connectivity in IoT devices.

Introduction: As the cost of computing continues to fall and processors continue to shrink, it is becoming more and more cost effective to add smart and connective capabilities to everyday items. This merger of goods with intelligence has sparked a revolution is smart devices, devices that can self monitor and almost always have increased functionality over their non-smart counterparts. As this technological progression has continued, companies have looked towards connectivity to provide additional value to their products. This revolution, the Internet of Things, unfortunately lacks a consistent definition in popular media. For there to be meaningful discussion about IoT devices, it is helpful to have a consistent definition, so this will be the first thing this paper attempts to do. After accomplishing that, this paper will discuss a view of current business models relating to the sale of goods and services, so that ultimately there can be an analysis of potential players that will benefit from the IoT revolution as well as how IoT products and their shifting value propositions will effect the final sale aspect of these traditional business models.

Section 1: Defining IoT and IoT devices

In this section, I attempt to give a background of the current Internet of Things (IoT) revolution, and draw a distinction between IoT devices and non-IoT devices by giving examples of .

1.1 Definition

To be able to have a substantive conversation on a given topic, it is helpful to first gain a consensus on what is discussion is actually covering. When first starting to research IoT, this was a major issue, as IoT was more a buzzword than anything else in popular media, used to describe a company that had especially advanced “smart” products. This was usually attributed to being able to be controlled remotely, although there are many other ways people justified using the IoT label.

As time has progressed, the definition has narrowed somewhat, especially in academic circles. The term IoT can roughly be equated to a change in how different products and devices interact with each other. Where the Internet was originally constructed to allow humans to interact with each other and later with computers, the Internet of Things represents the next step, where connected devices talk to each other instead of to humans. Michael Porter and James Heppelmann, in an article written for the Harvard Business Review, attempt to tackle the issue of defining IoT products by drawing a continuum of product integration and further narrowing in on capabilities of smart products to tease out a useful definition of IoT. What becomes clear from the beginning is that smart device does not equate to Internet of Things. The Porter article assigned four levels of capabilities to smart device, and while they never strictly addresses when something finally fits the criteria of being and IoT device. Their four levels in increasing complexity are monitoring, control, optimization, and autonomy. Monitoring allows you to remotely observe product condition, usage, and the external environment through the use of embedded sensors. Control allows you to modify product function and personalize the user experience. Optimization allows algorithms to optimize product operation as well as having predictive diagnostics to aid in service or repair. The final level, Autonomy, allows for autonomous operation, coordination, operational enhancement and self-diagnosis (Porter, p70). It is at this final level where I believe the distinction between IoT and non-IoT devices exists, although this autonomy does not necessarily need to reside in the object itself, but rather the system in which it operates.

This is where it might actually be more useful to take a step back and look at different levels of product interactivity and connectedness to draw a line between IoT and non-IoT devices. To explain this macro level distinction the Porter article has product technology integration increasing in sophistication over five stages until it is a part of a system of systems. For my purposes however, I believe it is useful to focus only on the first four categories, as the fifth stage, a system of systems seems more like an extension of the fourth stage, a product system. Either way, the first level of complexity is an analogue product, dependent on a human operator to use as well as monitor the condition and function of the product. The second stage of integration is what is traditionally seen as smart products. These products have the ability to give diagnostic information about themselves and enhanced utility due to more precise control. You can also program actions to be done by the product at this point in some cases. The third stage, smart, connected products, involves being connected to other devices. This connection allows for remote control, as well as monitoring. This is where we begin to see IoT devices. These smart connected products, however, need outside control to receive updated instructions. The fourth stage, the product system, is where devices truly become connected to one another, and where autonomous action is taken to improve the function of the overall system (Porter, p74-75). While not all IoT devices meet the autonomy criteria, in general to be an IoT device, the device should be able to connect to a product system, and in doing so either increase its intrinsic value or the value of the system itself. As seen in (Figure A) the circles represent the number of qualifying products, which each nested circle a smaller subset of the larger circle and also representing an increased level of technological integration and functionality. The red line represents where we can begin to say that different devices are IoT devices. While it might be sufficient to leave the definition at a smart, connected device, I believe it is important to note that the greatest value of an IoT device, a smart, connected device, comes when it is well integrated into a system to increase its value. Thus, for the purposes of this paper, I will use a definition of an IoT device as one that generally meets the criteria of a smart device but also has connective capabilities allowing it to interact with other devices autonomously.

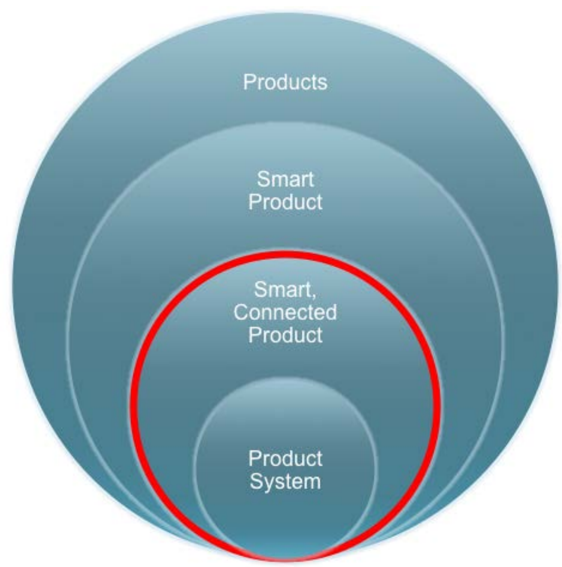

Figure A

1.2 Examples

Having defined what an IoT device is above. I think that is will help to clarify the above definition as well as the different broad stages laid out in the Porter article to cover several examples. Most examples given are already available or under development however, for this exercise, it is more helpful to look even at theoretical applications, as these applications become increasingly likely and viable as the cost of the related technology drops. You can skip to section 1.3 once you get the general idea.

1.2.1 Insulin Pump – For stage one, we can think of this as a person simply giving themselves daily insulin shots. The injection is fully analog and dependent upon human intervention for dosage and delivery. Stage two sees a smart pump, one that can be programed to monitor blood sugar levels and inject insulin as needed. However, these setting must be programmed into the pump manually and in person. Stage three has a pump that can do everything the stage two one can, but can be updated remotely by a doctor if new information becomes available for general guidelines, or something specific in the patient's health. Stage four allows for the pump to be integrated into a health care system that combines the data from the pump with other medical data to maximize the effectiveness or not only the insulin injections, but potentially also other treatments the patient might need.

1.2.2 Thermostat – Stage one has a thermostat that lets you control the temperature of the air coming out of your air vents. Stage two lets you set a temperature and the thermostat will adjust the air temperature accordingly as well as being able to pre set different temperatures during the day. Stage three lets you remotely control your thermostat. Stage four sees your thermostat knowing where you are and whether or not to start adjusting the temperature of your house, room-by-room depending on your preference.

1.2.3 Sprinkler – Stage one is a sprinkler you hook up to a hose and stick out in the yard where you watch it make the same motion over and over until you turn the water off. Stage two looks like an in the ground system you to program to turn on at a certain time every day. Stage three is when you can remotely control your water usage and adjust your sprinklers for the most effective coverage of a watering area. Stage four is a system that actively monitors plants and soil conditions as well as the weather to create optimal conditions for plant growth.

1.2.4 Cars – Stage one is a car that your grandparents might have driven growing up. Stage two is where most cars are today, with diagnostic systems that can be read when you take your car in for an inspection and can even tell you when it is time to get your oil or breaks changed, or notify you of other major problems. Stage three is a car that be controlled remotely, I like to use the example of Tesla vehicles for this, as they are all connected to a satellite network that allows for performance tweaks and safety updates from Tesla's headquarters. Stage four is self-driving cars, specifically ones networked together as opposed to being able to drive independently of other vehicles. This will be further explained in a case study later.

1.3 Case Studies

1.3.1 Camalie Networks and the $6000 Grapes

In section 1.2.3 I mentioned sprinklers as being IoT capable. As reported by Erik Mellgren on Xconomy, the case of Camalie Networks shows how IoT sprinklers not only allow farmers to save water, but also increase the quality of their product, drastically increasing it's value. It is common knowledge that the less water you can give a grape vine, the higher the quality of grape the vine will produce, assuming of course that you don't kill the plant. This level of control is one of the reasons Napa Valley, relatively sheltered from rain, is able to produce grapes of a quality that has allowed the valley's wines to become well known worldwide. On the valley floor, water is relatively plentiful, so irrigation is cheap and crop yields are high. However, as you move up the valley walls, the land becomes more arid, increasing the cost of water, but also allowing for finer control over how much water each plant gets. In an effort to conserve water, Mark Holler, former Intel researcher, owner of Camalie Vineyards and founder of Camalie Networks developed an integrated sprinkler system monitoring station. The problem of how much water was enough as he saw it while developing his system was that it was hard to know exactly how much water the plants were getting, as the few ground moisture monitoring stations he had were not providing enough coverage (soil moisture and plant hydration are highly correlated, so knowing the amount of water currently in the soil and how hard the plant needs to try to get the water out of the soil tells you a lot about how much water the vine currently has). His solution was to create a solar powered sprinkler/monitoring system that self connects to other similarly equipped sprinklers in the area once placed to allow all connected sprinklers in the network to connect to a main computer without the need to otherwise set up an independent network for them to hook up to. While this initially was made in an effort to conserve water, (he saved 60% on irrigation the first year he implemented the system) where the real increase in value comes in when looking at the value of the grapes. While typical grapes from the valley floor sell for $100 a ton in a normal year, his grapes, produced by vines toeing the fine line between wilting and the highest quality grapes, can go for as high as $6000 a ton (Mellgren). The yield is lower, so the increase in value is not as simple as 60 times what his harvest would otherwise have been, but between the large savings from irrigation (which California quite frankly needs all it can get in that area) and the large increase in value of the harvestable product, it is easy to see how value can be added when you reach the level of control available when you have a fully integrated IoT system.

1.3.2 Taxibot – There has been a lot of hype in the media as several leading technology and automotive firms compete to put the first self-driving cars on the road. While there are certainly a myriad of benefits that could be gained relating to freeing up the attention of the driver and safety improvements, what I find to be the most interesting is the findings of the Corporate Partnership Board presented to the International Transport Forum on self-driving cars. Their report focused on the effects of autonomous vehicle fleets on urban areas, with a case study on Lisbon, Portugal. Using a shared fleet of vehicles optimally controlled to keep any wait times for pick up under five minutes and maintaining comparable travel times, they size of the fleet required to still services all of the current trips in the Lisbon area is 10.4% of the original fleet (commercial and private ownership), dropping from 203,000 vehicles currently to 21,210 vehicles in the optimal scenario. In addition to this drastic reduction in the need for car ownership without sacrificing much mobility, there is also the benefit of the reduction in parking spaces needed to accommodate all of the vehicles. In the optimal scenario, using a 100% shared fleet combined with high capacity public transportation, the number of parking spaced needed to accommodate all of the vehicle drops from 160,000 spaces (50,000 of which is off street parking like parking garages and parking lots) to 8,901. This represents all of the curbside parking, an area equal to 1,530,000 m^3 or about 210 soccer fields, as well as 75% of the off street parking, an area equal to 1,200,00 m^3 or 170 soccer fields. This frees up valuable land in urban centers either for commercial or recreational use, allowing for expanded roadways, sidewalks, bike lanes or other uses. There is a slight increase in total vehicle miles traveled due to repositioning for optimal services, although the authors noted that the environmental impact of this would likely be negated by increased fuel efficiency of new cars relating to higher utilization, and thus higher replacement rates (International, p26-29). This of course assumes that the cars are working together to position themselves optimally, as opposed to the current goal in autonomous driving, which is that the vehicle can drive without a connection to a shared network, amongst a largely human driving population.

Section 2: Business Models, Comparing Service and Product Based Models

Having established a working definition of what IoT and IoT devices are, and having attempted to provide examples of IoT systems that create value in ways that conventional systems cannot, I will now discuss what this means for business models for companies that are in the IoT device business. This will be done by first differentiating between two broad business models, Services and Product, and then attempting to come to a conclusion on how to decide what is best for IoT companies.

2.1 The Product Model – This is a business model where we will loosely call what is being sold is a product, defining it as such because ownership of either a tangible or non-tangible object is transferred from the seller to the buyer. This is usually done in the form of a one-time payment. This business model is common when the good being provided had the majority of the value contained within what is thought of as the product. Other factors that influence whether something should be sold as a product are capital intensity, if the price is low, it is easier to purchase something outright than if you need a lot of resources to purchase the object outright. High utilization also increases the likely hood of a product model because there is value to the convenience of availability and the ability to amortize the cost over a large number of uses.

2.2 The Service Model – This is a business model where we will loosely call what is being sold is a service, defining it as such because ownership of either a tangible or non tangible object is not transferred from the seller to the buyer. This is common when there is either a large amount of the value residing outside of the object in question, or when it is very costly to learn or do something yourself. It is also common when utilization is low or infrequent, meaning there are few chances to spread out the cost across many uses.

2.3 Other Considerations – While it is easy to make these generalizations, they are just that, generalizations. Depending on the function of a product, it might be more advantageous to go with a product model even when utilization is low and cost is high because of the nature of a product. Putting these factors together, (Figure B) attempts to show that above the line, when utilization is high and cost is low, it is often best to use

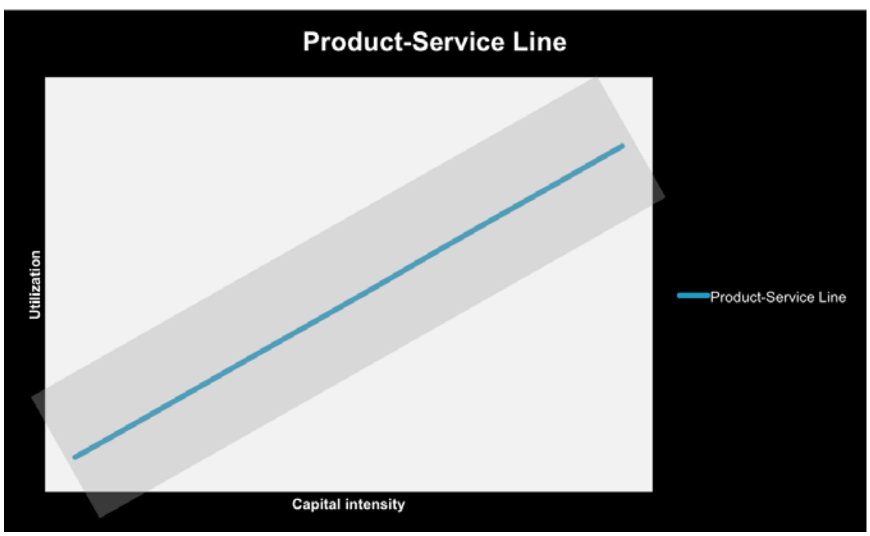

Figure B

the product model, while the opposite is true when there is low utilization and it is costly to either buy or otherwise use a product. There is a grey bar around the line however to factor in that depending on use, things that might be close could go either way, or even be in a situation when both models are viable. Also, what is considered capital intensive (expensive) or something with high utilization varies from person to person given people's financial situation as well as skill set. One other consideration is the effect of transactions costs. Costs relating to transfer of ownership or physical transfer can influence which is the better model to use, although the effect can vary with the intended use.

2.4 Examples of Product and Service Models.

Like in the previous section, to clarify my point, I will give examples of each model. I will concede before beginning that what model you use can depend on where in the value chain on a particular product you are looking. For the sake of this paper however, I will mostly focus on which model to use in relation to delivering a final product to an individual end consumer.

2.4.1 Cell Phones – I think it is interesting to see the change in how cell phones have been sold over the last fifteen years or so to illustrate the dynamics of the Product/Service decision. Fifteen years ago cell phones really first entered the mass market because the price of the phone had finally come down enough that people could buy the phone outright. However, even back then the question should have been asked, "where does the value of a phone reside?" The phone back then had its primary value outside of the object in being able to connect to other phones so one would think that the phone might qualify as a service. However, as mentioned before, the price point was low enough and utilization high enough where it made sense to buy a phone outright and then worry about the associated cell phone plan. However, the rise of smart phones has shifted this dynamic dramatically. With new phones retailing in the hundred's of dollars (an unlocked iPhone 6 currently costs about $650) the phone has now often become bundled with the phone plan. While there is some intrinsic value a phone being able to use apps and wifi, most of the value comes from having access to the very expensive data and voice networks built up by phone companies. With the ability to disable most of the functionality of a phone, cell phone service companies like Verizon and AT&T have no problem viewing the phone as part of the service they provide, essentially giving away phones at a cost of increases in the payments for accessing their networks, networks by the way, that a single person could not hope to build or maintain on their own.

2.4.2 A new set of stairs – suppose that you are building a home and that you need a set of stairs to get from one floor on your house to another. Which model should you use? The cost of a set of stairs might seem high, but compared to the value of the home it is likely relatively low. Ok, so we have determined that capital intensity of the physical set of stairs is low, how about the utilization? Will you be using the stairs often? The answer is yes, because even if you do not physically go up and down the stairs every day, what it actually does is allow access to an additional story of your house. Besides, it would be very inconvenient to rent a set of stairs in most cases because it would be very costly to take the stairs away should to decide you do not want them or can no longer afford them. The same could be said about a door. Whether or not you are opening it often, it serves the purpose of containing or partitioning rooms. If there is nothing that needs this function then it is perfectly acceptable to just have an open archway. Let us look now at the installation of the stairs. Assuming that you wisely purchased the materials to make your new set of stairs. It is not in most people's skill set to design and actually build the stairs. That means that it would be more efficient to continue at your day job and instead pay someone to do it for you. You don't need to buy the tools related to building the stairs. You don't have to spend the time to learn the skill set relating to how to build a sturdy set of stairs, a skill set that you might not ever need to use again.

While these examples might be extreme cases, showing opposite ends of the spectrum in the stair example and the complex decisions caused by the grey area in the cell phone example, what is probably most important is to think about each business individually and try to identify what is most palatable to the end consumer.

Section 3: Future Impacts

Having now discussed a Product and Service view of selling products, I will now address how this affects several groups going forward. I will address opportunities and growth areas for IoT companies and supporting industries as well as potential effects to end consumers.

3.1 Industries Directly Affected by IoT Products and their Support and Production – While IoT has the potential to alter the landscape of nearly every current industry with changing value propositions as technology becomes increasingly integrated, I want to focus on the decisions sellers of IoT products will have to make using the above framework, as well as industries directly supporting them, specifically chip manufacturers and pure play system access/data providers.

3.1.1 Chip Manufacturers – The current landscape for chip manufactures had them solidly in the product business model. The costs to develop a chip and build the facilities necessary to produce that chip are astronomical. The costs of the chips however are generally not very high and their functions are generally important to the device they are put into. It is also very costly compared to the price of the chips to attempt to reclaim one that has been put into an object. What they sell to device manufacturers is a product now, and I do not see that changing in the future. Where they will benefit is from the massive increase in volume for simple, small, low cost chips for use in sensor technology on one end, and high end chips for the system controlling units of IoT product systems. While I see the a potential for a race to the bottom style of competition on the low end, the uses of IoT products will be so varied that I believe there will be ample room for product differentiation, and thus moderately increased profits.

3.1.2 System Access and Data Providers – This is already a rapidly growing industry enabled not by IoT devices, but by increases in computing power that have allowed companies to start trying to process the tremendous amount of data produced by our various online and offline actions. One thing that many devices in the IoT ecosystem will be doing though is simply generating data. Data on weather, product usage, customer locations and preferences, manufacturing processes and a myriad of other sources that was impractical to collect before will now be collectable. The companies that can collect, process, and limit access to that data will likely see large increases in value as data becomes more important to the value proposition of IoT devices. While one-time sales of data under the product model are feasible, what I see as a better option is to continue to use the current service model, which you often see with database companies, where you sell access to the data, which is constantly being updated. The constant updating of the data renders the old data obsolete, allowing for a model where it is easier to pay a recurring fee for continued access on the part of the customer than to try to collect new data constantly, if at all possible.

3.1.3 While the first two groups have more clear cut answers for business models going forward, I think the group with the most interesting future is that of the actual IoT device seller. The IoT revolution for many will be an evolution of the current product model, with IoT capabilities added into existing devices to improve some aspect of the functionality. The increasing cost of the products due to the additions of technology, along with an increasing disentanglement of the value of the device and the device itself will lead to businesses shifting from using a product model to a service model. The question many will have to ask is “what business do I want to be in?” They will have the first choice in who gets the data generated from the devices they sell, and what system the devices operate in. Having this power means that they have the ability to vertically integrate with the system access/data provider group to capture a larger portion of the value chain that will also be increasing as IoT devices continue to proliferate.

Looking once again at the example of the Taxibots, we can see the potential shift that is taking place that I just mentioned. The current model for OEM’s is to sell a car and be done with it, possibly with the exception of fulfilling warranty requirements. However the most efficient model is one where a shared fleet is used. While the cost directly associated with each trip might seem higher, when factoring in the large capital outlay that many car owners are currently accepting due to the need to have the car at their disposal at any time, it is already more cost efficient in some areas not to own a car and use taxis or Uber or some other car service. Once you factor in the reduced inventory/capital needs, lower operating costs from not having drivers, and the benefits of the freed up space, it seems like people will be racing to be the first to capture this market. If the KPGM Global Automotive Executive Survey for 2015 is any indication, this is something that not many executives are seriously considering, even with reports coming out like the one on vehicle automation mentioned earlier, the percentage of executive surveyed that said connected car technologies were a high priority fell from 13% in 2014 to 8% this year. The outlook was even worse for self driving cars, with the number falling from 5% in 2014 to 3% in 2015. The general consensus for when the market will be ready for self-driving cars had the large majority of respondents saying that it would be either over 20 years or never, although the percentages varied by region surveyed (KPGM, p19-23). The reluctance of established players to significantly alter their business models could open up opportunities for companies like Uber and Google to gain a foothold in this area.

There will still be instances where IoT systems will be better sold under the product model, as will likely be the case with Camalie Networks since their system is self-assembling and self-contained. However, the general trend will be toward a service based model.

3.2 Effect on End Consumers – The main change I see for end consumers revolves around three related issues, Ownership, dependence, and privacy. With the shift towards more service-based models made possible by increased connectivity, there will be a decrease in traditional forms of ownership. This might bother some people and not others, but increasingly, things that you used to own, potentially including your personal information, will become increasingly not your own. There has always been a trade off between convenience and privacy, and this will be no different. Something that is going to have to be addressed in the near future is who owns your personal information. Also since the value of your things will be tied to how effectively they can use information about you, much like Netflix and its movie/tv show suggestions, the longer you stay with a particular product/service, the more the switching costs will increase.

Conclusion: In this paper, I came to a definition of what the Internet of Things is, and more importantly, what criteria generally need to be met for a device to be considered part of the Internet of Things. Having described and IoT device as one that not only had traditional smart capabilities but also has connective capabilities that are used to interact directly with other physical devices and non physical systems to increase its value proposition, I gave examples to attempt to clarify this definition. Once establishing this working definition I built a framework for thinking about optimal strategies for selling a good or service through a view of either a product-based model or a service-based model. This framework was then used to try to draw insight about upcoming systematic changes related to the sale and ownership of IoT devices and analyze industries most closely related to the production, sale, and management of IoT systems.

In the end, the most important insights relate to the shift in business model for businesses that traditionally have used the product model to sell smart devices and non-smart devices to end users. Due to shifting value propositions, it might be more profitable to vertically integrate with entities that collect and analyze customer data to give those businesses more control over the value of the product as well as helping them capture a larger portion of the value chain.

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