8-6-2018

Système

Trupti Pomaje
tdp2754@rit.edu

Système

by

Trupti Pomaje

A Thesis Submitted in Partial Fulfillment of the Requirements for the Degree of Master of Fine Arts in Industrial Design

School of Design
College of Imaging Arts and Science

Rochester Institute of Technology
Rochester, NY
August 6, 2018

Thesis committee members

Stan Rickel

Associate Professor
Industrial Design
College of Imaging Arts and Science
School of Design
Rochester Institute of Technology

Alex Lobos

Graduate Director and Associate Professor
Industrial Design
College of Imaging Arts and Science
School of Design
Rochester Institute of Technology

Abstract

In today's throwaway world, the rate at which and the amount of goods that are getting discarded has developed an alarming situation. Electronic industry has evolved rapidly since the invention of transistors in 1947. From these days onwards, efforts have been taken to make the products more efficient in terms of their performance, reduce design and production cost and have higher profit margins. However, this has led to products being designed in a way which makes people want to dispose them early, in turn making them part of waste after usage. Electronic products contain certain materials and components which are hazardous to human beings. Over past decade it has been observed that consumer electronics' life has reduced a lot. This is a severe issue when it comes to e-waste generation and hence needs to be addressed quite soon. Design and financial strategies of planned and perceived obsolescence are making these waste piles go high at an alarming rate. Recently, circular economy which is trying to bend this linear product life approach in to a loop, is being studied and strategies are being developed for the same. Businesses and designers are taking initiatives and shifting their focus towards circular economy by modifying their business models so as to guide the society into a sustainable future. This paper focuses on research about e-waste along with understanding the life cycle of today's mobile and computer devices. The study also focuses on design strategies and challenges for product longevity, analysis of the designing aspect of the mentioned electronic devices design and how user experience plays a role in reducing e-waste. With the help of this research, the goal is to develop a design concept for mobile and computer devices in this modern age which can have longer life span thus helping in reducing the rate and amount of e waste generated. For this, a study of evolution of aesthetics of electronics devices was very important. After reviewing those designs with a group, final concept is developed.

Keywords – design strategies for sustainable electronic devices, product longevity, modular electronic device.

Acknowledgement

Deep thanks to my committee members Alex Lobos, Stan Rickel also, professor Dan Harel for all the great advice and wonderful support.

I want to thank professor Stan Rickel for guiding us throughout these years and academics, being more like a parent.

A special thanks to Dr. Dorin Patru, associate professor at Kate Gleason College of Engineering for giving his input from technical aspect and sharing his thoughts; also Deanna Jacobs for guiding me through initial process and visiting at the final defense.

I want to thank my parents without whom I won't be able achieve and be where I am today. Thank you for always supporting me and being there for me my entire life.

I appreciate all those people who took their time out for brief interviews and gave their inputs and thoughts over the concepts throughout the product development.

I would like to thank Aditya Landekar for taking final pictures and boosting my daily motivation and inspiration of being my best in tough times.

Thanks to my loving classmates and friends who made my school years memorable and for always helping me throughout my academics. All those get-togethers and events and activities always cheered me up. Thank you for sharing wonderful various cultural essence.

Table of Contents

Introduction

Electronic waste generated each year is increasing at an alarming rate. In many developing countries e-waste has been considered one of the primary polluting factor when it comes to releasing toxic waste into the environment. Studies have also linked the case of birth defects in the new born babies to such toxic leaks. Despite of knowing the ill effects of such e-waste, only few countries have rules and regulations for manufacturing companies to take care of the wastes generated.

We need to loop back the paths in the linear system of take, make and dispose in other words extraction to production to distribution to consumption to disposal. The problem is, this is a linear system and it can't keep running indefinitely on a finite planet. This problem definitely won't be solved by changing one factor. This must be a system working together as one. Sustainability is not just about environment factors but balancing all three, ecological, economic and social pillars. There are many other factors involved as well such as bringing changes to companies business models, spreading awareness amongst people as to how their choices can have either a positive or a negative impact on the environment, incorporating new or reusable materials without compromising product's functionality, using renewable energy resources, design for upcycling or refurbishing etc.

Today, one can clearly see that electronic devices such as personal computers or mobile phones that once were considered to have a prolonged use now have a much lesser life span. Moreover, every year there is an upgraded version available. Marketing strategies have also been quite successful in making sure that people buy the newer models as soon as they are available on the shelf. Companies with their strategies, technological advancements and design keep coming with new product with some new added features and look and feel, which makes your current devices look old fashioned even though they are functional.

Here, I have studied design perspective and developed a concept that can contribute to circular economy. What if these devices were a system of hardware components instead of separate entities? What factors can help elongate product's life span?

Research

E waste

In today's tech savvy world, electronic waste has become one of the most pressing environmental issues along with becoming the fastest growing municipal waste component in America according to EPA. According to Electronic Recyclers international, with upcoming innovations and new technologies, it can be clearly seen that the lifespan of electronic devices such as laptops, desktops, cell phones, TVs, tablets and more has shortened, thus increasing the amount of e-waste that is generated.

However, even though electronic waste is currently a major environmental problem, if wisely used and recycled, not only will it help reduce the problem but also help generate a lot of revenue with the valuable resources that it contains. Cell phones and other electronic items contain high amounts of precious metals, such as gold and silver. In America, phones containing more than $60 million in gold and silver are dumped each year!

Facts about E-waste:

- E-waste represents 2% of America's trash in landfills, but it equals 70% of overall toxic waste.
- Cell phones and other electronic items contain high amounts of precious metals like gold or silver. Americans dump phones containing over $60 million in gold/silver every year.
- Large number of what is labeled as "e-waste" is not waste at all, but rather whole electronic equipment or parts that are readily marketable for reuse or can be recycled for materials recovery.
- Even when recycled, a significant amount of electronic material cannot be recovered. Only 12.5% of electronic waste is currently recycled
- 20 to 50 million metric tons of e-waste are disposed worldwide every year. If you put every blue whale alive today on one side of a scale and one year of US e-waste on the other, the e-waste would be heavier.
- Average life of cell phone is 18 months in America.
- For every 1 million cell phones that are recycled, 35,274 lbs. of copper, 772 lbs. of silver, 75 lbs. of gold, and 33 lbs. of palladium can be recovered.
- Recycling 1 million laptops saves the energy equivalent to the electricity used by 3,657 U.S. homes in a year.
- It takes 530 lbs. of fossil fuel, 48 lbs. of chemicals, and 1.5 tons of water to manufacture one computer and monitor.
- Electronic items that are hazardous include, but are not limited to: Televisions and computer monitors that contain cathode ray tubes, LCD desktop monitors, LCD televisions, Plasma televisions, Portable DVD players with LCD screens

E-waste is a global issue. We create too much e-waste and reuse way too little

Figure 1

Huge mass of waste is burnt to retrieve metals in developing countries, which releases toxic chemicals into the environment.

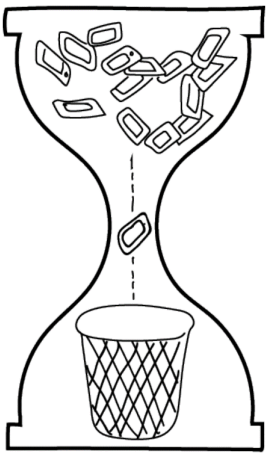

Figure 2

Technological advancements and planned obsolescence is making devices get discarded faster.

There are currently two approaches that are dominant towards recycling used electronic products: demanufacturing (or manual dismantling) and shredding.

1. **Demanufacturing**, involves manually dismantling the electronics in order to market the recyclable raw materials/products that are found. The dismantling process yields more components that can be reused in secondary markets. Demanufacturing or dismantling is most usually done by trained technicians who use a variety of machine and hand tools.
2. **Shredding**, involves a minimal amount of manual sorting and separation of components. In the shredding process, electronics are loaded into large pieces of shredding equipment. The shredding process allows recyclers to recover the maximum value from the recyclable metals in used electronics. Shredding operations employ fewer workers since most of the work is accomplished by large pieces of equipment.

Planned Obsolescence

As it is defined by D. Rutherford (*Routledge Dictionary of Economics (3rd ed.)* 2013), “deliberate feature of the design of a product to make the purchaser replace it at an early date because a fashion has come to an end or the product is useless. Extreme designs and gradually released new technology help to produce this built-in obsolescence.”

It is a business strategy to make product unfashionable or no longer functional after certain amount of time period. This compels user to buy replacement for that product. Planned obsolescence is not completely wicked. Many people are living better quality of lives because of consumer-based model, but at the cost of increasing global warming and contributing towards releasing harmful wastes thus, resulting in unhealthy environment. If we think about it, as much as company strategies and technological advancements are

making devices' life shorter and shorter, consumers not changing their attitudes and willing to accept the given, is driving this cycle.

In consumer electronics market, innovation and market competition makes technologies in components advance for example faster processors, better camera etc. According to the BBC article "here is the truth about 'the planned obsolescence' of Tech" by Adam Hadhazy, "If ever there was true obsolescence, it's in technology. It's almost as if the technology takes care of itself – this will obsolete itself whether you like it or not." (Howard Tullman 2016). Many people want to pay less price upfront since they know its components like batteries are not going to hold enough charge anyways. As technology rapidly evolves, people are not going value batteries with long life.

Counter to this consumer desire negotiated by planned obsolescence is the luxury goods market. People decide to pay expensive price for the product for finer craftsmanship, durability and resale value. Many luxury goods customer expect that their owned product value increase over the period instead of getting slammed. "If you buy a Rolex, you know it's going to last you and you expect to be able to drive a truck over it," (Slade 2016). With time, traits of luxury items being too expensive and made just for rich market can change and these products can gradually shift into mass market as the production cost goes cheaper. (Adam Hadhazy 2016) argues that planned obsolescence capitalism can also work in fulfilling consumer's interests. For example, safety measures such as airbags which were part of only pricier car models in the past are now widely incorporated in cars.

Circular Economy

> Ellen Macarthur foundation (2010) defines Circular Economy as:
>
> Looking beyond the current 'take, make and dispose' extractive industrial model which relies on large quantities of cheap easily accessible materials and energy that is reaching its physical limits, the circular economy is restorative and regenerative by design. Relying on system-wide innovation, it aims to redefine products and services to design waste out, while minimizing negative impacts. Underpinned by a transition to renewable energy sources, the circular model builds economic, natural and social capital. In simple words, there is not waste in this cycle, products are designed in a fashion that waste of one step is resource for next.

Fig 3 below is the butterfly diagram of circular economy, which shows technical and biological cycle. Technical cycle is concerned with management of finite materials - use replaces consumption. These materials are recovered and mostly restored in technical cycle. Biological cycle is associated with renewable materials, its consumption and restoration.

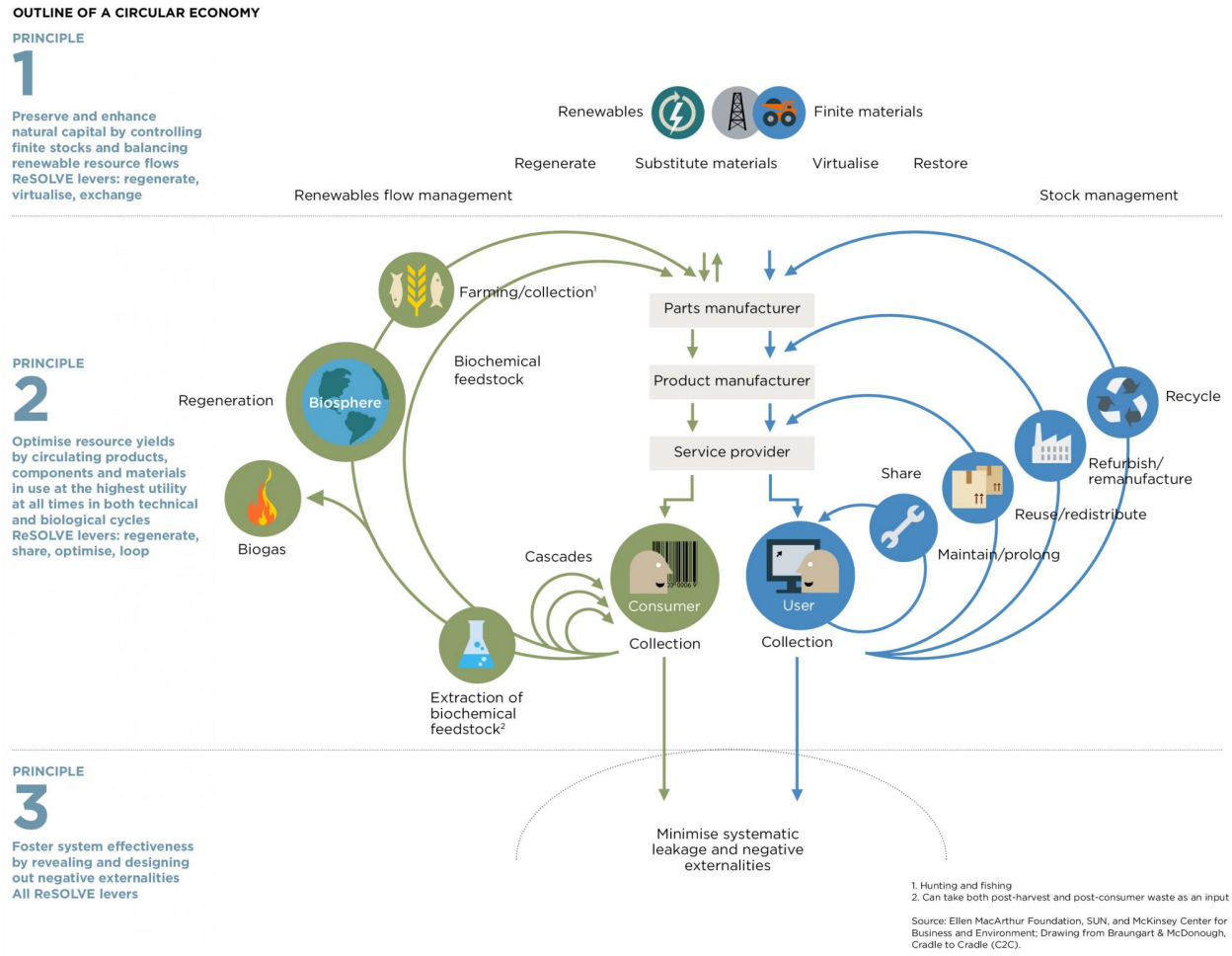

Figure 3
Picture credit: https://www.ellenmacarthurfoundation.org/circular-economy/interactive-diagram

Sustainable design for product longevity

At present many products are designed by not taking repairs in to consideration. As a result, it is often seen that consumers feel, repairing a product is an expensive and complex task. That ends up discarding entire product and buying a new one. If companies strive to come up with designs that makes repairing a device easy and cost efficient, the consumer would definitely look at repair as on option. One such example is Fairphone. Realizing the fact that as technology is progressing with rapid speed, product life cycle is reduced, the company has created a phone that is extremely modular. The phones components can be easily taken apart, replace and reassembled. With this approach, the company aims to increase the product life cycle. For Fairphone 2, a new updated camera was launched in September 2017. With the use of only screwdrivers consumer can quite easily replace the old components with upgraded ones. Their business structure is based on maintenance/ selling these components instead of selling entire product. According to latest lifecycle assessment by Fraunhopper institute using the Fairphone 2 for five years by repairing or

upgrading it with new modules would reduce CO2 emissions by about 30% (versus replacing the phone after three years). Research conducted by recycling expert Dr. Antoinette van Schaik (MARAS B.V.) and Prof. Dr. Dr. h.c. Markus A. Reuter (Helmholtz Association, Freiberg, Germany) says this modularity helps in improving recycling process with increase in the rate of precious materials recovery (Jonathan Chapman, *The Routledge Handbook of Sustainable Product Design* 2017).

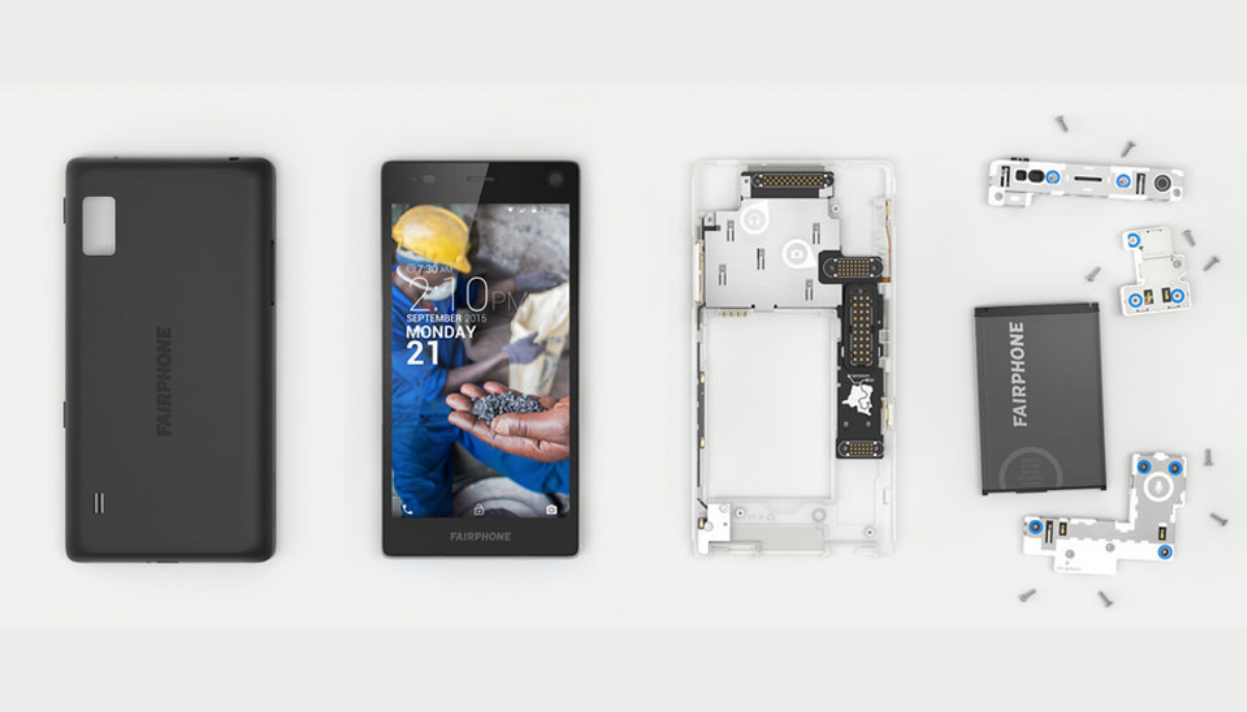

Figure 4
Picture credit: https://www.fairphone.com

However, products are not replaced just because they stop functioning. So, concentrating only on the technical aspect to prolong its functionality is not going to postpone consumer's replacement decisions. New technologies sometimes initiate new needs and new habits. For example, anticipation for types of screens, Internet and other communication protocols and size and shape of the phone has changed considerably. Phones, which were bigger in size, got smaller and again they are getting bigger in screen size. Also people have shifted from numeric keypads to QWERTY keypads to now screen touch keypads. This was driven by customer needs. Though we know that modular device can be updated as and when needed with certain number of components, it is not always possible to make the old devices with compatible with the newer technologies.

Fashion can be another factor for consumer to buy new products. New changes in the aesthetics of the devices, shifts in trends in the market can also make the product feel outdated for certain users. Some people are just early adapter who like to indulge in buying new products.

Strategies to increase product life cycle

Ruth Mugge suggested few design strategies for producing irreplaceable products (Jonathan Chapman, *The Routledge Handbook of Sustainable Product Design* 2017, 382-86) :

1. **Product personalization**: User is involved and to some extent have control over modifying the product to their preference and liking. This way, product is altered to better fit consumer's preferences regarding function and aesthetics. This implies self-expression. Not only that product is the outcome of consumer's design participation, but it also has a special meaning because of which the customer feels connected to the product. If one buys a house he/she gives their personal touch to make it feel their house such as, keeping your favorite paintings on wall, having one nook in the house that reflects your character. That gives us emotional attachment to the space similarly, if we could incorporate our own personal character into the product we are using so that we would want to keep or use it for long period of time.

   Sometimes this modification might not be as easy for some users or they might be afraid of ruining the product due to lack of skills. This is a challenge as well as opportunity for designers to make products in a way that will give consumers feel that they are truly creating unique product by making the task easy to understand in a way that won't spoil the product's aesthetics and functionality. A good example of this is pop light by Rina Bernabei and Kelly Freeman. Lamp facilitates owner to design his lamp by poking pre-perforated holes resulting in numerous end pattern possibilities. This is very simple easy to understand task and yet gives owner have his own unique lamp.

2. **Using Gracefully aging materials**: Using materials whose aesthetics enhances with time and or interaction; that time spend with that product is captured within that product for that owner. Wear and tear has aesthetic value to it.

3. **Storytelling**; Product describes owner's past experiences with it's owner. It forms a narrative of its past usage. However, the special bond formed by the product is not enough as this special meaning can be taken over by other products. To prolong product's life considerably the meaning has to be deeply developed and it becomes as if owner loses the meaning if he loses the product.

Although these strategies can help designers to develop long lasting product, these have some limitations. For example, a person might feel it is too tedious and time-consuming process to design or assemble a product in a way that it becomes expression of that person. People might be willing to do so in case of very important, valuable, expensive products for instance cars, furniture or maybe even a laptops. These strategies may apply to only certain category of products. Some people just enjoy buying new products; it is difficult to design a product, which will make them keep it for longer period. Hence it is important for designers to consider different circles than the innermost one in circular economy that product goes through.

Refurbished products

After the product has been discarded from its first owner, it is returned to the manufacturer where it's functional and aesthetic qualities are restored. Consumer study says that there is a market for used products but they expect the cost of that product to be very low. Many people are not aware of the refurbished products and people who do know about them have misunderstandings about it thinking they are second handed products and will not have as much good quality. This is also because of poor marketing strategy by refurbished product companies where they promote their product as cheaper option, which focuses on financial strategy.

With financial benefits, environmental benefits can be emphasized as many people are unaware of it. Besides informing people about those benefits through marketing campaigns, the impact would be more enhanced if we could incorporate some design strategies; for example, a product can have aesthetic changes that symbolize sustainability so that it becomes proud symbol of contributing to environment. People take visual perception as indicator for sustainability; product's package can be used to convey the product's environmental benefits of refurbishment. As products are judged on appearance, designers can analyze which part of the products are worn out the earliest and then design those parts in a way that would make it easy to resurface those parts.

Reducing the harmful impact and maintaining the prosperity is a challenge in today's world. People tend to not care about their responsibilities towards the environment and are oblivious to how changing the consumption behavior can benefit the environment. If designers have good perception of what user needs and wants, they can contribute to the circular economy and hence the sustainable society. In the end it depends on how user behaves and his opinions (Jonathan Chapman, *The Routledge Handbook of Sustainable Product Design* 2017, 387).

Evolution of mobile phones

1st portable phone Motorola DynaTAC 8000x was launched on March 13, 1984. Although it is huge in size by current standards, it was considered a 1st true mobile phone back then. This phone was expensive (3995$) and hence, was a luxury item and used only in sales or business world and not for everyday or personal use.

Although subsequent models were smaller and cooler, bulkier models like Nokia Mobira Talkman and the Motorola 2900 Bag became popular because of its longer battery life and more talk time. As the technology evolved, phone companies figured out a way to pack all the features that customer wanted in smaller size at affordable price.

Early cellphones were used just for talking, then features like texting and voicemail were added, later companies started developing concepts with more computing technologies to give more features like accessing and sending emails, use the phone as a fax machine, pager, and address book.

In recent years, cellphones or mobile phones have transformed themselves in to a multimedia device. They

are used more for browsing, access social media content, taking pictures, games than placing phone calls. According to Patricia Grullo, an Industrial design instructor at The Art Institute of Fort Lauderdale, “Rapidly expanding software titles, better screen resolution, and constantly improved interface make cell phones easier to navigate, and more fun to use. Add to that an expanding capacity that can hold as much memory as a computer would just a few years ago, and you can see why it’s an exploding market” (“The History and Evolution of Cell Phones” 2015). Now with the fast pace of changing technology, people use phones to click picture than using separate camera device. Since the shift in software technology to allow third party companies to install their applications on the phone, they have become a virtual tool box with a solution for almost every need.

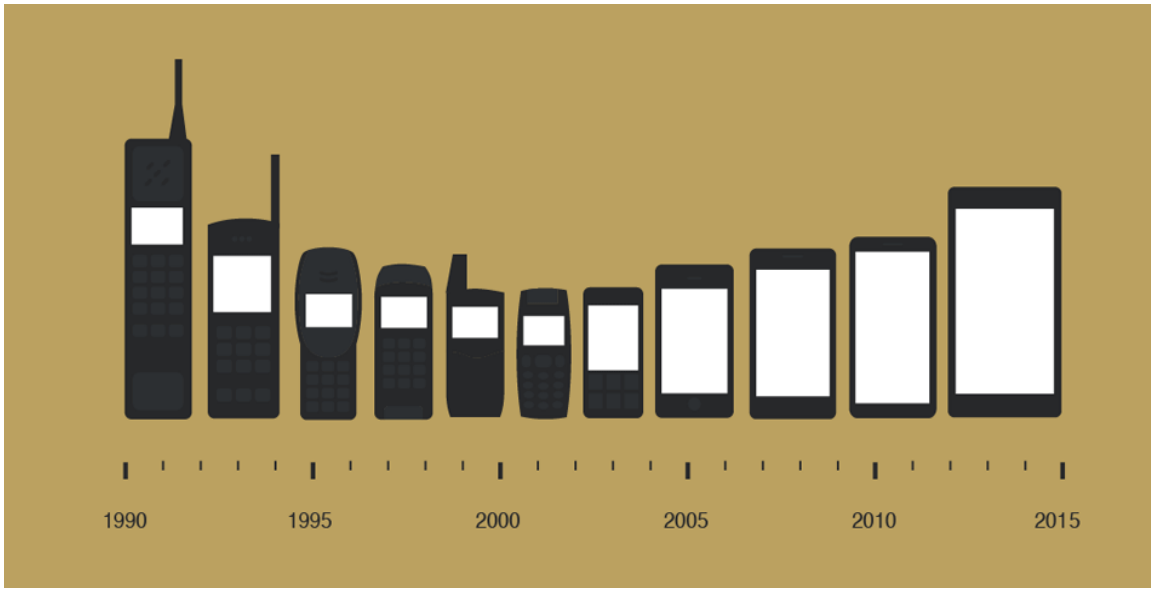

Figure 5
Evolution in the size of mobile phones
Picture credit: https://easytechnow.com/learn-technology/the-evolution-of-mobile-phones/

With software, physical appearance also changed over the period. Initial car phone was of the size of a computer nowadays, later they became smaller. Even though consumer’s reaction was ‘it is too small for interaction’ in mid 90’s, eventually their perception was changed and they wanted smaller phones. Then physical keypads got removed which gave more space for screen. Now smartphones are designed with less and less number of buttons and more touch tap interaction. Bigger screen sizes are getting preferred in contrast to the design preferences in 1st decade of 21st century where comfortably holding and one hand and easily fitting in to the pocket and cool physical interaction like different way of flipping screens, slide screen, QWERTY keypads were making their ways in to the trends. Phone designs are now simple slate style, large screen and almost no buttons on front face. 4G technology facilitated faster media streaming. With Samsung conquering the curved edge design and trying to make its appearance seamless for better media view experience, VR headsets turning your smartphones in to actual immersive movie watching experience, these devices are now powerful multimedia devices.

Figure 6
Picture credits: https://www.samsung.com; https://www.apple.com;
https://www.blackberry.com;https://www.engadget.com/products/motorola/dynatac/8000x;
https://www.indiamart.com/proddetail/motorola-moto-razr-v3i-black-flip-phone-15202122548.html

Kreg Jones, an industrial designer and Industrial Design instructor at The Art Institute of Philadelphia says, “The convergence of all our tech gadgets into one mobile device will continue to advance. Most of the hardware and the software can be moved to ‘the cloud’ and the product will mainly be comprised of the input and the display.”(“The History and Evolution of Cell Phones” 2015). Jamie Lending expects regular current cellphones concepts might not be there in the future or we won’t even call them smart and change this term completely. Interaction with phones will become more biological gestures and activities like eye movement, thought processes cultural activities (Grullon, 2015).

Smartphones are accompanied by supporting gadgets now such as smart watch, fitness tracker, 360 camera, VR headsets etc. All devices are talking to each other through software in other words they are physically separate devices but virtually they can communicate and share data.

Smartphone components

1. Screen; (LED or LCD) most obvious part of the smartphone is the display.
2. Battery; this can be removable or non-removable and they mostly use Lithium-ion technology.
3. 'System-on-a-chip' or SoC; Most important part of the smartphone. It not only has CPU but GPU, LTE modem, display processor, video processor, and other silicon parts that turn it into a functional 'system' in a phone.
4. Memory; no smartphone can function without RAM or memory that is needed to hold the data temporarily or permanently. Phone's internal memory is flash memory.
5. Modems; It is a phone in the end and needs communication component to send and receive calls and texts.
6. Camera; Now all smartphones have a front and rear facing camera. A smartphone has threemain parts for this: The sensor (which detects light), The lens (the component in which light comes through), the image processor
7. Sensors; Accelerometer, Gyroscope, Ambient light sensor, Digital compass and proximity sensor

In the near future

Flexible display: We have curved displays now but can we expect flexible or rolled displays anytime soon? Besides availability of material innovation and technology complexity companies need large volume or else they won't take the risk. Kris Carlson mentioned Dr Bill Liu's opinion in his article (2016) the reason behind flexible screens not making it to the market is that companies are not deciding to incorporate it in their designs. As they are not getting fabricated in enough numbers, no one has ample amount of experience designing it. User prefers the combined version of big screen to watch videos and movies and device portability even if it has a bit of rigidity. Screen size is the fast shifting factor over other aspects of phone.

Cloud Computing: is the practice of using a network of remote servers hosted on the Internet to store, manage, and process data, rather than a local server or a personal computer. People are shifting towards storing their data on the cloud and accessing media content online through streaming. There are applications and even operating systems running through the cloud. This is going reduce the load on the on-chip processor and memory, which in turn is going to benefit in the size reduction.

Concept Development

Th phone was invented in 1879 with a sole purpose of making communication between people easy. Similarly a computer was developed to perform complex tasks in a time efficient manned. Over the period of time, these two products seem to have started to share their purposes. We no longer use phones for just for calling purpose, rather it has become just one of the many functions it can do, to the point that it is now called smart phone.

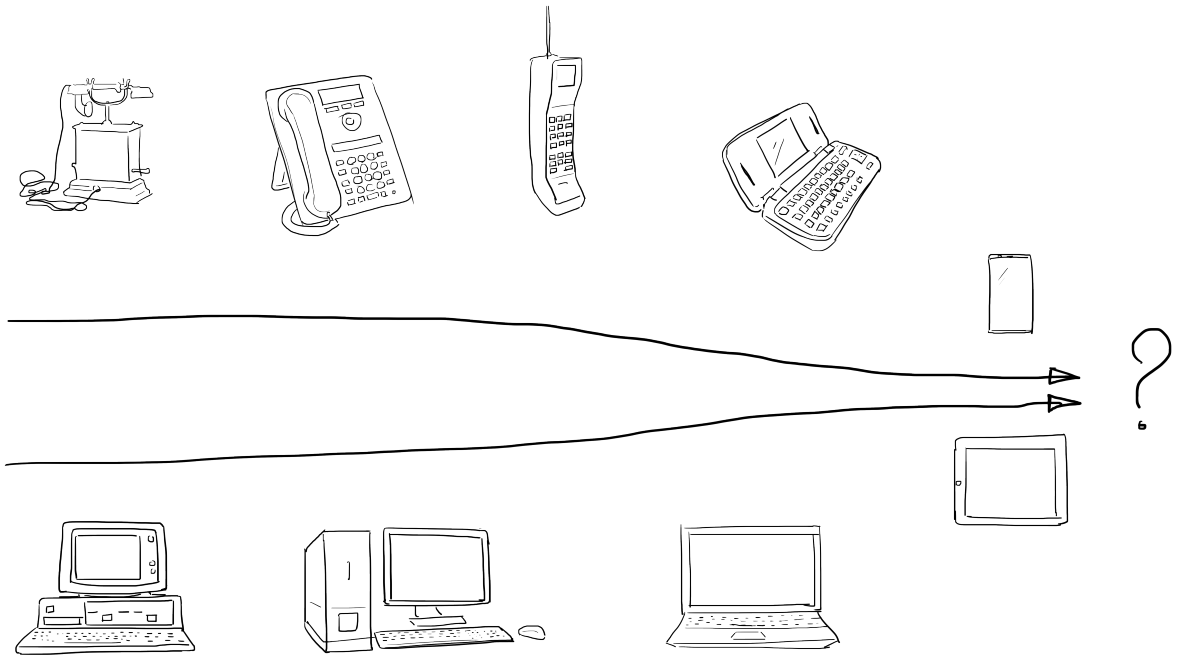

Figure 7

What could be the future generation device along the line? As we see these two paths coming together, is it possible to see them as one physical entity than two? These devices are already integrated on the software level. All the data is shared and communicated between the devices and the cloud. Why not make them connected system at hardware level too? Figure 8 shows the picture if we separate the components and regroup them differently.

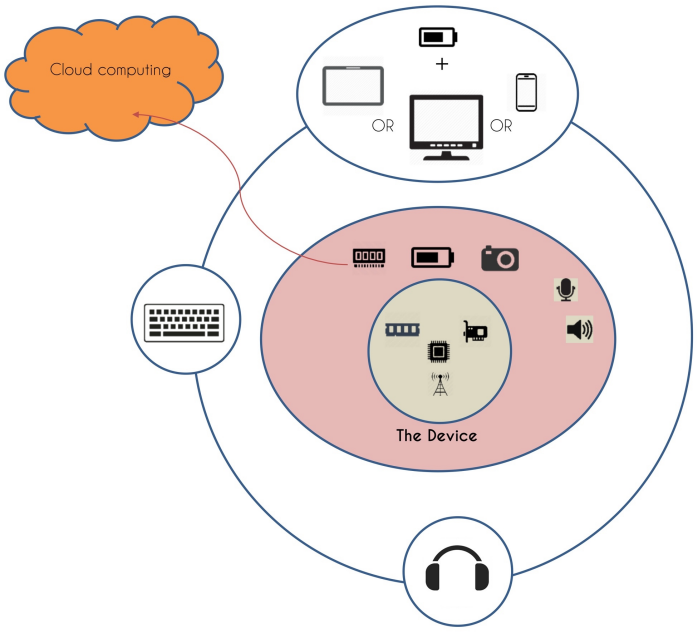

Figure 8
Component distribution

Giving easy access components/parts like old days could give users the customizing option for their product and ease to replace the damaged parts. Screen would no longer be the integral part of the device. Hence, user has a choice of type of screen they want to use with it. Screen has its own battery that reduces load on the charge consumption from the device. Figure 9 depicts how the user scenario might look like with this concept.

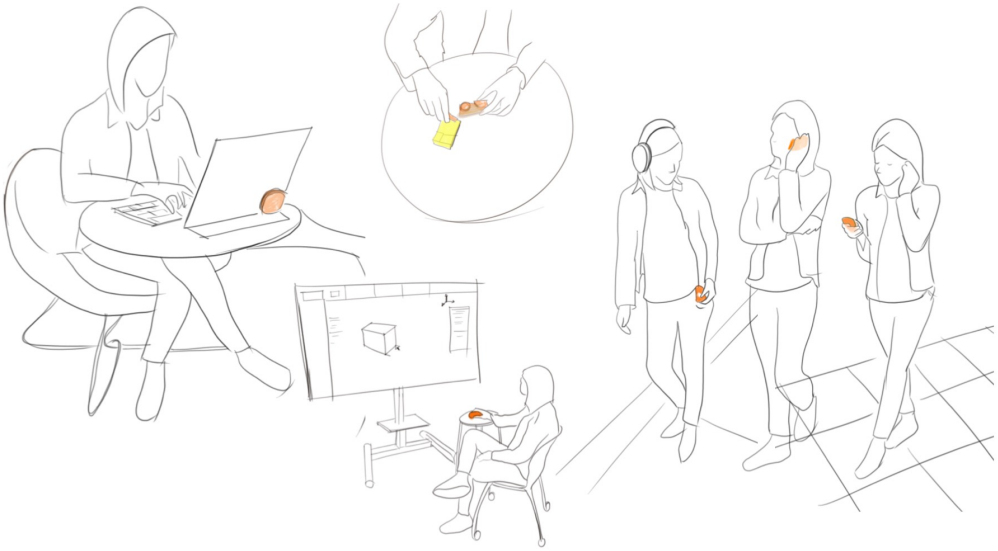

Figure 9

Benchmarking

Fairphone: Company's product value is 'Modular phone that is built to last'. Those modules are Display Module, Camera module, Battery, Core module, Top bottle, Bottom module. These modules can be replaced with mere detaching and attaching screws.

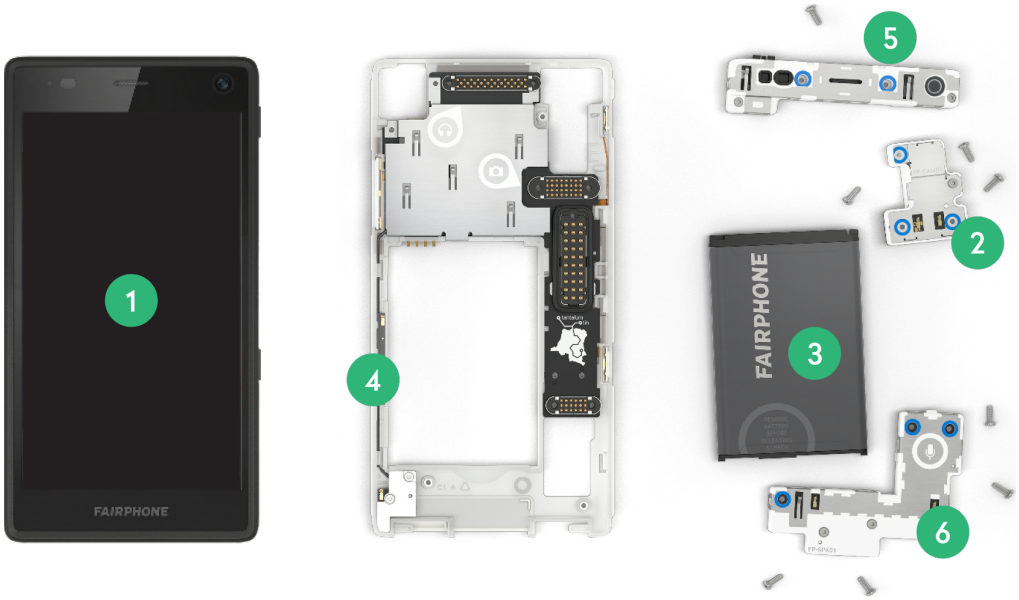

Figure 10
Fairphone
Picture credit: https://www.fairphone.com

Microsoft surface book: Elegantly designed Laptop that detaches from keyboard and functions as tablet. There is no need to carry two different devices.

Figure 11
Microsoft Surface Book
Picture credit: htttps://www.microsoft.com

Samsung S8: As a very powerful device, it can be as good as your computer. Just place it in the dock and connect it to bigger screen. Voila! It has become CPU of your PC.

Figure 12
Samsung S8
Picture credit: https://www.samsung.com

Essential Phone: Essential phone has customizability in terms of software and some accessories. There is no preinstalled application; you get to choose what you want to install and there is standard magnetic connector with wireless data transfer that keeps the phone as they call it 'cord free, future proof and always up to date.'

Figure 13
Essential Phone
Picture credit: https://www.androidpit.com/essential-phone-price-release-date-specs-features

LG G5: It is a modular phone designed by LG where battery can be removed from the bottom of the device and can be replaced by some other add on modules like camera grip or audio module, to provide additional functionality.

Figure 14
LG G5
Picture credit: https://www.notebookcheck.net/LG-G5-Smartphone-Review.165016.0.html

Google ARA: Although this project got cancelled, it had potential to make massive impact. Design was cool looking and very intuitive. There was possibility of making your device unique in configuration and looks. Perhaps way too much modularity is something that market is not ready for yet.

Figure 15
Google ARA
Picture credit: https://www.extremetech.com

Puzzle phone: Puzzle phone describes its three modules as Brain, Spine and Heart and it is reliable, upgradable and repairable. Brain is CPU,GPU, RAM and Camera. Spine is the structure, display and core spine elements and heart is the battery. Customer can repair and customize this device easily.

Figure 16
Puzzlephone
Picture credit: https://www.puzzlephone.com

Moto z2 force: Motorola had different approach in modularity. They have peripheral modules attach on the back of the phone. It is not much to do with upgrading the device or replacing the components but enhancing some features. They have speakers, optical zoom camera, gamepad, shell for powerless charging, power pack, projector, vehicle dock etc.

Figure 17
Moto Z and Mods
Picture credit: https://phonearena.com

Intel Compute Card: This powerful card which is of the size (95mm x 55mm/5mm) slightly longer than a credit card is an integrated computer chip that can be attached to interface devices like display and keyboard and will become a computer. Intel believes that with this new software architecture, they are opening up virtually unlimited potential for consumer, business, and industrial applications. Intel® Compute Card's modularity and flexibility allows for internal or external integration with certified devices via a compute card slot. Companies will be able to extend capabilities for devices such as digital signage and kiosks, All-in-Ones, smart TV's and appliances – all while reaping the benefits that modular computing can offer, such as simplifying inventory management and serviceability."

Figure 18
Intel compute card
Pocture credit: https://www.theverge.com

Ideation and development of ideas

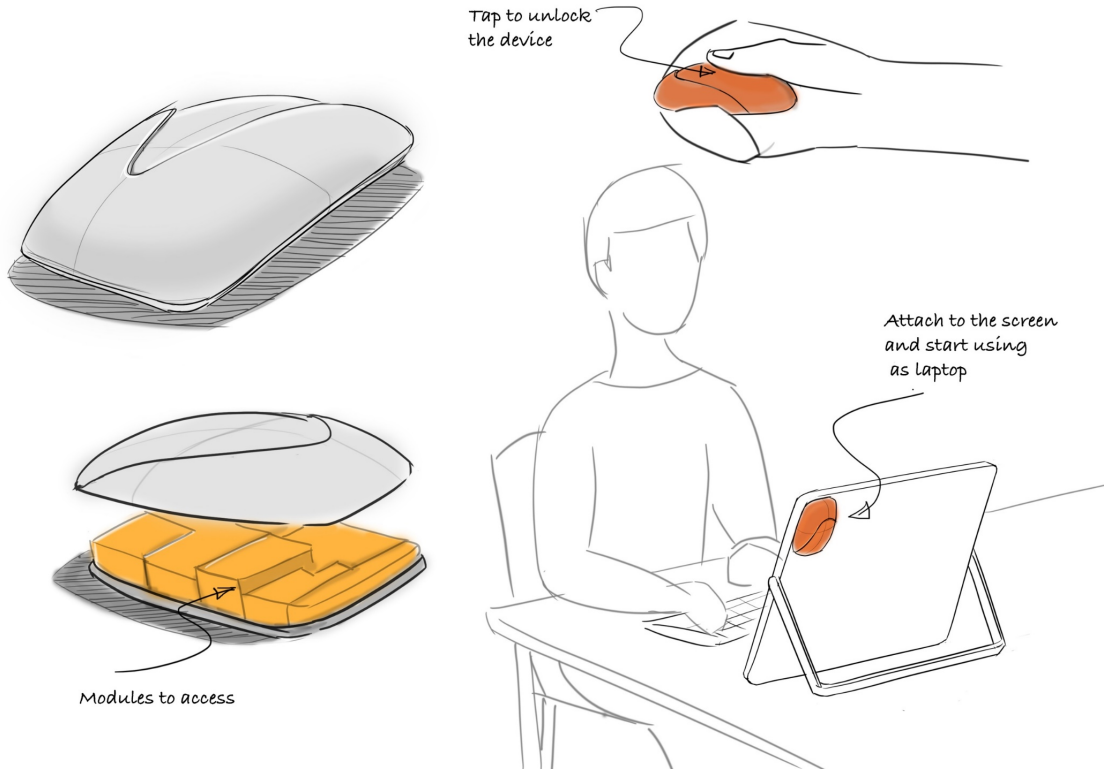

Figure 19

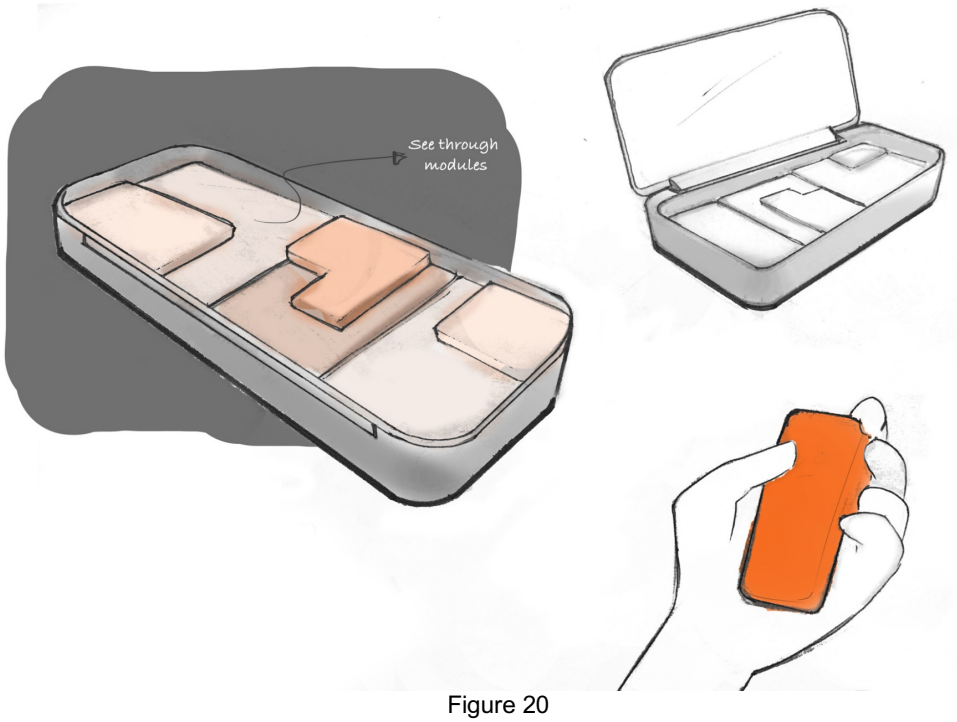

Figure 20

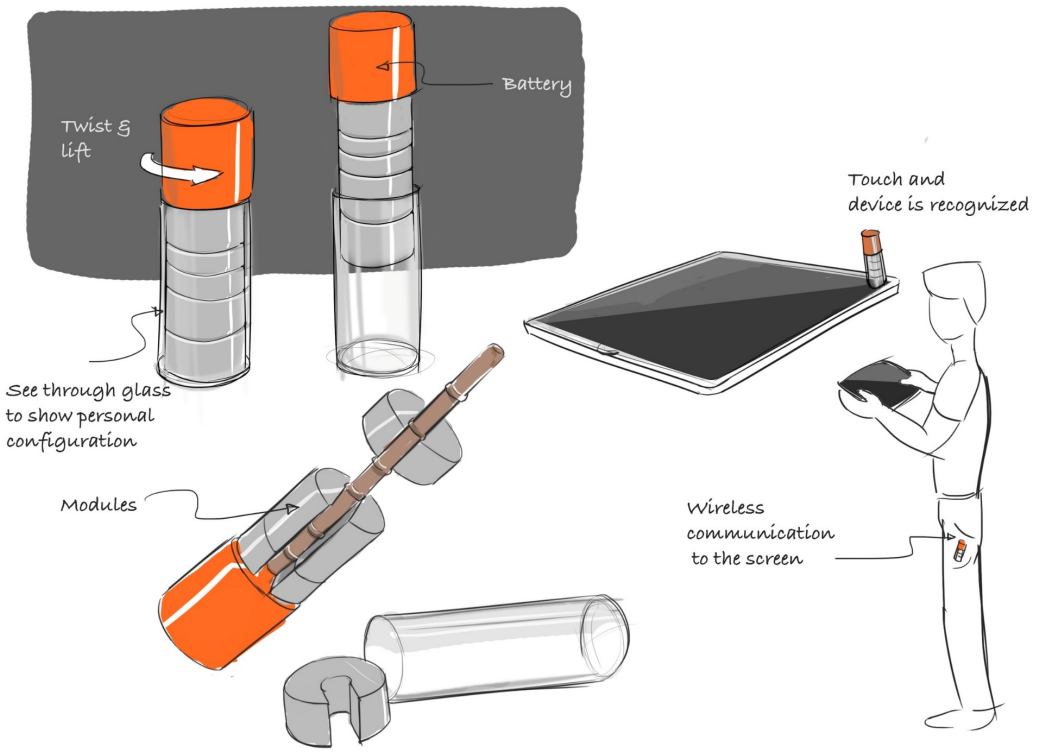

Figure 21

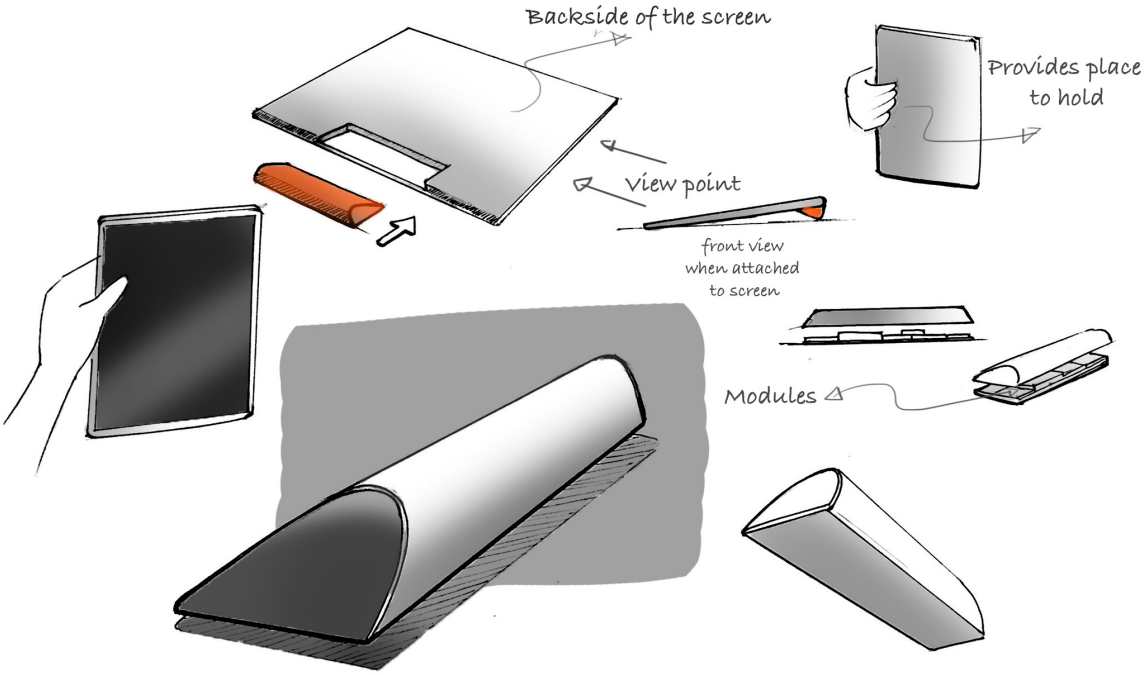

Figure 22

After testing the form with a group of people, it was noticed that they preferred the slender and long form.

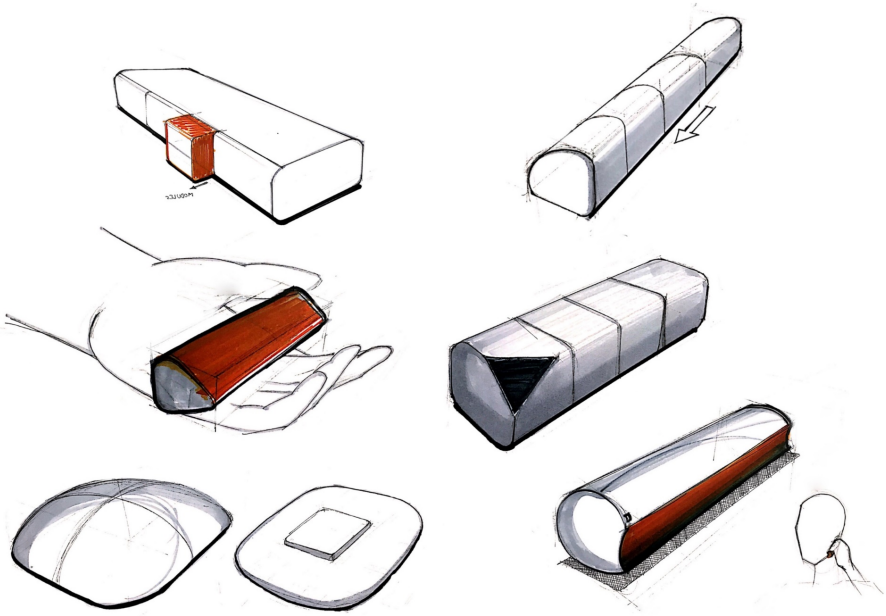

Figure 23

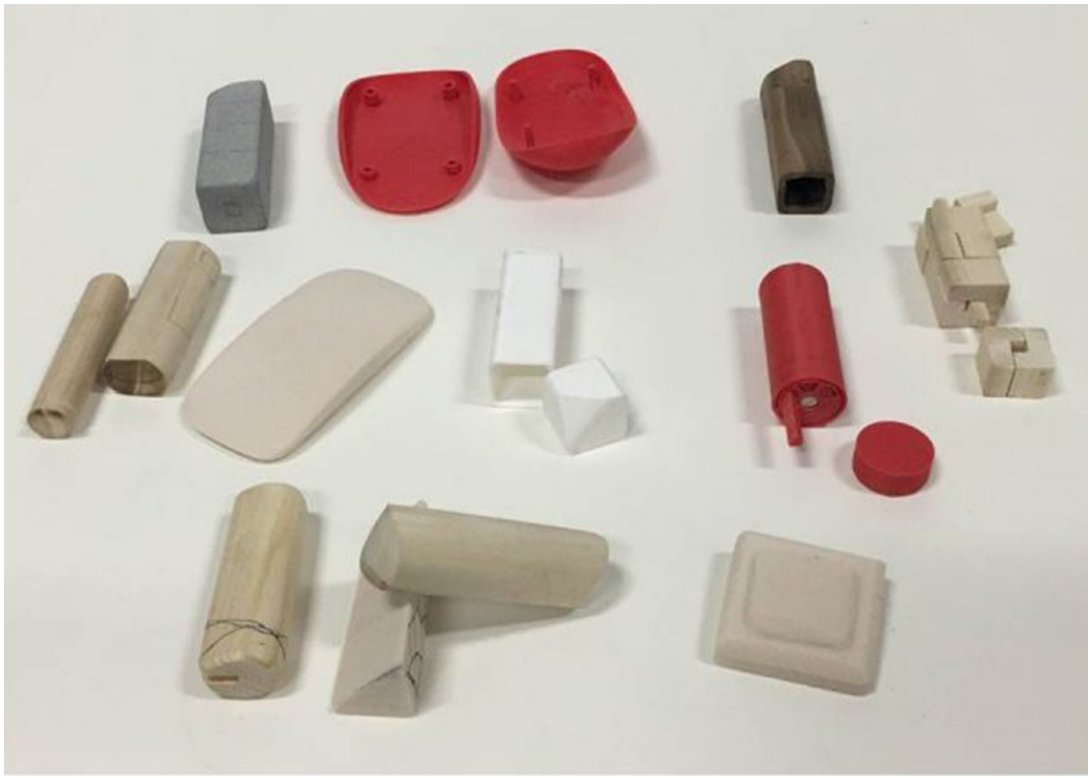

Figure 24
Prototypes

Figure 25

Material selection

Materials	Pros	Cons
Metal	**Premium look:** Well-manufactured phones always look good. **It's "modern"** **Heat transfer:** very good conductor of heat and can help transfer heated processor heat outside	**Bends and dents:** metal deforms fairly easily **RF transmission:** Signals are not easily transmitted through. **Heat transfer:** because of high conductivity helps transfer the heat away from processor, it feels hotter in hand when it's being used for a while. Phone will have a hot spot where chipset is.
Plastic	**Low Cost** of manufacturing the product. **Resilience,** Plastic is tough. **RF transmission,** allows radio waves to pass through with very little signal loss **Many color options**	**Feels cheap,** it lacks to give the precious feel to the product **Could stain** **Might not be 100% recyclable**
Glass	**RF transmission,** glass is dense, but it allows radio waves to pass through it **Stunning look,** with its transparency and refractive index, it can have depth look of material underneath it. **Feels good in hand**	**Scratches and breaks**

Final design has parts made of glass and metal for its body.

Final design

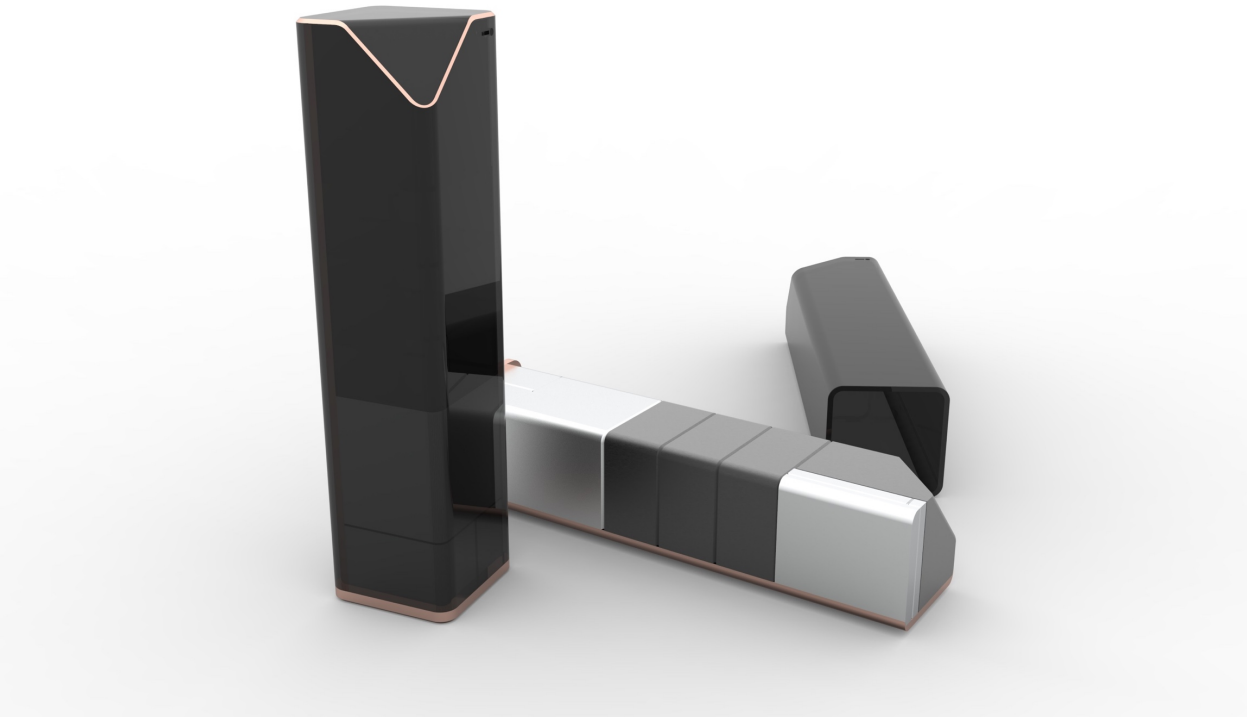

Figure 26

Figure 27
Communication with screen size of smartphone

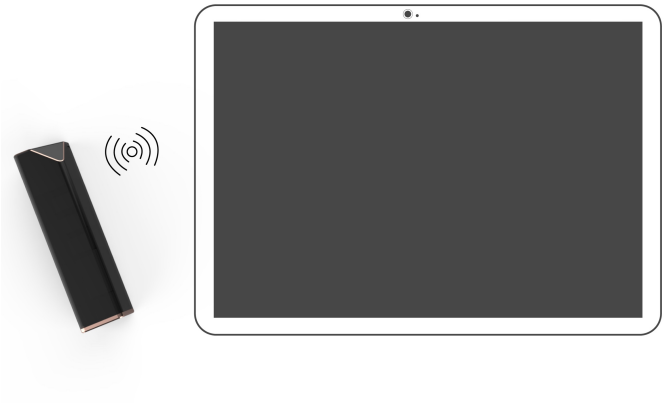

Figure 28
Communication with screen size of tablet

Système is a device that can be configured according to user's need, from simple to complex. It communicates wirelessly with screen and also has option to physically connect to it. Components body is made of metal (Aluminum/steel). Darker colored components are meant to be swapped or repaired by experienced person. Lighter colored components are easily accessible to user. Outer shell is either made of metal of glass which gives it a superior look. Its dimensions are 84cm x 2cm x 2cm.

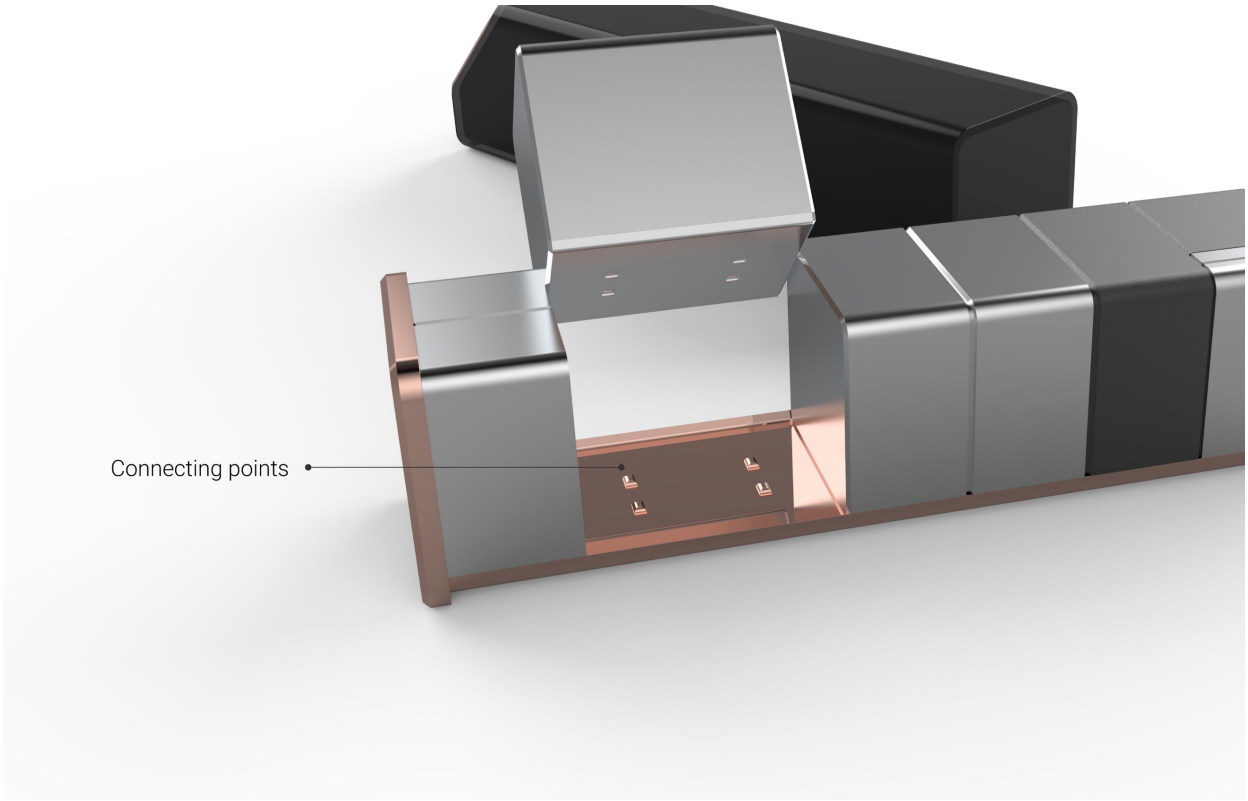

Figure 29

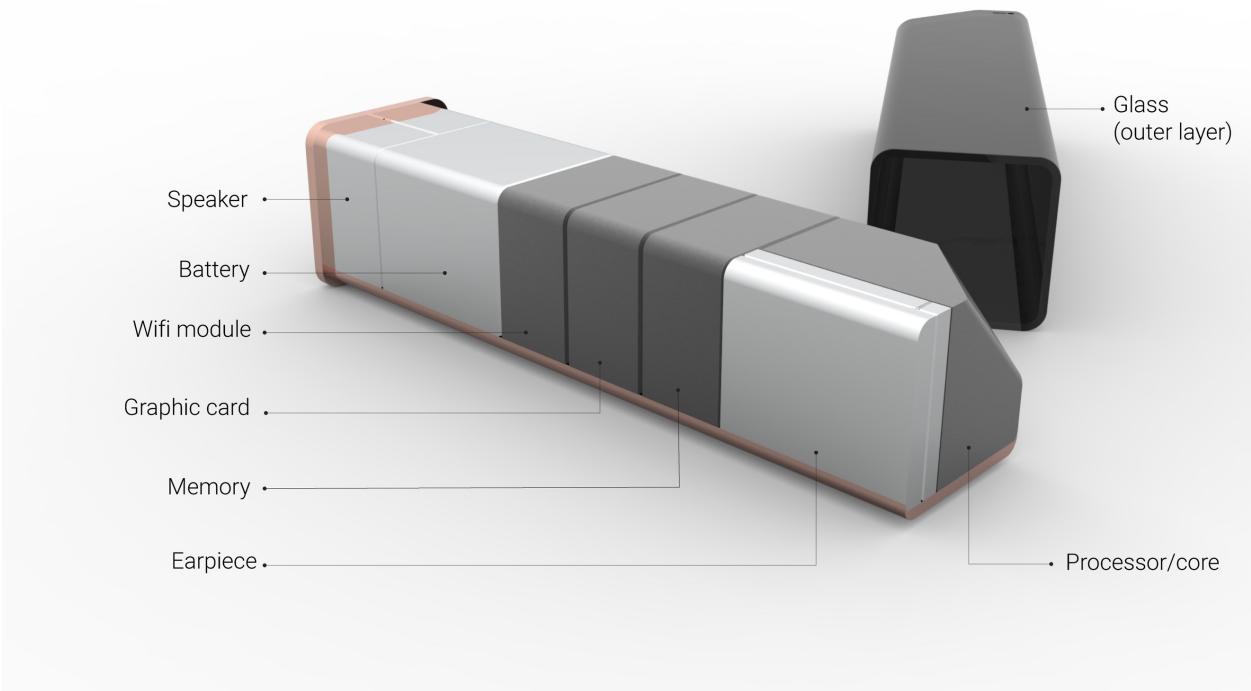

Figure 30

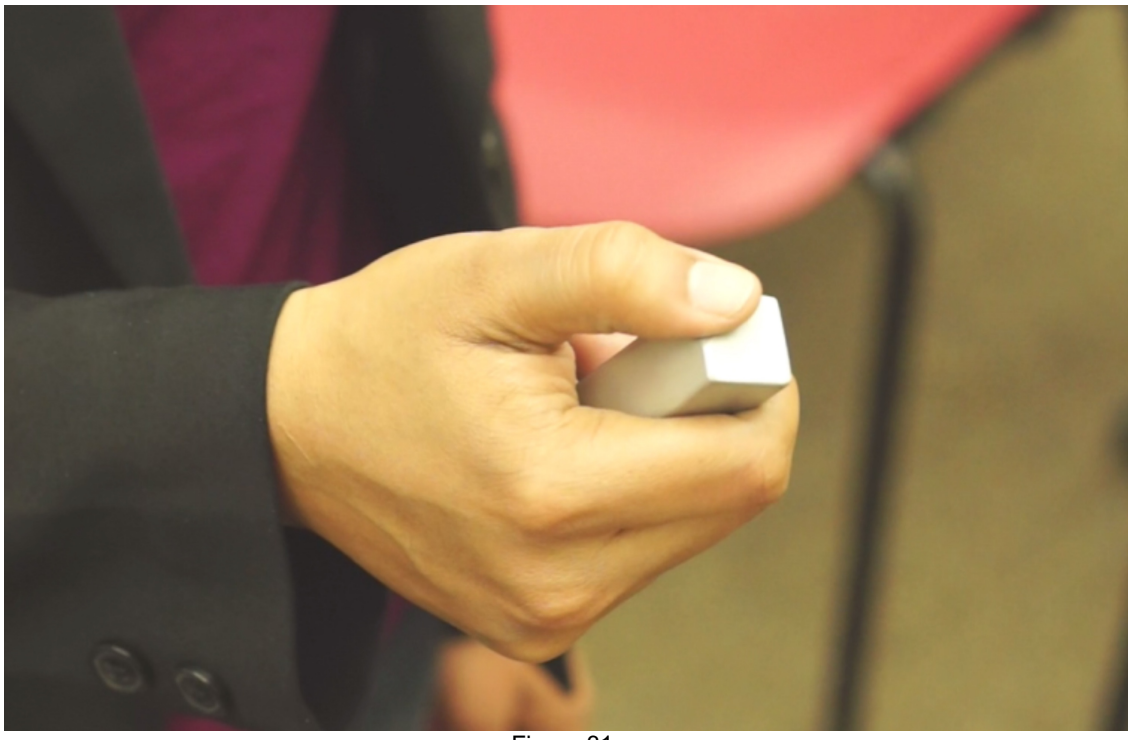

Figure 31
Turning on the device

Figure 32
Attach to the screen (optional)

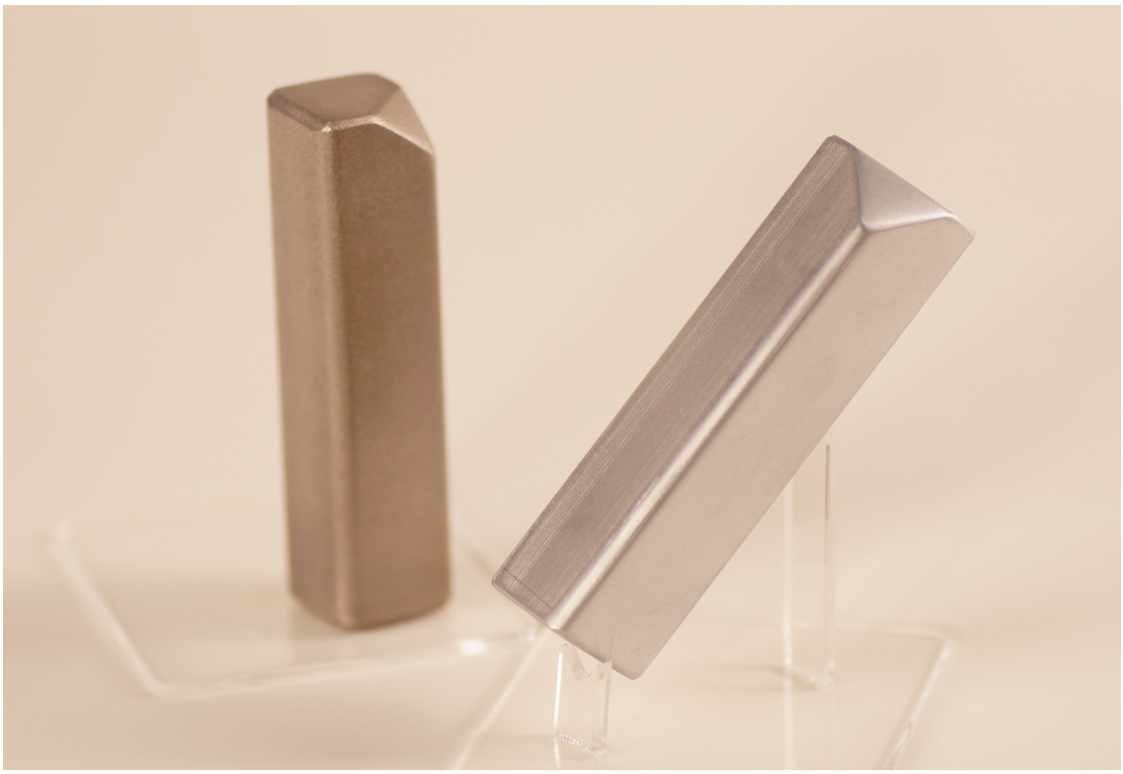

Figure 33
Prototype model

User Scenarios

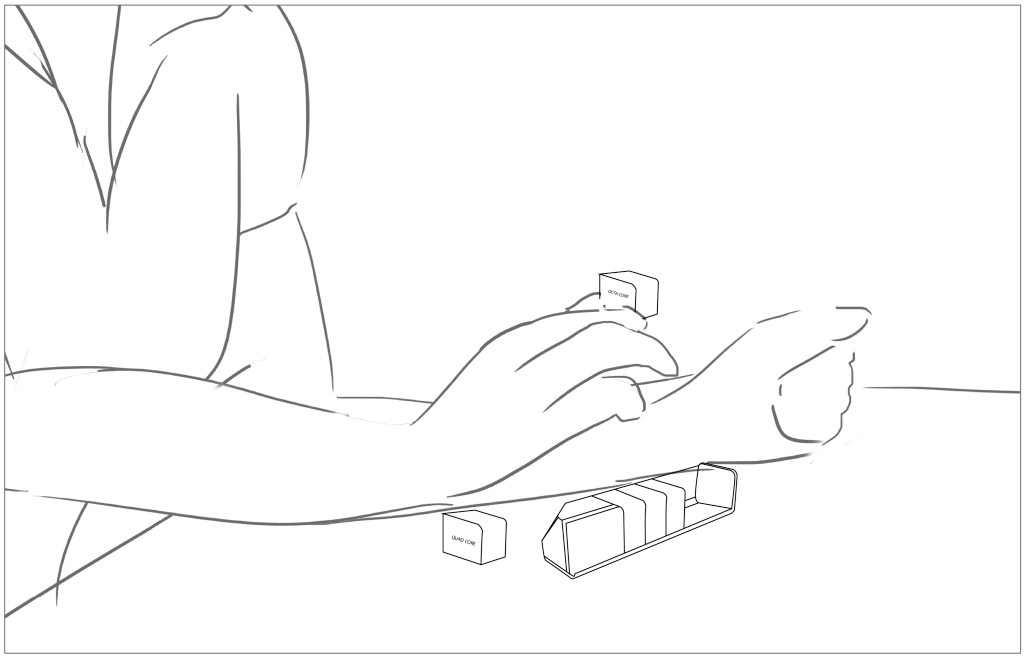

Figure 34

User is replacing the processor module with ease.

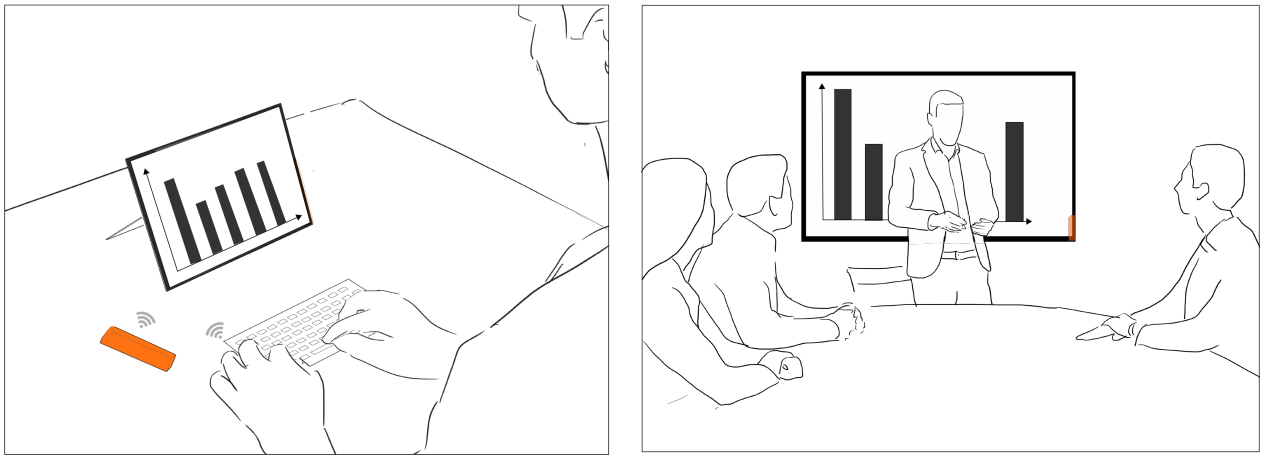

Figure 35

User who is a marketing/sales expert is preparing a presentation on tablet size screen and then with simply connecting the device later to the bigger screen he can now give presentation without any hassle. User now has more space in his bag/luggage when he travels as he doesn't carry multiple devices like tablet and laptop anymore.

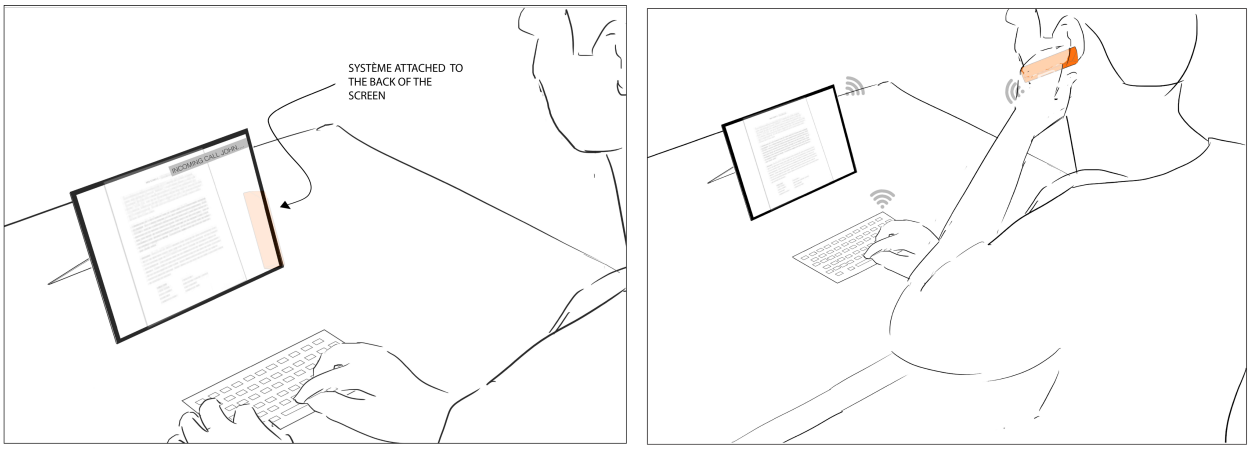

Figure 36

User receives phone call notifications on his screen and detaches Système to answer the call while it still remains connected wirelessly to the screen and keyboard.

The visual communication or interface is done through the screen connected to the device. Inputs are provided through screen or keyboard or any other type of input device connected. In other words Système acts as brain while its input/output peripherals helps communicate with it.

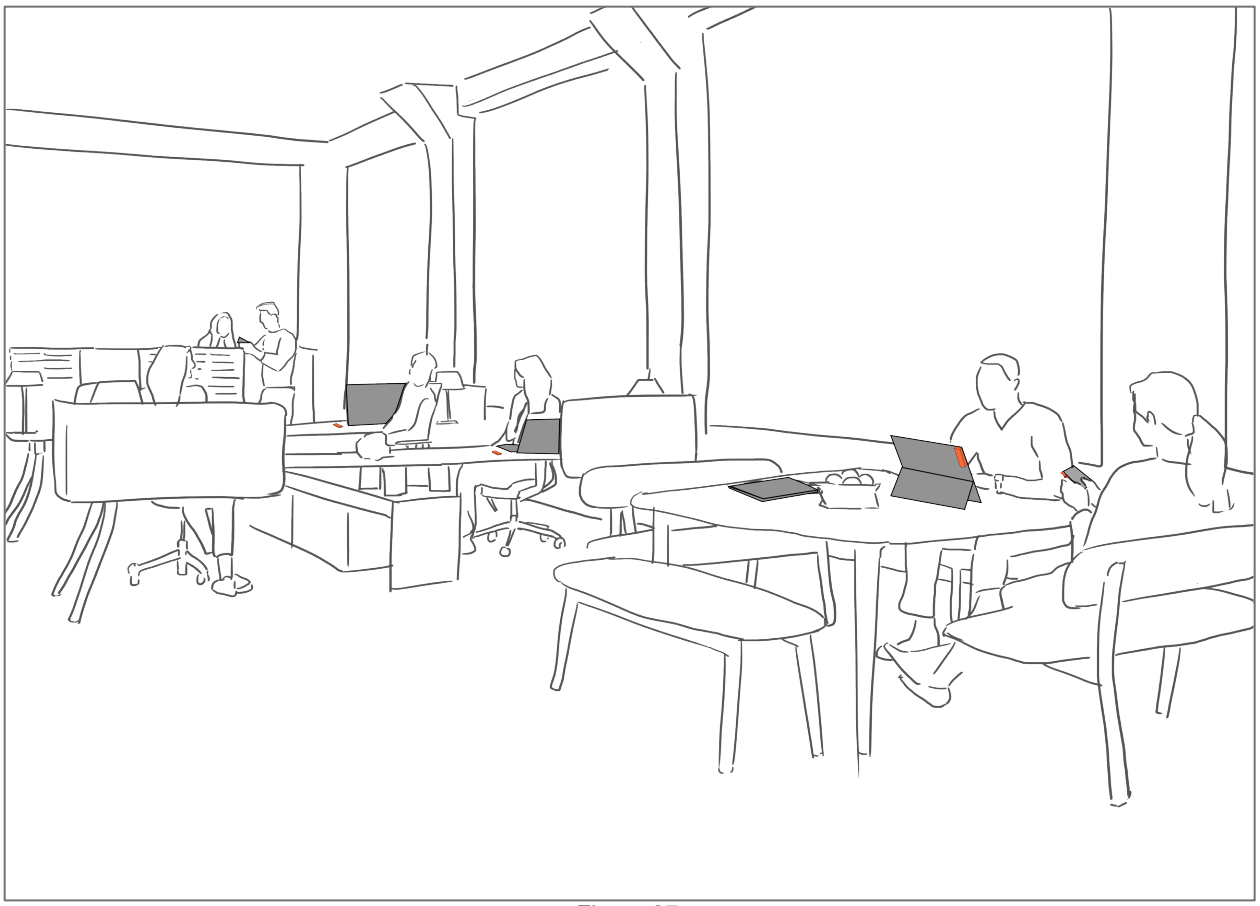

Figure 37

Above image illustrates a college library or collaborative space where different size screens are made available which users can just connect their devices to and start working. As these are just screens, not a complete device, it would also be a cost effective option for colleges, companies, organizations.

Final design addresses the problem statement

Système can be configured according to user's needs. Giving access to components facilitates replacing a specific part without throwing out the product completely (Ease of maintenance and repair and product personalization). Metal (aluminum/steel), glass gives it premium look which user would get attached to and would want to keep it with them longer. As screen is not integral part of the product anymore, it broadens the spectrum of types and sizes of screen people can choose from. Basically a user now has a choice as to how big or small of a screen he or she wants. They won't need to buy sperate devices or bigger screen interaction.

Conclusion

Our system predominantly works on linear based product cycle that is talking toll on the environment. E-waste is one of the serious factors contributing to those . Système started as a study of how personal electronics contributes towards the growth of electronic waste along with understanding the life cycle of today's mobile and computer devices. During this study it was found that the smart phone is the most widely used, discarded and replaced item in today's world and hence there is a need to find a way to prolong the smartphone's user life span.

Assembly and disassembly facilitates the ease of maintenance and repair of the product. Système is a design concept of personal electronic device that can help increase the life span of a product. This concept requires hardware and software standardization. With its feature of disengaging various components gives user freedom of configuring their device and change the configuration with time and their needs; in other words, Système grows with you.

References

"11 Facts About E-Waste." DoSomething.org | Volunteer for Social Change. Accessed September 11, 2015. https:/www.dosomething.org/facts/11-facts-about-e-waste#.

"The Problem with E-Waste - IFixit." Repair Is Noble - IFixit. Accessed October 25, 2018. http://ifixit.org/ewaste.

Walker, Lauren. "Mounting Electronic Waste Poses Major Threat to Environment, Health." Newsweek. March 07, 2016. Accessed March 20, 2016. http://www.newsweek.com/mounting-electronic-waste-poses-major-threat-environment-health-287885.

"E-Waste Solutions." ERI. May 11, 2017. Accessed Aug 02, 2017. https://eridirect.com/e-waste-solutions/.

Intelnewsroom. "Introducing the Intel Compute Card." YouTube. May 30, 2017. Accessed July 31, 2017. https://www.youtube.com/watch?v=Wv8ETAA1_6Y#action=share.

Storyofstuffproject. "The Story of Solutions." YouTube. October 01, 2013. Accessed September 02, 2015. https://www.youtube.com/watch?v=cpkRvc-sOKk.

Everton, Ryan. "'Take, Make, Dispose' We like It, We Justify It, but It Is Sooo Wrong." LinkedIn. November 25, 2016. Accessed August 10, 2017. https://www.linkedin.com/pulse/take-make-dispose-we-like-justify-sooo-wrong-ryan-everton.

Planned Obsolescence. (2013). In D. Rutherford, *Routledge Dictionary of Economics* (3rd ed.). London, UK: Routledge. Retrieved from http://ezproxy.rit.edu/login?url=http://search.credoreference.com/content/entry/routsobk/planned_obsolescence/0?institutionId=3255

Hadhazy, Adam. "Future - Here's the Truth about the 'planned Obsolescence' of Tech." BBC. June 12, 2016. Accessed September 10, 2017. http://www.bbc.com/future/story/20160612-heres-the-truth-about-the-planned-obsolescence-of-tech.

"The Circular Economy Concept - Regenerative Economy." Ellen MacArthur Foundation. Accessed September 10, 2017. https://www.ellenmacarthurfoundation.org/circular-economy/overview/concept.

Ma, J. & Kremer, G.E.O. Int J Adv Manuf Technol (2016) 85: 741. https://doi-org.ezproxy.rit.edu/10.1007/s00170-015-7979-0

Chapman, Jonathan. *The Routledge Handbook of Sustainable Product Design*. London: Routledge, 2017.

Sheth, Sarang. "Sarang Sheth." Yanko Design - Modern Industrial Design News. September 13, 2017. Accessed October 6, 2017. http://www.yankodesign.com/2017/09/13/the-laptop-with-a-card-for-a-soul/.

"The Evolution of Mobile Phones." Easy Tech Now. March 14, 2016. Accessed May 12, 2016. https://easytechnow.com/learn-technology/the-evolution-of-mobile-phones/.

"Blog." The History and Evolution of Cell Phones. Accessed October 02, 2017. https://www.artinstitutes.edu/about/blog/the-history-and-evolution-of-cell-phones.

Staff, Fossbytes. "What's Inside My Smartphone: An In-Depth Look At The Parts Powering Your Everyday Gadget." Fossbytes. June 24, 2017. Accessed September 12, 2017. https://fossbytes.com/whats-inside-smartphone-depth-look-parts-powering-everyday-gadget/.

"The Only Thing Stopping Flexible Displays from Taking over Is That No One Is Making Them." Android Authority. April 29, 2016. Accessed May 5, 2016. http://www.androidauthority.com/when-will-flexible-displays-arrive-688227/.

"PuzzlePhone." PuzzlePhone. Accessed September 20, 2017. http://www.puzzlephone.com/.

"Intel® Compute Card - The Latest in Integrated Compute." Intel. Accessed October 5, 2017. https://www.intel.com/content/www/us/en/compute-card/intel-compute-card.html.

Hildenbrand, Jerry. "Metal vs. Plastic vs. Glass: Which Is the Best Phone Material?" Android Central. October 18, 2017. Accessed November 18, 2017. https://www.androidcentral.com/metal-vs-plastic-vs-glass-which-best-material-phones.

"Understanding the Materials in Mobile Phones." Fairphone. Accessed August 02, 2017. https://www.fairphone.com/en/project/understanding-materials-mobile-phones/.