

**SCHOOL OF INFORMATICS & IT**

**Project**

Project Group : Group 2

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**Declaration of Originality**

We are the originator of this work and we have appropriately acknowledged all other original sources used as our reference for this work.

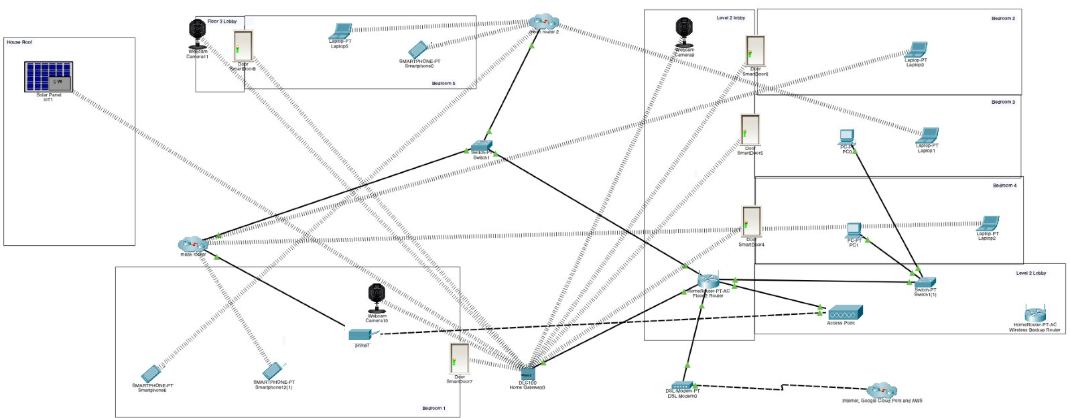
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**Network Implementation**

**Logical Topology: {Zoom in to see topology clearly}**



**Network Implementation Explanation:**

**Layout:**

The green family lives in a 3-level house. Bedroom 1 on 1st floor, Bedrooms 2, 3, 4 on the 2nd floor. Bedroom 5 on the 3rd floor. The main router is placed on the 2nd floor. The reason why we had left the wireless home router on the second floor was because 2nd floor has the most bedrooms and that is where the family members of the house would be doing their work. The placement of the router really matters a lot to ensure the network connectivity stays seamless, in the scenario where the router spoils, we have kept a secondary router, the backup router.

**IoT Devices & AWS cloud:**

We had IoT (Internet of Things) devices, Webcam, Door, and Solar Panel wirelessly connected to the home gateway which also connects to AWS Amazon S3 Glacier (for lower costs), where the devices’ data is stored. Since, home gateway is connected to the home router, individuals can now control smart devices wirelessly through their smartphones even when they are away from the house. We had placed smart doors for every bedroom to reduce the risk of physical breaches to prevent the losses of their devices or steal their data. Additionally, we ensured that we had placed cameras in the bedrooms of 1 and 5, and in Level 2 Lobby to capture who is entering and exiting the room. These are very important for the physical security of the network devices and data security of the Green Family. We installed a solar panel at the top of the house, instead of using non-renewable manufactured electricity, to utilise renewable electricity in the house.

**Password:**

We made sure that the passwords of the network devices and end devices was strong and not susceptible to hackers. Our passwords were at least 8 characters, used numbers, alphabets and different sorts of characters (e.g. $#%&).

**Routers:**

On level 2, since there are more devices, it would have been impractical for us to directly connect the end devices to the home router, hence, we decided on using an access point. Simply relying on the routers capabilities to connect to the devices in the house would result in limited coverage. The access points allowed us to seamlessly connect the wireless devices to the home router.

**Google Cloud Print:**

We are using Google Cloud Print for easy file and printer sharing purposes. Once the printer, is added to the Google Cloud Print, you can share it with others by inviting them to access the printer. A user with access to the printer, can print documents from any device that is connected to the internet. Using Google Cloud Print has enabled us to ensure that there is easy file and printer sharing.

**Mesh Router:**

Instead of using multiple routers, which would increase the home network latency & more, we decided in using a mesh router. Mesh routers provide a seamless and consistent coverage throughout the entire network, which in turn reduces the number of dead spots. Additionally, mesh routers offer faster speeds and better performance when comparing with Wi-Fi extenders, which we planned on using originally.

**Switches:**

We also included switches in our network because we have considered that the Green family would want fast and responsive network speeds, such as efficient data routing and faster local data transfer within the same local network, with the added benefit of being cost-effective than routers for a reliable local network.

**Our assumptions of the network:**

**Things we assumed:**

* We have checked and found that the current number IoT devices were bought a month ago, we have checked that they have been CLS (cybersecurity labelling scheme for Singapore, which IoT devices have been tested and certified to be secure by design, hence meeting one aspect of the robust security measure goal) certified.
* We also checked that they have been planning to add solar panels on their roof for an alternate green source of energy but given the size of their roof and due to their budget constraints, we are only able to add one panel. However, we saw that the attic is spacious, hence we plan to place the batteries to store excess solar energy.
* The Green family have considered for AWS student free tier so that they can store a considerable number and large sized files on the cloud.
* The Green family are a bunch of normal end users with little to no technological administration knowledge, hence they may want to use easy- to- use cloud tools.
* The Green family member are mostly working from their bedrooms during the day.

**Cloud services used and their benefits:**

We used Amazon S3 Glacier to store data of IoT devices, files of family members in the Green family, store the recording of the cameras & more. Despite Amazon S3 Glacier having security features, we decided on using Amazon IAM & Amazon Cognito. AWS IAM allowed us to securely control the access to AWS S3 Glacier, while AWS Cognito acted like a door, where it authenticated the individual trying to access AWS S3 Glacier.

**Networking**

**-> Amazon VPC:**

Virtual Private Cloud (VPC) provides a secure and isolated network environment. It ensures privacy, enables customized network configurations, and allows seamless integration with cloud services.

There are a few benefits when it comes to using a VPC in a smart home which are:

* Using a VPC can help manage smart home devices within a more controlled network environment while having a secure local network for an added layer of security.
* It can also manage computing resources, for example, when the Green Family may not be in the house, they can remotely control the energy consumption through significantly reducing the bandwidth consumed by networking devices.
* As an added implementation, device isolation can be considered by creating isolated segments for devices on different floors in our architecture, thereby improving the security posture of the Green Family network architecture.

**Storage**

**->Amazon S3:**

Amazon Simple Storage Service, Amazon S3, serves as scalable storage solution provided by AWS. The primary purpose of Amazon S3 is to allow organisations, individuals & etc. to store and retrieve any scale of data over the internet.

Amazon S3 is incorporated with measures of security; Access-Control (ACLs), Ser-side encryption & more. These security measures ensure that the data of the user’s is kept confidential and blocks unauthorised access.

With the aid of Amazon S3 we can manage.

* Internet of Things (IoT):
  + Using Amazon S3 we can store and manage the data generate by IoT devices. With the data we can identify potential equipment failures.
* Security Camera Data:
  + The data of cameras, as shown in our Cisco Packet Tracer, can be stored in Amazon S3. Storing camera recording data in Amazon S3 ensures that the data is secure and can be accessed by different devices in the house.
* Centralized storage:
  + With data being stored in Amazon S3, which is accessible over the internet. This allows individuals to access their files from anywhere. This allows for convenient sharing of documents within the individuals of access to Amazon S3 of the household.

**Security:**

**-> AWS IAM:**

Amazon Identity Access Management (IAM) is a web service provided by AWS that helps you securely control access to AWS resources. IAM enables you to manage users, groups, and roles within your AWS environment, allowing you to choose who can do what etc.

IAM can benefit the use of Amazon S3 by:

* Defining detailed access control policies:
  + We can specify which users or groups have read, write, or delete permissions on specific S3 storages. This can help to properly define user permissions.
* Creating and managing users and groups:
  + In the household, multiple individuals may need to access Amazon S3, so organizing users into groups and apply policies to entire groups can help to simplify access management.
* Auditing trail:
  + IAM has the capability to check detailed loggings. This allows users to track any changes made, identify any potential security threats, and maintain accountability.

**-> Amazon Cognito:**

Amazon Cognito is AWS service managing user identity and access control in mobile and web applications by allowing the user admin to authentication, authorisation, and user management, in this context the Green Family's Amazon S3.

Amazon S3 bolster Amazon S3’s security through:

1. Multi- factor authentication (MFA):

* MFA adds an extra security layer by having users to sign- in through w devices or methods to verify their identity, thereby meeting the robust security aspect. This choice can work in tandem with the above stated AWS IAM (which stated earlier that AWS S3 would benefit from AWS IAM, while the Green family using the Amazon S3 for file storage and sharing purposes through shared usage of account(s).)

1. Security Features:

* They use best security practices, such as data encryption in states of rest and transit using well known protocols like Open Authentication 2.0 (OAuth 2.0) and OpenID Connect (OIDC) for secure authorisation and authentication.

1. Cognito Sync:

* User data and preferences synchronisation across devices for seamless and consistent user experience on devices

1. Customisable UI and workflow:

* Customised look and aesthetics of login GUI. While providing default GUI defaults for common authentication which makes it suitable for the Green family.

**Sustainability Proposal (10%)**

## Student A: Shubham

* Proposal of practical solutions that **enhance** energy efficiency and **minimize** environmental impact.
* Ensure that network devices are incorporated with Energy Efficient Ethernet (EEE). EEE automatically adjusts power consumption without compromising designed for energy efficiency.
* Have a higher user density of devices in the house.
  + Higher user density enables more efficient utilization of the resources.
  + Rather than having a low-density network, high density network leads to better optimization of the available resources.
  + Hence, there would be reduced redundant infrastructure, and the overall energy usage would be minimised (no need of maintaining separate network)
* Use Wi-Fi extenders instead of multiple routers as a result, there would be lesser energy consumption as having multiple routers have to actively transmit signals. However, Wi-Fi extenders can result in reduced network speeds as they create a separate network. Hence, we opted for mesh routers.
* Using Network Virtualization to minimise environmental impact and make an efficient home network architecture.
  + As you create virtual instances such as virtual routers to create logical divisions, enhance security, etc. virtualization reduces hardware footprint as the need of redundant hardware is minimized this leads to a better
  + The consolidation of routers and other network devices into network virtualization has allowed for the reduction of network devices. This leads to energy efficiency.
* Recycle old equipment responsibly.
  + When upgrading to newer network devices, responsibly recycling old devices allows some manufactures to collect and recycle electronic waste. This minimizes the environmental impact.
* Configure wireless network’s Wi-Fi settings to optimize performance.
  + With the necessary configuration in the Wi-Fi settings, optimal wi-fi channel would be picked, transmit power would be adjusted and only the necessary network devices would be connected. This would lead to enhancing energy efficiency.
* Using Dynamic Routing Protocols
  + Dynamic Routing Protocols adapt to changes in the network according to the traffic patterns. As a result, network efficiency is improved due to reduction of unnecessary data transmission and energy efficiency is enhanced.

## Student B: Tevian

**My first proposal will be to make usage of Energy-Efficient Network Switches instead of regular switches.**

-> Upgrade to newer ones that have advanced power saving features, these types of switches can dynamically adjust their power consumption based on the current demand of the network. Where the traditional switches that are in many homes use up a certain amount of power no matter of the network activity in the house.

Here are some benefits for this proposal.

1. It is cost-saving, with lesser power consumption comes lower electricity bills leading to cost savings.
2. While using switches like these, it is better for the environment. Using less power means it is reducing carbon footprint which is the amount of Greenhouse Gases (GHG) being produced.
3. By adjusting power usage to when its needed and not too much when it is not, overall, the network will run more smoothly and efficient.

**My second proposal will be to have a low-energy Entertainment centre.**

-> This involves using energy-efficient devices, like smart TVs with low power consumption, and integrating smart power strips. Smart power strips turn off electricity automatically when not needed. For example, when your TV is turned off, this power strip switches off power to external devices connected to the TV like game consoles, home theatre components, so on and so forth.

Here are some of the benefits to this proposal:

1. The smart power strips prevent the energy used by cutting off power to any devices in standby mode, reducing the power consumption thus saving costs.
2. By minimizing standby power and optimizing usage, we can increase the lifespan of these entertainment devices, reducing electronic waste.
3. By using smart TVs and other energy saving devices, it helps the entertainment system to be more efficient.

Thus, by implementing these proposals I have given, more energy can be saved and there will be lesser impact on the environment.

## Student C: Xin Yu

The first proposal for green strategies is have automatic timers for AC units and devices within the architecture to reduce unnecessary power consumption.

* Because the house has AC units to optimise device utilisation, the group recognised that it may not be attaining the green energy strategies.
* For energy saving purposes, to meet the green energy goal in mind, we have set automatic timers to the air conditioners in the house to power down when the green family will not be in the house.
* To even improve the level of supervision on the power consumption of the IoT devices, we have proposed the Green family to be able to have remote monitoring and controlling of IoT devices even if the Green family away from home

Another green strategy is implementing solar panels on the roof.

* We implemented a solar panel on the roof of the house for renewable energy.
* However, given the physical space limitations, we are constrained to implement one panel; to compensate for this limitation, the group chose to install a huge, high- quality panel. We also saw there is extra space in the house.
* The reason, after much research, qualities we are finding in a solar panel would be build, durability and cost, which contributes to potentially 20 –25% of the Green family's energy needs, which is dependent on finding a solar panel­­

Thirdly, networking devices (for e.g., switch and routers) we upgraded them to be Energy Star certified.

* To further hit our green energy strategy goal, we have upgraded networking devices to be Energy Star certified, ensuring consuming less energy while meeting the networking needs of consumers, in this case, the Green family.
* The benefits are namely, both achieving the goal of energy saving and at the same time, the Green Family can have more economical savings in the long run.

***Student D: Yi Jie***

In terms of enhancing energy efficiency, a solution would be to implement edge computing for smart devices.

* Edge computing is simply moving parts of storage and compute resources out of the data centre and closer to the source of the data itself. Instead of having to send all the data to a distant cloud server, it is possible to process the data in the device itself.
* Since the data does not have to travel far, the device would be able to get a quicker response and reduces the amount of data that needs to be sent to the cloud, hence saving bandwidth.
* For example, imagine having a smart device like a security camera. Usually, when the camera senses something moving, it will register that information and send that to the cloud. The cloud will then process the information and then send back the analysis results to the security camera. However, in an edge computing setup, the security camera has a processor in the device itself to process the data at the edge of the network. This allows the camera to analyse the footage in real time and immediately act if anything happens, instead of waiting for data to be sent to a cloud server.

Another solution that comes into mind would be low-power IoT protocols.

* Low-power IoT protocols are communication standards for IoT devices with poor power constraints. The protocols are used to minimize energy consumption from the devices which can increase its battery life.
* By reducing energy consumption, devices can operate on a longer duration and hence this means there will be lesser battery replacements. This can help to reduce environmental impact as there will be a lesser production, distribution and disposal of batteries.
* An example of implementing low-power IoT protocols would be Zigbee. Zigbee is a wireless communication standard that is used in IoT applications. It is an excellent alternative to Wi-Fi and Bluetooth for some applications including low-powered devices that don't require a lot of bandwidth. It operates on low power, making suitable for battery-operated devices.

# Appendix & References (if needed):

* <https://www.techtarget.com/searchdatacenter/definition/edge-computing>
* <https://www.pocket-lint.com/what-is-zigbee-and-why-is-it-important-for-your-smart-home/>
* <https://www.forbes.com/sites/forbes-personal-shopper/article/best-solar-panels/?sh=7b64e9c224eb>
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* <https://aws.amazon.com/cognito/?nc2=type_a>