FTTR Smart Home WiFi Router

Hardware Based Smart Home Housekeeper

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FTTR Smart Home Wifi Router
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Abstract

In this project, I wish to take a glance at what WiFi routers can do in the future. The new solution could make the current WiFi routers have more physical meaning which can impact our real life while providing indispensable wifi signals. Besides offering WiFi signals, WiFi routers adopted with FTTR all-optical networking solutions can control and monitor all the IoT smart devices connected to the current local network. That means households no longer need to download apps from different IoT brands to control the smart devices in the house since all the operations can be implemented through the FTTR routers' access ports. The WiFi routers then become users' hardware-based housekeepers helping manage the future smart home. This project is highly focused on ICT technology study, tech-trend, and IoT user study. This is an attempt to apply emerging technologies to current products. I then utilized the research methods of literature reviews, Internet searches, and interviews for the technology study. To further explore the current routers' usage scenarios and issues, I conducted a questionnaire and interviews as my primary user study. The design was then realized through the methods of ideation sketches, CAD drawings, rough cardboard mockups, technical sketches, and digital renderings.

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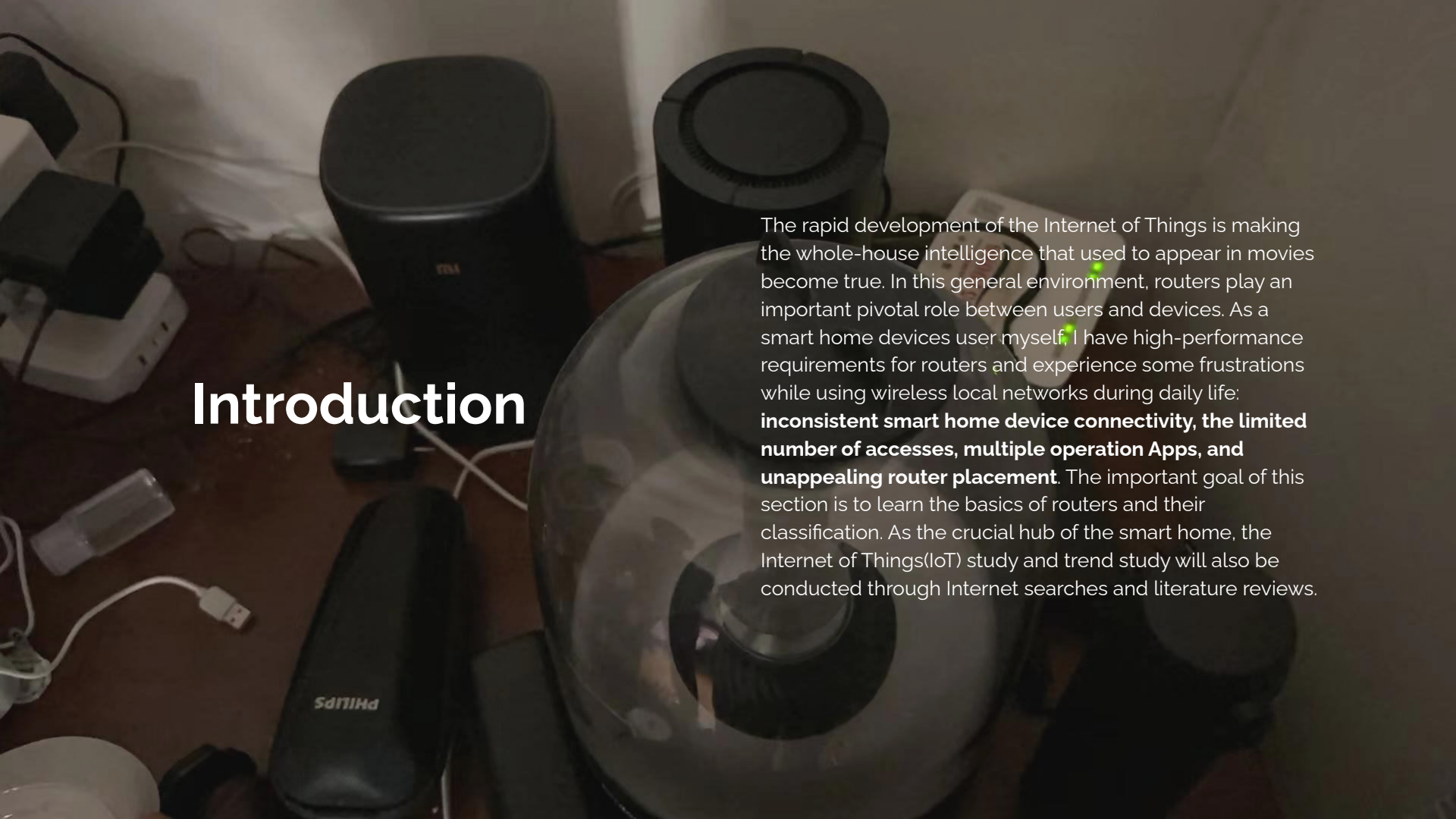


Introduction

The rapid development of the Internet of Things is making the whole-house intelligence that used to appear in movies become true. In this general environment, routers play an important pivotal role between users and devices. As a smart home devices user myself, I have high-performance requirements for routers and experience some frustrations while using wireless local networks during daily life: **inconsistent smart home device connectivity, the limited number of accesses, multiple operation Apps, and unappealing router placement**. The important goal of this section is to learn the basics of routers and their classification. As the crucial hub of the smart home, the Internet of Things(IoT) study and trend study will also be conducted through Internet searches and literature reviews.

What are they?

Routers

Cisco Integrated Services Routers

https://www.cisco.com/c/en/us/support/routers/4000-series-integrated-services-routers-isr/series.html

- A router is a hardware device that **connects** two or more networks and acts as a gateway between the networks. It reads the IP address in each packet to decide how to send it.

- Provide functions including packet **filtering**, packet forwarding, priority, multiplexing, encryption, compression, and firewall

- Routers provide functions including router configuration **management**, performance management, fault tolerance management, and flow control.

Classification of routers

Core Router

Service Provider

Huawei NE9000 Series

https://carrier.huawei.com/en/products/fixed-network/data-communication/router/ne9000

- The router is at the **center** of the network.
- It is mainly used for data packet routing and forwarding, and it is a router with a relatively **large throughput**.
- Large enterprises, data centers, and telecom operators use it as a main part of **network construction**.

Edge Router

Gateway Router

D-Link SR2800 Series

https://in.dlink.com/en/products/di-sr2800-10c-10-port-next-generation-multiservice-switching-router

- The router is used at the boundary point of a network (**LAN**) to connect to external networks (**WAN**) such as the Internet.
- Often used with a dedicated firewall to **protect** the network (LAN).
- Like a **modem**, cannot provide Wifi.

Cable Router

Interior Router

TP-Link R483G

https://www.tp-link.com.cn/product_444.html?v=detail

- **Receive** data packet from the edge router
- **Send** data packet to the end users.
- **Wired** connection to the edge router and end users.

Wireless Router

Residential Gateway

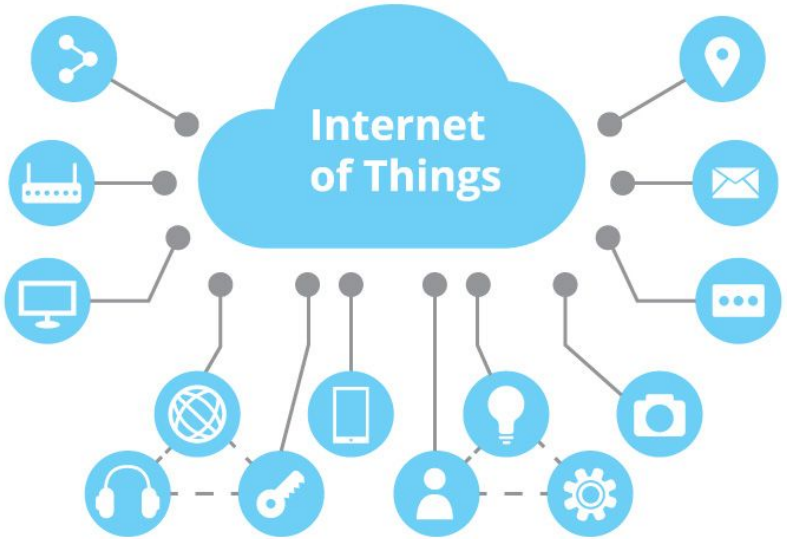
TP-Link VR300

https://www.tp-link.com/au/home-networking/dsl-modem-router/archer-vr300/

- **Forward** the data packet received from the edge router to the nearby wireless network equipment through the antenna.
- Common **residential WiFi** provider.

IoT Study

The Internet of Things (IoT) is a network that connects any object to the Internet through information-sensing devices such as radio frequency identification, infrared sensors, global positioning systems, laser scanners, etc. According to an agreed protocol, IoT can carry out information exchange and communication to achieve intelligent identification, positioning, tracking, monitoring, and management of the object. It is an important part of the new generation of information technology to realize the interconnection of people, machines, and things at any time and any place. **The rapid development of the IoT ecosystem is an important factor driving the evolution of router technology.**



4 Key Technologies for the Internet of Things:

1. **Radio frequency identification technology**
2. **Sensor Network**
3. **M2M System Framework**
4. **Cloud Computing**

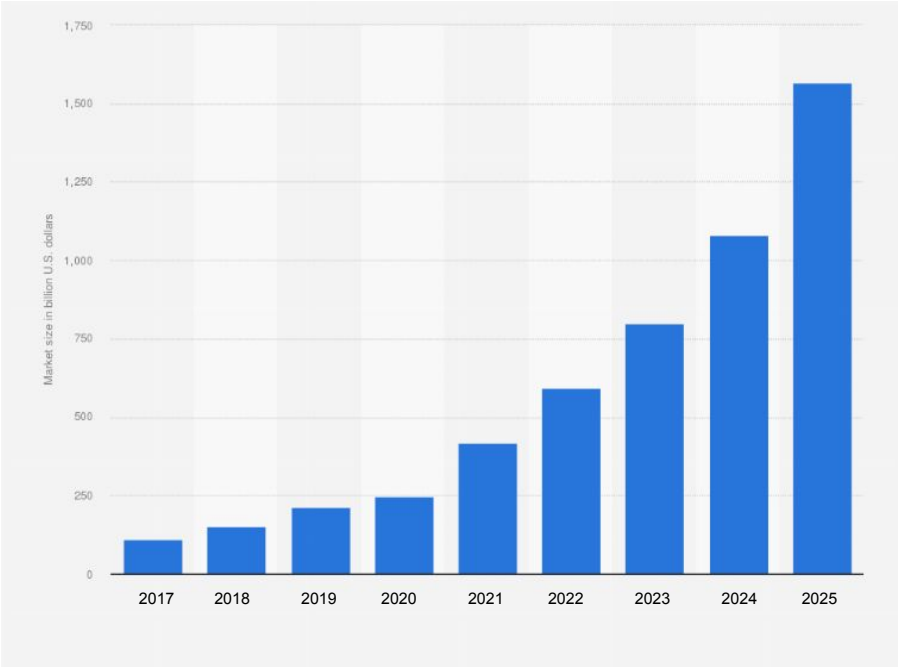
IoT Trend Study

Market Size

With the continuous development and application of IoT technology, various industries around the world are gradually applying IoT technology to increase efficiency, save costs and improve production processes. According to market research firm IDC, the global IoT market size will reach $1.6 trillion by 2025. Among them, China's market size will exceed $300 billion in 2025, accounting for about 26.1% of the global share.

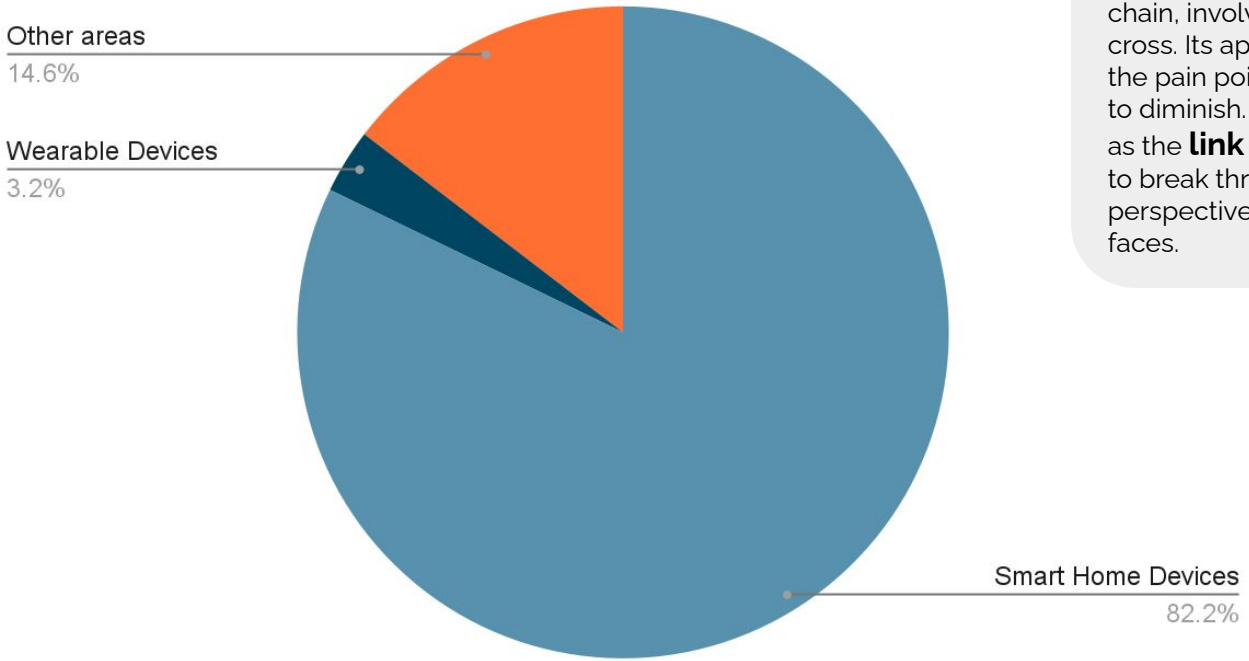
With more than **43 billion** devices connected to the Internet of Things worldwide in 2023, they will generate, share, collect and help people use data in a variety of ways.

IoT market size worldwide 2017-2025



https://www.statista.com/statistics/976313/global-iot-market-size/

Global Applications of IoT



Smart home devices as a mainstream product of consumer-level IoT have a long industry chain, involving multiple industry groups cross. Its application scenario is complex and the pain point is very common in use and hard to diminish. Therefore, the role of IoT in which as the **link** is particularly important, and how to break through from a cross-border perspective will be the primary challenge it faces.

User Study

The existing wifi routers are now in an awkward position: it is so important that every family has at least one of them and it is so insignificant in our physical world that we may never touch them or even look at them after we brought them home and turned them on. The user study aims at sorting out users' routers **placement situations, common issues, and demand for features** (mainly from IoT product usage scenarios). Study methods including questionnaires, interviews, and chart-making were utilized.

Primary User Study

Methodology: **Qualitative**

Method of Observation: **Photography**

Data Collection: **Questionnaire and Interview**

Interview Method: **Personal & Online Calling**

The goal of the questionnaire and interview:

- Observing the users' routers **installation** situation
- Understanding the **problems** that users face during usage
- Learning users' **demands** from the routers besides networking
- Identifying how much users **know** about their routers and their features.
- Studying the **service life** of users' routers.

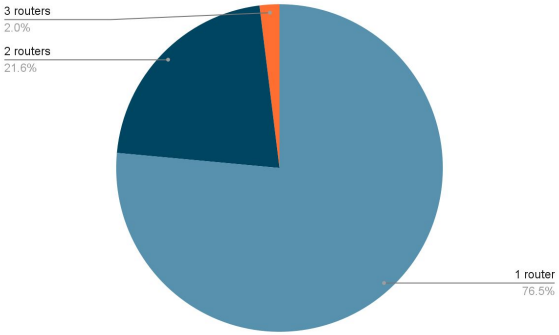
Wireless router as a WiFi provider has become an essential electronic product in almost every home. Such a large user base can lead to a variety of problems in the use of the router as a product as well as a widely varying use environment. In order to better learn and understand the problems that users encounter when using routers and the expected experience enhancement and feature expansion, I planned two questionnaires: one to study the **general router user group**, and the other to study the router user group with **demand for the smart home local network**. In addition, I also asked some participants to provide photos of their routers and planned several interviews to understand their needs in more detail.

Questionnaire 1

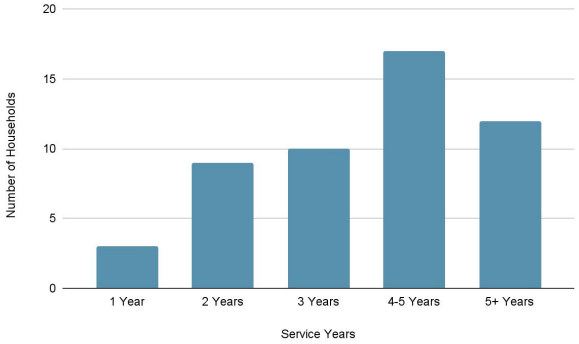
General questions for home routers users (51 participants)

- Do you own routers?
- How many routers do you have in your home?
- What brand do choose for your routers?
- Why did you choose to buy routers from this brand?
- Any features besides networking attracted you to buy the current routers?
- Where, in your home, do you install your routers?
- Are there any issues you've noticed with them?
- How frequently do you face the issues?
- How much are you willing to spend on buying a new router?
- How long have you been using your current routers?

Questionnaire 1 Feedback

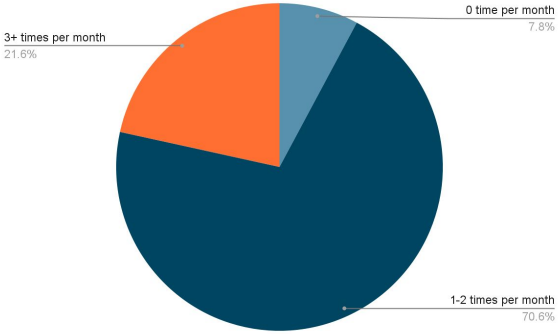


Number of Routers

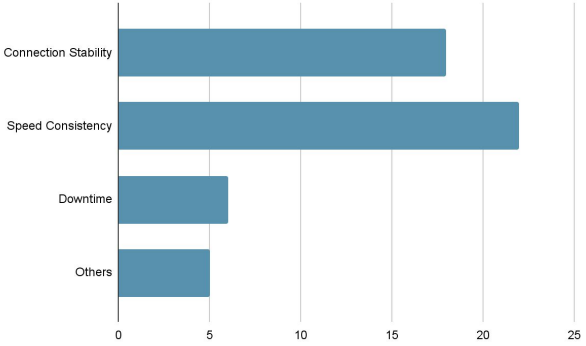


Service Years Distribution

According to the feedback collected from the general home router users, most users have one router in their homes. However, there are a significant number of users who have a house with a larger area and more complex layouts and tend to install 2 routers for better signal coverage. A very small percentage of users will choose to install three routers for specific needs. Up to now, the average service years of the participants' routers is 5-6 years and the number is still increasing. That is to say, routers have long service years as high-intensity working electronic devices at home.



Frequency of Issues



Types of Issue

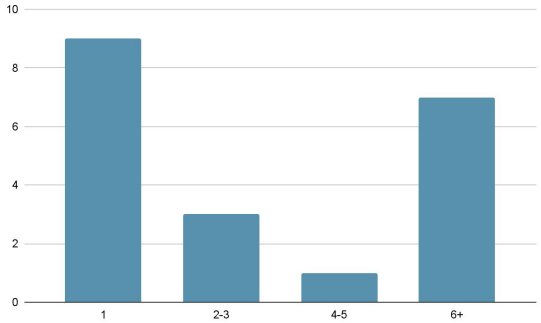
The two most experienced issues are connection instability and speed inconsistency. And these two issues are mostly experienced by those households that have a single router. There are also a significant number of users who experienced router downtime from time to time. The main reason for this is that routers usually work for long periods of time as electronic products and few people will purposely turn off their routers. However long periods of non-stop work can lead to intermittent router downtime problems.

Questionnaire 2

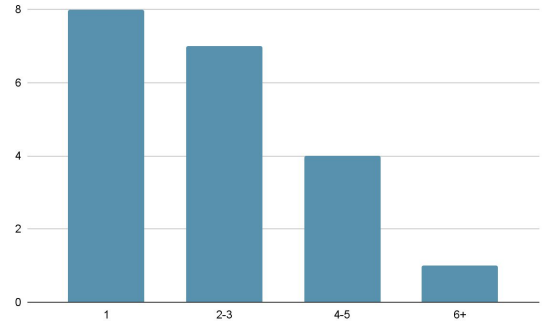
The specific problems of home router users who have a need for smart home construction (20 participants)

- Do you have any IoT products in your home?
- How many IoT products do you have in your home?
- What brand(s) do choose for your product?
- Why did you choose to buy IoT devices from this brand?
- How many remote control Apps do you have on your smartphone?
- How often do you use the remote control Apps to control the devices?
- Are there any general issues you've noticed with the IoT devices?
- How frequently do you face the issues?
- Are you planning to buy more IoT products for your smart home construction?

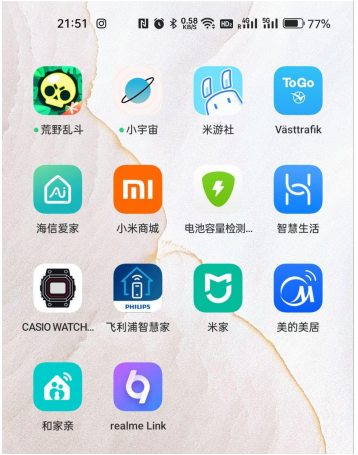
Questionnaire 2 Feedback

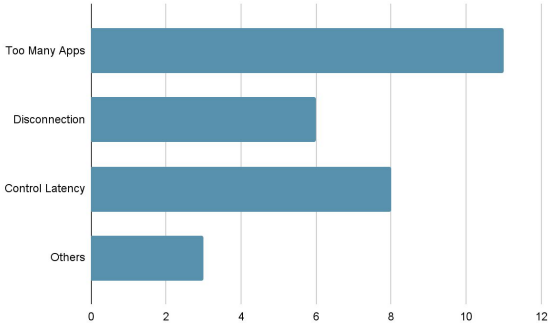


Number of IoT Product

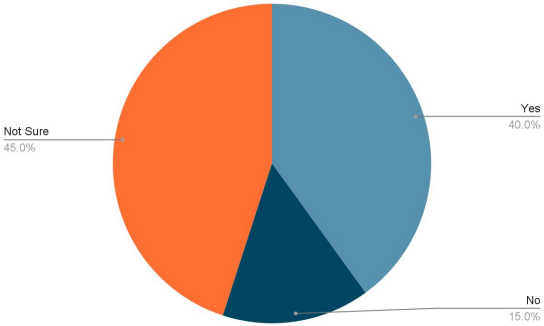


Number of Remote Control Apps





Types of Issue

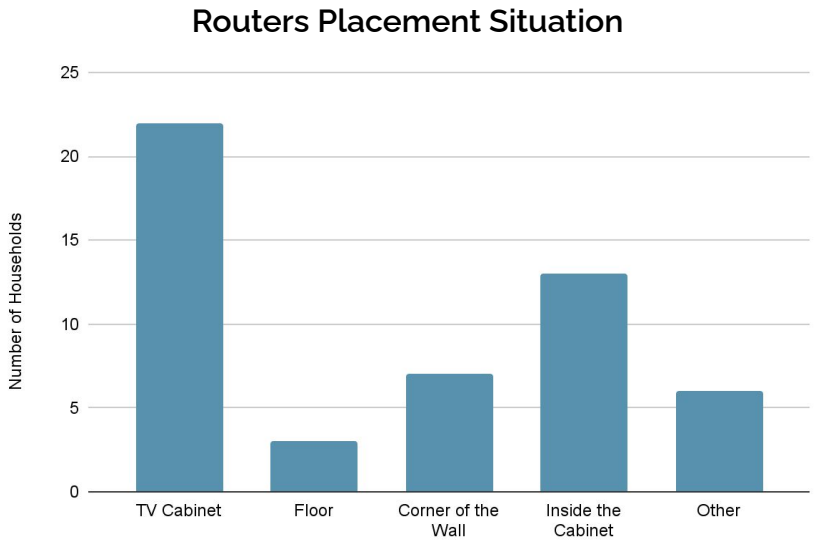


Future Purchase Intention

According to the results of the questionnaire, it is clear that although the IoT penetration rate is not that high today, a significant portion of users are already accepting more IoT devices to be installed. In order to control these IoT devices, most users usually need to install more than one App on their phones. And this common phenomenon turned out to be one of the problems that most users criticized. The other two problems are control latency and unstable connection.

Observations

29 out of 51 participants provide photos of their current routers layout status



According to the survey responses, most people prefer to place the router on the TV cabinet in the living room to get a larger signal coverage area for a more stable device connection. Another group of people tends to hide the router in a cabinet or corner. They usually have fewer devices connected and a smaller house area.

Primary Target User

- ## Smart Home Devices User

The household share of smart home products is increasing, and there is a greater demand for ease of control and management of multiple smart home products.

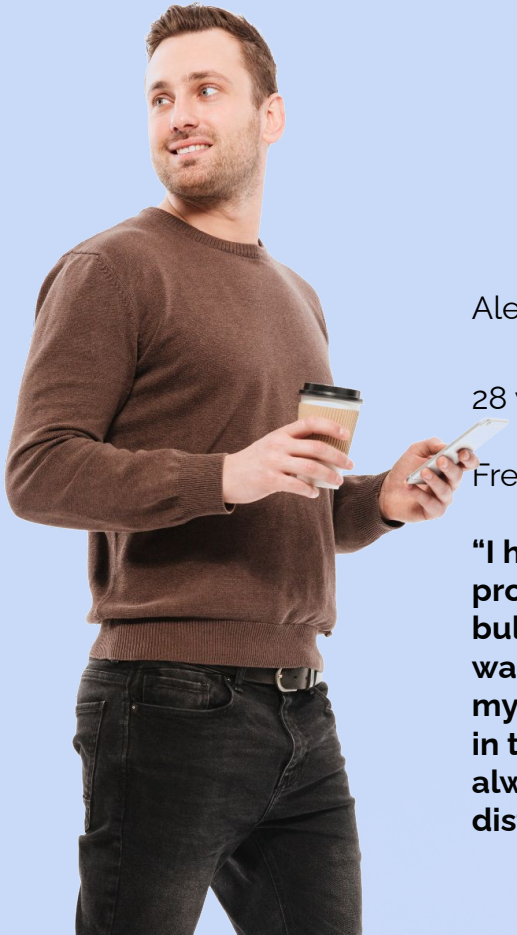
- ## Group Network Demand

For people with large homes, building a stable and high-speed home network is often difficult to achieve. I hope this project can focus mainly on designing a router for local group networking.

- ## High Quality and Safe Network

With the rapid development of IoT and the expansion of network information storage technology, many users will store their personal privacy and other important information in the network. The stability and security of the external and internal networks become particularly important.

Persona



Alex

28 yrs old

Freelance Designer

“I have 9 smart home products including light bulbs, speakers, TV, washing machine, etc in my home. The only router in the living room can’t always connect to my distant devices stably.”

Basic Information

9 IoT devices control

2.5 hrs online entertainment per day

Remote control to the home

Frustrations

- Unstable connection to the IoT devices
- Too many Apps need to install on the smartphone to control/manage the devices
- Distractive random online content
- Unsightly router placement

Expectations

- Easier control and connectivity to the IoT product
- Better online working/study efficiency
- Safer local network
- A warmer-looking router

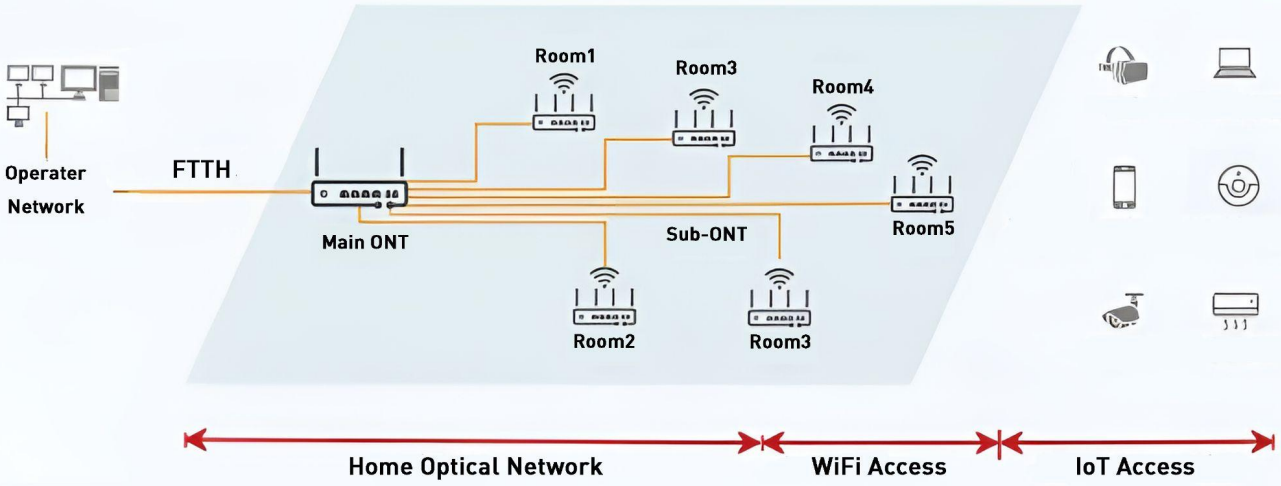
Technical Study

In order to comply with the trend of IoT home, the future home router must be able to maintain the high speed and stability of network connection while undertaking the access of ten or even dozens of devices. At the same time, it must also have high-security features while ensuring the efficient operation of a large local network. Traditional copper wire access network is almost impossible to achieve the above characteristics. However, an emerging ICT technology, FTTR, is rapidly gaining popularity in the last two years. This part of the study will focus on what FTTR is, the advantages of FTTR over traditional copper wire networking, and the importance of FTTR technology for future IoT home networks.

Technical Solution — FTTR

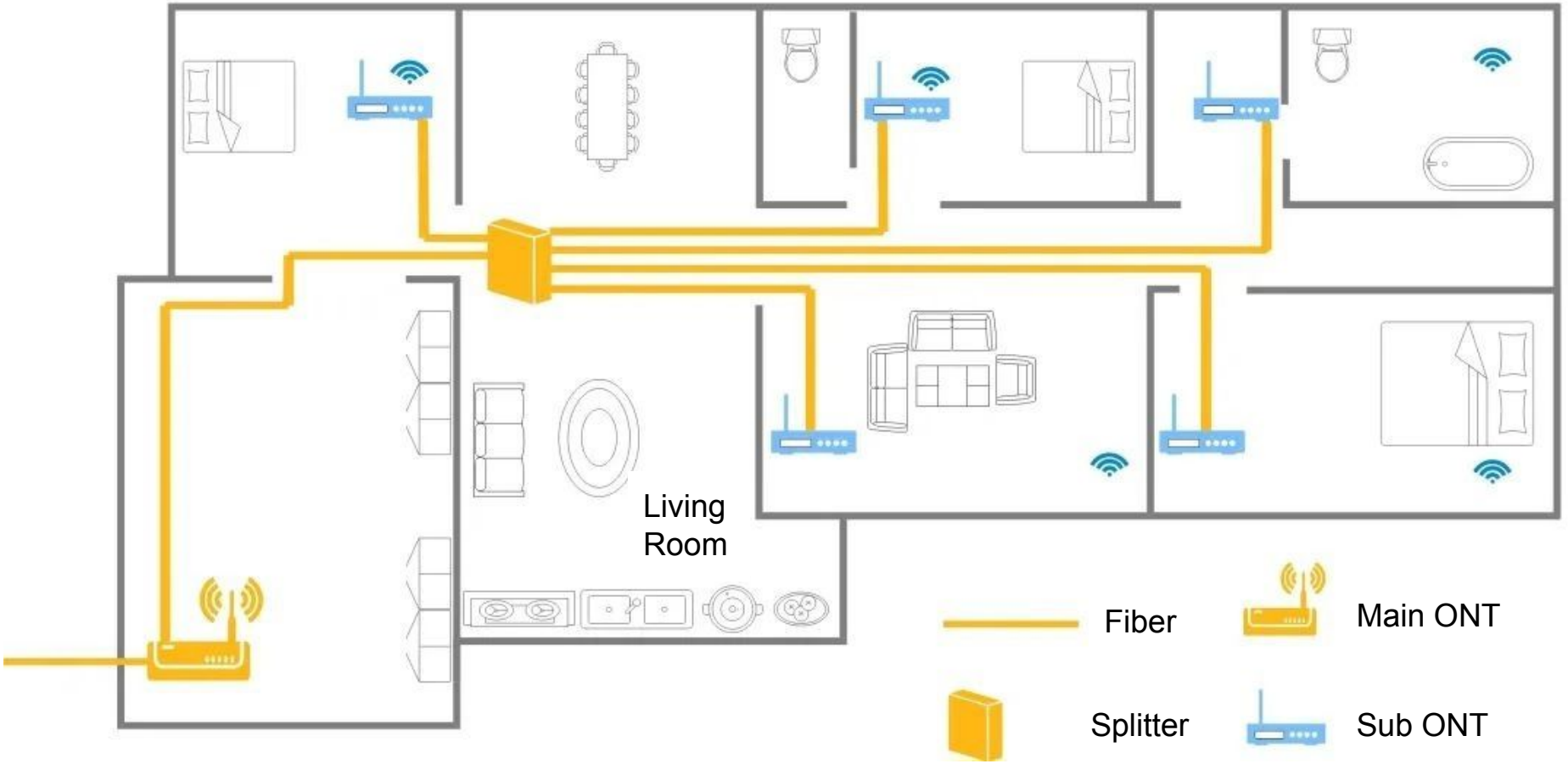
With the popularization of IoT and the development of innovative applications such as extended reality (XR) and metaverse, Omdia predicts that the proportion of FTTR among global FTTH users will rapidly increase to **25%** by 2030.

What is FTTR?



https://www.huawei.com/en/huaweitech/inspiration-lab/fttr-solution

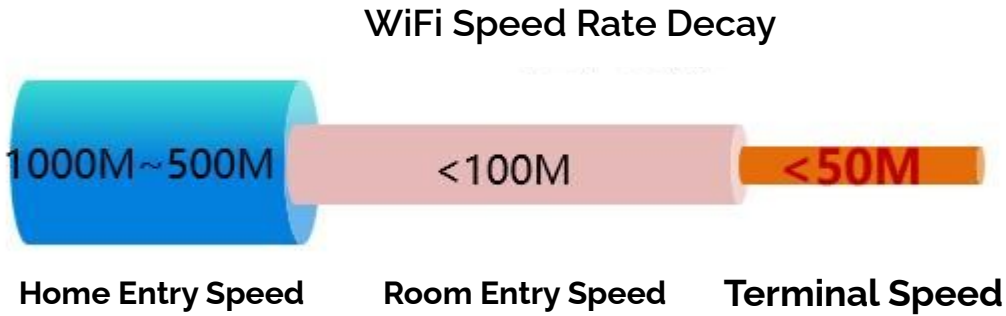
FTTR (Fiber to the Room) is a communications network solution that transmits fiber optic signals into the room. In an FTTR network, fiber reaches the distribution box inside the building and then enters each room in room through copper cable or other transmission media to provide network services to users. Compared with traditional copper access networks, FTTR has a higher transmission rate and more stable signal quality, which can provide users with more stable and faster network services.


Living
Room
Fiber
Main ONT
Splitter
Sub ONT

Why FTTR?

Solution	FTTR	AC+AP	Analog Line	Wifi - Mesh
Coverage Ability	More than 1km **without affecting transmission performance**	Less than 100m	Less than 200m	Greatly depends on the complexity of the environment
Network Reliability	**15 - 30 years service life**	Depends on the environment.	Depends on connected electronics	Greatly depends on the environment
Deployment and Installation	Complicated	Complicated	Easy	Very easy
Installation Cost	Low fiber cost, high installation cost	High cable cost, high installation cost	Low cost	Low cost
Operation and Maintenance	**OTA upgrade**	Offline	Offline	Offline
Number of End Terminals	**256**	8-10	8-10	8-10

Traditional Group Networking Solution



Mesh networking will have more than 50% attenuation of the Wi-Fi signal when it meets the wall, which leads to the Wi-Fi rate reaching 1000 megabytes only at the entry package splitter box although the gigabit package plan is signed. In reality, it may be only 80+ megabytes can be experienced in the bedroom.

https://www.cnii.com.cn/gxxww/rmydb/202208/t20220831_408933.html

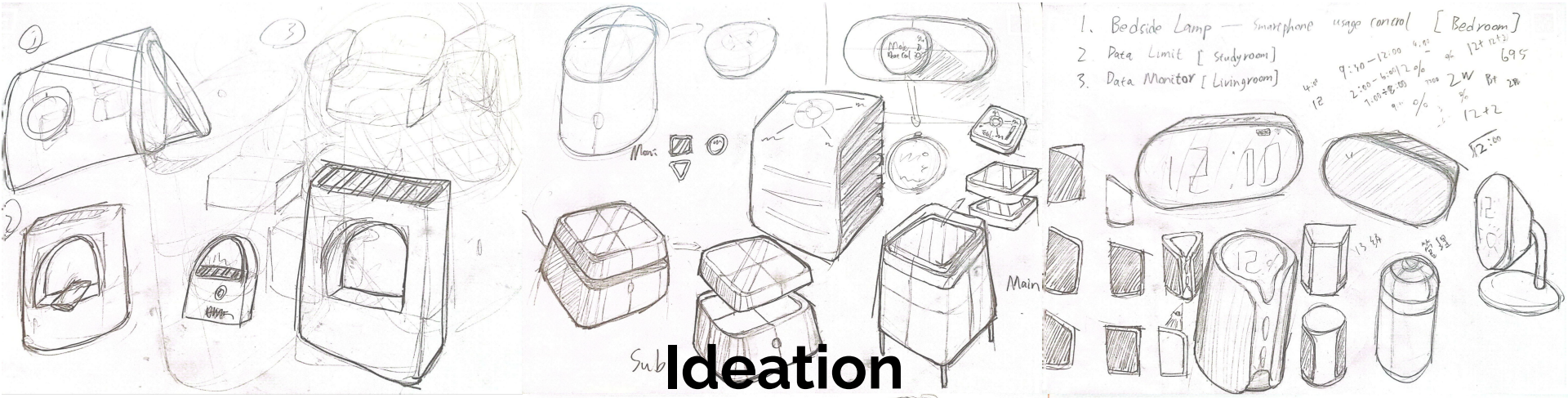
What does FTTR mean to IoT access?

FTTR solution utilizes fiber optic connection with strong transmission capacity, higher transmission rate, and longer cable life. The solution is able to support a 10 Gigabit uplink, dynamic display of wide technology signal; stronger signal penetration, reducing the signal attenuation, so that the fiber can be laid to each room, to achieve a true **whole-house Wi-Fi 6**. That means everyone in the family in every location at home can enjoy the best Internet experience brought by a gigabit optical band.

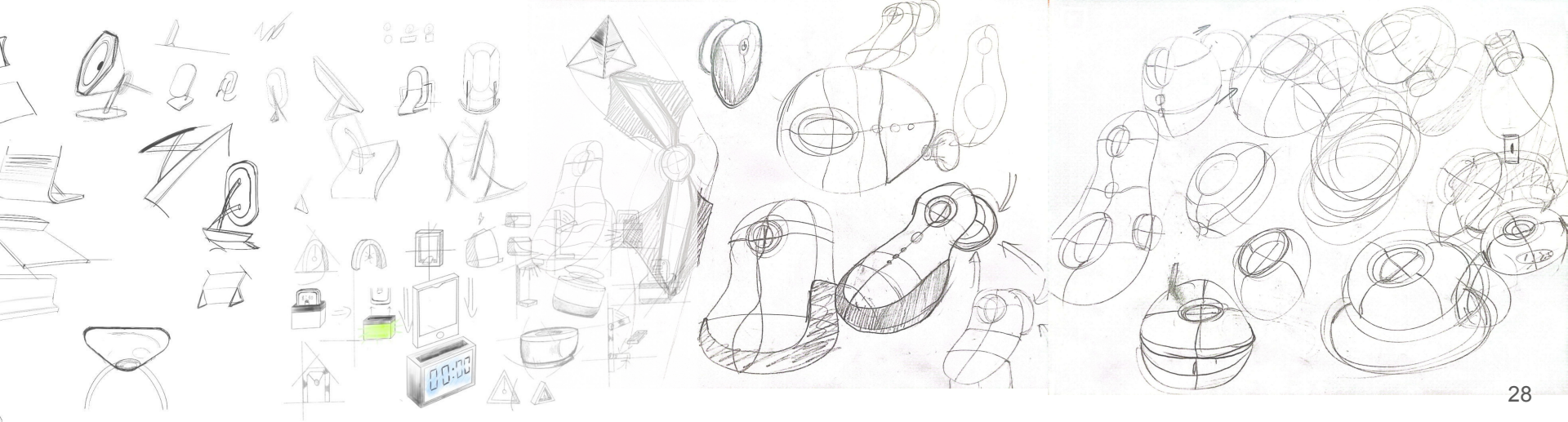
In addition to the advantages of fast Gigabit optical fiber network speed and whole-house coverage **without dead spots**, it can also support **256 terminal devices** to connect, which is 8 times the maximum number of connections in traditional networks (the maximum number of connections in traditional networks is 8-10), effectively ensuring the use of multiple whole-house smart terminals such as computers, TVs, cell phones, tablets, VR and other networked devices in the home. In addition, in the traditional wiring process, the problem of unsightly wiring in the update to FTTR whole-house gigabit fiber can also be easily avoided, compatible with the hair obvious dark wire networking, the line is also more beautiful, does not damage the decorative style, and the home environment into one; at the same time, FTTR gigabit fiber, especially suitable for more than 100 square meters of the large flat, villa and many other types of households.

Design Brief

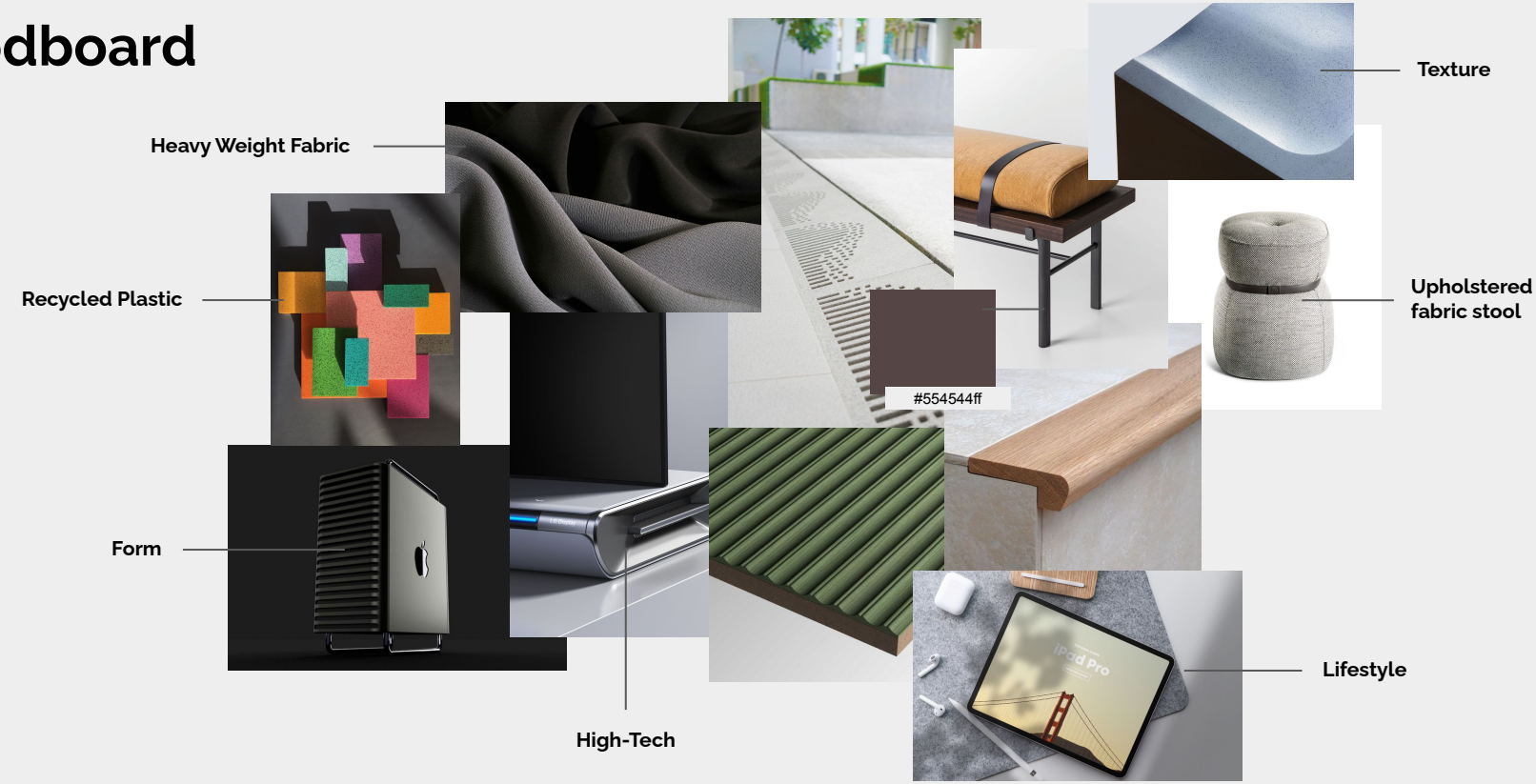
To design a router that can provide high quality, secured, and stable network environment while playing the role of a **housekeeper** to manage and control connected smart devices.


1. Bedside Lamp — Smartphone usage control [Bedroom]
2 Data Limit [Studyroom]
3. Data Monitor [Livingroom]
Main
Sub

Ideation



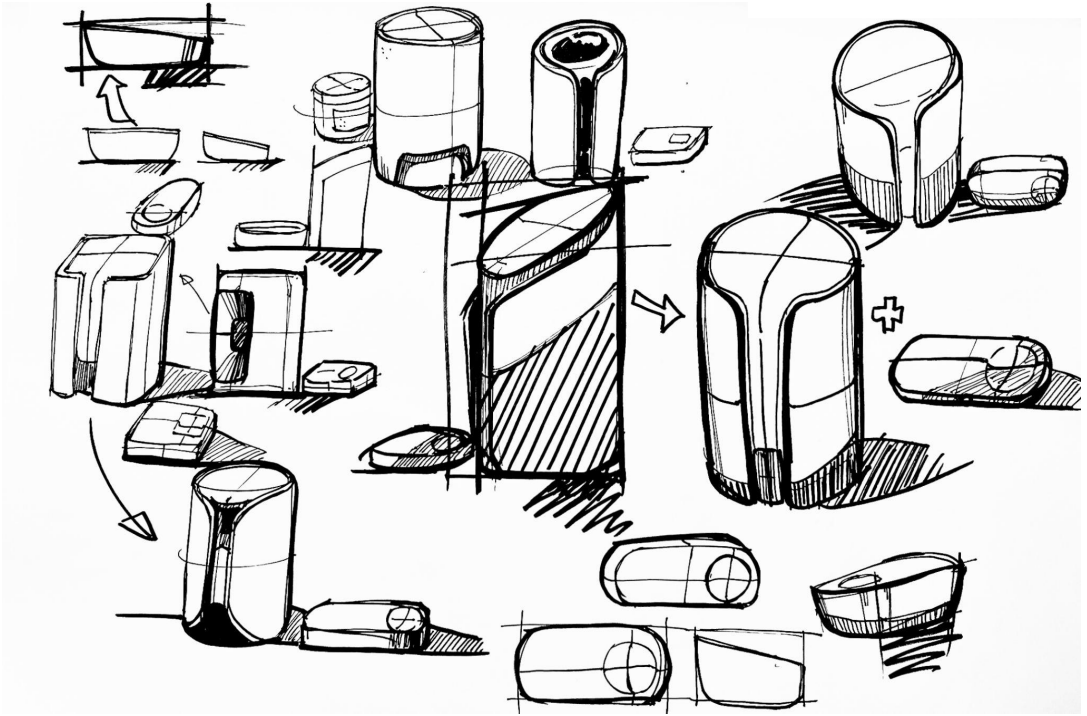
Moodboard



Most households keep their Wifi router way more than 5 years. In this project, I want to design a Wifi router that is not just a long life span **high-tech** device, but a **beautiful piece of furniture** that people are more welcome to display and use during daily life.

Concept 1

The concept consists of three products: a primary router and two secondary routers. The main router is placed in the living room, while the two sub-routers can be placed in other rooms according to their respective functions. In designing the main router, I mainly extracted the **high-tech, metal, and streamlined** elements from the previous moodboard. At the same time, I wanted to use warmer fabric elements with this hard and futuristic element to present a softer home atmosphere.



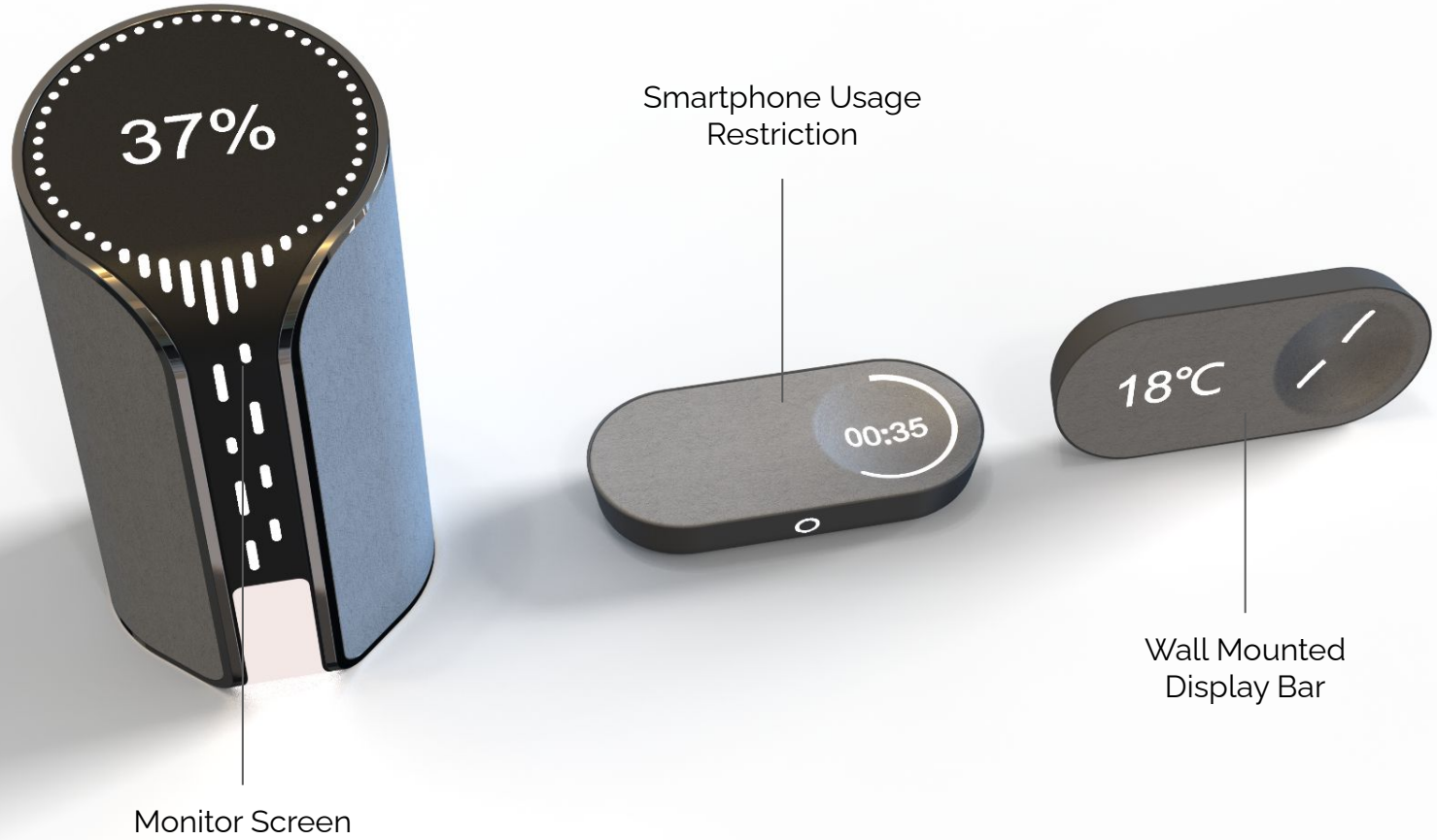
- Main: **IoT Managing & NAS Data Monitoring (Living Room)**
- Sub1: **Smartphone Usage Restriction (Study room)**
- Sub2: **Wall Mounted Display Bar (Bedroom)**

Initial Form Development

Sub-ONT1: ARC

Main ONT: WAVES

Sub-ONT2: CAPSULE


37%
Smartphone Usage Restriction
00:35
18°C
Wall Mounted Display Bar
Monitor Screen

Concept 1 Problems

To confirm the feasibility of Concept 1, I submitted this concept to my former colleague, the Design Manager of the Stockholm Innovation Center, at Huawei, and asked him for his opinion on my design. He mainly listed three shortages in my design:

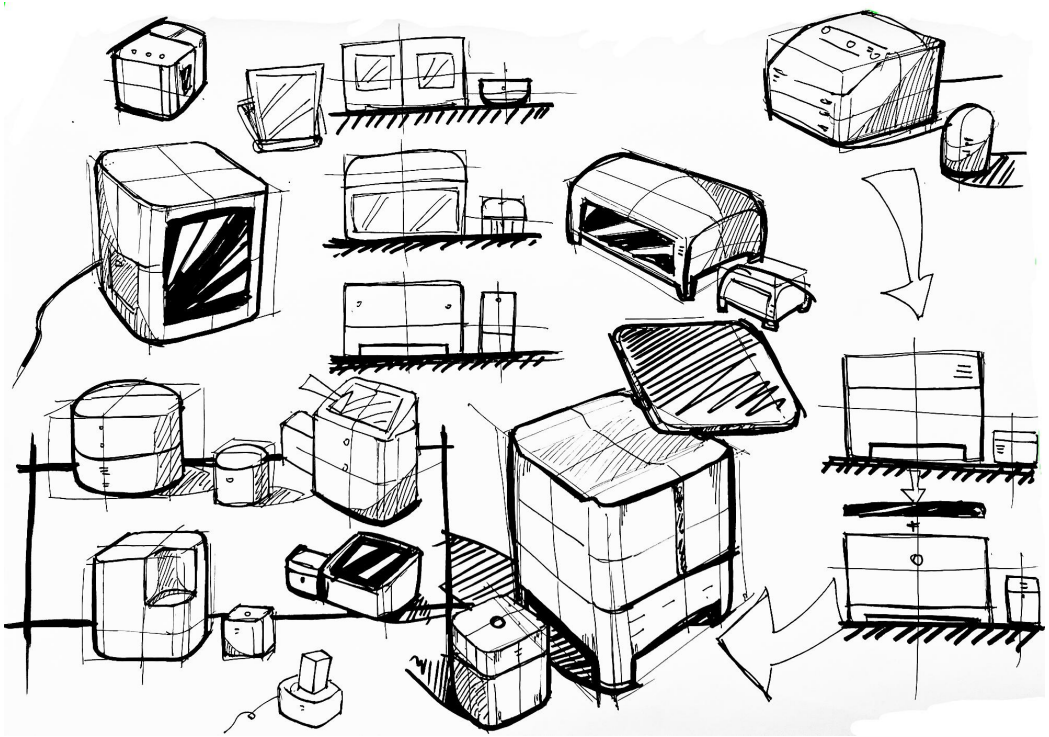
1. **Large radius** curved shaped screen is very hard to produce and the cost is very high.
2. Imposing **strong and single** features to sub-terminal may limit the users' choice.
3. Having **2 different** sub-terminals makes the users difficult to take the step to purchase.

Although the purpose of this project is to design the router of the future, the router is still a common home consumer electronics product after all, so the production cost of the router cannot be too high. The large radius waterfall display, although it looks cool, is too complicated for its production process. Its production cost will also make this router's pricing much higher than the pricing range of common routers. Secondly, the two additional sub routers come with two completely different functions that will make the future smart home with a wide range of IoT devices more complex as well as more difficult to manage. Therefore, I think another feature that this IoT housekeeper router must have in the future smart home is that the **function** and **operation** must be **simple** and **easy to use** so that everyone in the home can use it.

New Design Brief: **To design a router that can provide high quality, secured, and stable network environment while playing the role of a housekeeper to manage and control connected smart devices with low/no learning threshold to use.**

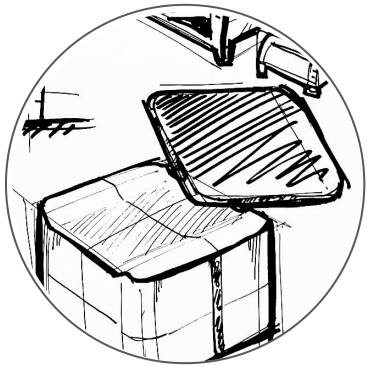
Concept 2

The number of products in Concept 2 has been changed from three to two in order to simplify the functionality of the product and the entire operation process. Among them, the structure of the main router has changed from a cylinder to a cube, while the display has changed from a waterfall screen to a detachable four-to-three ratio flat screen on top of the device. The new structure will be much less difficult and costly to produce, while the square screen can also display more information compared to the shaped screen. The overall shape of the cube will also make the inner architecture much easier.

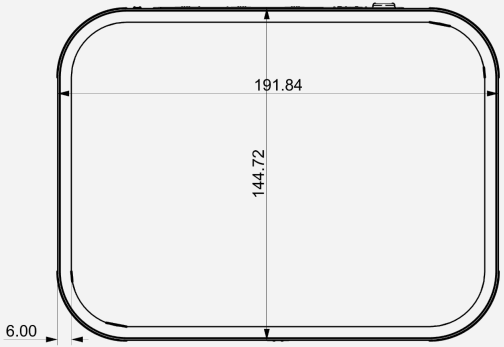


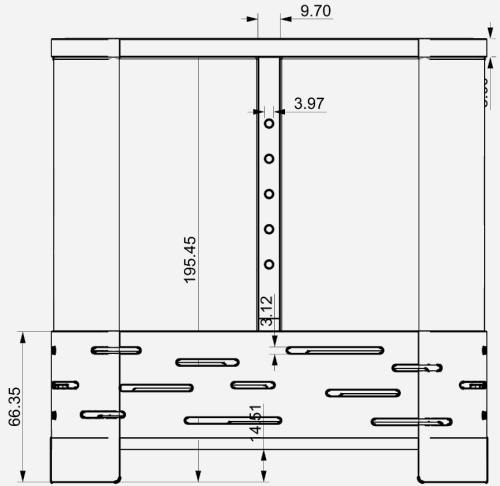
- Waves (Main): **IoT Managing & NAS Data Monitoring (Living Room)**
- Capsule (Sub): **Mesh Repeater & Mobile WiFi**

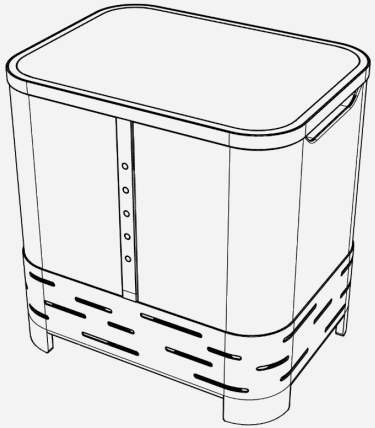
Specially designed sub-routers for a single function will make the future of the smart home, which is already full of IoT products, even more difficult to control. Therefore, I want to reduce the physical design features of the sub-routers and integrate them into the virtual control. The corresponding solution is to turn the Smartphone Usage Restriction sub router and Display Bar sub-router, which are designed for the study room and bedroom, into a single sub-router with more versatility. At the same time, all the smart housekeeping functions (IoT product control, Network Status Monitor/Control, Energy Monitor, etc.) are integrated into the control panel on top of the main router for operation.

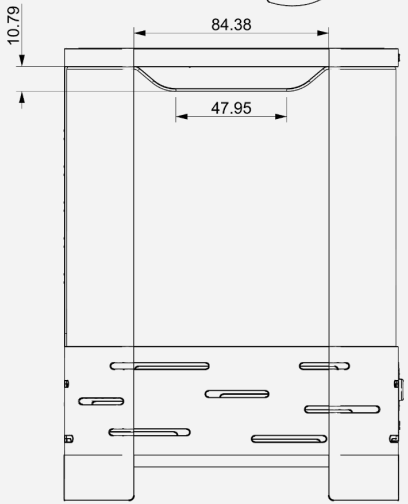


Main ONT Technical Drawing & Dimensions

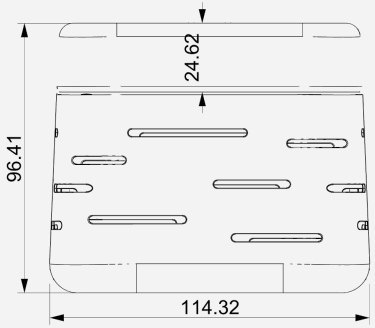


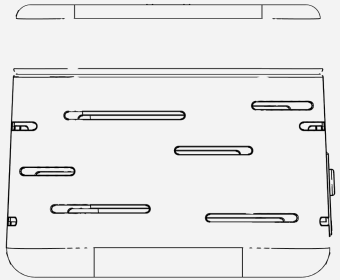




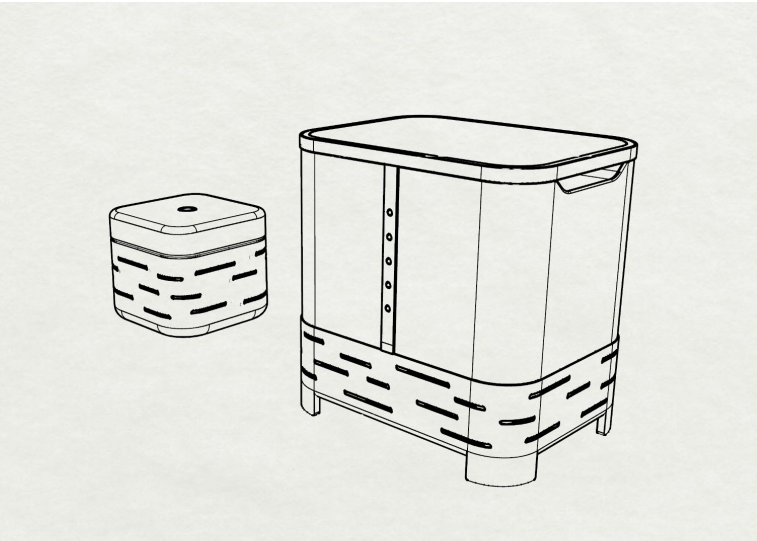


Sub ONT
Technical Drawing
& Dimensions





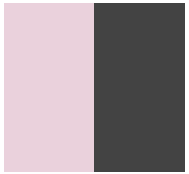
CAD Sketching &
Rough Rendering



CMF Palette & Material List

COLORS

GRAY & WILLOW GROVE

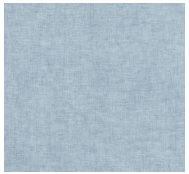


MAGENTA & DARK GRAY

BLUE & CYAN

MATERIALS

RECYCLED PLASTIC



HEAVY LINEN

STAINLESS STEEL

FINISHES

SOFT TOUCH

METALLIC GLOSS

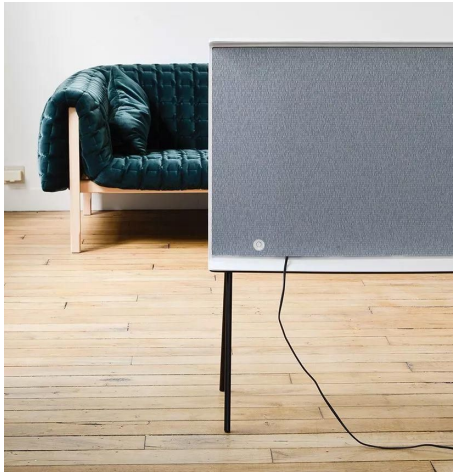
MATT

Parts Name	Picture	Material	Material Quantity
Cooling Pedestal		Recycled Plastic	40g
Main Body Cover		Heavy Linen	0.8㎡
Main Body Inner Shell		Recycled Plastic	90g
Indicator Light Bulbs		Glass	10g
Control Pad Frame		Aluminum	30g
Control Pad Body		Recycled Plastic	40g

Fabric Study

Fabric in Consumer Electronics

When the fabric is used in home appliances the softer feature can confront the traditional cold appearance to provide a **warmer** visual effect and blend into interior design better.



Safety Issue

The thermal lamination wrapping fabric solution can reduce to a certain extent the chemical solvents used in surface treatment that are harmful to the **environment** and **human body**.

Kvadrat Fabric Store Investigation

Founded in Denmark in 1968 and with deep roots in the world-renowned Scandinavian design scene. Kvadrat is Europe's leading brand of high-quality contemporary textiles, providing textiles and textile-related products to architects, designers, and consumers around the world.

Kvadrat has also been providing fabric material to 3C brands for electronics production.

To study more about fabric, I went to the biggest Kvadrat offline store in Stockholm.

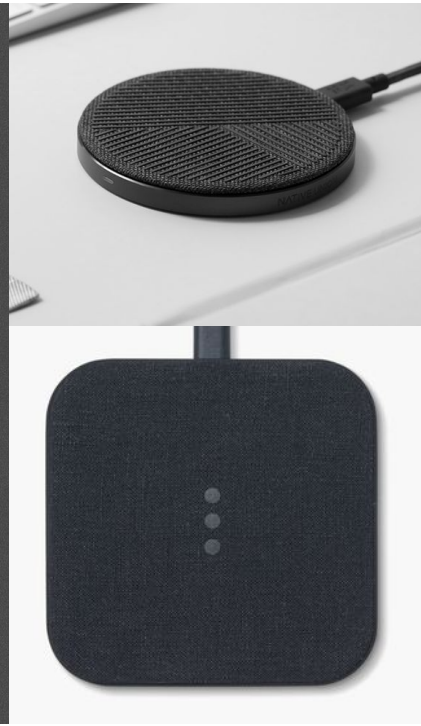
Ideation
Molly 2
194
FEBRIK

Linen

Natural Fiber

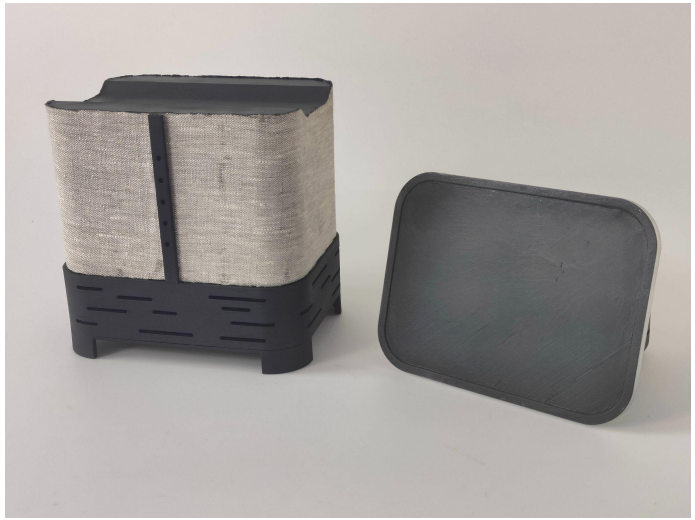
Linen fabric is woven with linen fiber as the main raw material, so linen fabric and linen fiber has similar characteristics, that is, linen fabric has very good **moisture conductivity** and moisture absorption. Linen fabric has very good **anti-allergy** properties, at the same time, linen fabric is also **antibacterial**.

Application of Linen on Devices



Model Making

Finished Model



Finalization

Capsule

Wave

Final Form

Aluminum has the characteristics of easy processing, high hardness, light mass, and good electrical and thermal conductivity. Secondly, aluminum has high ductility, high plasticity, good casting performance, and large production and fabrication advantages. The chosen Kvadrat Heavy Linen #0011 has a weight of 25oz, which makes it very durable.

Users can determine the number of devices connected to the local network and the resource usage of the local network by checking the **number** and **color** of the five lights on the front of the router.

Medium Load

Indicator Light

High Load

Docked Usage Scenario

The docked mode keeps the control pad in the charging state. The user can use the control pad directly in dock mode to perform any operation normally.

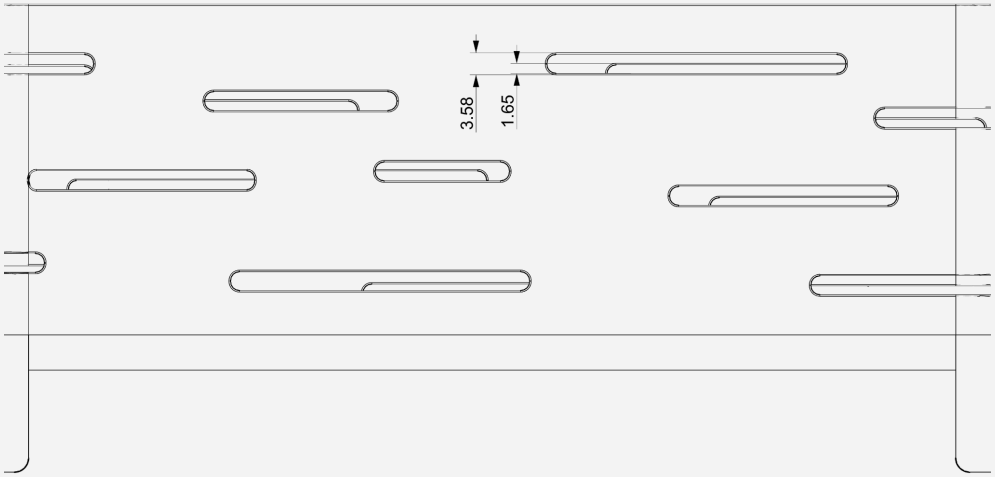
To enter docked mode for charging simply place the control pad on top of the router.

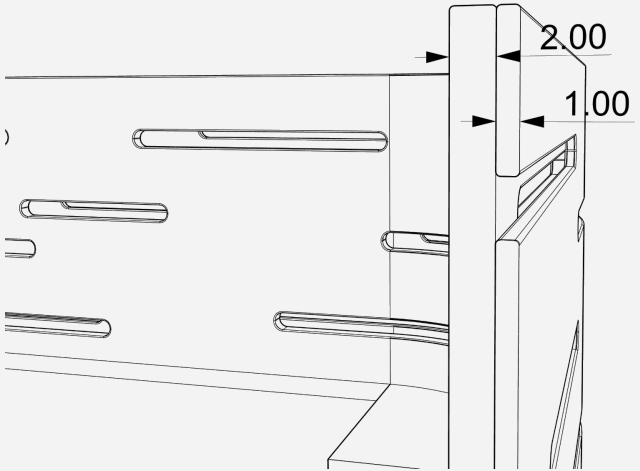
Cloud Style Vents

The main router's base uses a double-layer heat sink design, the main reason being that this double-layer opening design enhances the efficiency of heat dissipation while reducing the area of internal parts in direct contact with the external environment. The cloud icon is used mainly for the purpose of decorating the large double-layer openings.

Vents Design

Heat dissipation holes with height of 1.65mm provide large air contact area to allow better external cooling efficiency.

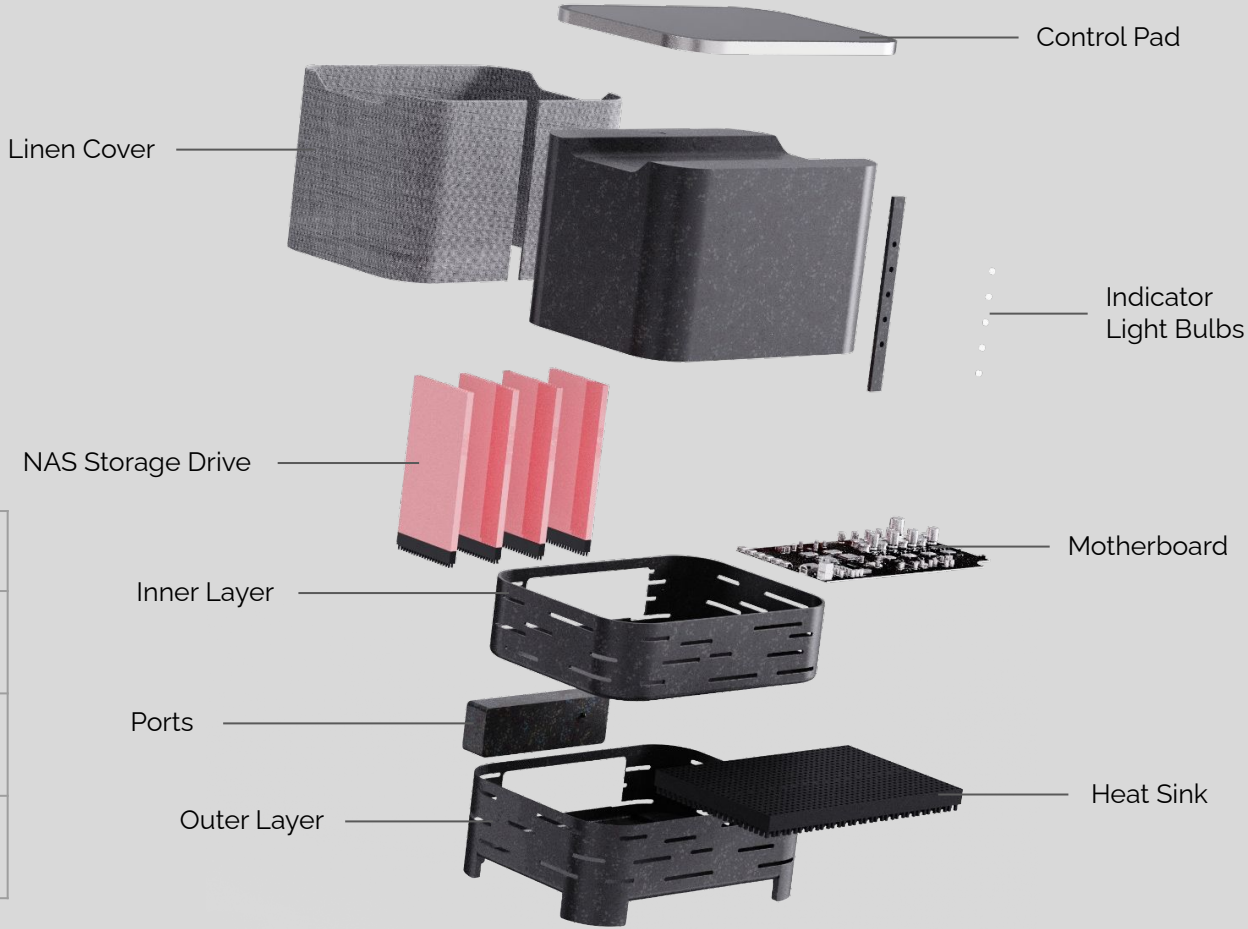




Double layers design also allows better external cooling efficiency by dividing the heat dissipation method into two approaches: **one through the thermal conductivity from the inner plastic layer of 2.0mm thickness; another one through the direct contact with air by utilizing the opening area.**

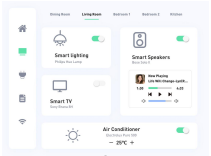
Exploded View

Inner Components	Specs
NAS Storage Drive*4	147mm*102mm*26mm
Motherboard	169mm*105mm*23mm
Heat Sink	166mm*97mm*36mm

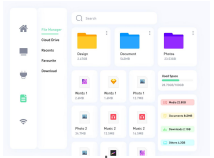


UI

User Flow

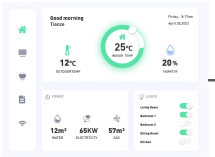


Smart Home Control

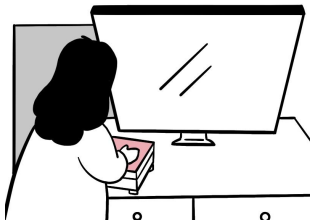


Cloud Management

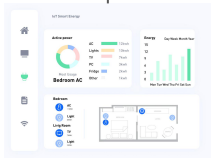
Screen Time Monitor

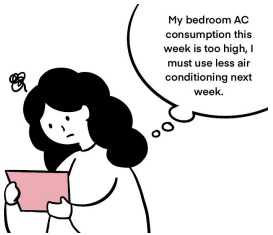


Home



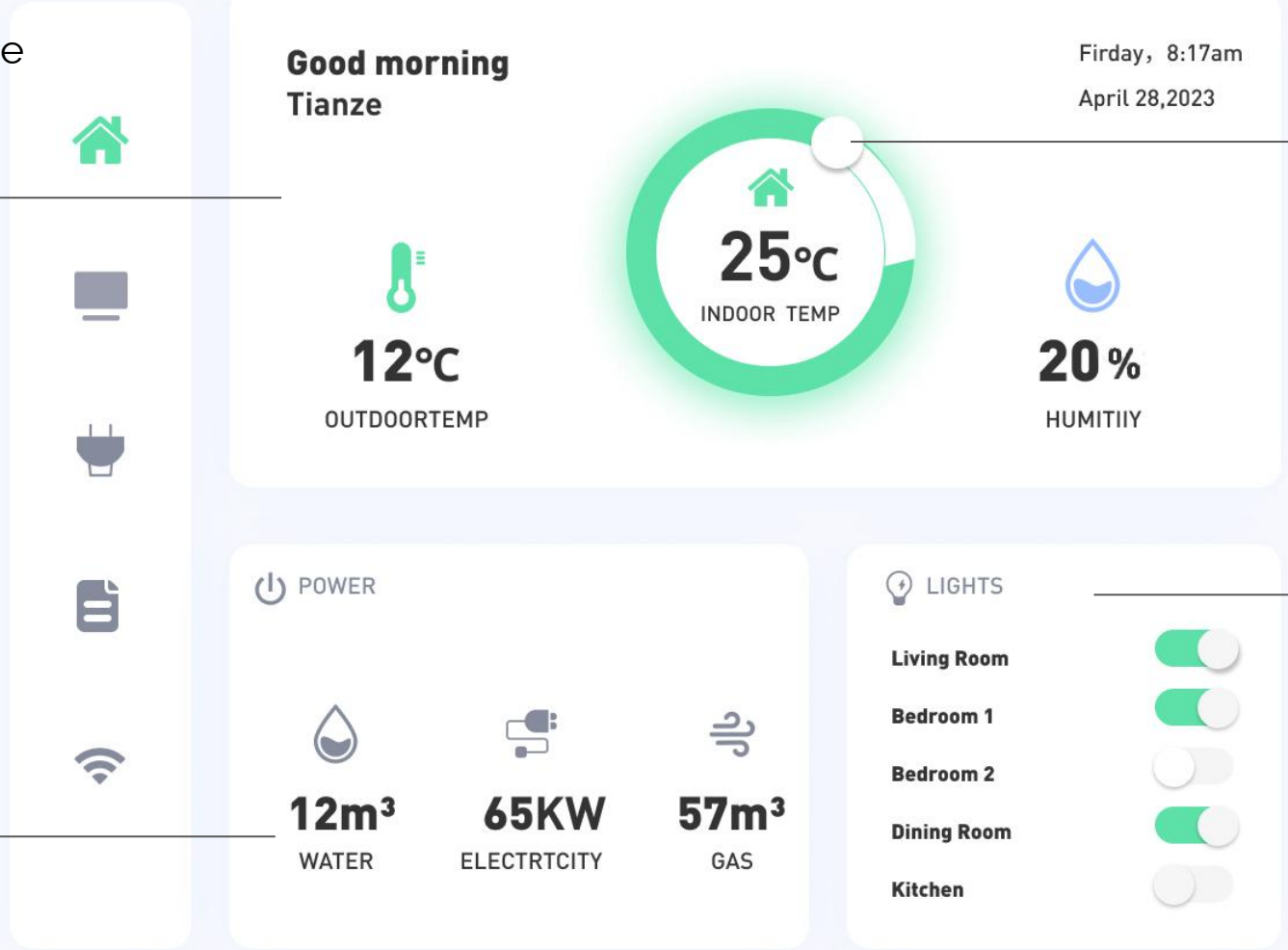
IoT Smart Energy





NAS Download Monitor

Home Page



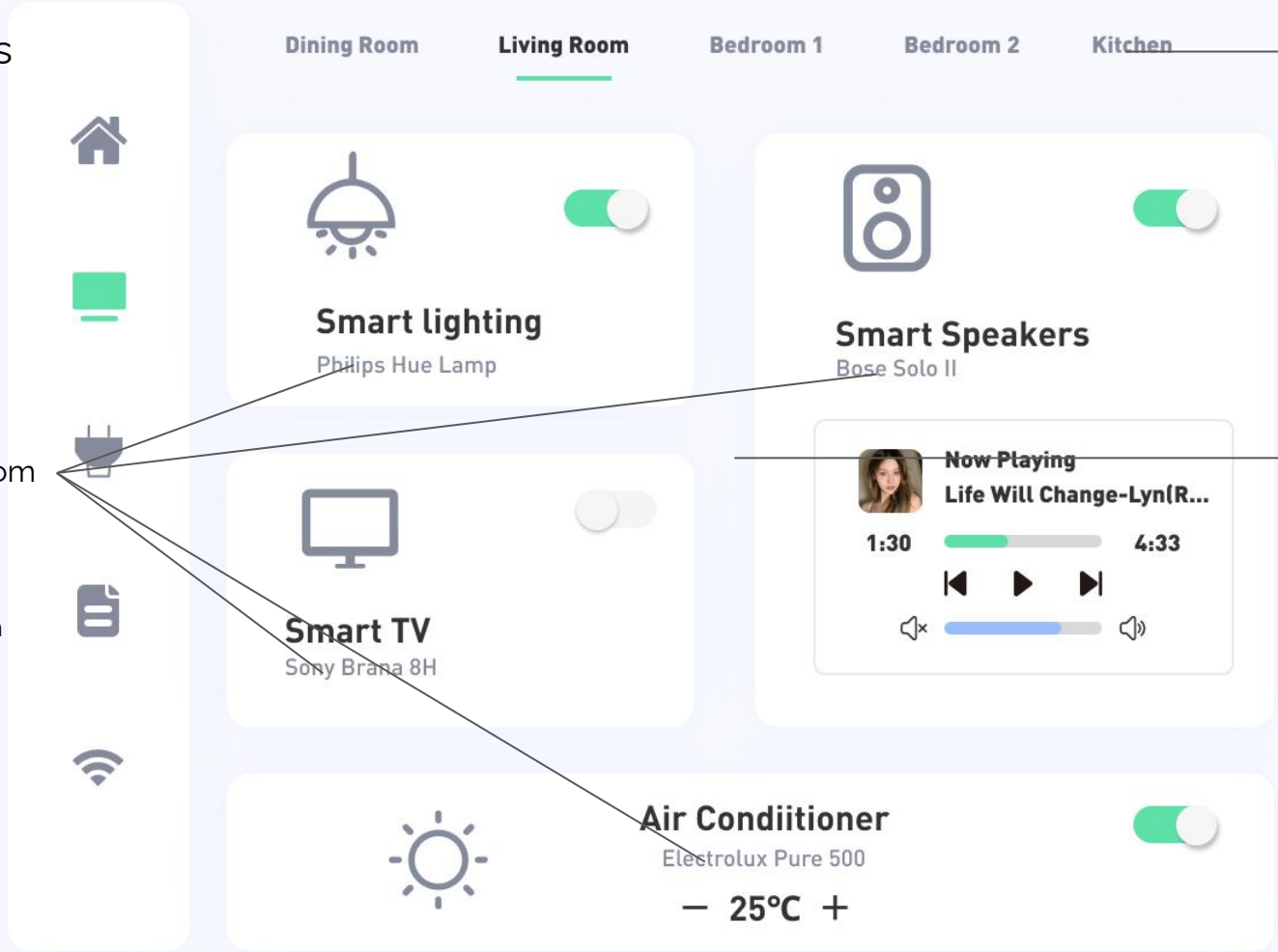
Environment Data

Temperature Adjustment

Energy Consumption

Lighting Management

IoT Devices Control



Room Selection

Devices Control Panel

Integrate control across product from different brands

*Achieved by the cooperation between operators and supported brands

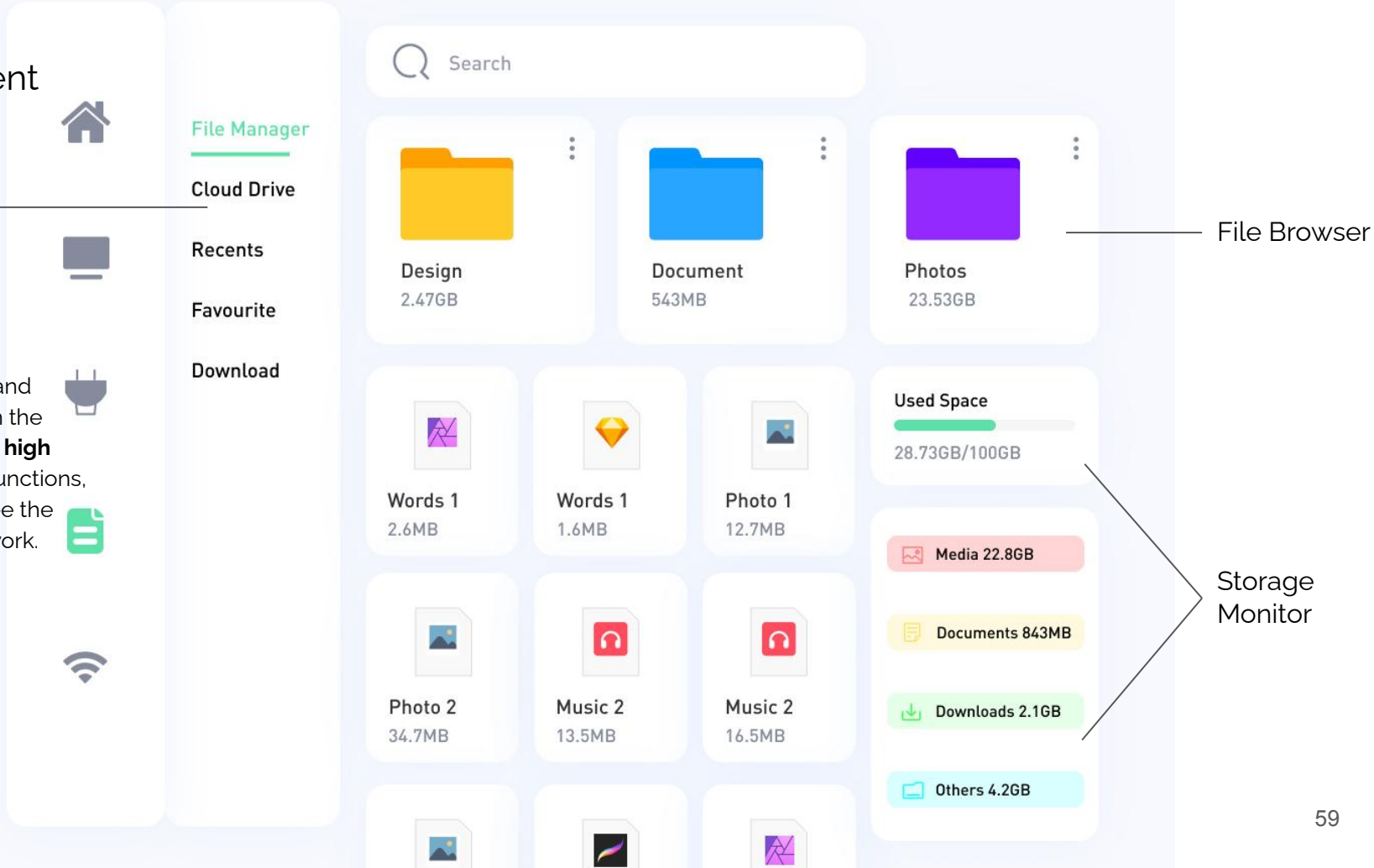
IoT Energy Monitor

Current Power Usage

Energy Consumption Calendar

Visualization Energy Monitor

Cloud Management



Group Filter

File Browser

Storage Monitor

The optical cables and transceivers used in the FTTR network have **high anti-interference** functions, which can guarantee the security of the network.

NAS Download Monitor

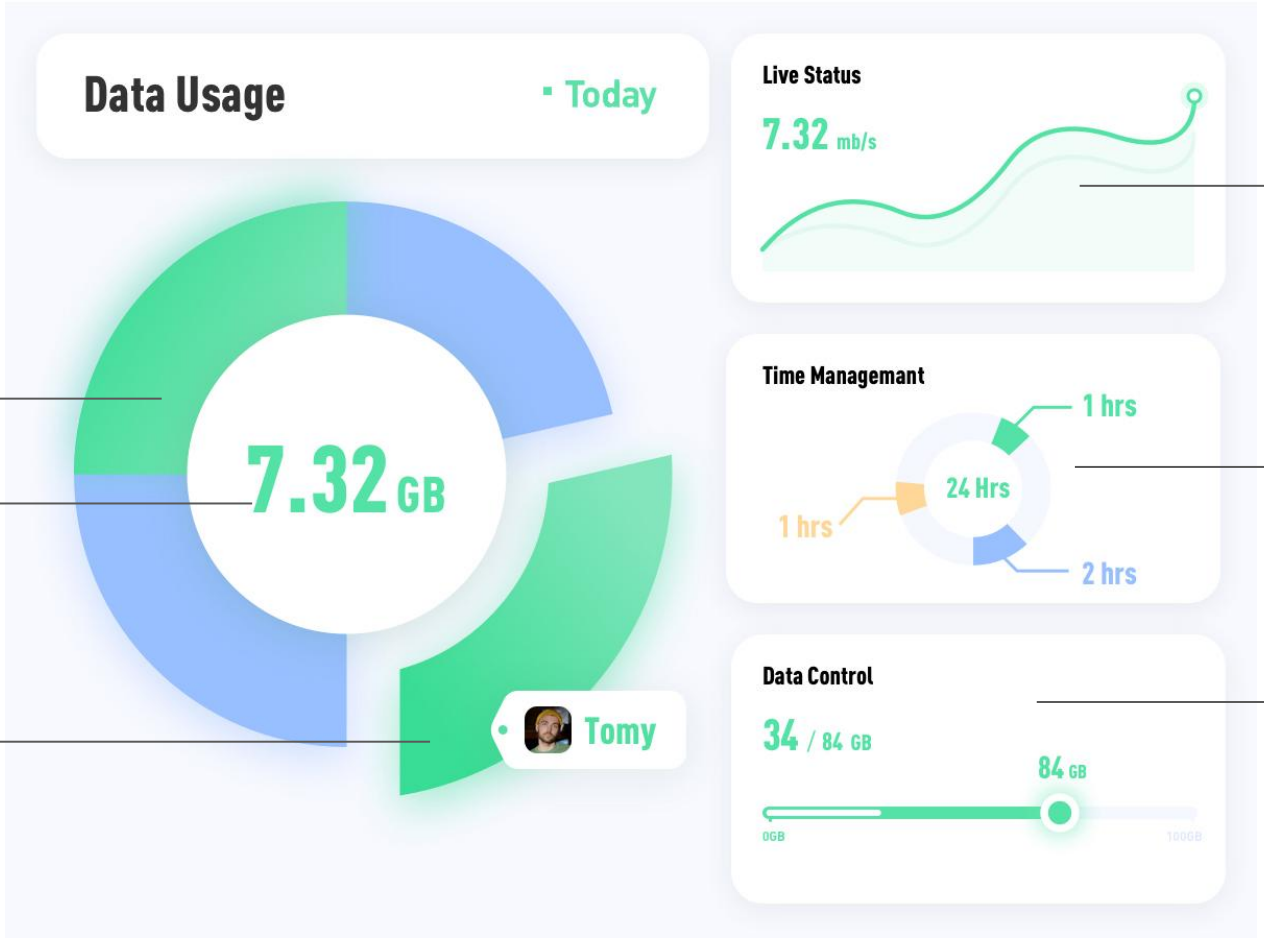
Overall Download Progression

Download List of All Files

Real Time Download Speed

Remaining Download Time

Screen Time Monitor



Usage Scenario

Bedroom Usage Scenario

Scenes to be used

Dining Room
Living Room
Bedroom 1
Bedroom2
Kitchen
Smart lighting
Philips Hue Lamp
Smart Speakers
Bose Solo II
Now Playing
Life Will Change-LynIR...
1:30
Smart TV
Sony Bravia 8H
Air Conditioner
Electrolux Pure 500
– 25°C +
TOM FORD
FASHION
150 Years
Couturiers
Designers
Labels
Charlotte
Seeling

Capsule

Power Indicator

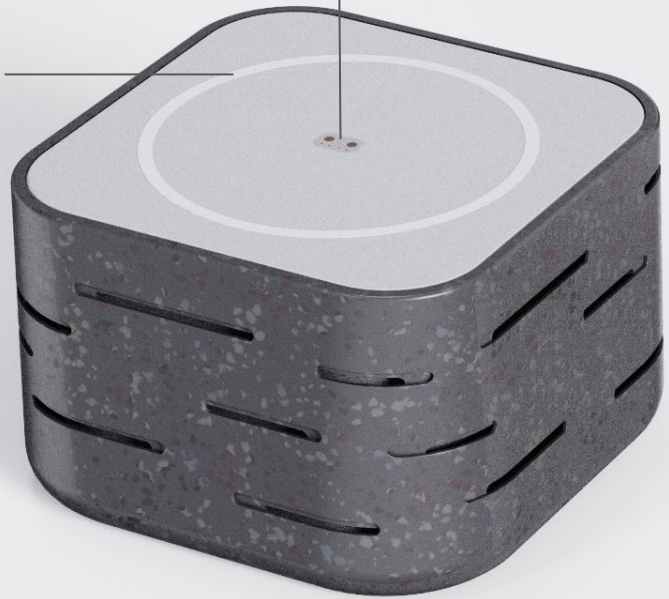
Mobile Wifi

Recycled
Plastic Cloud
Style Vents

Ports

Charging Port

Stabilizer



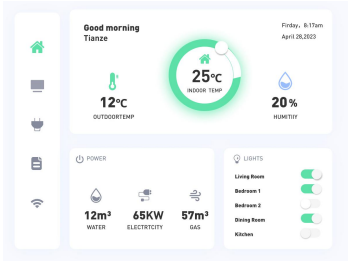
Operator SIM
Card Inbuilt

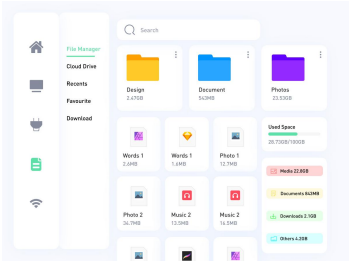
Aluminum
Mobile Wifi

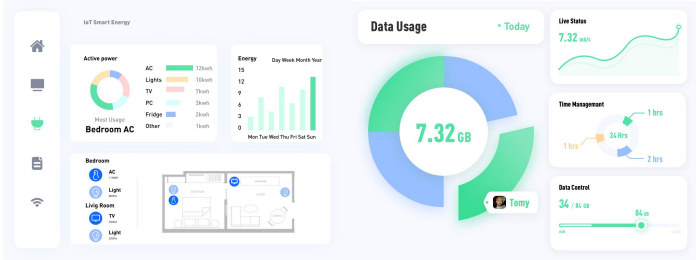
Docked
Usage
Scenario

To Go Usage Scenario

Final Showcase







One more thing...

Why would telecom operators like to and need to join this game?

That is mainly because the FTTR solution requires cooperation between the telecom company and the router company. The Telecom company is responsible for providing the optical network service and installation of the fiber while the router company provides the end terminal which is our router. And this cooperation can bring many things to come true, such as mobile WiFi, breaking the ecological chain of IoT brands, and integrating IoT control into 1 single platform. And OTA upgrade. This cooperation can also bring more revenue to the telecom company. Because dropping the OTA upgrade is not a one-time business. Just like how Tesla treats their OTA, the telecom company can add more features to the router base on users' needs.

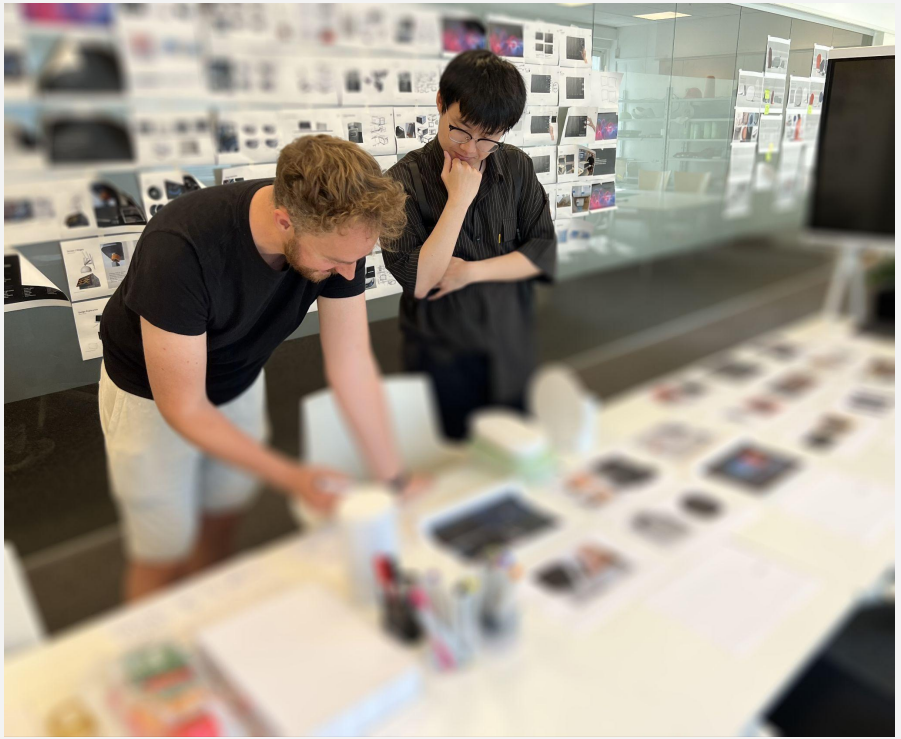
Conclusion & Reflection

The jury and my tutors gave me a lot of very useful advice after listening to my presentation.

The first was the reasonableness of the control panel at the top of the main router. My initial design intention was to use this control panel as a window for users to monitor and communicate with the router and the entire smart home. However, the design flaws in the control panel itself and the way it was placed resulted in the user being forced to go to the main router to operate it. This behavior greatly inconveniences the user's smart home life. What could be improved at this point is that the control panel itself could be redesigned so that it becomes a secondary router installed in different rooms. Changes must also be made to the form of the control panel. The first is to weaken the presence of the screen and redesign a way to display and interact with information. After that, the control panel needs to be designed in a way that how and where it can be placed in the room.

Another piece of advice is to reconsider the choice of materials. The use of three materials and production processes in one router can make the production of the product very difficult and costly. My initial idea is that the router as a long life cycle of home electronics can be combined with different materials to create a more beautiful visual effect. At the same time, I found through some research that the use of fabric will somehow reduce the pollution of the environment. However, I did not take into account that the environmental pollution caused by more carbon emissions from the use of multiple materials and production processes may be more than the environmental pollution reduced by the use of fabrics. So to add to this point, I need to do more detailed and in-depth research to decide on a more thorough material choice.

Thanks to everyone who has helped me with this project. I'm not an expert in the ICT industry but I did learn a lot in this area and I hope to bring the knowledge into my future career.



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