Innovation and Entrepreneurship Thesis

Vaibhav Kulkarni
EIT-ICT Labs Master School
Embedded Systems (TU Berlin - TU Eindhoven)
Distributed Systems Group, ETH Zürich

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Abstract

The Internet of Things (IoT) is amongst the fastest growing technologies in today's economy. The market value of IoT is predicted to be $1.3 Trillion. There are 15 billion devices connected to the Internet today, and it is predicted that by 2020 this number will rise to 50 B devices. These devices cover the domain of digital devices and physical "things" like windows, doors, flower pots, book shelfs, toasters and literally everything around us will be able to talk to the Internet. At the backbone of IoT lies a vast number of electronic devices which connect these physical "things" to the Internet using wireless radios. Thus, there will be a lot of devices around us wirelessly communicating with each other and to the Internet to give rise to novel futuristic applications. These devices create interference for each other and thus it is essential to mitigate the impact of the interference sources on the IoT devices. However, the first step to solve this problem is to adapt the current communication protocols to work under interference and to enable this, controllable interference generation is necessary. To facilitate interference based experimentation, we build an "Interference Box" which is capable of generating the interference patterns depicted by major interference sources. In this thesis, we formulate a business plan around this product, our dominant step being customer validation. Further, individual components of the business model such as the target market type, value propositions, customer segments, revenue model and organizational development based on Mintzberg methodologies and the interrelations between them will be discussed.

1 Introduction

Until some years back when the number of the wireless devices was under control, the IoT applications were performing seamlessly with minor disturbances, however the rising number of the wireless devices operating today have started creating disturbances for Internet of Things applications in the wireless spectrum. The mobile phones, TV remotes, microwave ovens, cordless phones, baby monitors, wireless headsets, game controllers and several other devices create interference for IoT devices. Hence, there is a growing need today in the research community to understand and mitigate the impact of this interference, in order to ensure seamless operation of IoT applications. These applications include controlling windows through mobile phones, controlling timing of toaster using a computer application, controlling the lighting in the house using a mobile phone application and several others. The applications also include life critical scenarios such as structural integrity maintenance, road safety via vehicle to vehicle communication, automated medical equipments and others. Thus it is essential to mitigate the impact of the interference sources on the IoT devices. However, the first step to solve this problem is to adapt the current communication protocols to work under interference and to enable this, controllable interference generation is required which is an actively researched topics today.

Today, researchers and companies conduct computer simulations to predict the working of their application under interference. However, these simulations are far from realistic scenarios and don't replicate the complex behavior of different interference sources. On the other hand some researchers actually use the interfering devices such as microwave ovens and baby monitors, Wi-Fi routers to conduct tests. This method is cumbersome and not at all controllable. All these tests are conducted in a test environment setup

called IoT testbed which consist of several IoT devices on which experiments can be performed.

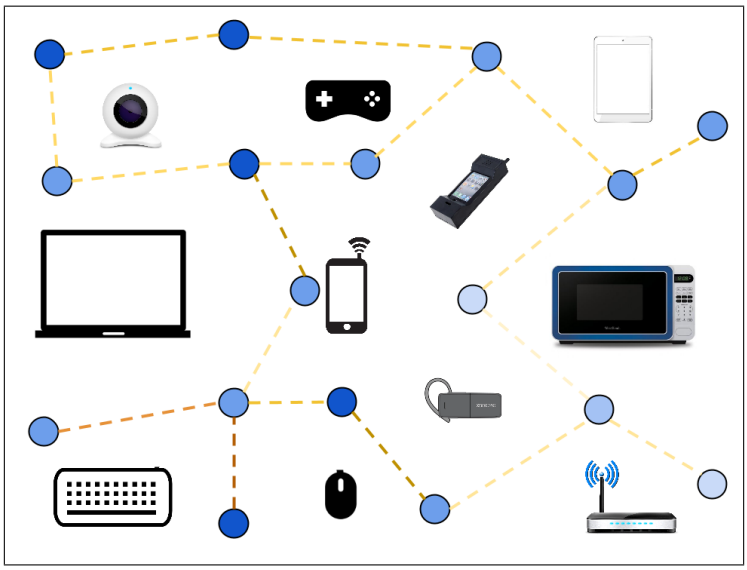

Figure 1: Impact of prevalent commercial appliances on IoT devices

My technical thesis at ETH Zurich focuses on establishing coexistence between the low power IoT devices and higher power interferers. The outcome will be a protocol which allows these devices to talk to the Internet even in the presence of high interference. To facilitate interference based experimentation a part of my technical thesis is designing an "Interference Box". This box will be capable of generating interference patterns depicted by prevalent interfering sources such as Wi-Fi routers, Bluetooth devices, microwave ovens, cordless phones, game controllers, wireless cameras and others alike. As a result, researchers will no longer have to rely on simulations or actual bulky interfering devices to conduct experiments, instead they can use a single device the "Interference Box" to test their IoT applications in the presence of generated interference.

Such a device can be used to test the viability of any IoT related product before deployment. This can lead to early discovery of potential causes of application failure which is helpful to correct errors and ensure reliable and robust application operation.

Business Development

The introduction shows that although there is innovation in the product described and it will serve new markets, the customers already exist. This I&E thesis will be a detailed formulation of the business plan covering the value proposition of the "Interference Box", customer segments, key partners, activities and resources in building the business. The thesis will also cover service distribution channels, costs and revenue streams. The dominant step being the customer validation stage. As stated by Steve Blank's in his book; The Four Steps to the Epiphany[10], an important step to consider before focusing on the customer validation is to be sure about your product market fit, he states "Customer Validation proves that you have found a set of customers and a market who react positively to the product: By relieving those customers of some of their money".

Since, we interacted with several IoT application developers and IoT testbed providers

before designing the Interference Box, in order to understand their difficulties to conduct interference based experimentation, we are confident about our product market fit. However, we decided to conduct a survey to understand the difficulties with currently available experimentation methodologies and how we can better serve our market. I conducted a survey with some of the widely used IoT testbed users and IoT application developers, popular IoT mailing lists, Facebook groups and IoT startups. (Detailed list and survey results provided in the Appendix).

Below is the preliminary business model canvas of our venture. It has been filled based on the survey results and interviews. We will use customer validation board by the lean startup machine [11], to track our progress in customer creation and discovery and focus on the problem we will solve for a particular market segment. We aim to build customer relationships by offering free hardware to big firms and charging for our software which will consist of interference packages of prevalent wireless technologies seen today. We will also update our database to include upcoming wireless devices and release two free device interference packages every year online on our website. This will in-turn result in visibility of our website to wide audience.

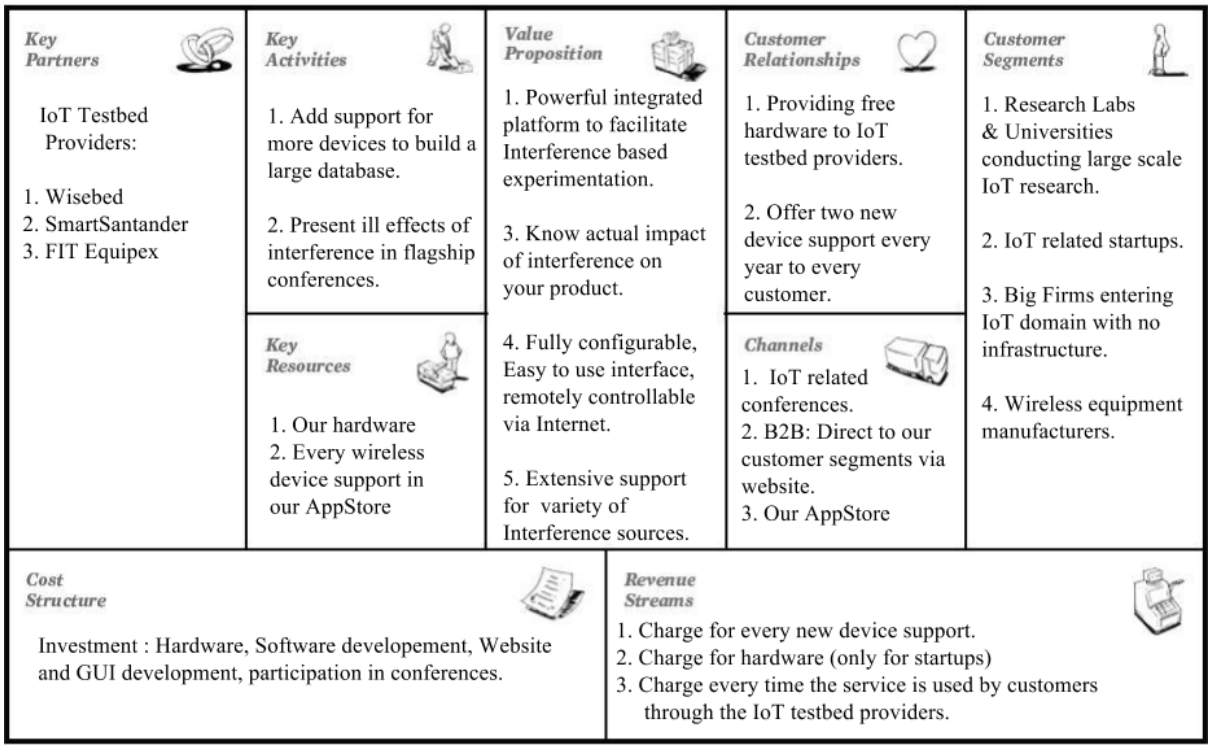

Figure 2: Business model canvas based on the survey results.

The survey can be summarized in the following main questions, the link to the form and the complete questionnaire is provided in the appendix:

1. Do you take effects of Interference in to account while conducting experiments ?
2. How do you conduct interference based experimentation ?
3. How many wireless devices you use for experimentation and what is the total cost?
4. How accurate are the simulation results ?

5. How many IoT application developers use the testbed on a monthly basis ?
6. Would you consider purchasing a single device capable of generating the interference patterns depicted by prevalent interference sources ?
7. How much will you pay for such a service ?

I studied the business models of public IoT testbed providers such as WiseBed [5], SmartSantander [6] and FIT IoT Lab [7]. These firms offer their devices to researchers and application developers for experimental purposes and charge them on the basis of number of devices used and the total time they are used for, which is similar to the strategy adopted by Amazon Cloud Services [8]. Thus, most of the IoT application developers rely on these testbeds to perform experimentation. However, these testbed setups have no interference generation capability as we observed from the survey results.

Our product "Interference Box" will be targeted towards two main customer segments.

- Selling the Box and associated application directly to big firms which do not rely on external IoT testbeds to conduct experimentation due to privacy issues.
- Targeting the existing IoT testbed providers in order to integrate the Interference Box in their setup. We will charge the testbed providers depending on the usage of our Box by their customers.

We have selected these segments based on the rate at which big firms are entering the IoT market and want to reduce the market entry and product launch time. These firms will need a realistic testing facility of the IoT products which is simple to use. Our second segment was chosen based on our survey results from which it is quite evident that none of the present IoT testbeds have a interference based testing facility. Thus integration of our tool in the existing testbeds will be profitable for the testbed providers as more users will prefer using them (also evident from our survey) and provide us an easier market entry opportunity.

Due to our presence in the B2B market the framework of a business development process fits the study we need to conduct about customer validation and company building. This framework will result in a complete business plan which will be helpful in decision making and approaching the testbed providers when the product development is complete.

As we saw from the preliminary survey results, there is currently no means to conduct interference based experimentation in IoT testbeds. We believe our product and the accompanied service can facilitate this. It will enable application developers to rigorously test their application before deployment and ensure reliable and robust real world operation. Currently, most of the developers use publicly available testbeds for testing. We aim to target this as our chief customer segment and gain revenue from the usage of our product through the testbed. We further analyze the financial aspects and funnels, however, our main focus will be on customer validation process. We also plan to create awareness about the ill effects of the interference by participating in networking conferences as the number of wireless devices is growing exponentially day by day. This presents a very good opportunity to establish our market presence, further we will use the already existing testbed infrastructure to advertise our service. Considering the market value of IoT which is predicted to be $14.4 Trillion by Cisco [9], a product which has the

potential to make IoT devices and applications reliable and robust can have significant benefits in the coming years.

2 Literature Survey

Introducing new products in new markets is by far the most "expensive demand-creation challenge" as there is nothing to compare your product against. Emerging markets such as Internet of Things (IoT) have few customers yet, as a result, there are a handful of people who know what the product can do or why they should buy it. Obtaining feedback from potential customers, reviewing similar cases is therefore important as creating demand is challenging, since the product is unknown to the users and market is unidentified [12,15,18].

The focus of this literature survey will be on Customer Validation process. Customer validation is one of the steps involved in customer development methodology, hence we will also briefly look at the important steps in customer development methodology to better understand the position of customer validation in the entire process. We also focus on the following aspects:

- What are the different methods and steps involved in implementing customer validation, related challenges associated and possible solutions to those challenges.
- How to conduct pivoting, employing strategies from the literature, based on the survey results and interactions, using the customer validation board.

2.1 Lean Startup

Lean startup is an approach to aid new firms to launch new products by acquiring a more scientific approach to entrepreneurship by iterative product tests with customer feedback. This approach helps startups gain a better understanding of how well their product or service will meet the demand and needs of their customer base without spending too many resources. It is a shorter and safer road to minimize market risk. The product market fit is the central idea of the Lean Startup Methodology (LSM). According to LSM, a startup must first identify a product-market fit with a scalable sales model before it proceeds to start scaling the business. The Build-Measure-Learn feedback loop is the main focus of the LSM. It involves the entrepreneur in getting customer feedback by testing the product with customers and using the feedback to improve the product in short iterative steps. In this way many hypothesis, that are often mistaken for being facts are rejected or validated early in the process, thus saving time and resources. [17] The key principles of LSM can be summarized as follows:

- Eliminating uncertainty by "getting out of the building"
- Working smarter not harder
- Develop a minimum viable product
- Validate learning

2.2 Customer Development Methodology

The customer development methodology developed by Steve Blank [13] gives a systematic framework for startups and entrepreneurs of how to develop products more successfully, with less market risk by developing better understanding of customers. The customer development process is conducted in parallel to the product development process, so as to create a balanced relationship between developing the product and understanding customers' needs. The Customer Development Methodology constitutes of 4 phases:

1. Customer Discovery: This stage focuses on testing hypothesis and understanding customer problems by getting in touch with the customers.
2. Customer Validation: This stage focuses on the uncertainty of developing a suitable sales model which can be replicated and scaled.
3. Customer Creation: Here, the goal is to create end-user demand and drive that demand into the company's sales channel.
4. Company Building: This is where the company transitions from its informal, learning and discovery oriented Customer Development team into formal departments with VPs of Sales, Marketing and Business Development.

We will focus on the customer validation step, as it constitutes the dominant step of our business development, corroborating our business model.

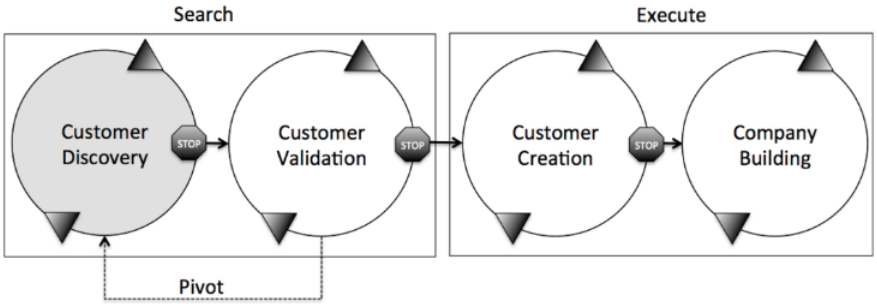

Figure 3: The Customer Development Methodology (From [13])

2.2.1 Customer Validation

The main goal of customer validation is to build a repeatable sales road map for sales and marketing teams. Customer validation can be started after having found a set of customers and a market who react positively to the product. This step comes after the customer discovery phase where the startup is searching for a problem solution fit. In customer discovery phase, the founders focus on getting the right product-market fit, that makes the startup's value proposition match the customer segment the startup aims at reaching. They try to better understand the customer problem and come up with the right solution which will be validated in the customer development methodology. In the customer discovery process the founders formulate hypothesis about the market size which helps startups map the size of the market, and realize the boundaries of their business model.

Completing the customer validation step verifies the market, locates the customers, tests the perceived value of the product, establishes the pricing and channel strategy. Only if a group of repeatable customers with repeatable sales process is found yielding a profitable business model one can move to the next step, else pivoting needs to be done as depicted in Figure 1 [13].

Customer Validation has four phases:

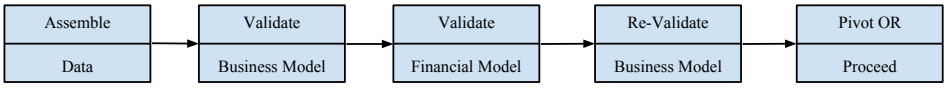

Figure 4: Overview of customer validation process

1. Phase 1: Stating the Sales and Marketing Hypotheses
   At this stage the company should have a general idea about how to make money from the product, how much the customers are likely to pay for it, how will they find the product and how to position and message the product. To summarize the first phase, the company should be well aware and should write down all of these hypotheses involving "get ready to sell" activities; such as product positioning, creation of a distribution channel plan, refining a sales roadmap, and creating an advisory board. These activities make the team best prepared early stage venture and overcoming challenges which may be faced at a later stage.

2. Phase 2: Validating product and figuring out the channels
   In this step the founders should attempt to answer the following questions. Where to connect with the customers, where will they buy/access the product, In case of B2B product, how to reach other business. This step also involves getting out of the building and validating the business model. The business model is usually validated if customers are interested in buying the product. At this stage attempt is made to sell unfinished and unproven product and getting feedback/orders. This is done through several channels such as brochures, powerpoints, sales materials and product demos. At this step the company attempts to validate the sales roadmap and prove predictability of sales funnel.

3. Phase 3: Refining product and company positioning This phase occurs after the company has a minimum number of orders and enough customer information to develop and refine the product and company positioning. The positioning is tested with industry analysts and with expanded customer audience.

4. Phase 4: Optimize and Iterate:
   At this stage the company stops all the activities to conduct a detailed pivot-or-proceed analysis and verify that regardless of the channel, customer validation is complete and the company knows how to scale. Once the company finds one or more channels to drive customers, the rest of the process can be optimized. However, as

the market changes and matures some of the old experiments must be revisited and tried again to verify if they make sense.

Customer validation phase is over when it's clear that there are real orders or users — not surveys or charts. Customer validation confirms that customers will accept the minimum viable product, proves that the customers exist, figures out how to reach them predictably, and crafts a scalable plan to engage and sell many more. [22,23]

2.3 Understanding Type of Startup Market

Understanding different markets and selecting the right one is important to strategize and to know the requirements in order to succeed. We studied the following four types of market types to gain a detailed understanding of the type of our target market [16,13].

1. Startups entering an existing market: One is in existing market if the product offers higher performance than what is currently being offered.
2. Startups creating an entirely new market: A startup creates a large customer base who couldn't do something before due to lack of innovation.
3. Startups that want to resegment an existing market as a low cost entrant: For customers at the low end of an existing market who will buy a product with "good enough" performance at a lower price.
4. Startups that want to resegment an existing market as a niche player: Targeted to a very niche part of an exiting market to address their specific needs.

As in our case we do not fall entirely in any of the above markets. As, although the IoT market exists, it is relatively new and will rapidly undergo changes in the upcoming years. Companies and developers will come up with novel futuristic applications which can be applicable in a wide domain such as agriculture, structural maintenance, entertainment and medical. Through the survey results we understood that, not everyone developing IoT products will need the interference based testing for eg. companies involved in pure software or web development for IoT. Thus we target a niche part of this new market, i.e. developers and product manufacturers who want to deploy their IoT based products in indoor environments which will need interference based testing. Along with the niche part of the new market we also target the existing market of wireless device manufacturers as they will aim to test their products in the presence of interference, since the shared wireless medium is becoming crowded day by day. Thus we lie in a B2B market, and target at resegmenting the existing as well as the new market in the area of testing wireless devices and IoT products which will be deployed in indoor environments.

2.4 Smartsantander Case Study

As a case study we looked into a firm "SmartSantander" and their business model [19,20,30]. They provide sustainable IoT infrastructure in-place, based on the provision of experimentation services and a trial environment to industry and research at a world city scale. Figure 2 shows the Business Model Canvas of SmartSantander. We studied their customer segments in detail as our goals and target markets are similar i.e. aid testing for IoT applications.

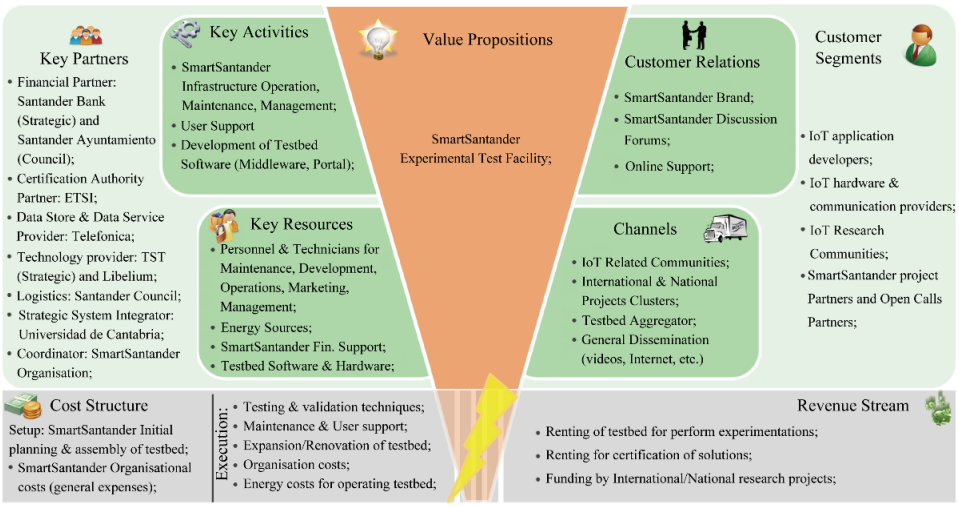

Figure 5: SmartSantander Business Model Canvas (From [20])

2.5 Use of Literature to Inform Current Practice

The literature is helpful to gain a deeper understanding of different methodologies a startup may adopt to launch new products in an upcoming market. We looked at the lean startup process and the customer development methodology by Steve Blank. The latter was more appropriate and better suitable for our business development as it focused more on understanding the customer needs and pivoting to eliminate market risks at a later stage. It also focuses on parallel (rather than sequential) development process to both reduce cycle time and to better incorporate customer and supplier requirements in the product and process design [18]. The study on customer validation helped in understanding detailed steps involved in the validation process, how to establish channels, conduct iteration and stop the process. The study on different market types will help us to focus on the right markets since IoT is a big domain with variety of different products and applications. We also realized that our product is generic to test other wireless devices as well and we aim to target existing market of wireless device manufacturers such as WiFi Router producers, gaming companies manufacturing game controllers, cordless phone makers and others alike.
The Smartsantander case study helped us to verify our original assumption of target customer segments, however, based on the survey results and interviews with IoT tested providers, our target customer segment also consists of testbed providers themselves. Based on this study, the literature survey, the conclusions derived from survey and interviews we fill in the customer validation board.

3 Business Model

By the year 2019, IoT is expected to be the largest device market in the world. Google recently deployed its new project Google Brillo, through which Google wants to do to Internet of Things, what it did to smart-phones with Android [24]. In such an era, where major industries are stepping in to the field of IoT, startups developing supportive technologies can gain a major advantage. These assist technologies can be either lead to performance improvement or testing under various scenarios. Our product, "Interference Box" contributes in this area by allowing full fledged testing of IoT devices under prevalent

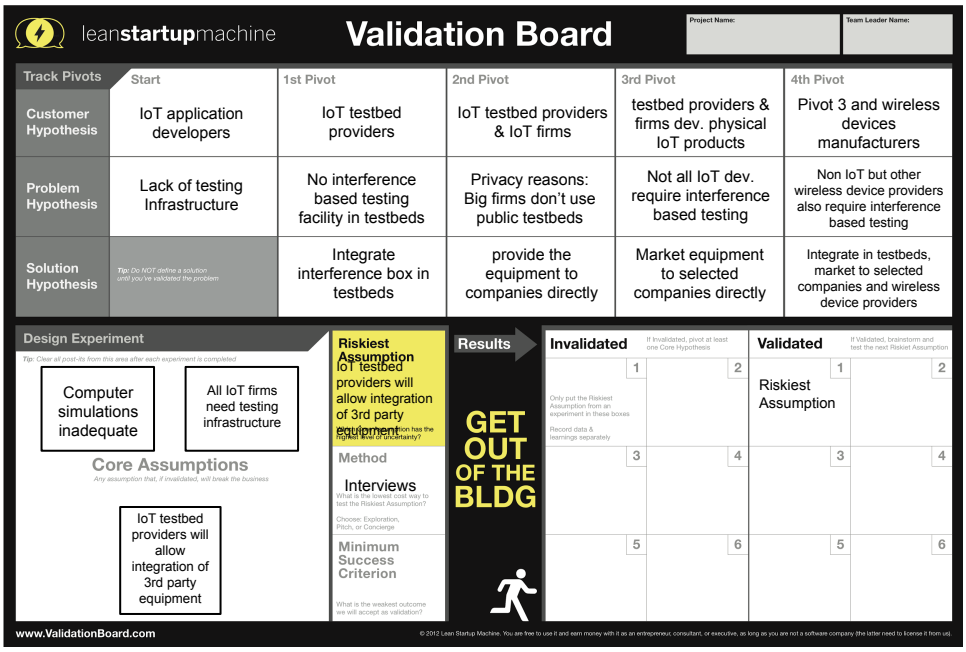

Figure 6: Customer Validation Board

interferer's present in the environment to ensure robust operation. In this section we will focus on the value propositions which can be incorporated to build a successful business model. Next, by using Osterwalder's canvas we will see how the business model looks like which will be centered around the value propositions described in the previous step. Further, individual components of the business model, the target market type, developing an organization based on Mintzberg methodologies and the interrelations between them will be discussed. The essay will conclude by looking at the major learnings from the thesis.

3.1 Business Model Canvas

3.1.1 Customer Segments

- Our major customer segment will be IoT testbed providers as none of the testbeds have interference based testing facility at present. Based on our interviews with testbed providers at ETH and TU-Berlin our product can be integrated in the existing testbeds without much changes in their framework. Depending on the size of the testbed, the firm might require multiple of Interference box's. These testbeds are accessed by IoT application developers for protocol testing.

- Our second customer segment includes research institutes and universities having their own private testbed. Our product can be integrated in to their testbeds to provide high quality testing facilities to the research community.

- The third segment consists of big firms and startups entering IoT market and rely on their private testing facilities. We plan to sell our product to them directly as such firms do not rely on public infrastructure for testing due to privacy reasons.

3.1.2 Customer Relationships

The customer relations outlines the type of relationship the firm establishes with its customers. We plan to establish good relations with our partners by providing free hardware of our product to the testbed providers and provide help to integrate it in their testbed. As in this case our major revenues will be from customers using our product in the testbed. We also plan to offer free upgrades to the database consisting of different interferer's which will include new device supports.

3.1.3 Channels

We plan to reach our customers by participating in IoT related conferences, through our website and our app store where we will provide packages consisting of new wireless devices producing interference to update the device database of prevalent interferer's.

3.1.4 Key Partners

We plan to establish partnership with major IoT testbed providers. Such as Wisebed, Smartsantander and FIT Equipex. These testbeds are used by a large number of IoT application developers and product testers. Partnering with them will provide us the visibility and subsequently more users.

3.1.5 Cost Structure

The initial investment should cover the cost of the hardware, software development including costs to setup the website, user interface and related activities. To build up customer relationships, we also need investment to participate in conferences.

3.1.6 Revenue Streams

We plan to charge for our hardware and related software packages to big firms and startups. In case of testbed providers, we will provide the complete product free of charge and aid in product installation. We believe this will build up positive relations with the testbed providers. We will charge only for usage of our device by the testbed customers. The testbed providers will be charged based on the time our product is used by their customers.

3.1.7 Revenue Model

Our product is quite similar to that of Amazon Web Services in the sense that we are both offering an Infrastructure as a Service. However, whereas Amazon rents out their servers, we are renting out a set of devices in order to emulate network interference. For this reason, our revenue model is quite similar to that of Amazon as our gross source of income stems from renting each of these devices to the testbed users.

Overall, our revenue model is the result of applying a formula that takes into consideration several variables, among which the 3 most important are:

- Time (in hours) that a interference device is occupied.

- Number of times our device is configured as a different interferer.
- Current utilization ratio of the network of these devices -the closer our network is to be 100% occupied, the more expensive it becomes to rent the interference generating device.

3.1.8 Key Resources

Our key resources include our hardware (Interference Box), the user interface which will enable the users to use the product. We also plan to provide an equivalent of App store which will host numerous wireless devices the Interference Box can support and the users can select which devices to select.

3.2 Target Market and Associated Strategies

Our target markets can be divided in to two major categorizes as discussed previously. The first one is niche part of the new market, specifically developers and product manufacturers who develop IoT products to be deployed in indoor environments. Secondly, we also target existing market of wireless device manufacturers which are operated indoors. Selecting the right strategy which will pave a way to the firms planned future, which includes achieving certain goals or solution to some problems is highly important. Thus, we carry out SWOT analysis for Porter's generic strategies and Porters Five Force Analysis to determine the right strategy [25,26] .

	Helpful to achieving the objective	Harmful to achieving the objective
Internal Origin (attributes of the organization)	**Strengths** **Uniqueness:** No other firm has a single generic device capable of representing multiple interferers. **Easy Integration:** Our product can be easily integrated in to existing IoT testbeds. **Large Database:** We provide a large database of interfering devices and customizable user interface.	**Weaknesses** **Product Limitations:** Not every wireless device manufacturers open source their implementation, thus there will always be devices not present in our database.
External Origin (attributes of the environment)	**Opportunities** **Future of IoT:** The market value of IoT is growing exponentially every year and the number of connected devices is rising. **Crowded Wireless Spectrum:** The wireless spectrum is getting crowded day by day, which requires every firm to test its products to analyze their behavior in the presence of interference.	**Threats** **Privacy Issues:** Big firms might not opt for our product due to privacy reasons. e.g. our product, logging the messages sent by the device under test and learning the product protocol design. Solution: Make the all the device software open source.

Figure 7: SWOT analysis of the business model

From our analysis, we select the focus-differentiation strategy since we have a unique quality product offered to a niche market segment. A focused differentiation strategy requires offering unique features that fulfill the demands of a narrow market. Here, a business aims to differentiate within just one or a small number of target market segments. The special customer needs of the segment mean that there are opportunities to provide products that are clearly different from competitors who may be targeting a broader group of customers. The premise of the focus-differentiation strategy is that the needs of the group can be better serviced by focusing entirely on it. A high degree of

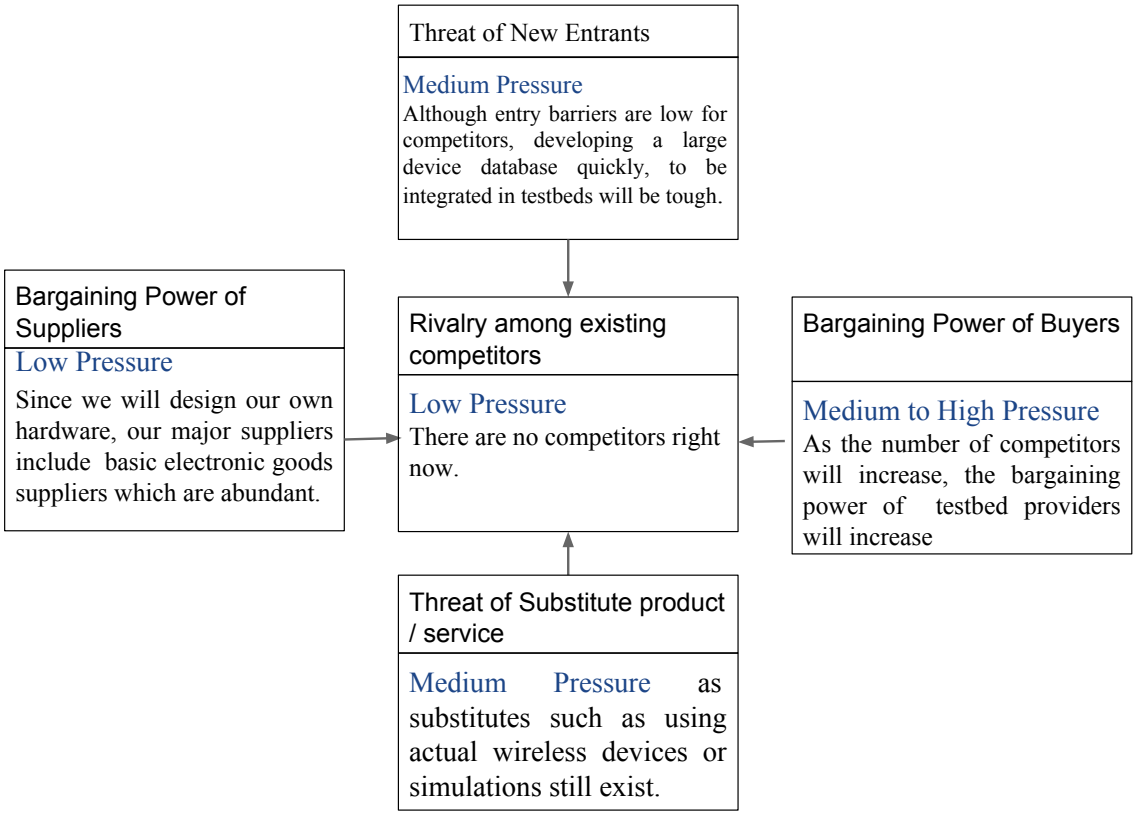

Figure 8: Porter five forces analysis

customer loyalty can be attained using a focus strategy, in-turn discouraging other firms from competing directly. We choose focus-differentiation strategy in order to be able to pass higher costs on to customers since close substitute products do not exist yet. Instead of selecting a pure focus strategy where we will have a narrow market focus resulting in lower volumes and therefore less bargaining power. Our main goal being, to tailor a broad range of product development to a relatively narrow market segment which we know very well. However the risks of focus-differentiation strategy include other focuser's trying to carve out sub-segments that they can serve even better or some broad-market cost leader adapting its product in order to compete directly [27].

Selecting and employing the right strategy helps to explore the fit between the organization and the environment, which can in-turn help to develop a sustainable competitive advantage. We plan to use the strategy as position approach, where our strategy revolves around the central idea of developing a niche product for a growing market to avoid competition. When considering strategic position we also conducted PEST analysis to understand our organizations bigger picture in relation to the external factors. Concerning the organization, we plan to have a simple flat structure and a small unit with one top manager. We want the organization to be flexible and thus we plan to keep it relatively unstructured and informal as compared with other types of organizations. We want to have a strict control from the top, managed by a strong leader to handle hostile conditions as the organization will grow. The benefits being, making the organization fast, flexible and lean. We select this particular organizational structure as our chief tasks involve

integrating the device in testbeds (this is one time task), direct sales of the product to firms and research institutes (which can be managed by a small sales team) , updating the device database and maintaining the website. The technical tasks can be handled by a team of 4-5 engineers thus requiring a small team initially. As the organization grows we plan to start sharing power of decision making with the middle level managers and the technical lead to relieve the chief decision maker as it can get overwhelming.

3.3 Reflection of the I&E Thesis

The concepts of literature review, specially literature concerning our dominant step "Customer Validation" and types of markets opened up a whole new set of market segment which we had not considered before. More specifically, our focus was only on integrating the product in the testbeds, however, the literature provided insights in other types of markets such as commodity wireless device manufacturers. In addition, we had envisioned positioning the organization as entering a entirely new market, but further analysis made it clear that we are entering a niche part of an already existing market. Although, we had to change certain aspects of the original vision of the selected entrepreneurial topic, the concepts of literature review strengthened the weak links such as target customers, position in the market and validating certain assumptions.

Certain challenges might arise due to some unforeseen circumstances such as the testbed providers refusing to integrate a third party component in their infrastructure. To avoid such situations, we utilized some techniques learnt from the state of the art such as validation of our riskiest assumptions based on the validation board and conducting pivoting until a repeatable sales process yielding a profitable business model was achieved. Studying the state of the art presented some new opportunities as well such as new market segments.

The I&E thesis made us conduct a thorough market research about the existing technologies present in the market having similar goals as ours, which led us to study the technical implementations of the products working on the similar lines which in turn contributed to more technical depth of my master thesis. The survey results were helpful in actually convincing the testbed providers at ETH to integrate our tool which we could use for experimentation. Indirectly, the I&E thesis also led to a better understanding behind the motivation of why such a product is required today.

4 Conclusion

In this era where the number of wireless devices exceed the number of people on the planet, it is utmost necessary to make sure that they do not disturb each others operation. Our product "Interference Box" will facilitate interference based testing of such wireless devices, providing concrete results to the manufacturers and developers about the changes required in the present design to make their operation more robust. In this thesis, we formulate a complete business model around this product where our dominant step is customer validation. We conduct a survey to learn about the current practices to conduct experimentation and facilities provided by various testbed. Through the survey results we validate our riskiest assumptions and gain a detailed understanding of our market opportunities. We also form the value propositions on this product around

which business model can be formed. Further, we address and discuss each aspect of the business plan using the business model canvas. We discuss our target markets and apply porters strategies after conducting SWOT analysis and Porters 5 force analysis about our business plan. We also discuss about the organizational structure and the lessons learnt from the I&E Thesis.
Our survey results and interviews followed by the validation approaches shows positive results and customer perception for our product. The initial capital required is moderate and the revenue streams calculated show profitable margins. Overall, the growth of the IoT segment, crowded wireless spectrum and a need for an infrastructure to conduct interference based experimentation is the right environment to launch our product.

5 References

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6 Appendix

Survey Questions and Results
Survey Form: https://docs.google.com/forms/d/1Hgq1JYQdVIcYx-56RGSxijFoLNUvBgUi-mLuirXzgPU/viewform
Results: https://docs.google.com/spreadsheets/d/19cQLnGlqPOSP3GDPhkgdrkO6pJOxBYV7R4yxRvkrfOs/editgid=1889569375

We received 42 responses from the sources mentioned below and by conducting interviews IoT developers.
Mailing Lists:

Figure 9: Interference Box

1. Contiki OS Users: Open Source Operating System for Internet of Things
2. Tiny OS Users: Operating System for Low Power Wireless Networks
3. GNU Radio Users: Open Source software to design new wireless protocols using software defined radios

IoT Testbed Users:

1. FlockLab TestBed, ETH Zurich [3]
2. TWIST TestBed, TU Berlin [4]
3. TU Eindhoven, Internet of Things, Course Students

IoT Startup Employees and Developers: Inventrom: www.inventrom.com

Facebook Groups related to IoT

A summary of the survey results
59% of the surveyed candidates consider effects of external interference while developing IoT applications and agree that the current communication protocols cannot deliver reliable operation in the coming years without any adaptation. Majority of the people (66%) which do not consider effects of Interference said its not a major concern right now and they would consider it as a problem after two to three years. Out of the people who consider interference 48% perform computer simulations and 40% of them are not satisfied with the simulation results. Others use actual wireless devices and physically place them while performing experiments. They agree that the experimentation procedure in this manner is cumbersome and are looking for alternatives. 30% of them use more them

15 wireless devices which cost about $2000. In the questionnaire related to awareness about problems related to interference, 56% of the developers and testbed users answered all question correctly demonstrating that, majority of developers today are aware of the grave problem interference is posing.
About 58% of the IoT application developers use publicly available testbeds to carry out experimentation and 80% of them confirm that there is no interference based experimentation facility provided in the testbeds. About 40% developers said that they would consider buying the Interference Box if the price is less than $2000, they as well said they would prefer an interference based testing facility in the testbeds themselves. In our interviews with testbed providers, 40% of them told they would consider integrating such a device in their testbeds as it in-turn would lead to more testbeds customers for them as other testbeds wont have this facility.