CREATING REAL LIFE SMART ENVIRONMENTS USING PACKET TRACER

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Approval sheet of the Thesis

This is to certify that we have read this thesis entitled **“**CREATING REAL LIFE SMART ENVIRONMENTS USING PACKET TRACER**”** and that in our opinion it is fully adequate, in scope and quality, as a thesis for the degree of Master of Science.

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I hereby declare that all information in this document has been obtained and presented in accordance with academic rules and ethical conduct. I also declare that, as required by these rules and conduct, I have fully cited and referenced all material and results that are not original to this work.

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ABSTRACT

CREATING REAL LIFE SMART ENVIRONMENTS USING PACKET TRACER

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The aim of comitting to this thesis is to develop the technology used in our everyday life and “smarten every environment our daily activities are carried on. This is all achieved from simulating these technologies while using a tool called Packet Tracer. A main goal is also to spread information regarding the Internet of Things and how this field can have the attention of different studies and its benefits.The thesis includes many simulations that imitate three real world environments : Home, Work and UNI where we have a lot of configurations and parameters included that make the simulation as close to the real world imitation as possible. The simulations carry a lot of technological aspects which may serve as future work such as networking, IoT devices, scheme components, programming and many more which compose this thesis

After the completion of all the simulations, every step was documented and all the results were displayed in the corresponding section in order for them to prove the success of both the experiments and the thesis. Future studies are also included for the readers who will direct their studies in this technological field and expand the information..

Keywords: Internet of Things, Smart Environment, Simulation, Experiment, Packet Tracer Tool

ABSTRAKT

KRIJIMI I MJEDISEVE "TË ZGJUARA" NË JETËN E PËRDITSHME DUKE PËRDORUR MJETIN "CISCO PACKET TRACER"

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Udhëheqësi: Dr. Julian Hoxha

Qëllimi i kësaj teze është të zhvillojë teknologjinë e përdorur në jetën tonë të përditshme dhe të "zgjuarsoj" çdo mjedis, aktivitet tonë të përditshë që kryejmë. E gjithë kjo arrihet duke simuluar këto teknologji teksa përdorim një mjet të quajtur Packet Tracer. Një qëllim kryesor është gjithashtu përhapja e informacionit në lidhje me Internetin e Gjërave dhe sesi kjo fushë mund të ketë vëmendjen e studimeve të ndryshme dhe përfitimet e saj. Teza përfshin shumë simulime që imitojnë tre mjedise të botës reale: Shtëpi, Punë dhe UNI ku kemi shumë të konfigurimeve dhe parametrave të përfshirë që e bëjnë simulimin sa më afër imitimit të botës reale. Simulimet mbartin shumë aspekte teknologjike të cilat mund të shërbejnë si punë e ardhshme siç janë rrjetëzimi, pajisjet IoT, komponentët e skemës, programimi dhe shumë më tepër që përbëjnë këtë tezë. Pas përfundimit të të gjitha simulimeve, çdo hap u dokumentua dhe të gjitha rezultatet u shfaqën në pjesën përkatëse në mënyrë që ata të dëshmonin suksesin e eksperimenteve dhe tezës. Studimet e ardhshme përfshihen gjithashtu për lexuesit të cilët do të drejtojnë studimet e tyre në këtë fushë teknologjike dhe do të zgjerojnë informacionin.

Fjalë Kyçe: Interneti i Gjërave, Mjedis i Zgjuar, Simulim, Eksperiment, Mjeti Packet Tracer

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Last but not least I would like to thank my family who made the pursuing of my studies available and which have filled me with unconditional support and love since my birth, and to whom I owe every success in this life.

PURPOSE AND OBJECTIVES

The goal of dedicating to this thesis is to develop the technology used in our everyday life and “smarten every environment our daily activities are carried on. This is all achieved from simulating these technologies while using a tool called Packet Tracer. A main goal is also to spread information regarding the Internet of Things and how this field can have the attention of different studies and its benefits.

This project required for a lot of knowledge, information and independent studies to be carried, while both the theoretical and practical part of it are included and perfected to details, for it to be as clear as possible to the reader.

The thesis OBJECTIVE is to include simulations that imitate three real world environments : Home, Work and UNI where we have a lot of configurations and parameters included that make the simulation as close to the real world imitation as possible. The simulations carry a lot of technological aspects which may serve as future work such as networking, IoT devices, scheme components, programming and many more which compose this thesis .

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CHAPTER 1

INTRODUCTION

There are two very common terms regarding to a system which gives the possibility for every device to be connected to each other and those are IoT and IoE (Internet of Everything). Internet is what keeps these devices updated and therefore preserves all their data in its cloud. This grid as it may me explained has exposed an infinite number of possibilities in which it can impact our daily life and better it, so the industry is head first on being the mastermind behind all the innovations leading to it.

Internet of Things is not a term recently created, as it has come with the concept and the creation of Internet itself, that is why it is very popular among us. Nevertheless, a brief introductory explanation will be done for IoT in this thesis, continued by its current usage and in the end a simulation and experimentation session. [1]

The aim that was set in order to build the most efficient thesis, in my opinion is the inavoidable combination of a clear and well presented analytical part with a close to perfect excecution of the practical experiments and simulation. This combination not only is clear to the qualified individuals, but through the experiments and simulations ,it is easy for technological field “amateurs” to understand the wide variety of IoT usage as in the simulator, the components, the network and all the tech equipments that are connected in a large grid of data where information interacts and they act as a body.

Since the topic I chose to present regards networking and simulations done to present it, the best tool to give the most accurate result and easy to use is the CPT (Cisco Packet Tracer). Since the main goal of this project is to create the realest network we can in a simulator where every device and equipment can interact with each other and all the data travel through the grid, it is the tool to be used . What is even more helpful is the fact that the CPT integrates all of the IoT components in its program (sensors, circuit and smart components, tech equipments) needed to complete our concept while their programming and way of usage is in your will. All the reasons above is why I chose CPT to be my working environment. [1]

As the aim of my thesis and project is to be addressed to a greater audience with a narrower point of view regarding the field of study, I thought that preparing and establishing different scenarios regarding the Packet Tracer Environment would be clearer and easier to understand. A brief introduction to every tool used in the Packet Tracer (especially those connected to the IoT devices) will be made so that the information is passed on correctly.

The packet tracer components include : switches, routers (wireless or not), Iot devices (sensors and smart components) and the cloud which backs all the data while the program itself creates the grid or the network for all these very important pieces of the puzzle. Although the environment is made possible by the tool (the integration of all the components) the logical implementation and the programming is for the user to be put in so that the simulations are accurate. It is also necessary to say that for the most realistic experience in the environment, the possibility of creating the network using microcontrollers and cables is also provided, but in this case the smart devices tended to be presented in my thesis can not be used so this approach will only be mentioned.

As for the methodology of my thesis, I have chosen a practical typical thesis containing simulations, experiments, results and feedbacks.

In order for me to start this thesis, a consultation about all the knowledge needed to fulfill the goals set and finish the project. It is to be mentioned that the concept of IoT, although briefly introduced to us in our courses is a new concept that definitely needed a detailed background check. Furthermore working with Cisco Packet Tracer is a skill obtained in courses and trainings in non curriculum activities, while being able to program components such as sensors and structure the network is a field where help was needed in order to reach the most accurate result. [1]

Developing of all the experiments using CPT Packet Tracer was our mean of reaching our goals. In order for us to learn the functioning of the CPT and the usage of its different components (but most important, Internet of Things devices) professional guidance was needed. Through these information, I was able to realise the full potential of the Packet Tracer tool and the shortcuts of using it and implementing IoT devices.

After clarifying my goals and obtaining all the informations needed , the next logical step for me to do is the preparation of the experiments and simulations which begins with the creation of the IoT integrated network. It is important to be mentioned that every step carried is to be documented and presented to make things crystal clear.

There are four simulations to be run in the Cisco Packet Tracer impersonating three real-world environments. The goal of the first two simulation would be to implement the idea of a Smart Home while the others would be useful ideas to implement in Smart Work Environment and Smart Uni.

Firstly, the concept of a Smart Home is not an unknown thing regarding technological innovations but making it a public and mainstream necessity has not been a success. The simulations in this case will have all the smart components and equipments which are connected and exchange information on many of real life events (temperature, humidity, alarm sensor, lights and many more). [1]

The concepts of the Smart Uni and the Smart Work Environment are similar to the concept of Smart Home and the same type of smart components and sensors will be used even in the simulation of them. A thing that differs is that we will experiment with the energy source in each environment (solar panels or energy produced by devices) which also needs to be accompanied with all the energy flowing and utilization schemes.

The final parts of my thesis include the conclusions which in these case derives to the way simulations can help create great and very helpful things in the future such is the Smart Environment idea and many others.

The thesis is organized in a few section with main ones including : an introductory chapter to the Internet of things and its usage, CPT Packet Tracer (the program needed to make it happen), the procedures completed and their explanation and finally the results derived from all these simulations.

CHAPTER 2

INTERNET OF THINGS

In this section, there will be an introduction to the IoT and the concepts regarding it. Furthermore we will also have a chapter dedicated to the tool used (CPT Packet Tracer)

2.1 Background and history of IoT

With the popularity of smart devices and the technological innovations taking over our civilization, it has been reported that the number of (IoT) Internet connected devices has surpassed 25 billion , a number incomparable even to the human population.

A term who is nowadays commonly used but its origin remains a bit of a mystery is the “cloud” concept. In other words, this term is used to describe a shared environment where different devices interact and communicate and it started around 1960. What this concept had in mind was the creation on a “network” where individuals had no power over computing while different services would be provided and different devices of the wide range of “average” user would connect. [1]

In the 1961, John McCharty, a scientist with vast knowledge regarding computers and innovative thinking proposed the public computer centers connected to each other or the “Computer Public Utility”. This concept was to be based on the concept of the public telephone cabins found everywhere and connected as a grid or network. [4]

The concept proposed by John McCharty was also supported and enforced by another specialist of the field by the name of Leonard Kleinrock. Being in charge of Advanced Researches Dep which requires a mastermind, he was able to foresee the spread of these computer public utilities while another collegue J.C.R Licklider predicted that the cloud (network) connecting the computers would be globally spread for people to exchange information and use programs.

As for the modern days , this term has had a different approach and is related to a far more technology. In the nineties, the term was commonly used by both the industry and the specialists of the field to describe a layer which made it possible to preserve and present data to a vast range of public networks and devices.

One of the most memorable achievement regarding the “Cloud” was in 1999 when a company by the domain SaleForce offered the companies software displayed by website. This was a historic event regarding the future of network and its benefits were finally displayed to the whole World.

Another huge accomplishment worth mentioning, since its CEO recently became the richest man in the world and that is not out of the blue, is in 2002 when AMAZON had a service provider known as AWS (or the Web Service) where data storage, computing and many other services were massively provided to the larger audience.

Since then, the cloud computing has evolved into unthinkable realities, where cloud computing services offered have become a random thing (ECC by Amazon and Google created their own engines deriving it into what it is today). Cloud computing itself could not have progressed as much as it has without many other technological innovations interacting with it such as : the innovative visualization field of tech, the creation of networks that support high speeds, a large quantity of data, the low costs surrounding CPUs, cloud processing and the security of data. They are all crucial factors so they are all mentioned in my thesis. [1]

2.2 IoT Definition

The previously mentioned cloud computing is a concept which eventhough had been talked about for a while gained a well known approval and recognition of its importance after a very well written and presented article by the US Technological Department (NIST) in 2011.

There it was mentioned that this soon to be popular term known as “cloud computing” was a very convinient model of sharing the information or having an interaction by giving access to every technological device to a computing pool configuration full of resources to be shared. The cloud computing was now not only a concept, but a soon to be composed by its characteristics, models and deployement.

Another way to say it is that the cloud offered access of resources anywhere and everywhere in the world, all that with minimal effort. Although access was offered, ground rules were put to regulate its functioning such as scalable resources, management requirements and many others.

Iot or Cloud computing characteristics are : self-service provided directly (no delays) in the asking time, a widely spread connection of devices (network) access, the pooling (sharing) of the available resources and services that are pretty scalable and low cost.

As far as the models of the Internet of Things, there are three of them and each one’s importance is immeasurable : Software providing service, Infrastructure providing service and the Platform one.

In the end it is safe to say that there are four ways for a cloud computing model to be deployed and those are; publicly, privately, community ones and last but not least hybrid ones.

2.2.1. Cloud Computing Characteristics

The on demand characteristic means providing self-service directly(no delays) in the asking time to the resources made available withour no intervention whatsoever by humans. This is all made possible by portals which were created to share the resources between visitors (storage data, network entrance, software). This characteristic of a cloud computing environment enforces the idea of it being a service provider. [1]

The widely spread network access is another main characteristic that represents the cloud computing as it relates to users being able to access the network in any location at any time using IoT devices. Devices such as smartphones, PCs, laptops are all able to access the grid eventhough their internet protocols are far from similar. The access given is so broad that ground rules and requirements were put to regulate.

Resource pooling or sharing of the available sources refers to stratigically managing resources so they can be used in the most efficient way considering the demand for these services. These pools are revelead to the day to day user in order for him to gain access and be transparent but the location of what is known as cloud service is not provided. We previously mentioned that the evolution of the visualization industry has had a huge impact in the innovation of the cloud computing because it has now alloweda large number of cusomers using just one shared infrastructure. This is also referred to as multitenancy. Eventhough the sharing of the resources continues, the users are not aware of it in terms of interruption as any resource used by him is isolated.

Allocating resources is one of the most important things that characterize cloud computing (elasticity).The resources are retrackted and released at any moment for the user to exploit them while all is done automatically. Another thing worth mentioning is the scaling of the resources in order for (storage,network) to be shared and be available to any possible customer.

Another important characteristic is the fact that cloud computing was created to be measurable in the service that you are getting or the resources you have been exploiting. This happens for billing (users are charged the ammount of resource they use), in order to monitor data usage and so on. This is a very important characteristics helping cloud computing services.

Another concept about cloud computing which has gained a large ammount of popularity over the recent years is resilience. It translates into justifying the cloud using and exploiting itself against the pre erranged conditions of the systems.

In other words it can refer to the service of cloud computing failing to be deliveredand being ridistributed into another pool(sharing) of resources in different places. The mechanisms that debug the errors and detect whether a failure is about to occur are pretty efficient so the service is almost never interrupted.

2.2.2 Service Models

The cloud computing runs based on several service models which in themselves represent the type of service they are provided or the resources (instructions included) offered by the cloud computing industry. Each of them provides the user with a different configuration based on their needs and all of them are of a specific field and pre instruction loaded.

The Service of Infrastructure provided by cloud computing or IaaS is the cloud environment where every day to day user of IoT devices is granted an isolated tech environment containing different resources and applications which are maintained and administered. Eventhough this environment is mostly composed by physical components and services such as networks, storage, processing and run by the cloud consumers in contrary to all the other models offering operating systems. Directional advices and pre loaded instructions in the environment are offered to the customer in order to make his experience easier and more likeable. [4] Another common thing is that the cloud computing providers (large multinational companies) offer the same service to smaller ones (cloud infrastructure to be used) in order for them to integrate their own services. Having control over the environment the user is working is this model's most important asset but not owning the IT resources makes it easy for him to be the administer of it. Previous examples included cloud computing environments and engines created by Amazon and Google.

Another very important service model provided by Cloud Computing is the platform model which presents the user with a pre-built environment that matches his requirements in order for him to implement his own services and applications. Contrary to the Infrastructure model, the sources here have to be fully prepared and provided to the customer. These models are oftenly accompanied by tool kits that allow custimizations and the development of applications to the user's will. Eventhough the customer can customize the infrastructure based on the service he provides or the applications he wants to develop, this model is characterized by a lack of customer's responsibility regarding the infrastructure administration (resources also) as the pre built environment is not that customizable regarding certain aspects. Models led by companies like Google, Apache and Windows lead the path in the development of these Platforms.

The last but not least service model worth mentioning is the Software model. As you expect, this model offers the combination of the neccessities the other models do not offer due to their purpose. Here the user enters a fully loaded, pre-prepared cloud computing environment which is available at any given time and location and the user is "just a passenger".This service can be both free or containing a fee which goes to the company granting the service.Free of charge service is provided on the basis that the advertisement information of the users is passed to the company for future use involving a term known as big data analytics. The most known examples of companies providing this service are : Microsoft Office and Google Apps.

Eventhough there are currently only three types of major service models, with the evolution of the cloud computing through these years , many other services are provided by innovative companied such as : Storing information and Data, Testing, Processing and many more. Also, a new phenomenon that is gaining success in the technological field is the combination of two or more service model in order for the end user to have the most complete package possible (with a combination of Infrastructure and Platform).

2.2.3 Deployment Models

One of the foundation of the IoT and Cloud Computing concept which in themselves are used to describe the ownership of the cloud environment and contains innformation on the users able to gain access to it. As it was mentioned before, we are dealing with four types of cloud deployment models : public, private, community and hybrid ones and we will talk about each one's characteristics and funcionalities.

Firstly, I would like to start with the private infrastructure cloud. By the name of it, it is immediately understood that this infrastructure belongs only to a specific company/organization which owns its access rights. This cloud may be locally connected on well sustained by another provider. This private type of an environment has come as a need of many different organizations to centralize their cloud computing environment and IT resources connected to it or offer services to solutions related to the field of IoT. In this case we can easily say that we are dealing with a middle man, as the cloud consumer is also the cloud provider to the end user and in need to complete their mission they are assigned specific roles. These type of deployment models (private models) are ones that require a far larger budget than normal due to the costs of physical components and devices doing the computing and making sure they are accessible allocatelly. [10]

On the other hand we have the opposite cloud deployment model to what was mentioned above or what is known as public cloud. These cloud environments are creted with the goal to be easily accessible to every IoT device and end user trying to access it but similar to private cloud they are also managed by a different party. They are generally free of charge and tend to attract the general audience. Although the benefit of easily these publicly spread clouds and most of the time free of charge, a major downside(concern) regarding their utilization is the security of the end user's devices. This comes as a result of many untrusted devices gaining access and making the cloud vulnerable by launching attacks.

Community model, although similar to the public one not only by its name but also its functionalities differs from it by the number of consumers that have access to it as it belongs specifically to an organization that have a joint goal and shared need. As in the case of the other deployment models, they are also owned by a third party but it can also be one of them(the community). Trying to get access while not being a part of the organization/community is nearly impossible.

For the final deployment model, we have the Hybrid one which is the latest innovation and probably one of the most efficient ones. This model comes as a result of two other models combined, a neccessity in our technological times. I say that confidently because we are now dealing with communities that need clouds to both support the public audience while also having to implement the private cloud for certain users to protect them and their data. The hybrid model is the environment that joins all the users together while being managed by third parties.

2.3 IoT Networking

In the past section of the thesis, it was mentioned that the cloud has its own characteristics, service and deployment but when the network is mentioned, we can not say it is its characteristic but what enables cloud computing in the Internet of Things. Network in the modern era being characterized by its wide range, its incredible high speed, the reliability and the security it offers while maintaining unbelieveably low costs is what has affected the spread of the technology especially cloud computing and IoT.

Historically there have been many types of networks enabling the IoT devices to interact with each other. Some honorable mentions include : Bluetoth, WAN (Wireless Local Area Network) and the newest invention LPWAN (a network that is characterized by its low power usage). Eventhough different networks have different goals and purposes, some have gone to extents to dominate the technological field and offer the latest innovations.

The technologies that are dominating the network aspect of the technology are Bluetooth and WLAN and it can be easily derived to this conclusion by the spread of these technologies in the general audience and consumers. What they have in common is the usage of the radio frequency bandwidth but in contrary to radio transimission the transfer rate is ensured to be pleasant and the technology is on the cheaper side. The only limitation or downside to these technologies is that the range of transmission is limited to a handful which makes them unsuitable for applications dependent on long ranges. The range of WLAN is up to 50m at its most while as for bluetooth is does not surpass 10 meters.

Relying on the fact that cellular coverage and so on are not at its best and there are room for improvements, the industry has turned to the usage of WLAN to cover these inaccessible areas. A version which has the same function but is fare more efficient regarding battery life of the devices is LPWLAN. The power consumption is a real concern regarding every device owner and elecriticy producer and that is why the influence of the LPWLAN is starting to reach new heights.

What makes them even more special is their ability to combine an admirable communication rate, long reach of usage with the low battery consumption made possible by sensors and structure.There are a few LPWLAN technologies I would like to mention starting with LoRaWAN, Narrowband IoT and SigFox.

2.3.1 LoRaWAN Technology

The LoRaWAN technology is an infrastructure created by the company it was named after LoRa to provide the infrastructure needed for the devices to be connected. Its characteristic is that there is a single hop receiver which has the functionality of connecting to these devices and simultaneously redirects the information using traditional IP to the physical servers.

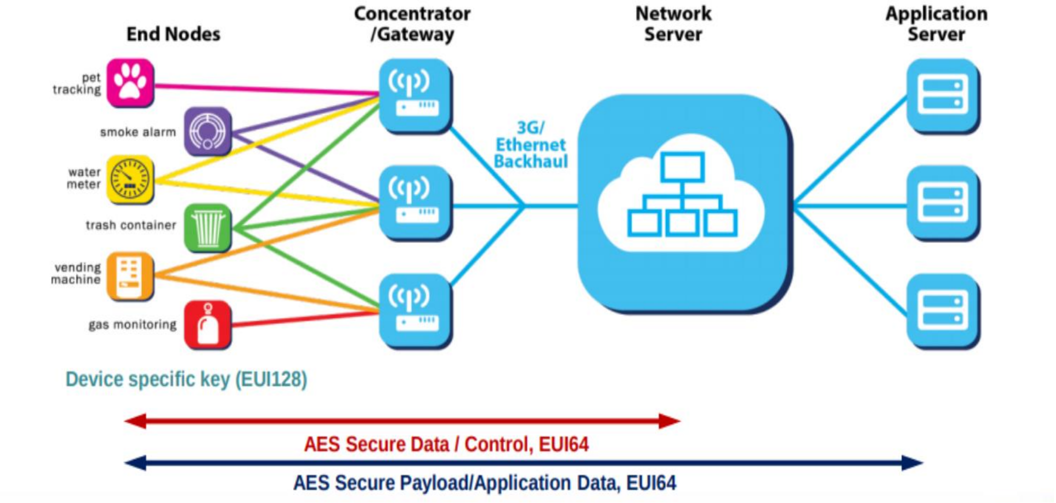


Figure 1. LoRaWAN Infrastructure

This technology makes it possible for the connectivity to be bidirectional with a very satisfying bitrate that varies from 0.25 to 52 kbps and a range that extendes to many kilometres. The traffic prefered by the infrastructure itself is the uplink one (eventhough we just mentioned the connection going both ways).

In order for the infrastructure to work as it was built, the devices that do the transmission of the information are classified in three classes A,B and C. This seperation occurs on the basis of the power needed and the device’s throughput.

The first or the A class contains devices that tend to run on low power and have a neccessity in communicating bi-directionaly to the receiver. Also a common thing about the devices in the A class is the fact that they run based upon a specific type of protocol named ALOHA. The bidirectional transmission of the information means that both up\downlink should be communicating but not synchronizing as when the uplink channel is receiving the information, the response will come in 2 downlink timelapses. Once all this process has been completed, the downlink channel traffic proccedes.When we are dealing with a period that no communication is occuring, the benefit of this technology kicks in, allowing the infrastructure to be on low power mode and consequently save battery life and energy consumption.

The second class or the B class includes devices which are structured to be a part of applications that need a second downlink.Contrary to the first architecture, periodical messages are sent in order for the second downlink to be active and not wait a successful response from the uplink channel. This is also its main drawback as sending these frequent messages takes a lot of energy consumption and lowers the battery life.

The final class is the C class which in contrary to the other classes, is always ready and waiting for downlink information to pass through. What characterizes this class is its ability to provide low-latency information exchange while the gateway controls it and always transmits information. As for the battery consumption reduction, the infrastructure and the purpose of the class C makes it impossible to achieve but the switch between classes (C to A) ensures it.

The downlink response time and the duty-cycles that characterize the LoRaWAN infrastructure is what contribute to its weakest links and costly disadvantages. There are also limitations on the traffic which adds to the dislike of LoRaWAN making it more complex and difficult for devices to connect.

2.3.2 SigFox Architecture

The SigFox architecture is a Low-Power WAN created by a french company after which it was named and was its solution to the cellular networks.

As in the LoRaWAN structure, this is also concepted to connect the device to the GW(gateway) by single-hoping while the telecommunication structure (SNO) offered what the devices need, the network coverage. The gateways in this infrastructures tend to be placed in the cellular towers.

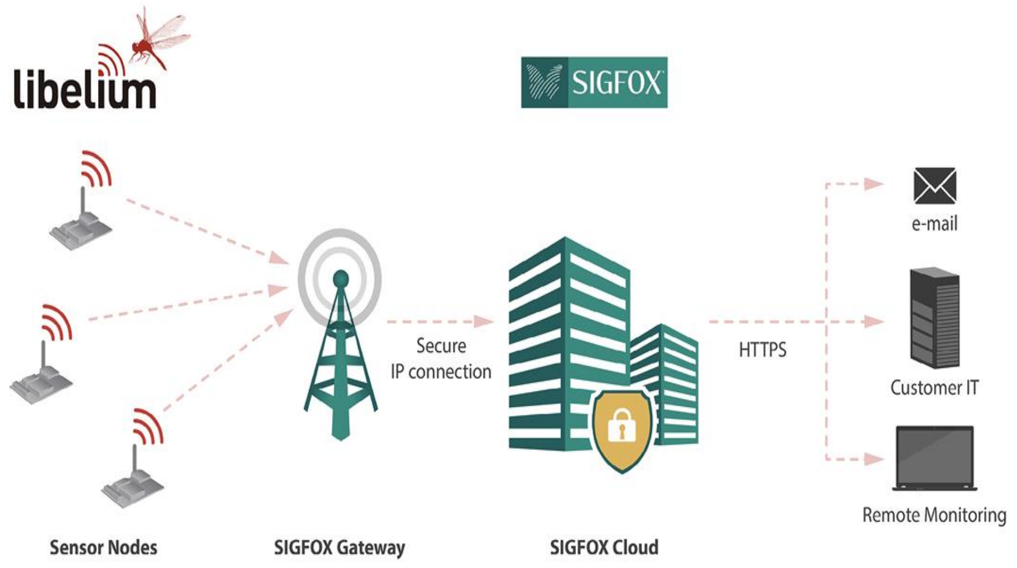


Figure 2. SigFox Infrastructure

The SigFox Infrastructure functions based on radio frequencies and consequently on different bandwidths in different countries, for example 870 MHz in Europe,916 MHz in the US etc. Its ability to pass the signal through anything in the path of it (even solid objects) comes as a result of the UNB (Ultra Narrow Band). As a consequence the range of transmission is one of the heighest with kilometers achieved and it also helps the transmitting devices to run the electricity more efficiently and preserve battery life.

Although there is no standard and no requirement for the LPWAN technologies power consumption and battery life expectation, an interesting fact claimed by the developers is that 2 AA batteries should be sufficient enough for the SigFox device to achieve a 10 year span of work.

SigFox architecture makes it able for the devices connected to it to reach a transmission of up to 150 packet per day. Each one of these packets should be at maximum 12Bytes while a limit of 100 bps is the most throughput the uplink channel can sustain while wirelessly transmitted.

The type of environment plays a huge role in the range of transmission because as we have seen before with similar infrastructures, open spaces reach ranges up to 100km while urban areas a maximum of a kilometre. Similar to the LoRaWAN technology, SifgFox is also limited on its data throughput.

2.2.3 Narrowband-IoT Technology

Regarding the Narrowband technology, it is a LPWAN infrastructure which is characterized consequently by a very strict power optimization in order to reach maximum energy consumption efficiency, a bidirectional flow of information containing both up\downlink and having as little costs as possible while providing great service.

Similar to the SigFox Infrastructure, we are also dealing with a technology that merges into cellular networks and the frequencies used while also tending to manipulate the 4G layer (LTE) to serve its purpose of reducing hardware complexity.

This technology's latest upgrade is currently under development, so its specifications still remain unknown to the general audience. Speculations have been made that both channels (up/down) will surfe on a 250kbps bandwidth while having an UNS of 190 KHz. All this is accompanied with a latency not so great of 1.5 to 11 seconds. If you thought that the lifetime of SigFox architecture dependant on 2 AA batteries was unimaginable, the Narrowband technology even surpasses it making it the longest lasting of the three.

This technology is so innovative and its impotance is so noticeable that major cellular companies have offered to inegrate it into their ecosystem and profit from its benefits.

2.4 Challenges for IoT

Working with the IoT technology and trying to integrate them to real life conditions does not come with a few challenges presented along the path. There are a lot of them, but the three most important will be discussed about today.

2.4.1 Interconnection and implementing standards

The standard in which the creation and functioning of the IoT is totally based on is the separation of the network into many layers : application, physical etc that in themselves are vital in their role to support every task performed. The process known as standardization or the standard developments into the IoT technology is nowadays a widely spread concept , with a direct role in the creation of smart environments and at the center of technological focus regarding their development.

Interconnection/operability is another concept that tends to explain the exchange of the information and the constant communication between several devices or machines. The networking and the IoT concepts would not even exist if the interconnection was not possible, while usage in smart environment creation is as important as their existence. To achieve this interoperability between IoT devices and techs, platforms have been created to assure it being secure, reliable, as fast as possible and scalable to the point where many users can share the resources and tools.

These platforms is important to say that are characterized by the protocols regulating every aspect of it, but mainly transport and encoding ones, to make the link up reliable. Example of these platforms are the OPC Arch while embedded controllers are an example of a device which used these standards and protocols to achieve the interconnection. The tasks performed in this example are very simple such as deriving notifications in case of a security breach or threat, managing the authorization of the users process while also letting them be responsible for all the server and connection integrity by giving them a managerial role.

The field where these concept have come to life and thrived are automations and although in different smart environments, standardization will not be as complex or as advanced as in others there are still plenty of options to be worked on.

Here the best example is the Smart Home and Smart Work Environment automations which differ a lot in terms of complexity and standards they are automated on. Bear in mind that the implementation of standards in these technologies is not always as easy as it sounds, and eventhough fast developing sometimes they become an obstacle due to its limitations. These are all the reasons that threaten the interconnection and makes implementing standards a focus point.

2.4.2 The personalization and adaptation of this technology

There is a trend going on regarding the technological evolution and the IoT based field is also one that is going to be affected by it and that is resource Personalization. Having personalized resources regarding networking and the components of it integrated into the smart environments is a must nowadays and it comes with a few challenges of its own.

Firstly I would certainly like to address the transparency and the beforehand mention challenge of interconnection as the main concerns of a personalization. Then it is easy to understand that in case of an interconnection between networks and components in an open environment, the challenges become clear as everything operates well in isolation while connectivity and adaption is a necessity in the first scenario. Cloud computing is also a case in which the concept of personalization is implemented and has presented a few challenges.

An aspect which is to be carefully addressed is the algorithmic processing of information in order for the user to be given different point of views or solutions to a problem faced and their adaption into these type of environments. A common example regarding this problem is the connection between actuators and smart components such as sensors and for that to be replicated in the real life conditions. Large acceptance of the new innovations entering the large user markets and the usage of them in very long time spans guarantees the best results and performance due to regular updates and so on, but they also need to be useful and technologies easy to be implemented in the day-to-day life of the users.

This also comes as a must for the concept and implementation of the smart environments, which need to be regularly updated, innovated and have guaranteed performance with minimal effort regardless time and location. Having real time information brought in is what motivates these sort of creations, while surpassing the input values desired by the users can lead to a certain course of action planned beforehand. This is the reason that these are called smart environments and components, on the way they gather all the information needed to create a pattern identical to the human behavior.

All these thing are achieved through several algorithms implemented through the programming of the components, which react to change in no time and carry duties without the need of human presence, eventhough supervision and intervention is able to the users 24/7. The improving of these algorithms eventually leads to a better concept, architecture and logic all of which influence the end result.

The second but not the least important aspect of this technology is its adaption to the user market. It has to be user-friendly or in other words easy to use for people of all ages and backgrounds, as its architecture represents the completion of the most basic tasks in our everyday environments. Although installing, managing and monitoring the well-functioning of the architecture are all a responsibility of a specialist provider, the usage is up to the user itself and it should be simplified in the largest scale possible. That is why the implementation of these technologies should be accompanied with real time feedback on both the functionality and the user experience regarding the technology. Continuous updates and improvements should be made to the architecture and the logic in order for this innovation to succed in its purpose and longevity. Creating smart environments is a bit costly at its first implementation, but then only maintainence costs are needed while the improving it does to the quality of life is simply irreplaceable.

2.4.3 Entities and Virtualization

A lot of elements and components are needed into the integration of the Internet of Things architectures which have different functions and parameters all of which contribute into the creation of very complex structures of interconnecting devices and servers. The process of identifying and distincting all the different entities inputed in the system is a task that does the vital function of complexity management while it also ensures the operation's security and assembly are fully functional and ready. Entity codes are needed not only for these tasks but also for the IoT supporting while they are known to be widely integrated in such forms such as : locations, objects, devices and so on.

These are key roles into building such complex smart environments and structures, but in the lack of these components, their replacement was tried using identifiers of communication. Although they kind of have the same role, their limitations regarding communication, the connection between entities and interfaces have made the usage of entity identifiers a crystal clear choice. Although what should be mentioned is that these components are not put into the same physical space as the IoT gathering point.

Another advantage coming from the usage of the entity identifiers is the security these components guarantee to the relationship between them and systems, and their managerial role in the monitoring of resource sensitivity. But what is even more important than this is the fact that it enables IoT visualization, a display of the interconnection between devices and resources, which in this case are both digital and physical.

2.5 Cisco Packet Tracer

The Cisco Packet Tracer is a development under the Cisco brand which serves as a multi-tool or a simulation environment for student to realize the concept of networking eventhough there is a lack of physical devices or certain environments. This simulation tool is free to download and work on, is compatible to every operating system in existence but also has many lookalikes if you do not chose to.

Being part of a Cisco CCNA course has given me the opportunity for this program to be available to me and support all the practical excercises. The version I chose to work on is 7.1.1.

The Cisco CCNA Academy is one of the largest spread courses in the world with a participation of over 8 million individuals and with a reach in every country of the world. It is a working place for up to 20 thousand lecturers and has a partnership with some of the biggest names in the technological industry and beyond. The CPT Packet Tracer is a tool commonly used through these routines.

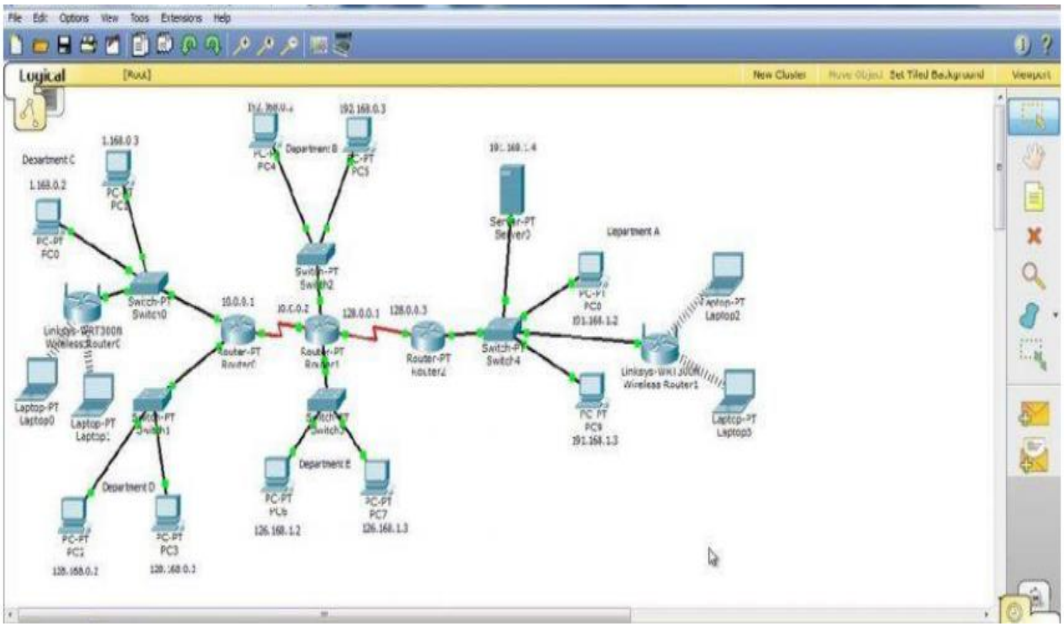


Figure 3. Cisco Packet Tracer UI

This simulation tool or environment as it can be referred to allows us to do experiments and simulations regarding networks and their components without actually having the physical devices required to perform them and surpassing long procedures with no cost. Eventhough there are no physical hardware required to explore networks, the idea of connecting them and putting components to use is also mirrored on this tool which allows the complexity of a network built to be at your will and teaching students real life valuable lessons. It also obtain the option to find and regulate mistakes and errors caused (troubleshoot) the process of building a network while also debugging.

In the later versions of the Cisco Packet Tracer, IoT devices and automations have received a special attention by not only being involved in the package but also offering a large variety to chose from and therefore many options. Worth mentioning are the implementation of sensors in the architectures of Cisco Packet Tracer.

The thesis represents only the involvement of the IoT devices needed to fulfill my goal and complete the simulations intented to so not any other IoT simulators will be compared to the one chosen in this thesis.

More and more IoT funcionalities are implemented and integrated in these simulation tools (networking environments) due to the importance and the attention IoT is getting from the technological point of view. Furthermore other tools and funcionalities inside the tool are explained in the next sections.

2.6 Types of sensors

Smart components such as the sensors are frequently integrated into smart architectures due to the vital role they play gaining information on real time environmental conditions. These components are physically attached to main physical environments such as homes, work environments, university and many more. The usage of IoT devices such as smartphones, laptops and tablets has made the monitoring of the data transmitted by these smart sensors easily accessible at any time and location through connection to a mutual network. However being able to construct these kind of architectures poses their own challenges and threats.

Another interesting fact is that in the recent years, smart devices have been built with integrated sensors to gain data on essential information needed at the moment, eventhough they are far from being completed with all types of sensors. Some of these sensors include the heartbeat detector or the oxygen level monitoring or the walking step monitoring which are all concepts widely available in almost every smartphone released. The best usage of the smartphone is finding a way to represent there all the information of the sensors placed in the corresponding environments and make sure uninterrupted communication is provided.

Sensors can variate and be both digital and analogue which both have a very large field of application in every smart environment possible, especially in the Work Environment and Industry where the processes should be monitored at any time with extreme caution. All these factors influence the complexity of a sensor and the accuracy of their data monitoring and transmission, as less useful ones tend to be simplier and less accurate.

These components are also build to gather information regardless the environment they are put in and the conditions such as humidity, temperature, movements and so on which tend to prove the quality they are built of. This quality also makes the difference between a home and industrial sensor which need to be on point to withstand far worse conditions than a home environment.

CHAPTER 3

METHODS AND MATERIALS

This section is as impotant to the thesis as any other, because its purpose is to introduce the methods used in the project, give a detailed description of the processes occuring and the practical steps taken while also mentioning the thesis methodology. Regarding the second subsection of this part, attention will be directed to the way the IoT simulations were built but briefly as more detailed descriptions are made in the correspondent chapter.

For all those asking on wether how the idea of chosing a topic like this came, it was my third year in Bachelor studies when an innovative professor introduced the idea of Smart Environments. The knowledge on IoT came on independent studies as the topic's surface was just scratched during my studies while the opportunity of having practical simulations came as a result of CCNA course knowledge.

As for making a simulation using real hardware, the difficulty of having real hardware and working tools such as microcontrollers, sensors and not being able to access environments due to Covid-19, I chose to use an IoT simulator. The first choice, having previously worked on it which makes it easier to understand was CPT Packet Tracer.

After having carefully made my goals clear, ticked all the list of the tools and needs to be taken care of, the next logical step for me was to structure the schedule in order for the practical sessions to be accompanied with a specialist of the field that would recommend a solution in case of a crossroad.

Worth mentioning is that the methodology of this thesis is typically from those of the IT field of study (simulation/documentation/results/conclusion).

To make the thesis comprehensible and structurely correct, it was divided into five chapter with each being critical to the transmission of it while sub-chapters are introduced in order to make the content more understanable and let the information flow smoothly.

The processes of creating this thesis begin from information gathering, choosing the tool and explaining its purpose and functioning, explaining the developing and the conditions sorrounding the simulation environment created while achieving and documenting simulations and getting feedback (as described in the picture below).

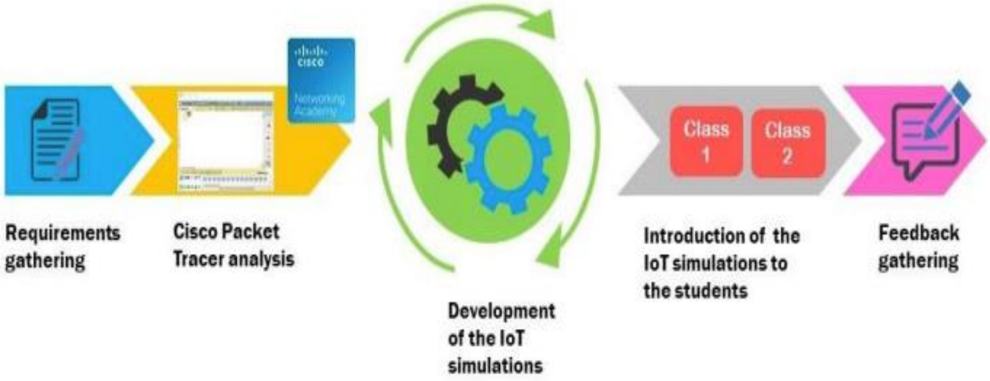

cisco
Networking Academy
Class 1
Class 2
Requirements gathering
Cisco Packet Tracer analysis
Development of the IoT simulations
Introduction of the IoT simulations to the students
Feedback gathering

Figure 4. Process of making the thesis

Gathering and making the requirements crystal clear in the thesis is an important process that was reached after a few consultation with the supervisor of my thesis and also experts of the field. The need was to have seen pre-built envitonments through tool simulations for better understanding. Practical sessions attented shouldhave made it easy for the writer to understand the functioning of the simulations but to also be able to further develop them.

After most of the basic configurations are presented as a basis for these future developments, the focus will be directed towards the IoT devices implemented and not so much on the networking part. An important characteristic of these simulations is their flexibility in order for the schemes to be easy to change or integrate other components to make it more complex.

The fact that in this thesis the simulations appear in three different types of environment (home, work, uni) with specific characteristics, is made possible by the large variety of contents and themes in the simulation and its ability to flex.

After being certain about the clarity of the representation of needs and possible results, technical aspects regarding the whole processes of the simulations is what raise big questions. The most important of them is the one wether the Cisco Packet Tracer is really the right tool to simulate a network environment containing IoT devices. This is because never before had I used such a tool to integrate an IoT simulator in it, and with inexperience come insecurities. However from all the knowledge obtained on the Cisco CCNA courses and consultations with both the supervisor and lecturers, it was found to be the best choice by far away, having an unthinkable advantage over the other simulation tools used.

These requirements were now fixed but now comes the real commitment to making this thesis work. The two main phases contained of firstly getting used to the CPT Packet Tracer simulator and understanding the IoT funcionalities integration in it and secondly performing automations with these IoT components.

As it was briefly mentioned and explained in the previous chapter, the CPT Packet Tracer is a vital tool in the mirroring of real life networking concepts, main purpose of Cisco courses where it is used so commonly. With a tool so spread to the general public, you will find it hard to believe how difficult it is to find instructions of usage in the browsers. Howevers search engines such as Youtube and Blogs such as Reddit played a huge part in gaining the necessary knowledge. However, being a part of the Cisco community, the courses themselves had sufficient information in understanding the way the tool works.

Apart from that, the information gained for the purpose of writing this thesis on the functioning of the simulator tool was to be acredited to : Introduction to CPT, Intro to IoT and Packet Tracer 1o1.

These chapters were also accompanied by online classes on Youtube which were viewed for both practical (usage of the CPT simulation tool) and theoritical reason.

Detailed excercises were presented and the build-up of correct schemes and setups was supervised for maximum results.

Regarding the integration of the IoT funcionalities in the simulation environments of the networks, it is easy to say that basic information was found and presented but that is more than sufficient since simple IoT automations are required to complete the experiments and conclude the thesis. The difficult part was the fact that the integration of IoT simulations made a far more complex scheme which made the process of debugging even more difficult. As for the microcontroller programming, it was a skill obtained during a course attended in Bachelor studies.

After spending more and more time practically developing smulations in the CPT Packet Tracer, it became even more obvious of its ability to integrate and work with IoT functionalities and meet their requirements.

The next phase of the project is where we needed to put into practice all the knowledge possessed as the goal now is to complete all the simulations. As far as the thesis methodology, my strategy was clear : firstly we needed to create the networking environment or the first layer where all the components were input and connected to each other, then the IoT devices were implemented and tests were run. In other simulations we have the involvement of the microcontroller, its programming and also the addition of many sensors linked to our simulation environment to provide real- life information.

Prior to presenting the final simulations that included all the IoT funcionalities and automations, consultations with experts of the field were made in order for me to understand wether the requirements were met. It came as a result of the complexity of the simulations by the addition of IoT devices.

The first simulations made were not that comparable to the final results I was after eventhough the majority of the network components and IoT devices were included. The only difference regarding the simulation complexity was during the Smart Work Environment, where many other components were added not part of the first bundle.

After a lot more dedication and consultation, while also internet surfing to gain information I made some adjustments that proved to be spot on and make everything work greatly. The purpose was also to create a guide type of overview for the reader in order to explain important creations such as: the network, the IoT functionalities and automations and all the IP credentials and addresses used while also describing the process of simulation in itself.The content regarding these explanations are included in the next chapter.

After all the developing of these experimentation and simulations had been completed, it was the turn to present the results of the and the conclusion derived from them.

CHAPTER 4

IOT ENVIRONMENT SIMULATIONS

The following sections of this chapter share the similar goal to explain in details everything regarding the excecution of these experiment, while firstly giving an introduction to it and the tool used (Cisco Packet Tracer). In the later sections, all the simulations are carefully explained and analyzed in a far more technical approach regarding networking and IoT while also leaving room for future work.

The goal of the thesis (and the goal of the explanations) is for the reader to be fully aware of what was done in these experiments and maybe make it a reference for future Packet Tracer usage.

4.1 Simulation Introduction

As by the name of this sub-section, it is easy to understand that here a review and analysis of all the simulations will be done. The starting point to this explanation will be the usage of the CPT Packet Tracer and the IoT components in it. This was not easily achievable as modifications had to be done in order to be accustomed to the IoT simulations due to complexity.

Each one of these simulations/exercises is characterized by seperation of the physical layer, which in our case in pre built for each of them, a fully configured network which is composed of all the components needed to perform which are connected to each other (IoT components included), the integration on the simulation of many IoT devices to create real life conditions and the programming logic to make everything work automatically. The integration of microcontrollers and sensors is made possible by their programming using Blockly language.

Each exercise and simulation as previously mentioned is step by step documented, from the network configuration, to the addition of the components into an infrastructure, to the programming logic using the language of Blockly and all the simulations and results coming from the usage of the Cisco Packet Tracer.

The four simulations include: two simulations of a Smart Home with different configurations while the other examples include Smart Work Environment and Smart Uni simulations. Although the first two simulations of Smart Homes would initially appear identical as they are both characterized by an IoT automized home where each component on the network or grid is connected to the WLAN and smart devices interact, they are far away from it. Conceptually, what divides them is the backing of the first IoT automizationes in the WLAN while the other one's components are in a different party's network which is constructed only by the LAN's connectivity layer. The cloud computing here is also offered by a third party.

In both of these simulations, it is worth mentioning that we are running a remote network which belongs to a corporate, where the occupant can access in order to gain every real time information of the sorroundings of his home by monitoring the IoT smart devices implanted.

The third simulation came to realization after the understanding that every environment could be "Smartened" and being a student why not propose something similar to the university environment. Basic networks were used to simulate a campus while all the IoT devices are integrated on a third network which also tends to be the most complex one. The access to the network in this case can not be for anyone, so a authorization mechanism was implemented to monitor the real time information and all the campus environments.

And last but not least, I decided to include as a part of my thesis the simulation of a Smart Work Environment where a few networks are prepared and integrated to satisfy the needs. A switch was used to produce electricity by the two IoT integrated networks which is then used to a third one in the production line (that consumes it). There are also two other networks added in order for the simulation of a Work Environment and a control room to be achieved, which will contain all the IoT connections(servers) that enable the users to access the data far more easily and store it.

For these simulations to be on point and perfectly performed, as said before the knowledge on Cisco Packet Tracer tool usage was necessary. This comes as a result of not only exploring basic network components or basic IoT devices to be integrated, but fare more complex ones and deal with new concepts such as IoT backend servers, the programmming and logic of the IoT components, variables and coefficient of the simulated environments and many more. In the next chapter components which are not so related to networking are furthermore explained both theoritically but most important practically.

4.2 CPT IoT technology

In this sub-section there will be an introduction to all the technology and networking regarding the involvement of the IoT components. Although always a part of this Packet Tracer Simulator Tool, the recent years have seen a large variety of previously not involved IoT components being included due to the rising request for them.

Its goal is to explain the IoT funcionalities in details while not giving so much attention to the network ones. This happens because the main focus of the thesis and studies was on the IoT therefore the documentation of the simulation will be greatly focuse on that aspect of it and making the Internet of Things application a lot more approachable.

All the simulations done will have an undivided attention towards the IoT components, unlike the networking ones that are only the tool of reaching our goals and creating the grid for the IoT functionalities to be connected.

As mentioned before, each experiment and simulation has its own distinct architecture and build up regarding the layout of the network eventhough what never change is the involvement of basic components. In order to build a network layout, components like routers (wireless or not), switches and so on are needed.

The Cisco Packet Tracer simulation tool used to imitate processes in real world environment is equiped with every component needed to fulfill the goals (in the figure are shower the routers to choose for the network layout you wish), while servers, Pcs, switches and many others are widely available to use. However the hardware limitation is also a problem during the layout of the simulations, as not preparing the schemes beforehand will lead into having less than necessary ports available, insufficient slots and so on.

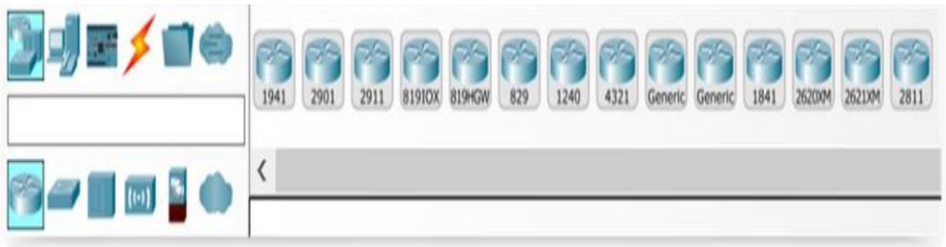


Figure 5. Routers available in the CPT

Considering that a Smart-Home simulation of environment without an internet connection would be seamless, an attempt to simulate this Internet connection in the environment created in the Cisco Packet Tracer makes it possible to the customer to have access to the infrastructure by using an external network (a cellular device or a office computer which have their own network). In contrary to the first Smart Home Simulation, the Second one is able to allow every device registered to access in the IoT intelligence as it is a service implemented in the infrastructure (IoT funcionalities).

Furthermore, in a different type of simulation (Smart Work Environment) , a cellular network was implemented so all the additional components that come with it should be integrated into the fuctioning of the entire network. Some of the cellular network components include backend servers and cell towers. This was done for the sole purpose of increasing flexibility in the connection to the outside IoT devices. Completing the layout was not a difficult job as there were no limitation on ports or range as in WLANs of the real life conditions.

After completing the first step which regarded the network device build up the attention turns to its configuration and for that the CPT Packet Tracer offers two possiblities. One of them is User Interface which is commonly known while the other need more specific Cisco commands and is known as CLI(command line Interface). It raises the bar and requests a lot more device logic computation while using the UI comes more naturally and while it does need parameters it asks for no specific commands.

As for the setup and layout of the network environment, different type of cables to connect the components are used (optic internet ones, straight ones, copper ones etc) as a neccessity of creating different types of layouts. Another specific type of cable is used to connect the microcontroller to the IoT components.

As mentioned different types of cables are used and they are all available in the Cisco Packet Tracer Tool in order for us to create every setup possible (as shown in the picture below). When you see the picture closely there is also an option to auto-cable the network interfaces together and being a “smart” application it will directly choose the correct one.

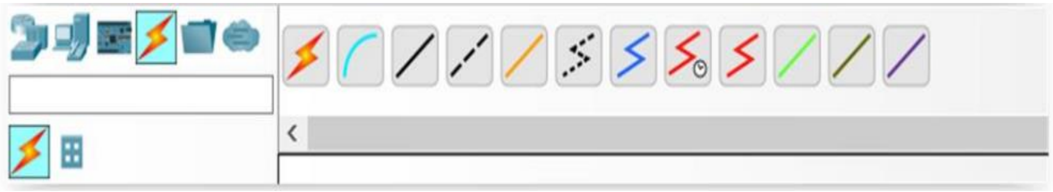


Figure 6. *Cables available in the CPT (in the lower left corner we see the auto-cable function)*

Another reason why the Cisco Packet Tracer was chosen, is its ability of seperating the network composed by different physical layers by dedicating each of them to a different type of environment (room ,city, building etc).The switch between the physical and logical layer is made visually available in the following illustrations.

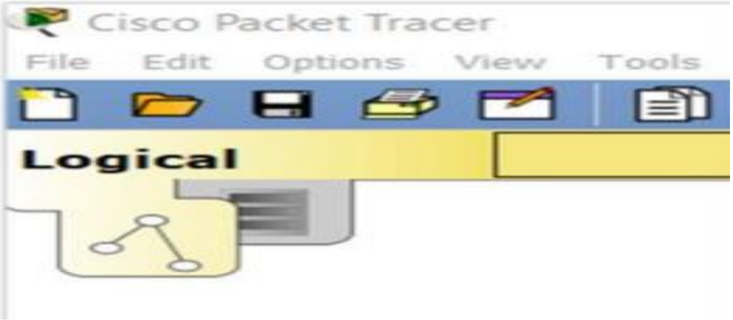


Figure 7. Logical View

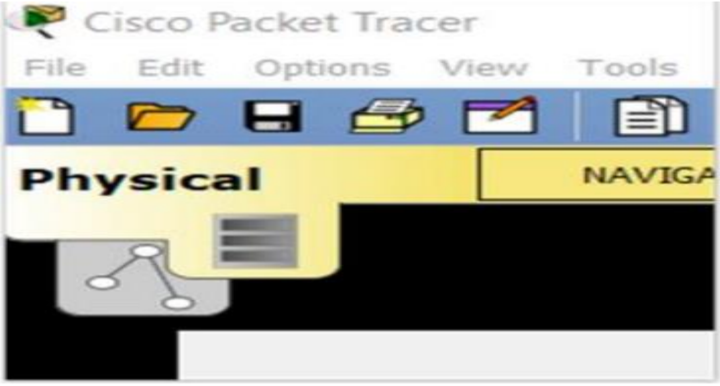


Figure 8. Physical View

A thing to be kept in mind, is that in case of a network simulation to be created is the space administration of the physical components, so that they can be connected in the same environment. Pre planning of the schemes and the layouts is crucial when dealing with such complex setups involving the IoT functionalities. A suggestion that was made keeping that in mind was adjusting the environment using the networks physical layers and therefore being a crucial influence to the IoT devices. This physical division is greatly shown in the Smart Work Environment layout containing five sub-layouts for each sub environment by the division of the physical layers.

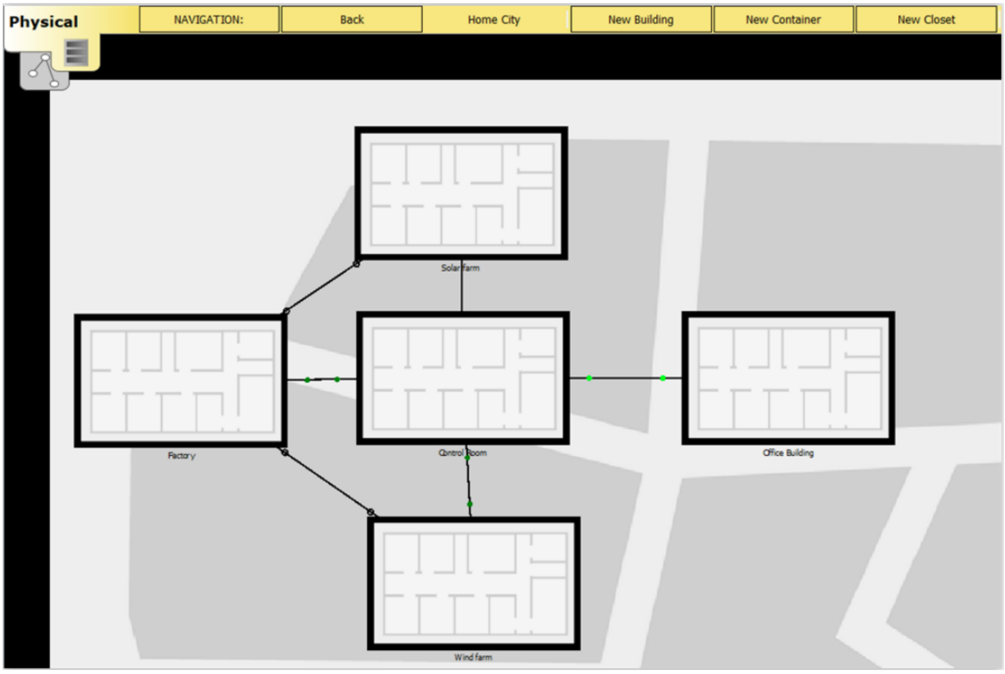


Figure 9. Smart Work Environment Physical Layout

The process of seperating the network’s physical layer into subnetworks representing different real life environments and with this come real life challenges such as backbone connections, a limitation of the physical cable’s lengths ,the range of coverage by the WLAN device or even including the parameters every environment is represented from. [1]

As the seperation of physical layers represents sub environments, each of them needs a set of variables attached to them and they need to be fully customizable (not the wiring). These variables represent real life environmental conditions such as : temperature, humidity, oxygen, winds and so on. A postive aspect of working with the Cisco Packet Tracer is its involvement of more than 50 of these variables for the users to adjust them. In the figure below two parameters are shown through a graffic that contains their values in the twentyfour hour span.

These variables or so called parameters play a very important role in dictating the smart sensors behaviour during the CPT Packet Tracer simulations. These parameters are easily monitored through the sensors which send the data to the network and action is provided when necessary. These parameters adjustment also helps us understand if our simulations are done as they are supposed to and produce the correct results.

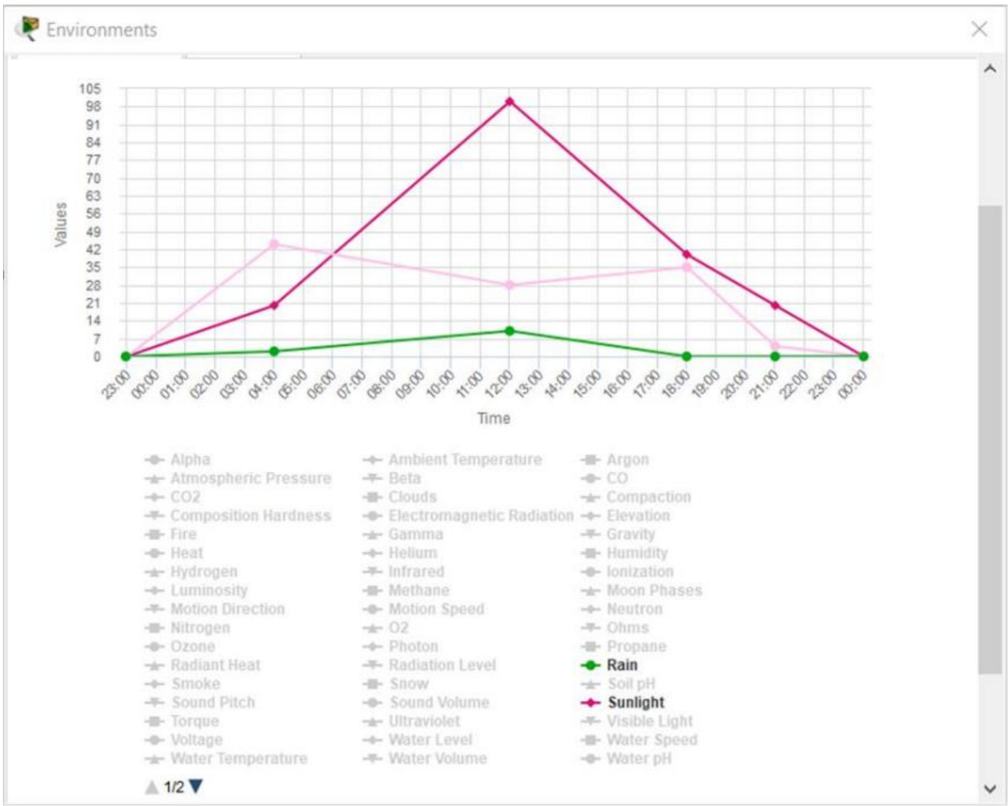


Figure 10. Environmental Parameters monitoring (24 hour lapse)

Regarding the parameters used in the simulations of the environment, the following were chosen : wind speed and the ammount of penetrating sunlight. The reason they were chosen is that in a Smart type of Environment of the Future we would need these parameters not only to be monitored but also to be exploited in order for the concept to gain electricity by turbine and solar panel usages. Another important parameter to be used in a Smart Home environment would be the ammount of raining at the water levels monitored by specific sensors. Their purpose is to stop the waterning of the plants by the sprinklers in case of a rainy day or add water in case of a drought to perfectly support gardening. Temperature and humidity are also parameters needed to be measured so that in temperatures beyond normal or unpleasent, the network immediately turns on the air conditioning for better conditions. [2]

As far as the monitoring of these conditions , the best choice is to select the smallest environment possible, where the changes of the variables can be significantly seen and observed, contrary to enormous spaces where the changes as as tight as it gets. For example, if a car pollution would raise the level of carbon dioxide in a city by an unthinkably small ammount, in a small garage it would be the opposite and the levels would sky-rocket while it makes it easier for us to observe this change.

All the components of the network and the physical layers in its setup are easily found and presented in the Cisco Packet Tracer which make it even more capable in simulating these IoT environments. [3]

There are a few main categories regarding the components used in the Cisco Packet Tracer : sensors, microcontrollers, smart components and actuators. As for the samrt components and devices that are represented in the CPT Packet Tracer they are shown in the picture below.

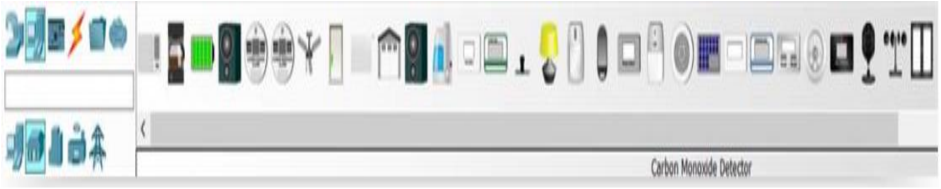
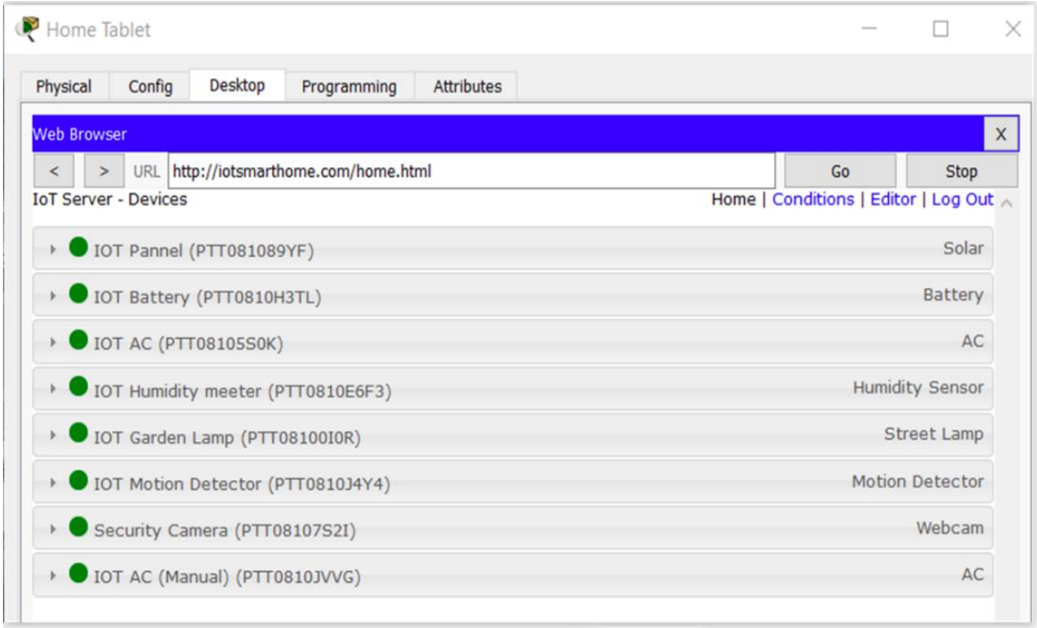


Figure 11. Smart devices available

Devices that have the capability of connecting to a network (wirelessly or mot) and have a behaviour logic that can be inputed in them using different programming languages are also known as Smart devices. Some of the smart sensors decided to be included to the simulation environment include : Air Conditioner, alarms, smart lights, temperature, humidity and many more other sensors which will transmit real life information and carry actions themselves. [4]

In order for these Smart devices to be ready to complete their functions, they firstly need to be connected into the LAN, but if the connection is possible to be done through WLAN wirelessly, the setup is completely doable by only swapping their Interfaces.

After every smart device, sensor and component is connected to the networking grid, they need to also be remotely connected and their information to pass through the IoT backend server. This makes it easy for the user to access the information at any place and time very easily through his IoT devices that have authorized access. In the picture below, an example of the homepage created to obtain the informations is displayed while for more information it will lead to the homepage.



http://iotsmarthome.com/home.html

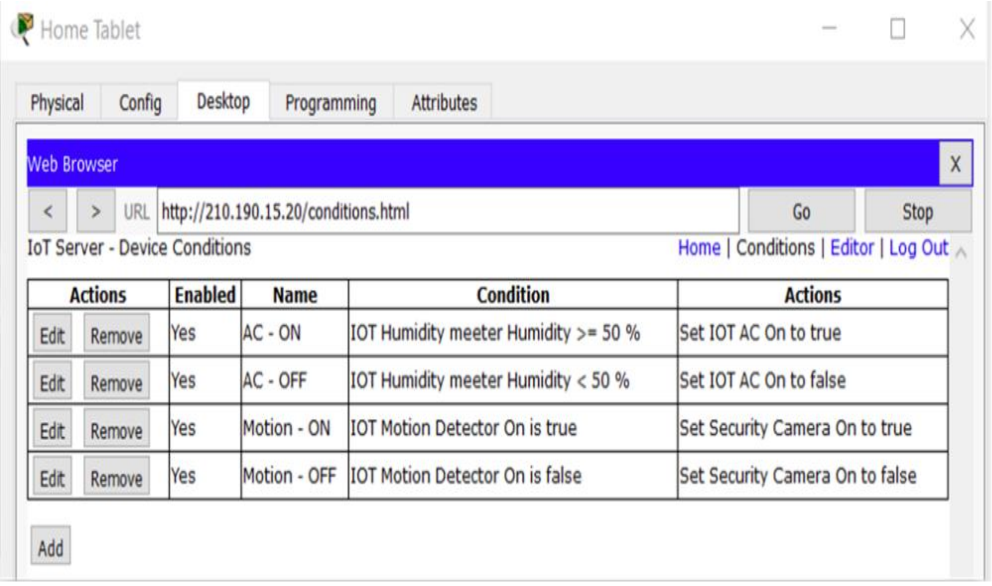
IoT Server - Devices

● IOT Pannel (PTT081089YF)	Solar
● IOT Battery (PTT0810H3TL)	Battery
● IOT AC (PTT08105S0K)	AC
● IOT Humidity meeter (PTT0810E6F3)	Humidity Sensor
● IOT Garden Lamp (PTT08100I0R)	Street Lamp
● IOT Motion Detector (PTT0810J4Y4)	Motion Detector
● Security Camera (PTT08107S2I)	Webcam
● IOT AC (Manual) (PTT0810JVVG)	AC

Figure 12. IoT Homepage connected devices (Smart Home Example)

Being that each device listed displays its parameters clearly, accessing the homepage is simply a visualization of the real life conditions of the environment “smartened”, while using your device will interact with the network. Easy tasks such as lighting a room by the smart light or check the battery life can be performed by the user’s IoT device. [5]

After carefully observing the Homepage which included all the IoT devices, it came as an idea to connect multiple devices in order for them to interact and take necessary actions without the need of users monitoring. For example: connecting the temperature sensors to the Air Conditioner unit, it would be a magnificant combinations as when the temperature sensor detects temperature beyond the parameters pre-set, it can turn on the AC to regulate it to the user’s wishing. A more detailed explanation will be unveiled in the next chapters but a visualization of it is displayed in the figure below :



http://210.190.15.20/conditions.html

IoT Server - Device Conditions

Actions	Enabled	Name	Condition	Actions
Edit Remove	Yes	AC - ON	IOT Humidity meeter Humidity >= 50 %	Set IOT AC On to true
Edit Remove	Yes	AC - OFF	IOT Humidity meeter Humidity < 50 %	Set IOT AC On to false
Edit Remove	Yes	Motion - ON	IOT Motion Detector On is true	Set Security Camera On to true
Edit Remove	Yes	Motion - OFF	IOT Motion Detector On is false	Set Security Camera On to false

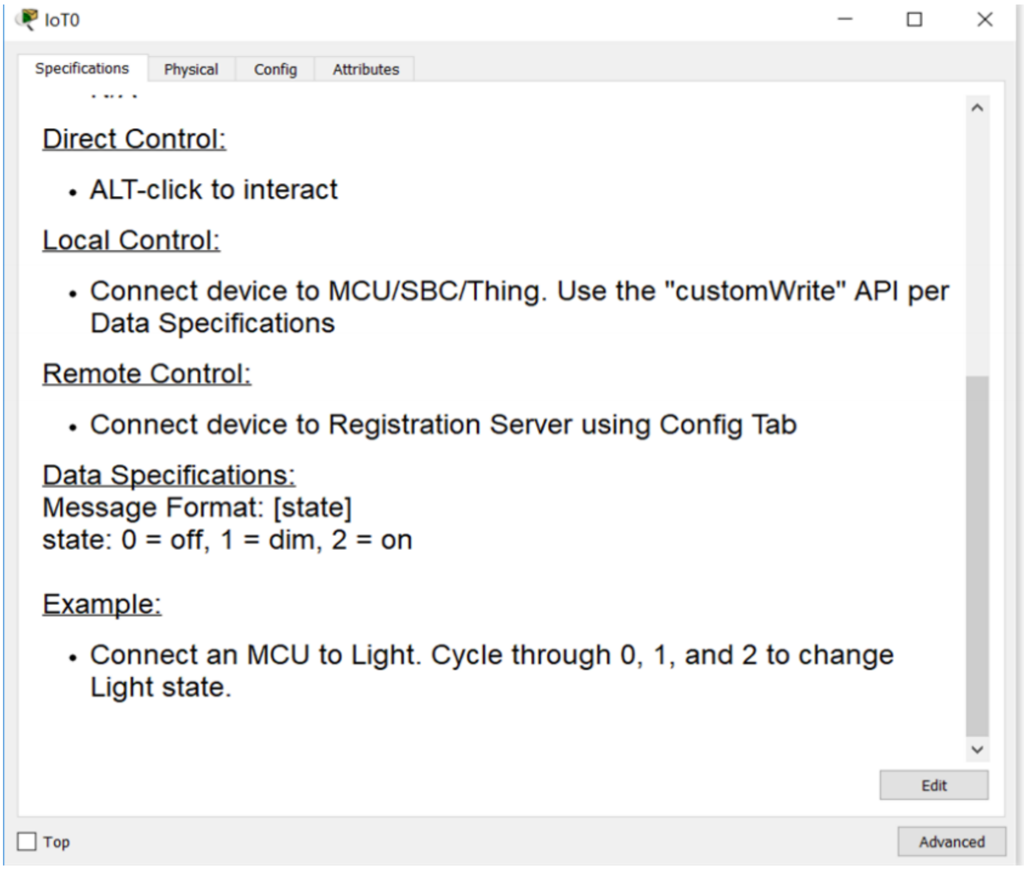
Figure 13. Pre-set parameters in Smart Home

As for the CPT Packet Tracer, there is a large variety of components available for usage, both smart and non smart ones. One of the last ones are also the actuators, whose usage is a bit complex as a consequence of additional effort for them to be connected and put into functionality. Let this downsie alone, and the simulations profits by being more realistic and real life environment based and also gaining flexibility in its setup.

The involvement in the network setup of the non-smart components comes as a surprise, as most of them are not compatible to this types of environments unless they are programmed to function a certain way by the help of a microcontroller and connected using special IoT cables. The microcontroller in this tool simulates the function of an Arduino in real life, taking the inputs of all the smart and non-smart components, sensors while also producing output through actuators. [6]

Creating the simulations and running them, was said that did not only need knowledge in the usage of the Packet Tracer tool. Whenever dealing with a microcontroller, knowledge in programming language such as Java,Blockly and so on is vital and impossible to deal without. JThe script languages (Java and Python) although very efficient and useful in programming and controlling all the components and sensors need far advanced and specialized knowledge in doing so. On the other hand, Blockly does the same work as them but being directed towards the less skilled programmers (being in the electronics engineering does that) it is far easier to work with and understand. This is the reason Blockly was chosen to perform these simulations and program the devices. [3]

Eventhough a pretty easy and understandable programming language such as Blockly was chosen for usage, before programming sensors or non smart components their specifications should be well known. These specifications should be included before the simulations, in order to understand these component's behaviours and the results expected from them in different scenarios. In the picture below some of a smart lamp specifications were introduced to understand its behaviour and apply the right commands.



Direct Control:

- ALT-click to interact

Local Control:

- Connect device to MCU/SBC/Thing. Use the "customWrite" API per Data Specifications

Remote Control:

- Connect device to Registration Server using Config Tab

Data Specifications:
Message Format: [state]
state: 0 = off, 1 = dim, 2 = on

Example:

- Connect an MCU to Light. Cycle through 0, 1, and 2 to change Light state.

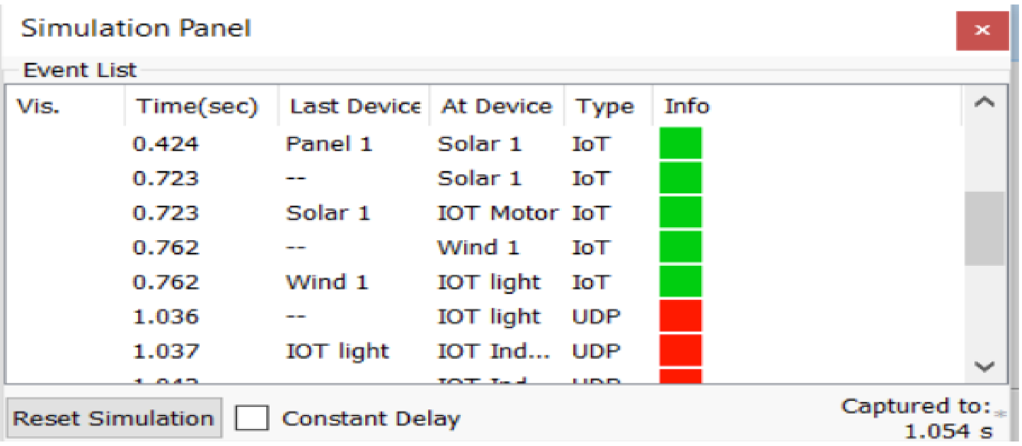
Figure 14. *Smart Lamp Specs*

This figure shown the behaviour of a smart lamp in certain placed conditions. As shown the lamp can directly be commanded and operated by the IoT device, programmed to act in every condition preferred through the microcontroller and insert commands to control its functioning. In this case we gave the lamp three states which are dependent to the real life sunlight condition, an information provided by the light sensor integrated in the scheme.

A very positive aspect of the tool used (Cisco Packet Tracer) is its ability to customize and specify every action supported by the devices, therefore specifying them. [6]

Furthermore to add to the reasons that the CPT Packet Tracer was used, is the fact that the real time environment can act as a simulation world at just the press of one button (command). While firstly it enables the creation of a network full of IoT devices and its logic, the simulation mode provides even more validation of the way the network exploits its network layers.

Simulation mode is even more useful in imitating the transmission of data and information throughout the whole network (routers, cables) to check their connectivity, routes and help the user visualize how the network flows all its information and figure the solution of many problems (troubleshoot) in case of future errors. It allows the data to travel deep into the network , testing every corner and space of it.



Vis.	Time(sec)	Last Device	At Device	Type	Info
	0.424	Panel 1	Solar 1	IoT	🟩
	0.723	--	Solar 1	IoT	🟩
	0.723	Solar 1	IOT Motor	IoT	🟩
	0.762	--	Wind 1	IoT	🟩
	0.762	Wind 1	IOT light	IoT	🟩
	1.036	--	IOT light	UDP	🟥
	1.037	IOT light	IOT Ind...	UDP	🟥
	1.043		IOT Ind...	UDP	🟥

Figure 15. Simulation Mode Packages

4.3 IoT Simulation

The reason of writing this chapter is the guidance of the reader through the simulations made in the Cisco Packet Tracer.

It includes deeper and more detailed analyzation of every process occuring especially the seperation of the network and IoT setup, docummenting the steps through the simulations and making a presentation on all the information derived from it. Feedback is excpected in the later chapters of the thesis.

4.3.1 The first Smart Home Simulation

The first of the two simulations regarding the concept of the Smart Home is also the first one to introduce us to the integration of the IoT is such environments. As said before , the network was composed of smart devices which after being fully connected to the Internet of Things simulated all the interactions between components and the control of the devices through these connections.

After verifying that you are an authorized user (gaining access to the network), the owner can pass through many commands to be performed in real life such as : lighting a lamp, oppening a garage door or even checking on the livestream information passed to the network by the sensors such as the monitoring of the temperature, wind speed, humidity etc.

This prototype can also be improved and expanded by adding the possibility of using a foreign network chosen to gain access to the home environment LAN and supervise from there.

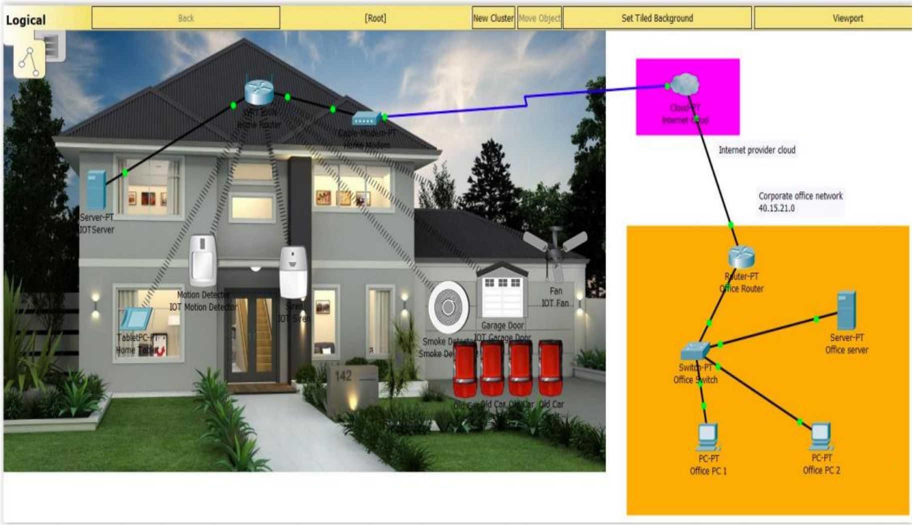


Figure 16. First Smart Home Simulation Layout

Network Layout

The network in the first simulation or the Smart Home was by far the easiest to prepare and setup as it was only composed of three areas. Those areas were : the home net, the cloud doing the computations and in addition an office network to have access to the home network.

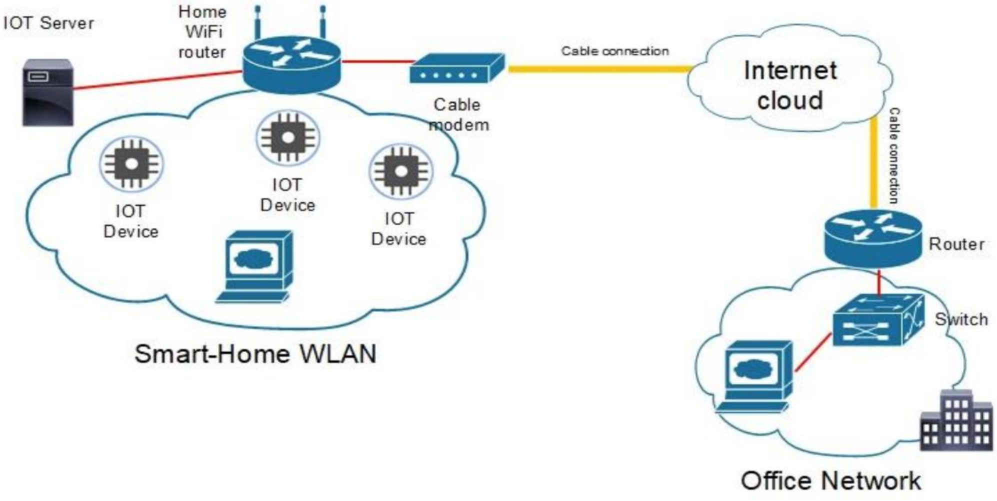


Figure 17. First Smart Home Network

From the picture above, it is easy to realise that the most important part of this network topology is the home network, which has in itself integrated every IoT device, network smart and non-smart components, sensors and backend servers all tied to the WLAN. The simulation here is one of a real life home environment where wireless networks are irreplaceable in the connection they offer to every home IoT device, while having the model linked to the router by cabling. The modem is used in our architecture due to it having in its composition ISP connectivity, a characteristic the router missed by only having Ethernet ports.

As far as the default Internet characteristics such as DHCP and ISP, they were left untouched while internal WLAN DHCP was removed. This was achieved by using the Graphical User Interface, while other necessary information involved username and password.

A thing not worth forgetting is the parameters all wireless devices need to run on, mentining all of the characteristics above. The exception here is only the server which uses static IP.

Even in the case when we have a rebooting of the WLAN device, the purpose of the static IP is to remain the same. This is a mojor advantage of it since in these cases extra configuration with the IoT devices is not necessary as all the information has been preserved. IoT and also DNS services and functionalities can come as a result of using the server's IP, not only the one previously mentioned. The servers and the IoT support ensured the backend logic added to the simulation done in the Cisco Packet Tracer and the setup of the homepage, all of which are neccessities for the user to gain access and complete his goal. DNS is also used into the translation of the homepage to the server.

AS for the next part of the network, the Internet Cloud is the talking and analyzing point. Two interfaces were merged and joined with each other in order for this server to be artificially simulated, while the setup as mentioned before is composed of a modem-router connection of networks.

As far as for the last part of this architecture, or the Office Network is the least complicated of the three, containing basic components such as router (linked to

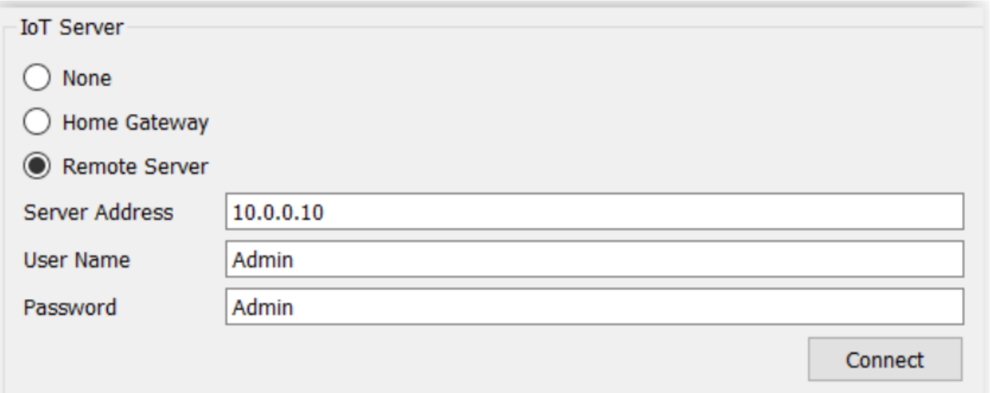
Internet and switch), PCs and a server that does all the connection and has the access authorization. A special protocol was used (RIP) in order for this connection of networks and access gain to be provided.

All the components are characterized by their default settings, while the server uses as always a static IP to benefit from its ability to not change.

IoT Layout

In order for this simulation to be fulfilled, it was mentioned that the neccessity of IoT server and devices was crucial and this connection should be in one WLAN.

The logic of the IoT connections should be the top of the pyramid of the network connectivity. In the figure below, a display on the way the IoT devices are to be connected to their server while including credentials to authorize the access. When the Connect button changes itself in the way it shows Refresh, we have a successful try of connectivity.



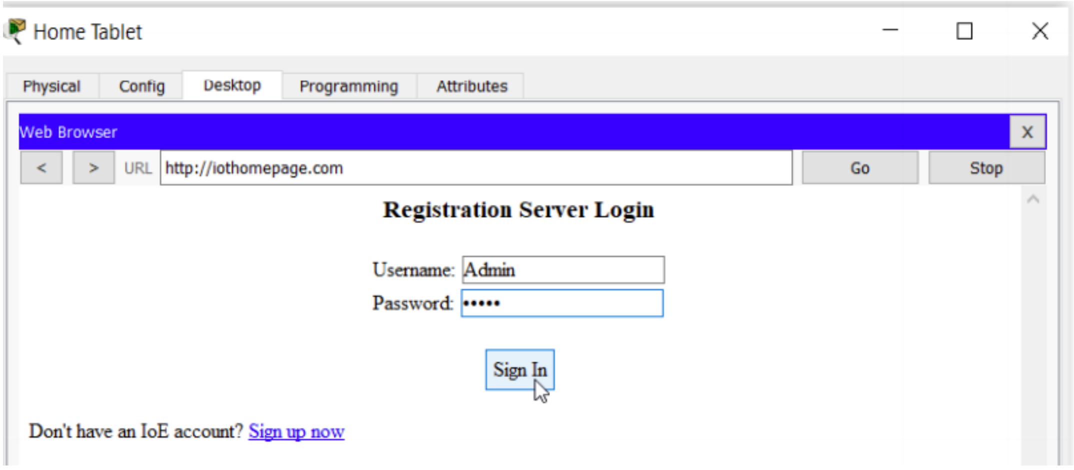
IoT Server

○ None
○ Home Gateway
● Remote Server

Server Address: 10.0.0.10
User Name: Admin
Password: Admin

Figure 18. IoT setup

The IoT devices will all have something in common, they will all have the same enchryption credentials which will lead to the user having its authorized access at any time while connecting to the IoT homepage through his IoT device as shown in the picture below.



http://iothomepage.com

Registration Server Login

Username: Admin

Password: •••••

Sign In

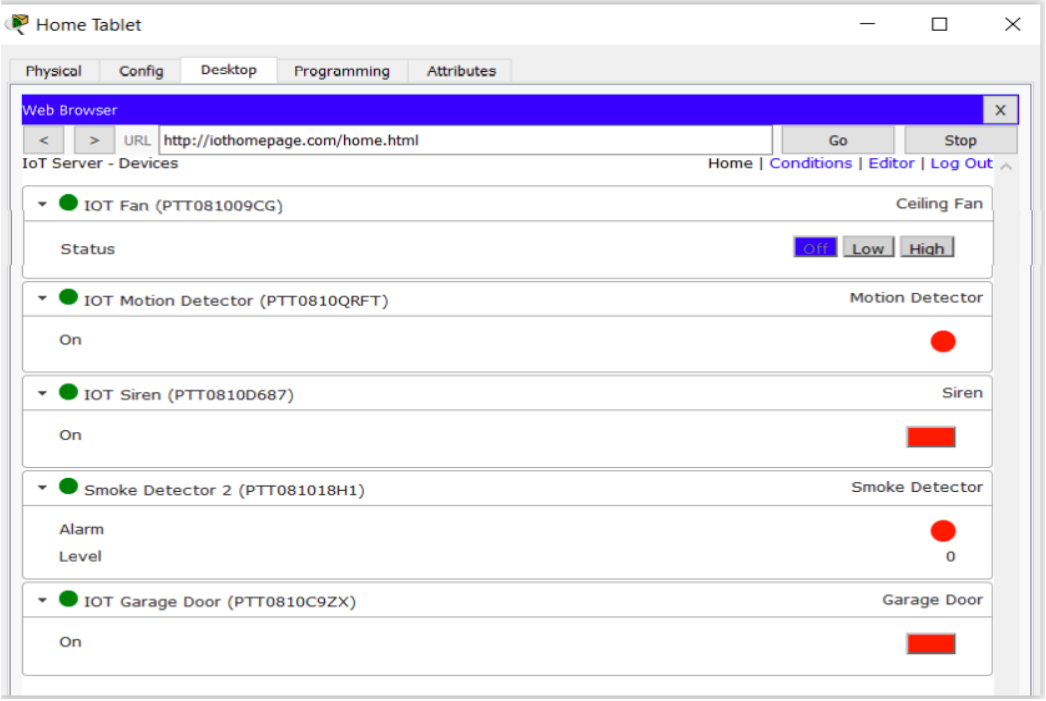
Don't have an IoE account? Sign up now

Figure 19. IoT Homepage (Login)

The IoT server like any other servers is constructed to support DNS, while its domain was regulated with a static IP.

After using the right credentials and gaining access to the Internet of Things homepage, the visualization and display of every device is presented, with also an opportunity of monitoring the interaction between them.

In the figure below, a fewsmart IoT devices are presented while they were being used. Some of the sensors captured results while we entered a car in the garage, which was done for experimental purpose while the smoke detector, motion sensor and alarm all seamed to be perfectly working.



URL http://iothomepage.com/home.html

IoT Server - Devices

IOT Fan (PTT081009CG) Ceiling Fan

Status Off Low High

IOT Motion Detector (PTT0810QRFT) Motion Detector

On ●

IOT Siren (PTT0810D687) Siren

On 🟥

Smoke Detector 2 (PTT081018H1) Smoke Detector

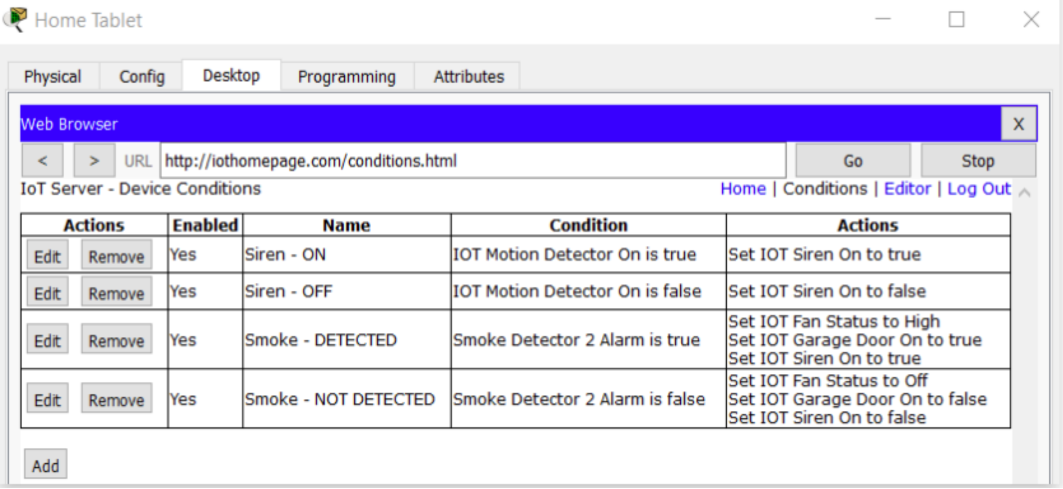
Alarm ●

Level 0

IOT Garage Door (PTT0810C9ZX) Garage Door

On 🟥

Figure 20. IoT devices display



URL http://iothomepage.com/conditions.html

IoT Server - Device Conditions

Actions	Enabled	Name	Condition	Actions
Edit Remove	Yes	Siren - ON	IOT Motion Detector On is true	Set IOT Siren On to true
Edit Remove	Yes	Siren - OFF	IOT Motion Detector On is false	Set IOT Siren On to false
Edit Remove	Yes	Smoke - DETECTED	Smoke Detector 2 Alarm is true	Set IOT Fan Status to High Set IOT Garage Door On to true Set IOT Siren On to true
Edit Remove	Yes	Smoke - NOT DETECTED	Smoke Detector 2 Alarm is false	Set IOT Fan Status to Off Set IOT Garage Door On to false Set IOT Siren On to false

Add

Figure 21. Parameters set beforehand

As we see in the picture above it is very easy to program all the IoT devices to respond to the conditions we would like them to, all this while being connected to the IoT homepage. A visualization of the simulations will appear in the following examples.

In the first wxample we are dealing with a motion sensor which in certain cases will give the order for the alarm to go on (activate the siren). In the contrary conditions when the sensor does not detect any motion the siren is off. Through a specific command, it was very easy for the user to trigger the siren itself, without waiting for the information of the motion sensor.

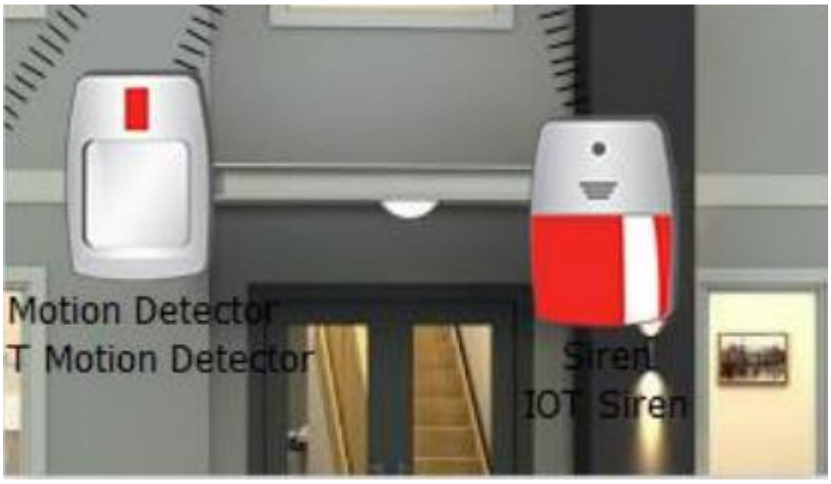


Figure 22. IoT Siren

As far as for the second example involving the simulations, we decided for the garage to be our experimental environment in order for us to test the CO2 levels. Upon a vehicle entering the garage, it was well visible in the homepage that the sensor passed the information of rised CO2 levels. Not only that, but having connected several IoT devices, the fans immediately turned on after surpassing the normal parameters inputed by us to be kept constant. If the carbon dioxide levels were in the range of the pre put parameters no action was taken. The simulations involved the user remotely controlling and starting the cars and when the CO2 levels became alarming, not only the fans were turned on but the garage door opened and the siren was on.

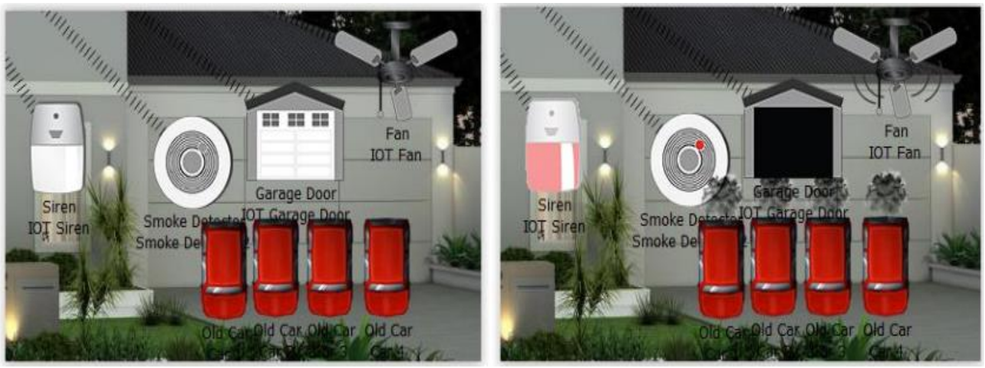


Figure 23. CO2 level monitoring simulation

IoT Microcontroller

In the Cisco Packet Tracer simulation, an example would definitely be made involving the SBC in its architecture. This type of environment involves devices and other components not being connected to the WLAN or network. IoT cables were used to connect every possible component to the SBC board.

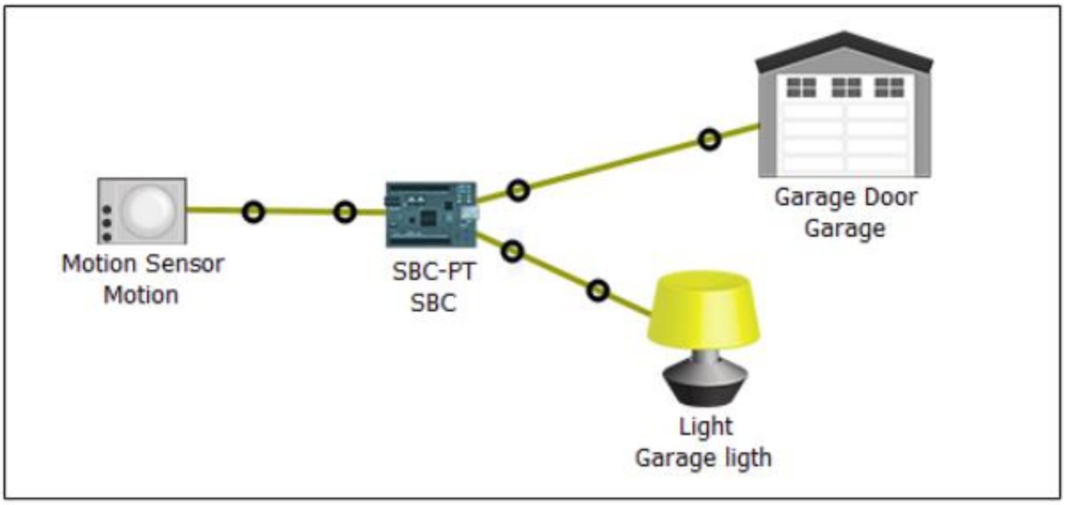


Figure 24. Microcontroller Example

In these example, simple functions will be put to test such as the light turn-on, opening garage or smoke and movement detection.

In this case we are not dealing with the involvement of the IoT backend servers which are accounted for the logical part but with a software related to the SBC that does the exact same thing.

The logic of this software is the same as the logic in the backend servers. Values are inputed to the SBC and microcontroller, after which the checking with the normality range of the variables is made and a command is ordered. This happens only when the sensors detecta movement let’s say, or a parameter changing. In case of a personal wish regarding actions taken, an example of that would be the lights turning on after the garage is opened and so on.

This is all made possible through the programming of components based on Blockly and its logic.

Future Work

As seen in this types of exercises and simulations, expanding them is a very easy and quick job based on the concept of necessary additions to them. A nice addition to the simulation would be the expansion and merge of the office network to the one containing all the logic (home network) in order for the user to gain unlimited access and pop up windows of possibilities.

In terms of complexity by adding more complicated IoT devices and logic, some examples would include : energy production (solar panels/ small turbines), nightvision cameras, smart kitchen devices and so on.

The microcontroller sample can be easily expanded by just connecting more and more components and sensors to the board and making their programming a bit more complex and specific.

4.3.2 Second Smart Home Simulation

The second simulation regarding Smart Home environment is very similar to the previous simulation done, with tha main difference being the IoT servers provided by a third party which remotely does it.

The setup on the home environment netowrk included all the components being linked to the WLAN while as far as the backend logig server, its funcionality is offered by a remote company using the cloud computing server able to be exploited.The control homepage of all the IoT devices is to be connected using a cellular network through different devices (phone).

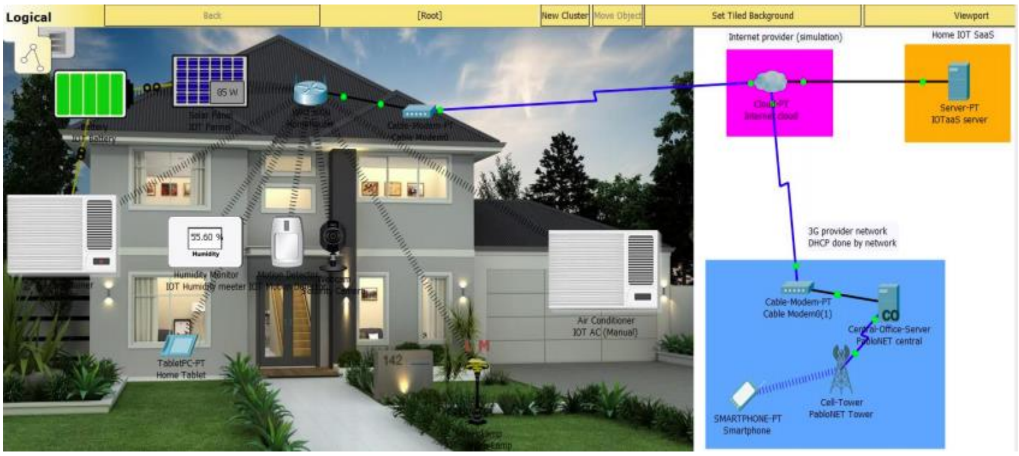


Figure 25. Second Smart Home Layout

Network Layout

The second simulation of the smart home is characterized by a more complex and difficult to understand setup in contrary to the first one. So for better understanding and planning, four major sub areas were created: the home environment network, the cloud provider(internet one), the cellular network making access to the homepage possible and the backend IoT server provided by a third party.

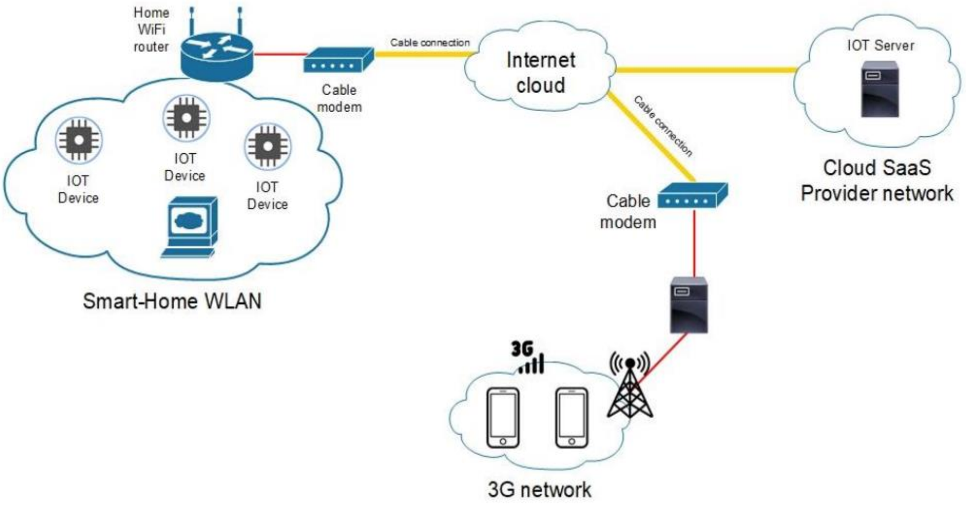


Figure 26. Second Smart Home Network

Eventhough we have a more complex design of the network requiring no more three but four sub networks, what makes this design far easier to be constructed is that not being responsible for the IoT logic server, all the IoT devices, servers and connections like DHCP and DNS are not to be made to the WLAN. In this case the wireless router's only function is to provide the architecture the DHCP functionalities.

As the construction of the home network being standard, its infrastructure can be accessed using authorized infornamitons such as username and password. Modem makes it possible for the router to be connected through the internet as they are linked by a cable so no different configurations can be presented.

The cloud computing network/ server as in the firstly built example is used to connect the interfaces of home and cellular networks in order for the simulation of the internet connectivity. The components used to achieve this goal is the coaxible cable linking the modem (from the home environment) and the cellular network to the Ethernet where the logic server is stored (IoT server).

For the simulation of a network whose funcionalities are provided remotely, the cellular network infrastructure comes to the rescue therefore resulting in the access of the IoT homepage at any given time/location through your mobile. The setup of this network was very uncomplicated , containing only a cell tower and an office server.

All the information and data passed from the towers in the form of signals, are strongly supervised and stored on the server whose access is dependent on Ethernet connections and consequently cloud computation server.

Both of the components of the cellular network have fixed parameters which are pre inputed and have a low range of deviation. The office network can be provided with signals and information by a certain number of cell towers discussed before the configuration.

The IoT devices excpecting to be connected to the network should all have the correct credentials.

As for the IoT which is remotely provided by a third party, to simplify the structure it is connected to the cloud computing server by not using any other components such as routers. Its static IP makes it easy for every device to be connected to it even in case of a reboot as the characteristics would remain the same.

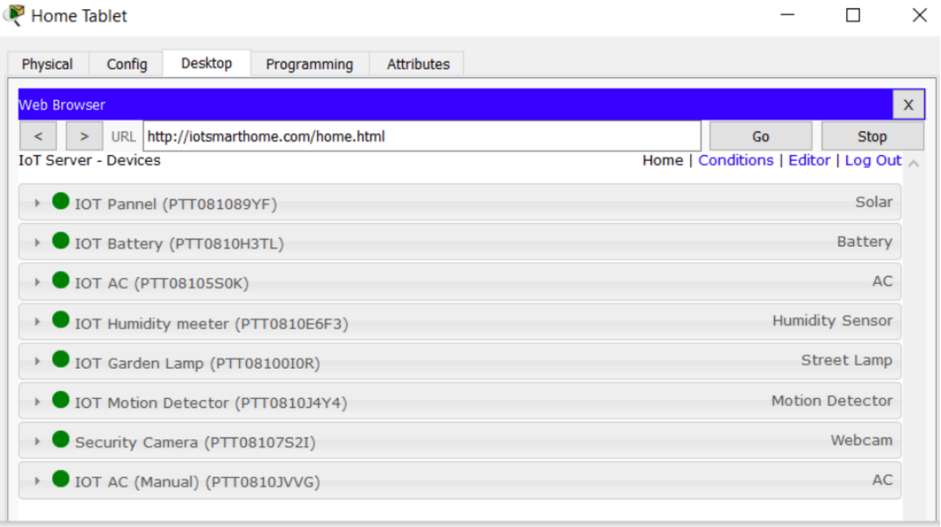
It is worth mentioning that this setup infrastructure of this simulations would not be effective or even possible in a real life environment but thanks to the Cisco Packet Tracer it is.

IoT Layout

While also been done in the previous example, simulating a smart home environment, it should not be forgotten that IoT devices must all be interacting with each other in the same network otherwise problems will show up. The difference here is that their meet-up is not the LAN anymore, but the remotely controled IoT server. This means that the WLAN only does the functioning of a DHCP server as the other IoT funcionalities are supported by their own dedicated server.

For all the devices to be loged in and access the IoT homepage, credentials like the username and password are needed so that the user may do so in every location with every mean possible (browser, phone etc).

In the picture below, a few smart devices are being presented while in action and having some conditions pre installed in them. Some of these we notice are: batteries, sensors ,panels, lights and so on.



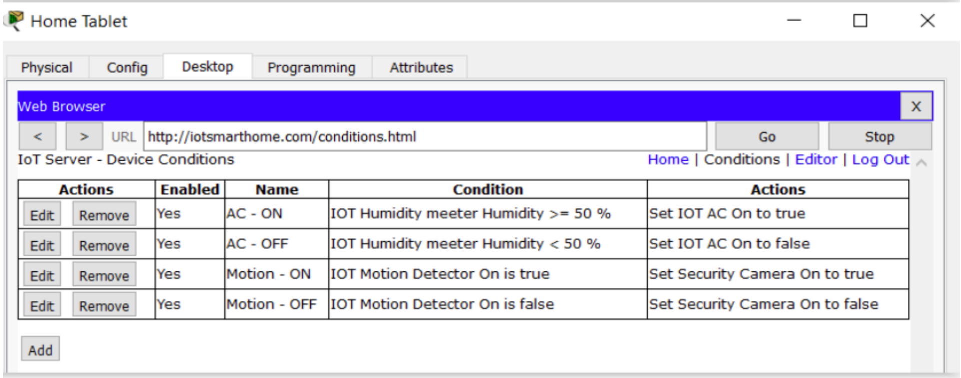
URL http://iotsmarthome.com/home.html

IoT Server - Devices

● IOT Pannel (PTT081089YF)	Solar
● IOT Battery (PTT0810H3TL)	Battery
● IOT AC (PTT08105S0K)	AC
● IOT Humidity meeter (PTT0810E6F3)	Humidity Sensor
● IOT Garden Lamp (PTT08100I0R)	Street Lamp
● IOT Motion Detector (PTT0810J4Y4)	Motion Detector
● Security Camera (PTT08107S2I)	Webcam
● IOT AC (Manual) (PTT0810JVVG)	AC

Figure 27. IoT devices in the second simulation

We can also closely observe how two IoT devices are configured beforehand in the picture above



URL http://iotsmarthome.com/conditions.html

IoT Server - Device Conditions

Actions	Enabled	Name	Condition	Actions
Edit Remove	Yes	AC - ON	IOT Humidity meeter Humidity >= 50 %	Set IOT AC On to true
Edit Remove	Yes	AC - OFF	IOT Humidity meeter Humidity < 50 %	Set IOT AC On to false
Edit Remove	Yes	Motion - ON	IOT Motion Detector On is true	Set Security Camera On to true
Edit Remove	Yes	Motion - OFF	IOT Motion Detector On is false	Set Security Camera On to false

Figure 28. Pre-configured IoT devices

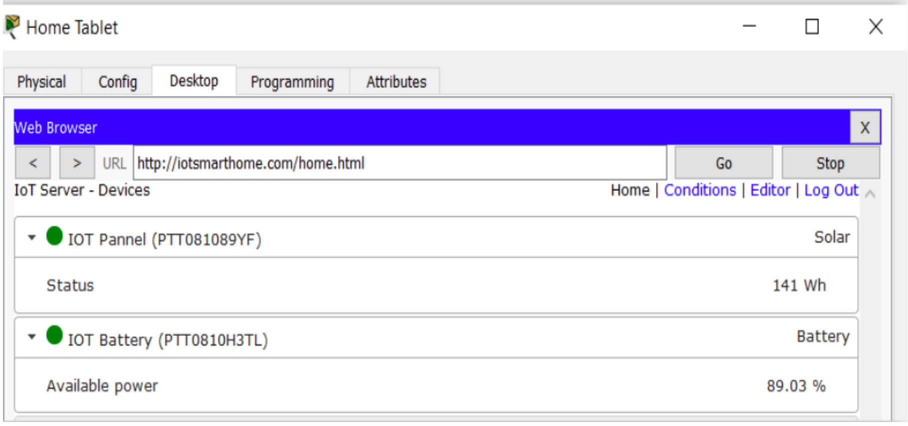
In the first simulation, a real life scenario where a humidity sensor was installed to do its job in the home environment. As with the other parameters, if the sensors notices any dramatic changes that disobey the parameters pre-set, this triggers the sensor to set information and being connected to the network, forces the Air Conditioning to turn on for the conditions to go back to the normal range. This data is then monitored in the IoT homepage.

In order for a more complex simulation to be built, it was agreed in the first place that the addition of solar panels and batteries was the perfect idea. With the future technology heading towards its zero carbon emission challenge, their integration in any infrastructure is the next innovation of the field.

The idea was that the network specific components, needing electricity and battery can be powered through the solar panel through daytime while also charging the extra batteries for nightime use. They would also cause a chain reaction that the network would benefit very much from, for example the sunlight increases the temperature which then turns on the AC which can use the electricity of the batteries powered by the solar pannels. Although it is not able to support all the power AC needs, every fraction is a win-win situation.

What is worth mentioning regarding the usage of the CPT, is that its simulation is so real that battery drainage is caused even in no usage situation or the AC not functioning solely on battery.

The ammount of battery charge produced by the solar pannels and its current status is easily shown in the InternetOfThings homepage as below :



http://iotsmarthome.com/home.html

IoT Server - Devices

Home | Conditions | Editor | Log Out

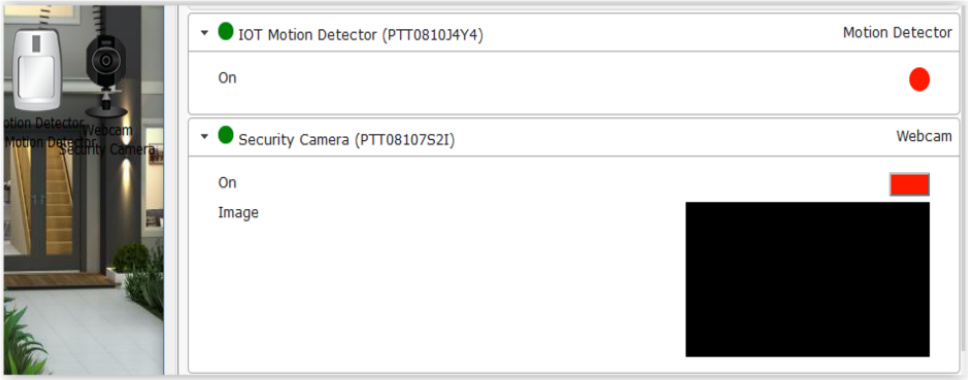
IOT Pannel (PTT081089YF)	Solar
Status	141 Wh
IOT Battery (PTT0810H3TL)	Battery
Available power	89.03 %

Figure 29. Electricity produced and battery status

As for the second Smar Home simulation, it included many things the first simulation included such as home alarm. But in this case, when the sensor is activated by gaining information on motion a camera captures the images and starts a broadcast contrary to the sirens going off.

This simulation can be easily commanded to imitate a real life situation by pressing specific buttons, which crete the conditions preferred in this type of environment. The motion can be mirrored through your PC’s mouse and the images are immediately captured.

The picture below shows exactly the detection of the motion by these sensors and the resulting image displays as a consequence of it :



IOT Motion Detector (PTT0810J4Y4)	Motion Detector
On	●
Security Camera (PTT08107S2I)	Webcam
On	🟥
Image	

Figure 30. IoT motion sensor camera broadcast

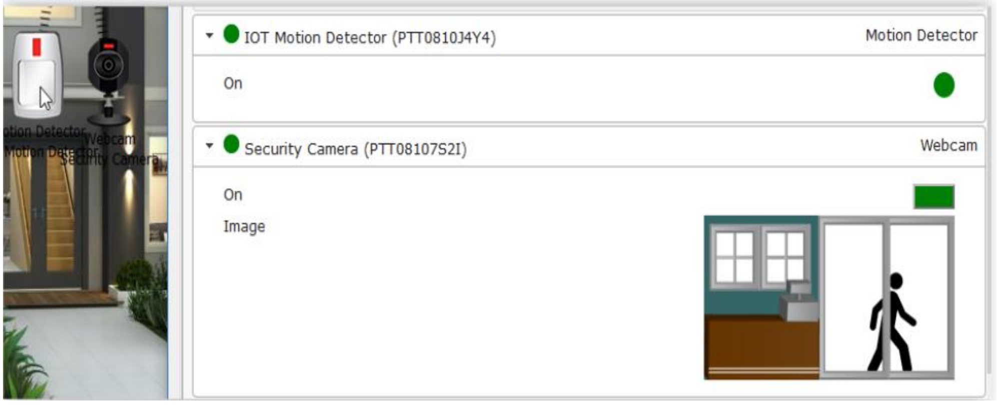


Figure 31. Movements mirrored through the webcam

Another example of a simulation occuring, previously proposed on the previous chapter is the turning on of a light in a specific part of the home. It represents a smart device which has pre-configured parameters and is part of a complex network interacting with many components such as sensors. The light is programmed to automatically turn on on low sunlight conditions (using lighting sensor) or when a person is entering the home (using motion sensor).

The use of pre set parameters to cinfigure the environment was the most important difference to the first smart home simulation alongside with its architecture including four network. These variables included in the CPT Packet Tracer create more real life conditions and make the simulation fare more accurate in its results.

The most common parameters pre-configured in these simulations are : humidity and temperature build up, sunlight level, energy production and many more.

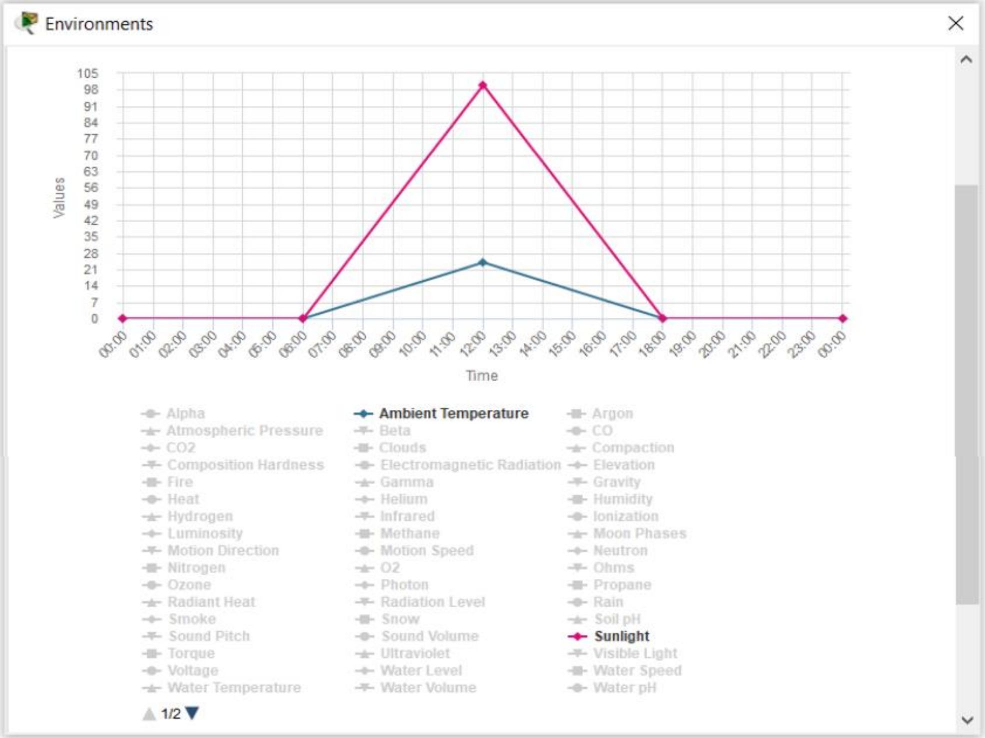
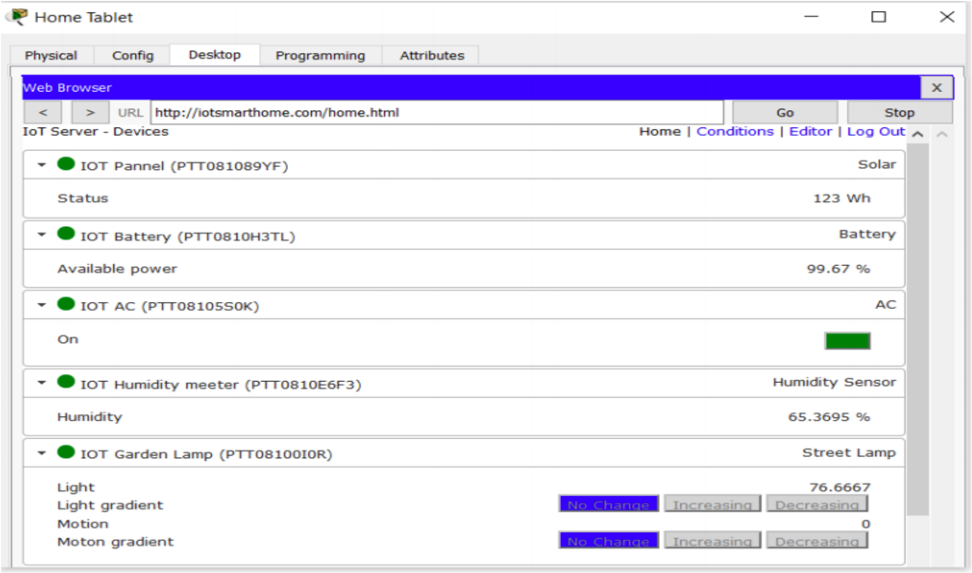


Figure 32. Parameter graph

In the picture above, the behaviour of some parameters through a summer day is presented using a graph equivalent to a 24 hour lapse. The behaviour of these parameters has a huge impact in the one of the IoT devices which have a certain reaction to the change of the parameters.

If you carefully examine the graph, it exactly shown in which hours the sunlight exposure is at its highest, the temperature are at the peak or the levels of humidity require the turning on of the Air Conditioning. Another thing monitored is the energy production, which at night appears to be zero due to it being solar powered.

In the picture displayed above, the scenario includes a daytime where solar panels carry their function to produce electricity and therefore charge the batteries while because of the high humidity and temperatures the Air conditioning is turned on.



URL http://iotsmarthome.com/home.html

IoT Server - Devices

IOT Pannel (PTT081089YF) Solar
Status 123 Wh

IOT Battery (PTT0810H3TL) Battery
Available power 99.67 %

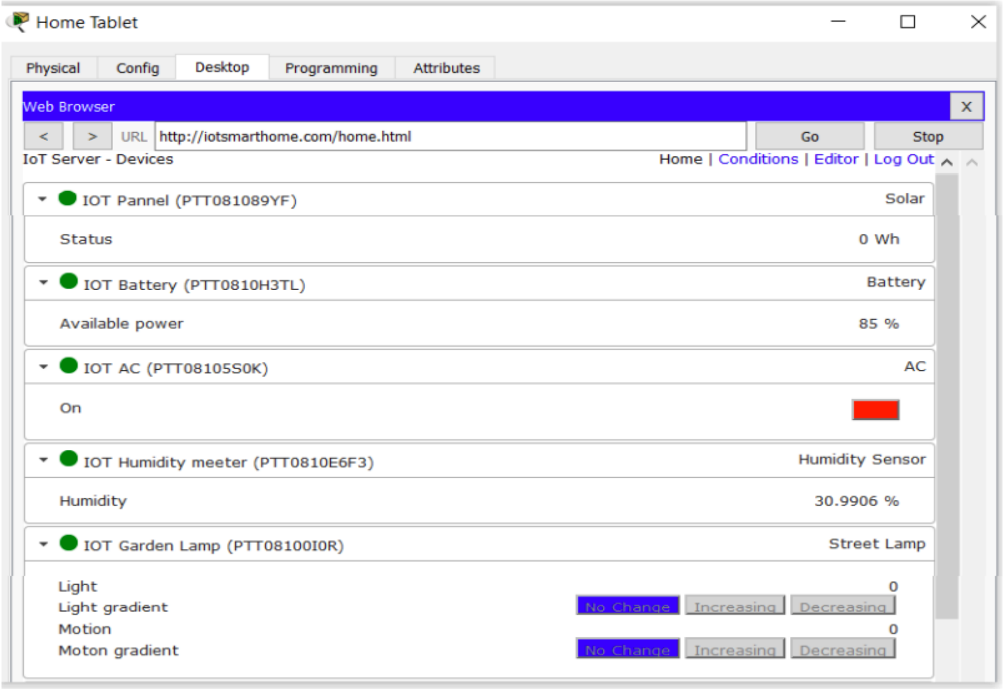
IOT AC (PTT08105S0K) AC
On 🟩

IOT Humidity meeter (PTT0810E6F3) Humidity Sensor
Humidity 65.3695 %

IOT Garden Lamp (PTT08100I0R) Street Lamp
Light 76.6667
Light gradient
Motion 0
Moton gradient

Figure 33. IoT devices during daytime

The next figure dispays the scenario of a nightime when the solar panels do not produce energy while we have the light turned on.



URL http://iotsmarthome.com/home.html

IoT Server - Devices

IOT Pannel (PTT081089YF) Solar
Status 0 Wh

IOT Battery (PTT0810H3TL) Battery
Available power 85 %

IOT AC (PTT08105S0K) AC
On 🟥

IOT Humidity meeter (PTT0810E6F3) Humidity Sensor
Humidity 30.9906 %

IOT Garden Lamp (PTT08100I0R) Street Lamp
Light 0
Light gradient
Motion 0
Moton gradient

Figure 34. IoT devices during nightime

Microcontroller Example

In the previous example, an exercise explaining the sensor-actuatoe connection was simulated through the Packet tracer. In order for this one to be achieced, SBC board will be used to connect them and the microcontroller while needing no connection to a network.

In the figure below, the exercise includes a sensor whose purpose is to monitor the temperature while if parameters change drastically beyond the pre set variables the fans are to be turned on. The sensor here is inputed into the pins of the microcontroller connected to the SBC board while it should be mentioned that we are dealing with a non-smart sensor. The sensor sends the values to the board all the time while the pre conditions are programmed to it using the microcontroller Blockly language. There is a comparizon happening all the time in order to know when to interact with the other devices such as fans or Air Conditioner. The output pins of the SBC display the temperature by utilizing an LCD screen connected to them.

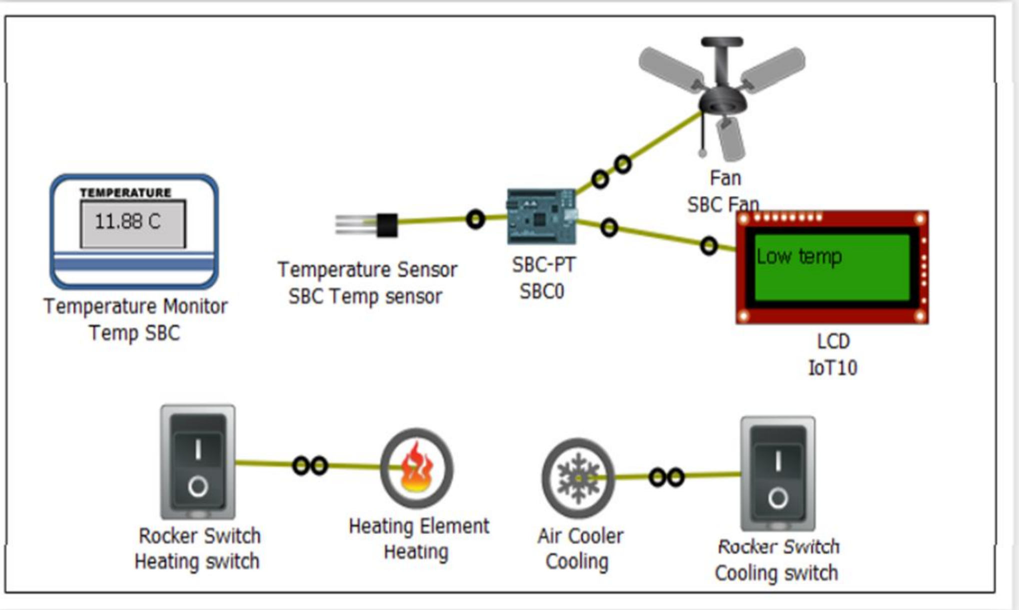


Figure 35. Microcontroller included Infrastructure

As explained in every simulation provided, the need for monitoring of the real time variables comes as a neccessity of its interaction with the other IoT devices to better the conditions and influencing the environment in the desirable way (in this case cooling or heating it). A simulation can occur even without the real life parameter changed due to the Cisco Packet Tracer providing this possibility.

In the next picture, it is seen that when the temperature rises (due to the heating element), the fan is automatically turned on and regulated through it.

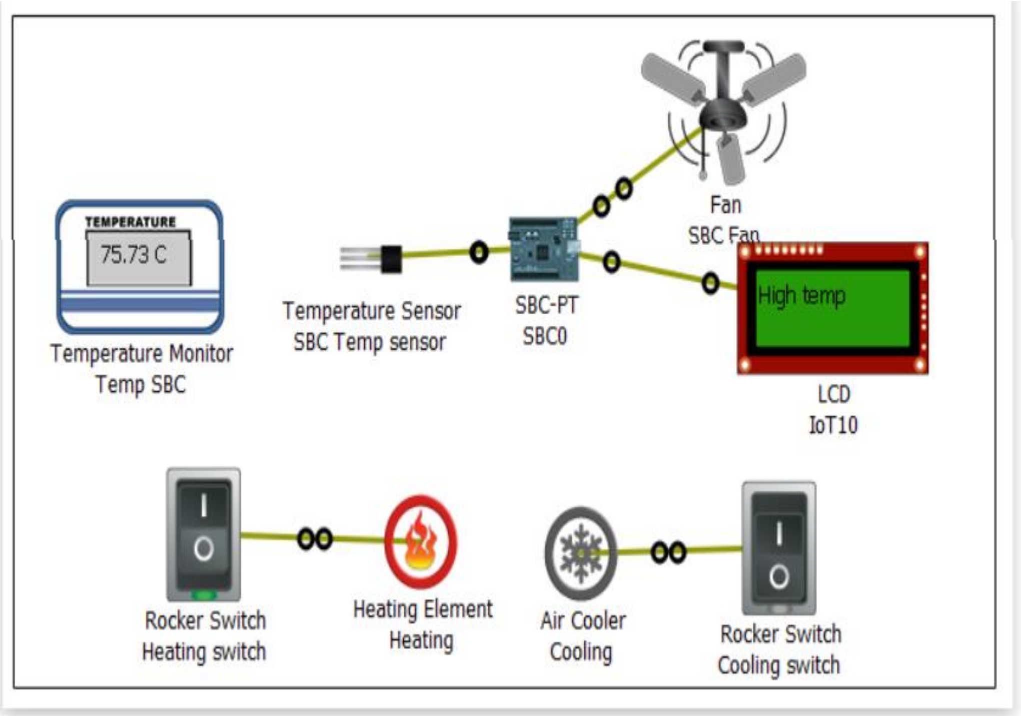


Figure 36. Experiment setup

Future Work

Here we are dealing with a far more complicated and loaded simulation compared to the first Smart Home simulation but the addition on the infrastructure is widely and easily available.

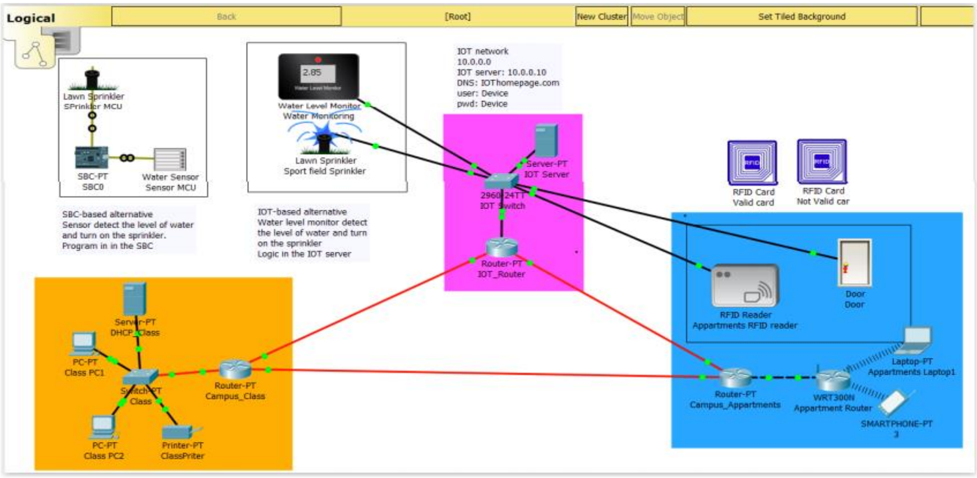
Regarding the networking, having a remote server regarding the IoT backend logic has many advantages as it improves the network layers and its components : routers, security and so on. A simulation based on this concept is very realistic to the real time infrastructure as most of the users nowadays have network access using clouds provided by a third party.

The additions on this infrastructures can also be regarding the IoT devices the user need to integrate to the network or the parameters he would like to be monitored. There are many aspects which can upgrade a Smart Home environment such as the : improvement of the sexurity features using far more complex sensors, integrating smoke and fire sensor which will result in adding extra fans or sprinkles which would prevent the most common hazards in this type of environment.

Since the programming of the non-smart devices is done through the microcontroller using the Blockly programming language, sky is the limit and every option thinkable can be implemented.

4.3.3 Smart UNI

An IoT involving exercise and experimentation is far more easy to understand in case of simulating a university environment, but the build up of the network and IoT setup were far more detailed and loaded due to having more components integrated and a tighter device to device connection. It is also the best simulation to expand for further addition of components. Here a university environment is simulated, composed of classes and apartment networks and an Internet of Things network that makes the connection throughout the whole infastructure possible using IoT devices. Controlling the accesses to the networks and the “smart”watering of the football field are examples which are shown in the simulation.



IOT network
10.0.0.0
IOT server: 10.0.0.10
DNS: IOThomepage.com
user: Device
pwd: Device

SBC-based alternative
Sensor detect the level of water and turn on the sprinkler.
Program in in the SBC

IOT-based alternative
Water level monitor detect the level of water and turn on the sprinkler
Logic in the IOT server

Figure 37. Smart UNI Layout

Network Setup

In the introductory chapter , it was said that the network layout of this simulation would be the most complex and loaded one compared to the previous ones. It comes as a result of the infrastructure being composed of :router network, classroom network (in this case it is wired not wireless), WLAN appartment network and the IoT server using a specific switch.

The router network is composed of three of them which in these case are interconnected between each other (one router is simultaneously connected to the other two). This structure is created for the sole purpose of building an architecture that can withstand both physical and software failures that can interrupt the whole network connection.

In order for the thesis to present a realistic simulation to the university environment and this network, routers are placed all around the campus and connected by Ethernet cables (optic fibre fast cables) in order for the best performance substraction.

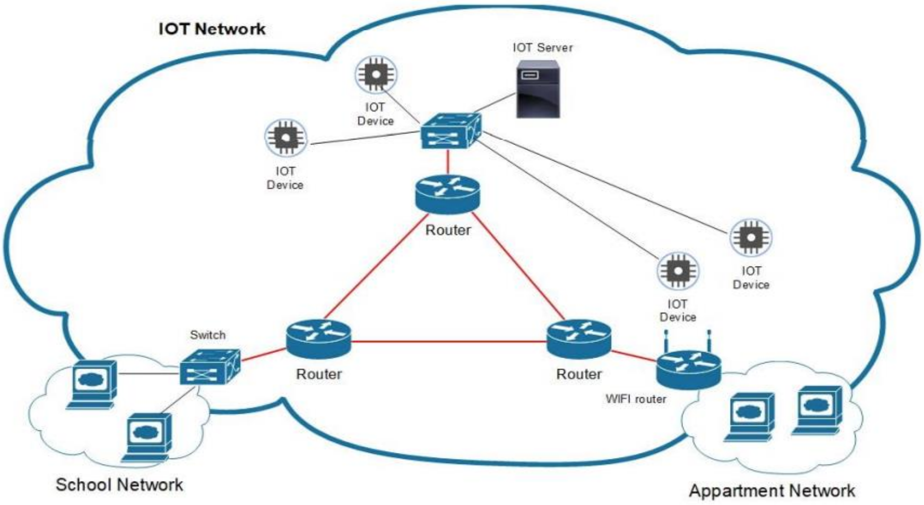
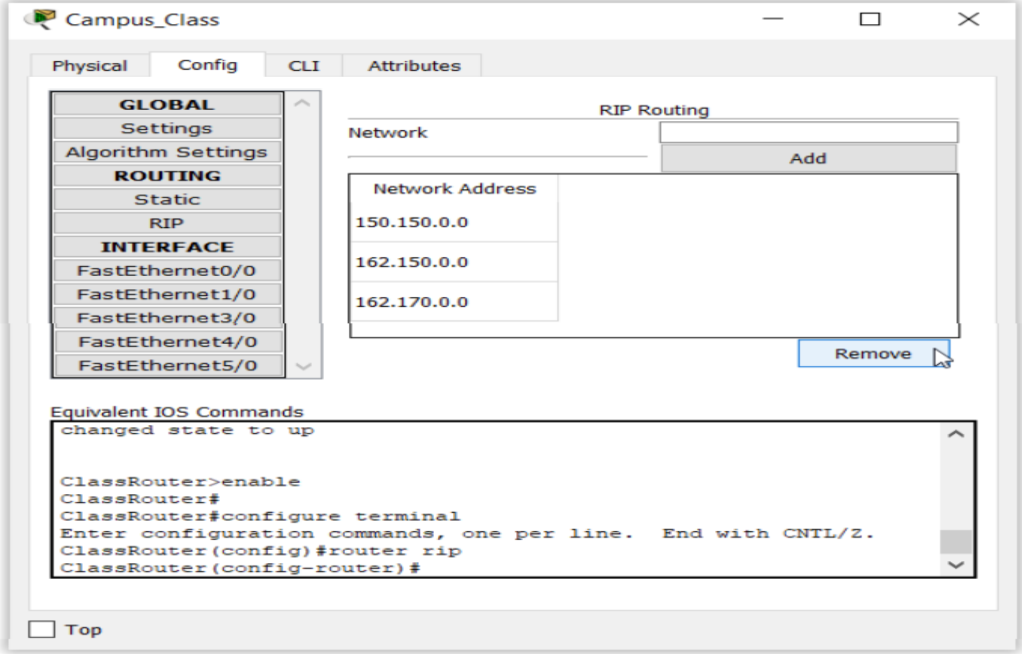


Figure 38. Smart UNI network layout

In order for the process of routing to be done between all the backbone devices and have them fully connect to each other as each represents a full scale network a protocol named RIP is used. This protocol's purpose is to configure routers and although simple and very old, still finds usage in the tech field as it periodically shares routing duties to all the devices it is implemented. Although it is very valuable, its ability to support only a small number of hoops and other limitations make it a liability in the real life conditions and scenarios.

Being as simple as it is to use, it was the best suited protocol to be implemented in the simulation using the Cisco Packet Tracer.

While setting up and configuring each router using the IP they are assigned by the network , the protocol will take care for the spread of routing through all three of the router networks for the scheme to have maximal efficiency. These things are visualized in the pictures above.



RIP Routing

Network

Network Address
150.150.0.0
162.150.0.0
162.170.0.0

Equivalent IOS Commands

```
changed state to up


ClassRouter>enable
ClassRouter#
ClassRouter#configure terminal
Enter configuration commands, one per line.  End with CNTL/Z.
ClassRouter(config)#router rip
ClassRouter(config-router)#
```

Figure 39. RIP Protocol implementation in the class environment

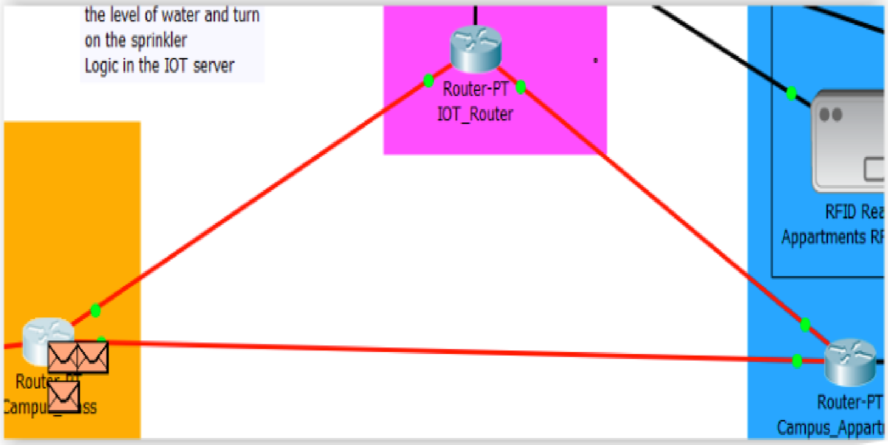
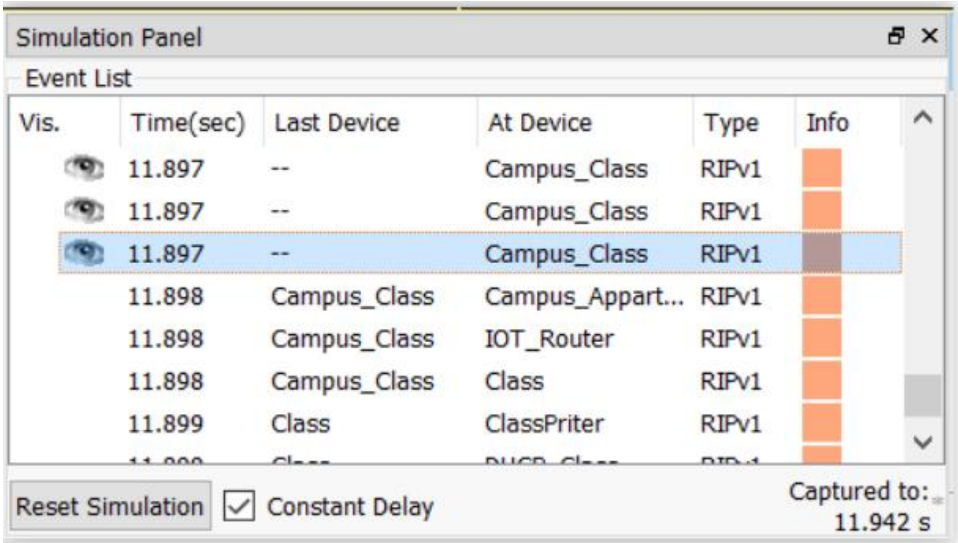


Figure 40. Broadcasting of RIP messages



Simulation Panel

Event List

Vis.	Time(sec)	Last Device	At Device	Type	Info
👁	11.897	--	Campus_Class	RIPv1	🟧
👁	11.897	--	Campus_Class	RIPv1	🟧
👁	11.897	--	Campus_Class	RIPv1	■
	11.898	Campus_Class	Campus_Appart...	RIPv1	🟧
	11.898	Campus_Class	IOT_Router	RIPv1	🟧
	11.898	Campus_Class	Class	RIPv1	🟧
	11.899	Class	ClassPriter	RIPv1	🟧

Figure 41. The capturing of Packets

If the interconnection between the three routers was not enough, they also have to be connected to the three other networks composing the infrastructure : class, appartment and IoT network. As these networks present different university environment and different concepts , they are physically put into different locations.

The first and the easiest network to be built and setup was the classroom network. It is composed of only two PCs, a printer which is connected to the network as an IoT device and a server which using a switch are all paired by Ethernet cables. The setup then continues with the router being introduced and the switch being linked to it while the servers carry out the DHCP duties.

As for the apartment related network, the structure is also an easy one containing a WLAN network which introduces to all of its users wireless connectivity. The WLAN router in the center of this network is connected to one of the interconnected routers in the router network to create its own, while the DHCP functions are a responsibility of the WLAN itself. A phone , laptop or tablet is sufficient to have access to this network.

The IoT is the last network to compose this architecture, while it is definitely the most important part of it. The IoT network is built using a switch (dependent on it) which is connected to the third interconnected router.

Since this network is based on the switch, all the IoT devices are also while they are connected to it. In the other simulations the IoT devices were all linked to the WLAN router as it was its purpose tobe a network where these devices can gain access (an approach closer to real life).

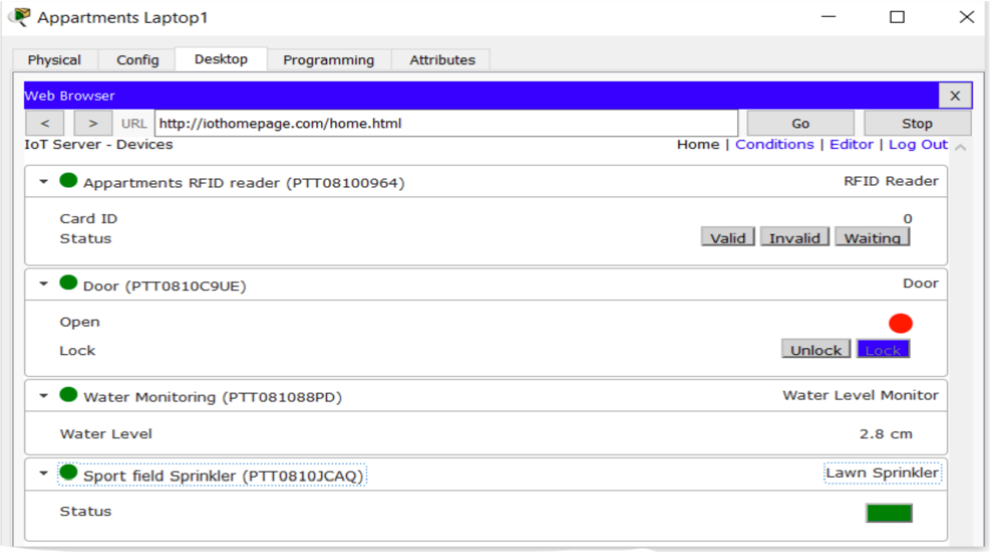
But considering the fact that WLAN has a coverage range up to a few ten meters which is a great disadvantage to the IoT devices linkup, problems as connection interruptions and timeouts would occur. Using the cables and the switch is better suited to the simulation in a perfect condition environment created in the Packet Tracer. DNS and DHCP functionalities are used by this network to represent every IoT device with its own IP adress and recognizing them.

IoT Layout

All the IoT automations and simulations have a lot of things in common, one of which is the connections to the server using the same credentials such as the username and the password. A static Ip is used to complete all the connections due to it not changing offering a great advatage as it is awlays recognized by the same characteristics.

Another important part of the simulation is the network setup and the integration of certain protocols such as the RIP one. To the IoT homepage , it is able te enter and gain access through every phone and laptop in the university environment or remotely. Also carring the function of DNS, the hompage is characterized by a static IP.

After entering the homepage and placing your credentials in order to gain access, all the IoT devices and the connection between them is displayed to the user.



http://iothomepage.com/home.html

IoT Server - Devices

● Appartments RFID reader (PTT08100964) — RFID Reader

Card ID	0
Status	Valid Invalid Waiting

● Door (PTT0810C9UE) — Door

Open	●
Lock	Unlock Lock

● Water Monitoring (PTT081088PD) — Water Level Monitor

Water Level	2.8 cm

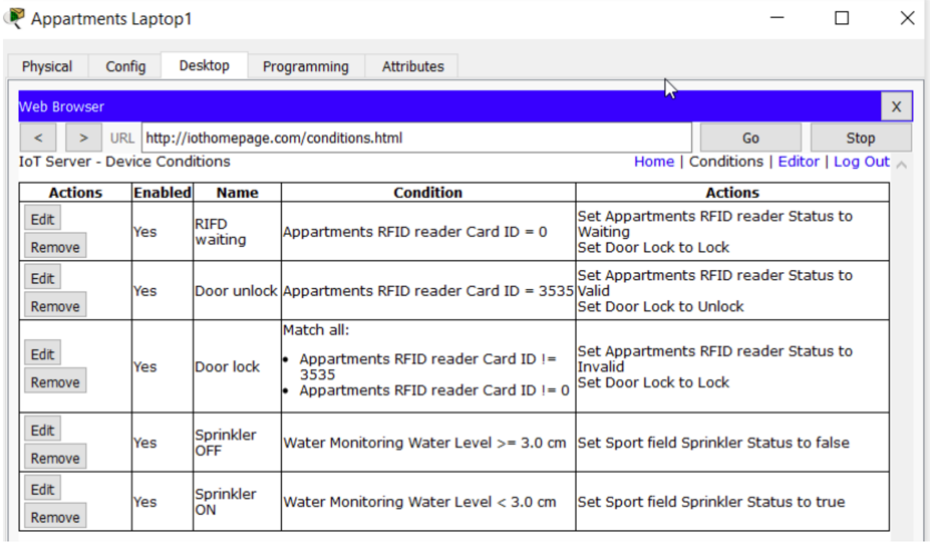
● Sport field Sprinkler (PTT0810JCAQ) — Lawn Sprinkler

Status	🟩

Figure 42. Smart UNI devices

In the figure above, it is easy to observe the devices connected and the parameters shown by them : ID reader, door opener, sensor measuring the level of water and sprinkler sensor.

Also in the figure below , we have a set of pre-conditions applied to each of these parameters of the IoT devices in order for them to be to the desired range :



http://iothomepage.com/conditions.html

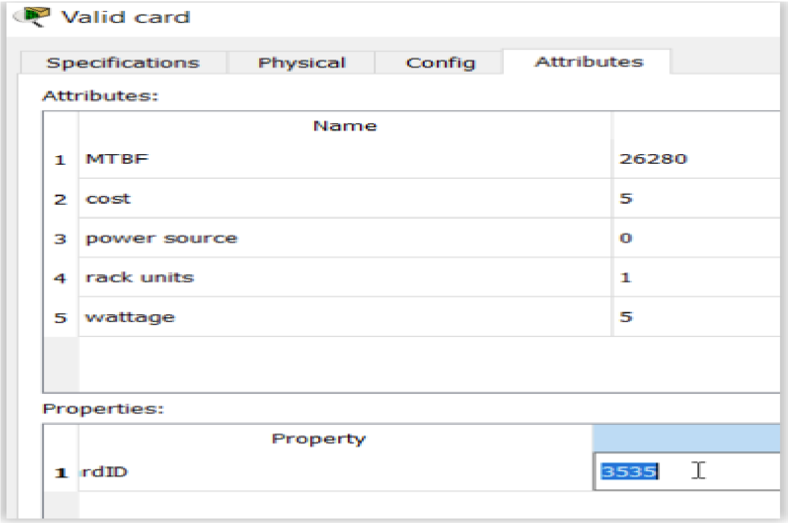
IoT Server - Device Conditions

Actions	Enabled	Name	Condition	Actions
Edit Remove	Yes	RIFD waiting	Appartments RFID reader Card ID = 0	Set Appartments RFID reader Status to Waiting Set Door Lock to Lock
Edit Remove	Yes	Door unlock	Appartments RFID reader Card ID = 3535	Set Appartments RFID reader Status to Valid Set Door Lock to Unlock
Edit Remove	Yes	Door lock	Match all: • Appartments RFID reader Card ID != 3535 • Appartments RFID reader Card ID != 0	Set Appartments RFID reader Status to Invalid Set Door Lock to Lock
Edit Remove	Yes	Sprinkler OFF	Water Monitoring Water Level >= 3.0 cm	Set Sport field Sprinkler Status to false
Edit Remove	Yes	Sprinkler ON	Water Monitoring Water Level < 3.0 cm	Set Sport field Sprinkler Status to true

Figure 43. Pre-set parameters

In the first simulation, one of the main purposes was to create an student's ID reader IoT device which would be connected to the network. It would provide the students to access their apartment by only using their ID card while a smart door mechanism should be implemented.

The perception came as said, the right ID card would cause the door to be opened while an inappropriate one leaves it unlocked. The card attributes should be registered and editted for this purpose to be achieved as shown in the picture below :



Attributes:

	Name	
1	MTBF	26280
2	cost	5
3	power source	0
4	rack units	1
5	wattage	5

Properties:

	Property	
1	rdID	3535

Figure 44. ID card properties

In order to illustrate the functioning of these cards and the logic behind them two cards were used, one with the correct value and one with the inappropriate one. The logic behind it is preserved in the IoT backend server, where the conditions are also implemented. All the processes from the swapping to the message appearing were all done through simulations in the Cisco Packet Tracer. When the green light turns on, meaning the card was an authorized one the door opens while a red light appears in case of an unauthorized card and the door remains looked as in the pictures below :

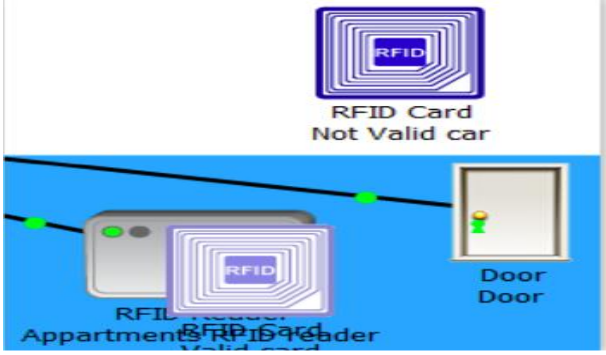


Figure 45. Authorized card SIM

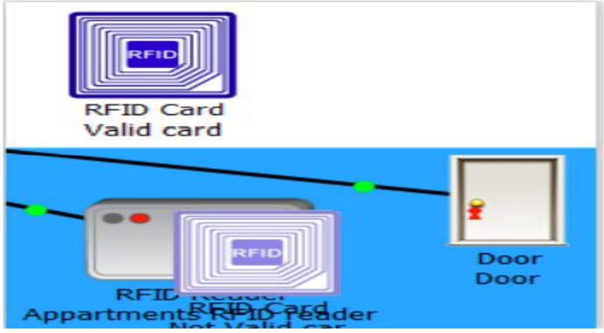


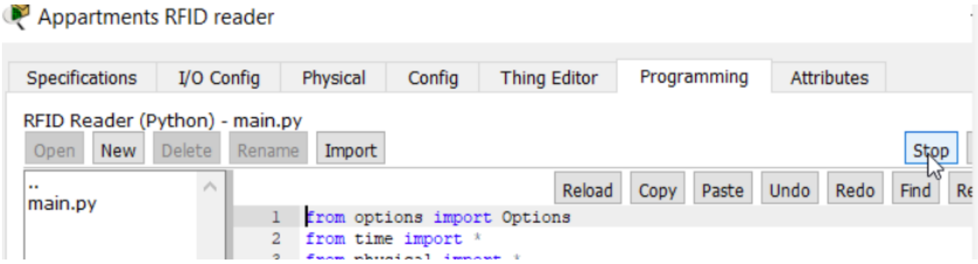
Figure 46. Unauthorized card SIM

There are also specific cases to be implemented to the simulations and pre parameters to be set, one fo which having in mind the way a reader works, a waiting condition can be applied. This condition involved accepting new, previously unregistered cards placed until access through the IoT homepage while in the process the smart door remains locked.

All the reader characteristics and specs and the simulation steps are explained in the chapter.

Worth mentioning is the fact that the usage of these smart IoT devices and components makes it able to create many more infrastructure and more complex ones in spite of pre setting conditions to them. The simulation of the door in the Cisco Packet Tracer is done by pressing certain commands which go through it and produce a result.

The ID card reader simulation is only a small example to how complex simulations and what the technological future has to serve to the future environments, in this case the university ones. However in the making of these complex simulations and automations, a thing should be kept in mind that due to this reason even the servers and devices used are not appropriate to carry out in real life everything simulated, so better IoT server solution is to be found. Another thing worth mentioning is the unreliable functioning of the ID reader, where the programm had to be restarted multiple times but physical conditions such as scratched cards or reader malfunctions can cause nerve-wracking problems to the students not being able to access their appartments. That is why the stopping of this program is also a vital option to be provided.



RFID Reader (Python) - main.py

..
main.py

```
from options import Options
from time import *
```

Figure 47. Program stoppage

Then in the second simulation what we are dealing with is a water sensor implanted in the football field, which smartely decides to water it based on the pre-set parameters and all time monitoring. The simulation of a 24 hour lapse of rainfall has been presented in the graph below :

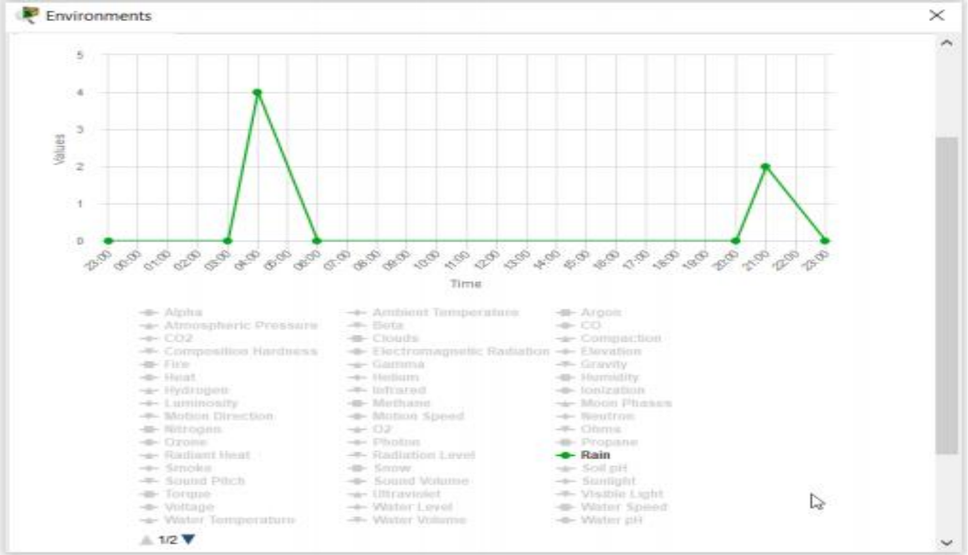


Figure 48. Environment parameter (Rain)

By the data of the graph, it is easy to observe the times therainfall has happened which then resulting in the increasing water levels and the observation of it by the water sensor which in the case the goals have been accomplished, shuts down the sprinklers. In the picture above we have the illustration of both sides of the medals, when the sprinklers work and when they stop :

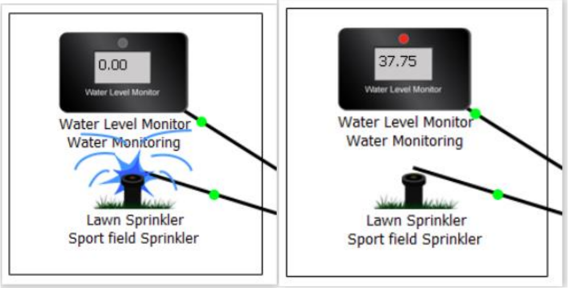


Figure 49. Sprinklers reacting to the water sensor’s information

There can also be a regulatory scheme implemented regarding the very high levels of water present in the football field, by adjusting it using temperature and sunlight providing mechanisms.

Microcontroller Example

As in all of the previous simulations, one including the microcontroller component was created in order for the exercise to be even more related to the Electronics field and while Cisco Packet Tracer makes it possible why not. The case presented in the simulation including the microcontroller is the one with the sprinklers, but with an exception of all the smart components. The non smart components (the water sensor) in this case is connected to the SBC board inputs while the microcontroller outputs are connected to the sprinklers as shown in the figure below :

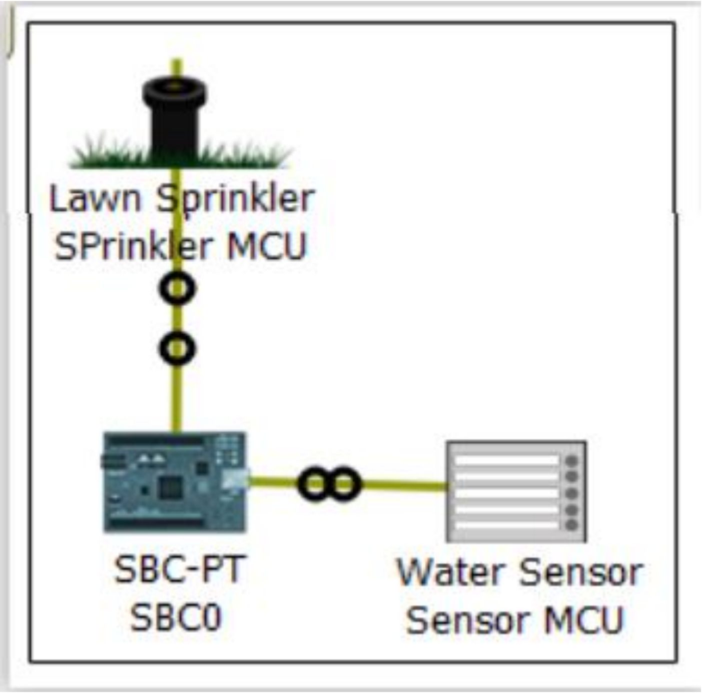


Figure 50. Microcontroller Scheme Layout

Taking the same steps otherwise as in the IoT smart component inclusion, the purpose of the water sensors is to send information to the SBC board and microcontroller everytime the level exceedes the normal range pre set.

The main difference here is the logic implemented through programming of the microcontroller (SBC) while in the other simulation the IoT server contains it.

Another very apparent different between these two simulations is the values asserted into the sensor programming and the vlaues it is supposed to represent.

The rain parameters are configured to display certain conditions in our simulations in order for the better understanding of the simulation.

The logic of the SBC functioning is presented in the latter chapters.

Future Additions (Work) to the scheme

The possibilities of making additions in the scheme to make it even more complex are always present in these types of simulations. It mainly includes the involvement of new components, IoT devices or networks.

A great addition to the network simulation would be the IP addresses of all the authorized devices access where all the information is preserved in the remote IoT server.

As said before, the usage of the WLAN is a big disadvantage regarding its limited range of reach which is up to only tenths of meters so consequently a switch was used. In the real world conditions it would not be possible so creating a network of interconnection WLANs would be another future work to be supervised.

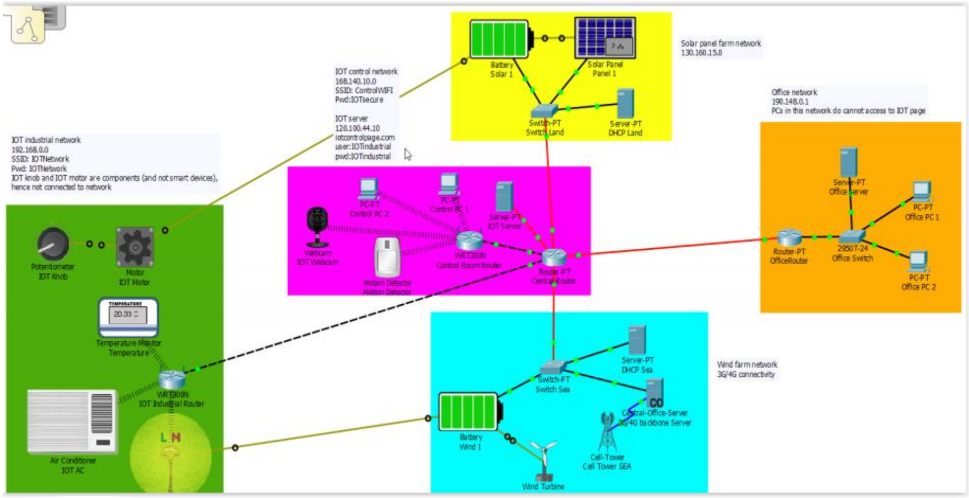
As for the addition of many other IoT devices and components, an infinite number of services can be provided and implemented such as security sensors, electricity production, emergency plans etc.

The microcontroller can be included in many other simulations of different scenarios when the problem of WLAN is presented.

4.3.4 Smart Work Environment

Probably the most detailed and difficult to setup simulation in this thesis is the Smart Work Environment one. The reason behinf it is the architecture of the network as well as the logic put in connecting all the IoT devices and the servers.

Here a work environment is simulated, where we have a lot of smart devices, components and sensors carrying technological defying duties such as : solar panels producing electricity, charging the batteries and using it in other funcionalities by using actuators. This energy can also be used to supply IoT devices such as the AC (Air conditioner) or turning on the lights.



IOT industrial network
192.168.0.0
SSID: IOTNetwork
Pwd: IOTNetwork
IOT knob and IOT motor are components (and not smart devices), hence not connected to network

IOT control network
168.140.10.0
SSID: ControlWIFI
Pwd:IOTsecure

IOT server
120.100.44.10
iotcontrolpage.com
user:IOTindustrial
pwd:IOTindustrial

Solar panel farm network
130.160.15.0

Office network
190.148.0.1
PCs in this network do cannot access to IOT page

Wind farm network
3G/4G connectivity

Figure 51. Smart Work Environment Layout

Network Setup

Thhe setup of the network environment as in the previous simulations is the most requiring and difficult step to be completed, since we have to carefully analyze every aspect of it, have its physical layers seperated due to fulfilling the logic requirements of the experiment.

The concept of this network's setup is the division in a few more other sub-areas, five to be exact where we have : two environments composed of energy producing and storaging devices (solar panels and batteries), a subnetwork for the office and the IoT devices connected to it, another one where the utilization of the electricity is defined and lastly the subnetwork responsible for all the IoT logic and management. It is a no brainer that they are interconnected through a router placed in the last environment (IoT server). It is a far easy scheme to be completed in the CPT Packet Tracer wether than in real life where its complexity would be troubling.

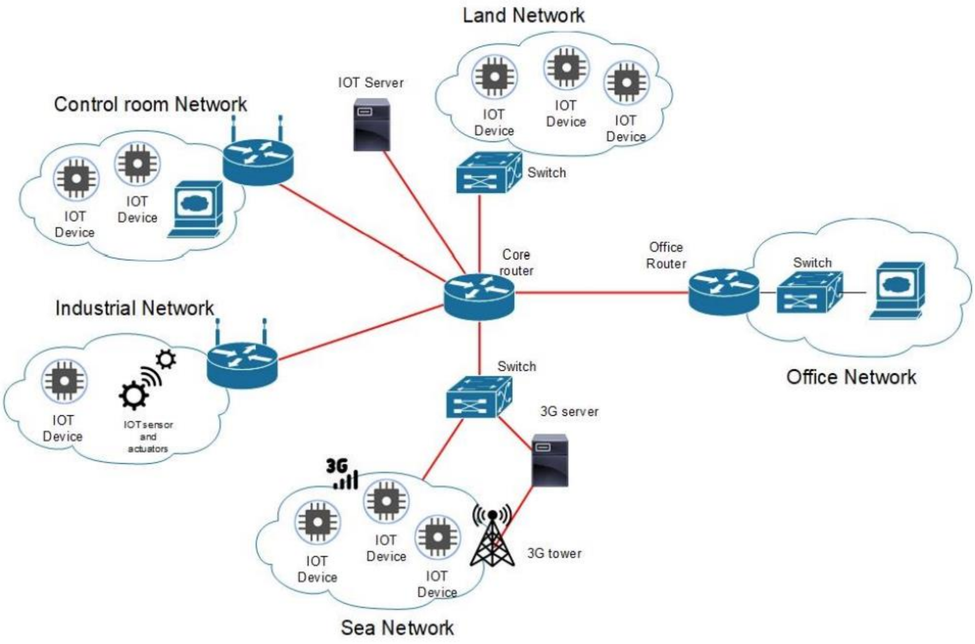


Figure 52. Smart Work Environment Network Setup

The office LAN was the sub-network where the least attention was paid due to its simplicity. The structure includes the main router, which is then consequently linked to both office router and switch. DHCP funcionalities and usage of the PC's are provided by the connection with the switch component.

In the design of the architecture and the network, it is easy understandable that the office PC's are not among the devices aleglible for authentication, in other words they can not enter the homepage or monitor any of the IoT devices. It is build so on the sole purpose of not everybody having access to such valuable information or management over the IoT devices so they are isolated and only a user with the correct credentials and a physical connection can enter. The two networks providing the electricity through solar panels and other components are named Land and Sean and both of them have LANs that directly and physically link up to the central router.

The network named Land is a model based on the switch component and its purpose is to simulate an environment where electricity is produced and stored in batteries using solar panels.

The scheme is simpified using the cables that connect each and every IoT device to the switch. In the real life environment other more sophisticated tools and components such as wireless or optic fibres may be used since they are simplier and more reliable. The DHCP server is integrated in the network and it does the assignment of all the IPs to the IoT devices.

The other network named Sea relies on the same principle of the above mentioned network (Land), however the production of the electricity is not done by the solar panels but by the wind turbines. It is also similar to the network containing the switch which is linked up to the central router but the turbines are connected to a celullar network which was used to make a more complex architecture as an example, but also make it more realistic.

In the second Smart Home simulation, it appeared that the integration of a cellular network to the infrastructure came with a lot of complexity and component additions.To provide the connection to the turbines an antenna is added. A server component is then added, so that the establishing of the tower signals is done to the Ethernet. It should be mentioned that the central server is connected to both Sea and Land networks. Same to the network above, DHCP server to assign the IPs to the IoT devices was added.

The least complex and the easiest to build is the IoT Work Environment WLAN. Its main purpose is providing every IoT device connected to it access to the network. These are the devices which exploit all the nergy produced by the Land and Sea networks through their components. A thing worth mentioning is this network's connection to the central router.

And the last , most important and complex network out of all is the IoT management LAN. The networks work on reaching the ultimate goal of connecting every WLAN to LAN, but they also play a managerial role regarding all the fuctioning and behaviour of the IoT devices. Worth mentioning is the fact that every IoT device is connected remotely to the server. The routers are the most important part of the grid while NIC cards serve perfectly in order for all the sub-networks to be tied to the central one.

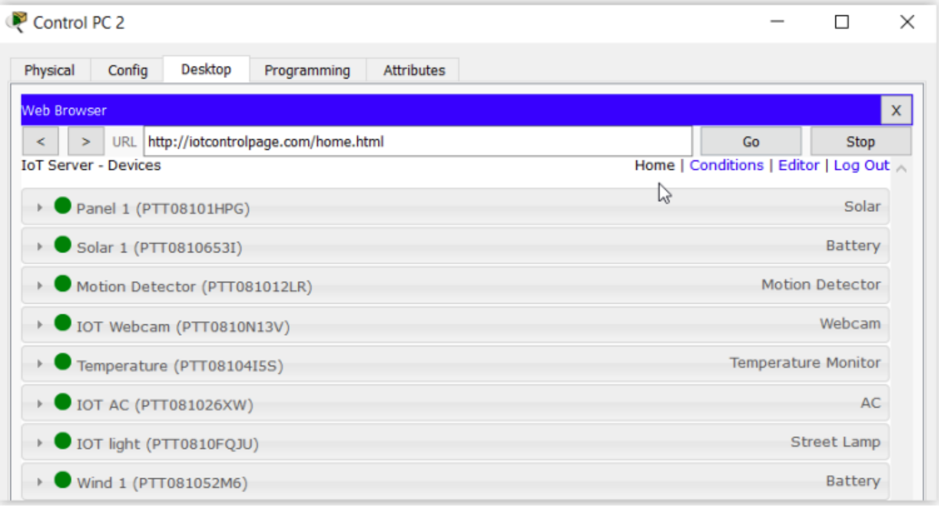
Another very important tool in the well functioning of the whole architecture is the implementation of the RIP protocol as it connects the remote IoT components to their server. Being very simple to use and very handful to the infrastructure eventhough a bit old, it was the preferred component for the automations.

This server also has its WLAN router which is consequently connected to the main router while it also providing wireless connection the the PCs and the IoT devices included in the simulation.

IoT Setup and design

The IoT layout is almost identical to the setup of all the other environment simulations, which eventhough have been connected to LAN's that are seperated from each other are all connected to the IoT server.

Another thing all the devices share together are the credetials such as the username and the password. In the CPT tool, the simulation allowed only the PCs to have authorized access to the homepage.



http://iotcontrolpage.com/home.html

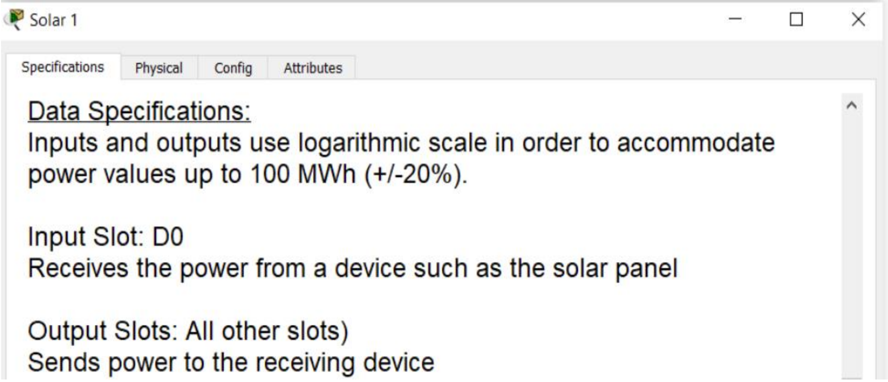
IoT Server - Devices

● Panel 1 (PTT08101HPG)	Solar
● Solar 1 (PTT0810653I)	Battery
● Motion Detector (PTT081012LR)	Motion Detector
● IOT Webcam (PTT0810N13V)	Webcam
● Temperature (PTT081041SS)	Temperature Monitor
● IOT AC (PTT081026XW)	AC
● IOT light (PTT0810FQJU)	Street Lamp
● Wind 1 (PTT081052M6)	Battery

Figure 53. IoT homepage

In the figure above, the IoT homepage is displayed containing several IoT devices connected to it such as the solar panels, batteries, Air Conditioner, lights, sensors and many more. For all the electricity producing and storing components in the two located networks no IoT backend logic is needed as an IoT cable does the connection between these components (panels/turbines to batteries).

The programming of the devices consisted of exact commands to be performed and necessary configurations for the simulation to be performed (inputs and outputs sorted). In the picture below a representation of the connections done using the input/output ports is represented.



Data Specifications:
Inputs and outputs use logarithmic scale in order to accommodate power values up to 100 MWh (+/-20%).

Input Slot: D0
Receives the power from a device such as the solar panel

Output Slots: All other slots)
Sends power to the receiving device

Figure 54. Battery configurations

As said in the previous paragraph in this simulation we have no backend logic which is a part of the infrastructure but that does not mean that a homepage monitoring live information regarding the component’s work is not presented (energy produced/stored).

As for the future work, which can be implemented to expand the simulation scheme and carry as many functions as possible in a future smart environment. A great example would be adding an alarm when the battery percentage is as low as we want. Another great addition would be the power meters whose function is to measure the energy produced.

As far the parameters of the simulations, the conditions go head to head to the generation of the energy by the solar panels and the turbines. In the figure below we have the display of the environment charactetized by different conditions throughout a 24 hour lapse. By the observing, the sunlight is at peak exposure during daytime while it remains zero during night while there is wind all the time.

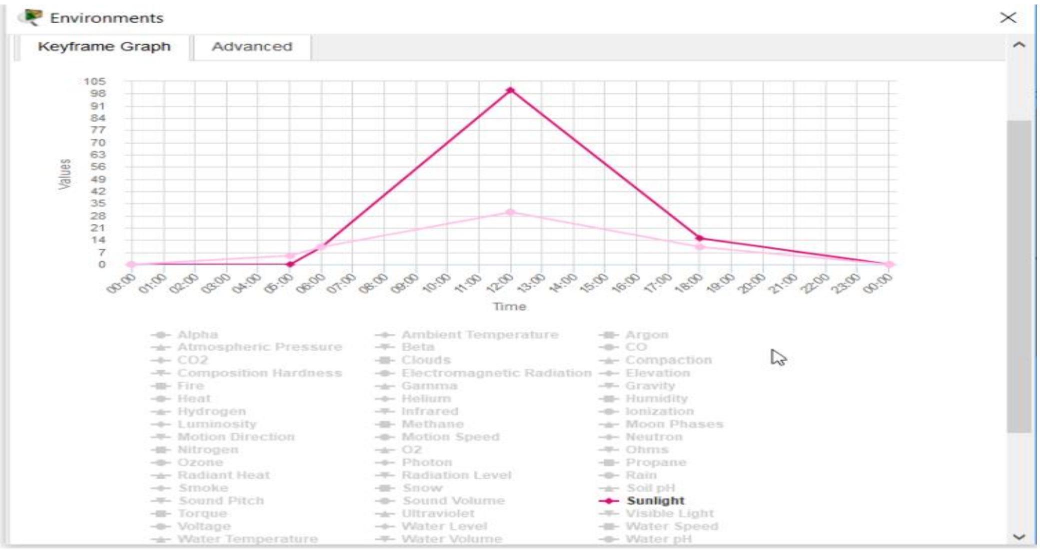


__Figure 55__. Environment parameters

Observing the solar production throughout the day it easy to see the sunlight peak during the midday hours (shown in the picture below).

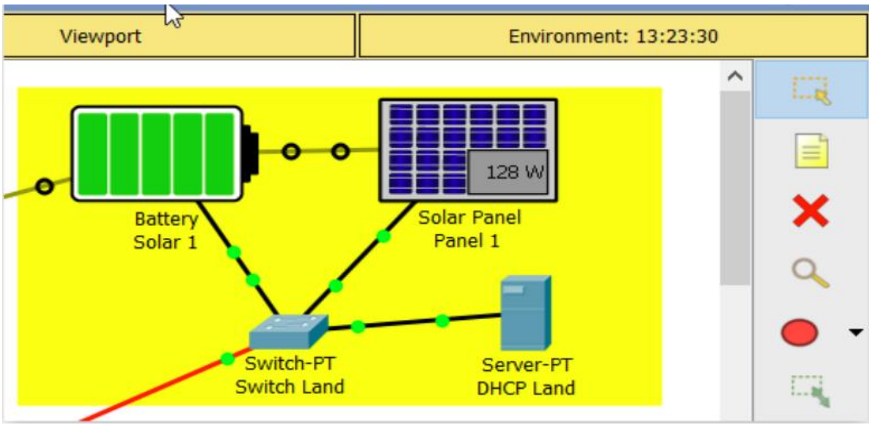


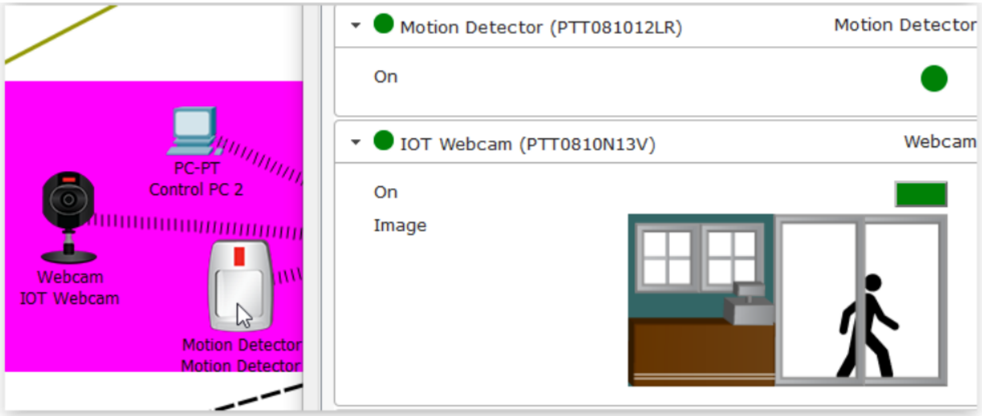
Figure 56. Production of electricity

In further observation it is noticed that there is continous discharge of battery when it is not used to power a network IoT component.

In the simulation we have the integration of the IoT server to the network. The server purpose is to distribute the IPs to the IoT devices, static ones which makes sure it remains unchanged and access can be guaranteed at every time for the authorized devices while functioning as an DNS.

There is another example that can be presented which is related to the IoT control and is related to the concern of surveillence. A security system is imitated which is located in the Work Environment and detects motion. Once the detection is made, live images and broadcast of the environment starts.

This experiment can also be performed completely virtually by simply pressing the right commands and using the computer to simulate a motion for the sensor to catch. If the user is observing from the IoT homepage , the icons will change colours while images will be processed and presented in real time. This process stops with the stopage of motion.



● Motion Detector (PTT081012LR) Motion Detector

On ●

● IOT Webcam (PTT0810N13V) Webcam

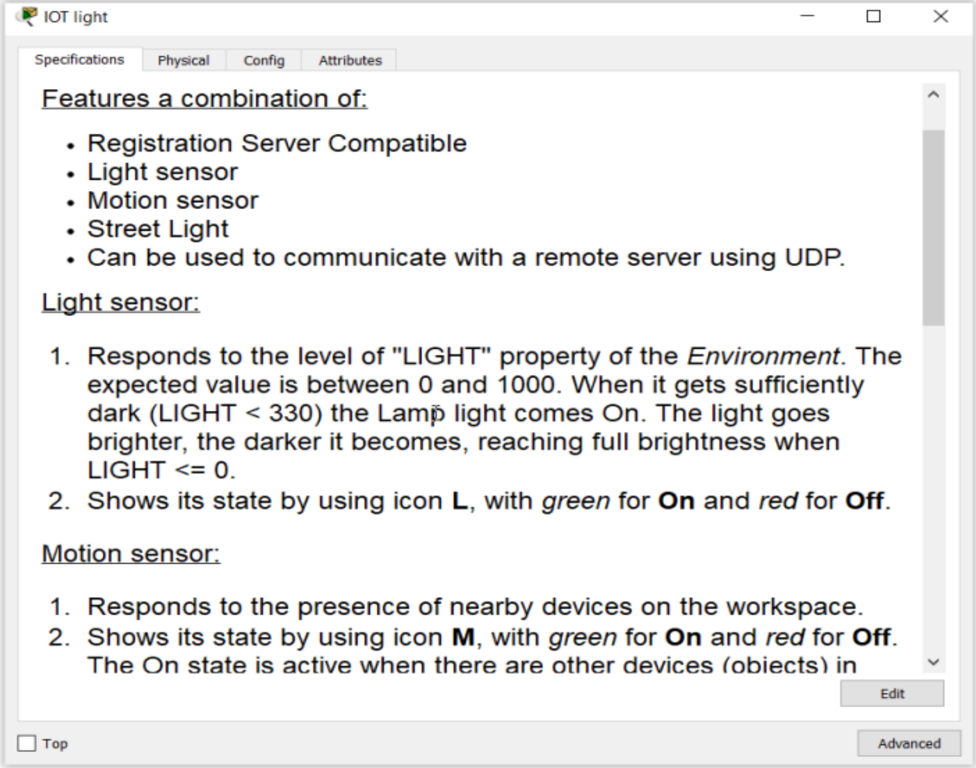
On 🟩

Image

Figure 57. Motion detection and image broadcast

There are many IoT devices that are integrated in the network and function as a part of the infrastructure such as lights, Air Conditioner, motors and many more others.

In the case of experimenting with a lamp (a smart one) as said in the previous paragraphs is not necessary to use the backend logic. This comes as a result of using smart components and sensors that observe the sunlight or the motion parameters. Whenever it is dark or a lack of sunlight the lamp will automatically turn on or in case of someone entering a specific environment (the work environment). It can be also connected to the power supply as an example of an IoT device using the energy produced. In the figure below we have the example of a smart lamp that has been pre configured and specific components (IoT cable) were used to connect them and make them available.



Features a combination of:

- Registration Server Compatible
- Light sensor
- Motion sensor
- Street Light
- Can be used to communicate with a remote server using UDP.

Light sensor:

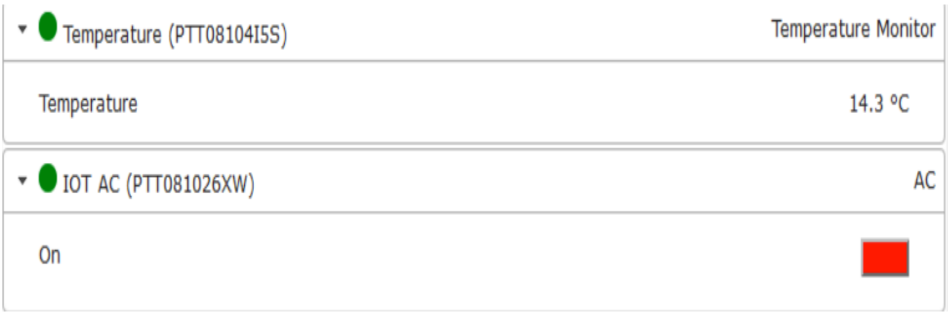
1. Responds to the level of "LIGHT" property of the *Environment*. The expected value is between 0 and 1000. When it gets sufficiently dark (LIGHT < 330) the Lamp light comes On. The light goes brighter, the darker it becomes, reaching full brightness when LIGHT <= 0.
2. Shows its state by using icon **L**, with *green* for **On** and *red* for **Off**.

Motion sensor:

1. Responds to the presence of nearby devices on the workspace.
2. Shows its state by using icon **M**, with *green* for **On** and *red* for **Off**. The On state is active when there are other devices (objects) in

Figure 58. Smart Lamp configuration

But, opposite to the first simulation in this environment where we had no need of the IoT logic server, an example will be presented which does. It will contain an environment where the parameter of temperature will be measured using a sensor/meter. Both the meter and the smart Air Conditioner will be connected wirelessly to the IoT Work Environment WLAN router. In the IoT logic server, a few conditions will be implemented in order for the parameters to stay in the desirable range. As soon as the temperature variable varietes beyond the normal limits (measured by the temperature meter/sensor) it will trigger the activation of the Air Conditioner to perform and manipulate it. This parameter and the IoT device’s status can be visible in the homepage.



▾ ● Temperature (PTT08104I5S) Temperature Monitor

Temperature 14.3 °C

▾ ● IOT AC (PTT081026XW) AC

On 🟥

Figure 59. Parameter and IoT device monitoring

In the last exercise, an experimental example was provided regarding the implementation of a non-smart sensor, where not even the microcontroller was integrated. Its purpose was to show that architectures and infrastructures can be created even in the absence of backend logic of the Internet of Things or a microcontroller by using components such as sensors/actuators. A thing to keep in mind though is that the functionalities it provides will also be more limited compared to the other schemes.

In this experiment. A knob which functions as a potentiometer according to the architecture is linked up to a motor which works by exploiting the power obtained by the energy producing components (turbines). To connect all of them, special IoT cables hd to be used to maximize the performance.

The motor can be tested and put through a simulation by entering the right commands and performing the right actions (if you rotate the knob which is responsible to the control of the motor rotations). Their homepage monitoring is not available due to not implementing IoT logic.

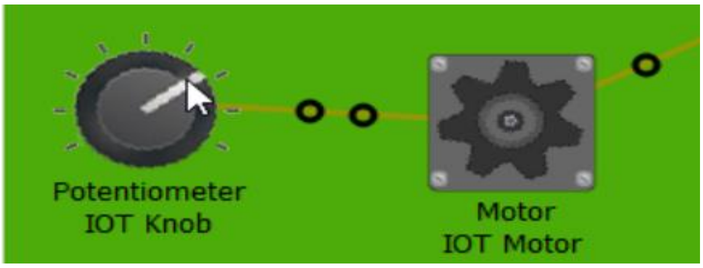


Figure 60. Knob and Motor

Using the CPT tool, it is very easy for the sensors and actuators to imitate smart components which by being inserted the right commands can be configured, programmed to require authentication and so much more.

But once they were added into the homepage, there were no more options to configure or monitor available.

Microcontroller Example

Even in the Smart Work Environment an example will be presented where the scheme will be composed of a microcontroller centered structure. However we also have the absence of the IoT devices here.

In the figure below, we created the scheme for the same example and simulation used by exploiting the IoT devices in order to make a fair comparizon. It envolved a solar panel which is the component able to produce energy and the battery which is the component that makes its storage available. All the components and their programming are done by their connectrion to the SBC board.

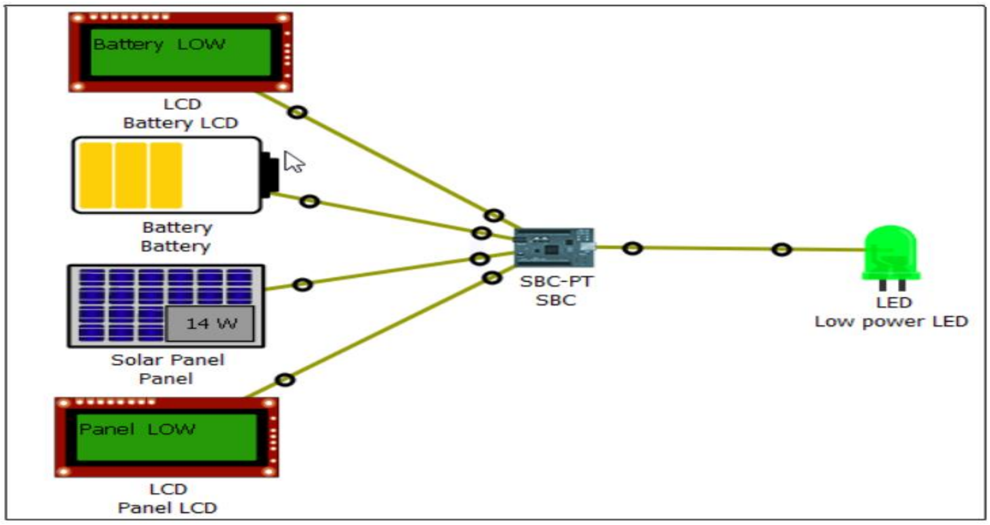


Figure 61. Microcontroller Example Layout

After programming all the components using the Blockly language in the microcontroller, while they are connected to the SBC input port we have also entered LCD screens, in order for the information gathered by the components to be available and displayed (energy data).

An alarm was also pre-set to monitor the data and give warning in case of undesireable parameters.

Future Work

Eventhough the Smart Work Environment project is the most detailed and complex setup by all the four simulations, the additions and expansions which can be applied to it are endless, in both infrastructure and devices connected.

On the addition of the network structure and configuration, worth mentioning is the hierarchy between different users authorized to access it while also dividing the information displayed to every different “status” users with some having less possibilities. IoT devices such as phones can be integrated to also have access to the homepage using their cellular network.

In the IoT backend logic setups, there are the most possibilities for expansion and creating a more complex infrastructure. An example would be the addition of a more secure alarm system which would include sirens, smarter sensors that detect motion,noises and many more others.

Regarding the Work Environment network , a more complex connection between the electricity producing component such as solar panels and turbines with devices that preserve it can be made in order for the scheme to carry the function of a real provider. The addition of monitoring devices immediately becomes a neccessity which will add even more to the scheme.

4.4 Internet of Things Simulations (Additions and Limits)

In every simulation composed of the integration of the IoT devices, the example was close to perfect due to exercise being simulated in the Cisco Packet Tracer where the maximum efficiency was provided without the need of dealing with physical IoT components and connection, which may be unavailable or not properly functioning all the time. As mentioned after each simulation and network layout, the expansions of each scheme and architecture was more than possible and in the majority of cases as easy as it gets. However due to tool or time limitations, the examples chosen to be provided in the thesis were on the average side.

Another setback on using the Cisco Packet Tracer was the lack of ISP availability in the simulation environment so a made up solution was to be thought of. The usage of the static IPs combinated with the positive aspects of implementing routers came as a perfect replacement for the ISP. In a certain example we had the IoT server logic being provided as a service by a third party remotely so the routers used different IP to enter the cloud while in real life conditions the functioning of this architecture would be in doubt.

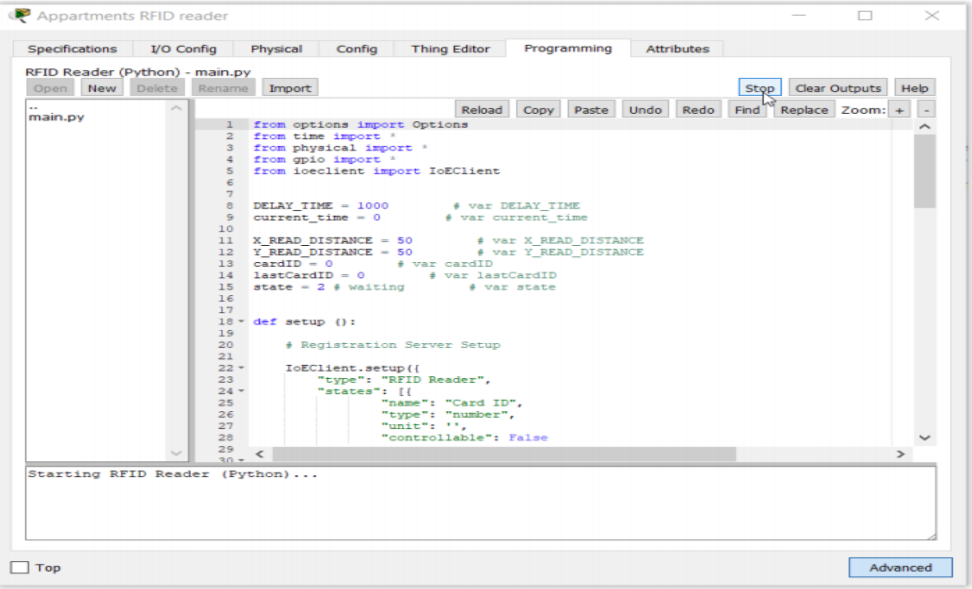
We also had a lot of simulations on other exercises which implemented not so real-life based infrastructures (Smart UNI ans Work Environment) where the scheme was made possible due to the integration of the switch component, used to make connection through all the IoT devices using cables. Although more unsuitable rather than impossible, the cable's lack of range is a major directive to this verdict.

There are even more drawbacks to be mentioned while doing the simulations and experimentations in the simulation environment and a lot of them came as a result of the Cisco Packet Tracer being buggy as well. Compared to other similar tools and previous versions, it seemed to be the most perfect environment to simulate the schemes. However after using it, crashes were a big timewasting problem while component's link up was also a major problem observed eventhough they were correctly structured and linked.

 Configuring the devices and pre inserting parameters into them has also appeared to be a little problematic to be achieved as we rarely had an interruption of the connection between the device and the server which requred the process to be repeated eventually.

A solution to it was redoing the scheme from the start by replacing the components with new ones or changing the scheme.

Programming of the devices with the Python language derived the logic to be flawed sometimes eventhough the program showed no sign of malfunction as in the case of the ID reader. The simulation done after the reprogramming was delayed to be performed after a restart of the tool in the ending of the programming.



```
from options import Options
from time import *
from physical import *
from gpio import *
from ioeclient import IoEClient


DELAY_TIME = 1000         # var DELAY_TIME
current_time = 0         # var current_time

X_READ_DISTANCE = 50         # var X_READ_DISTANCE
Y_READ_DISTANCE = 50         # var Y_READ_DISTANCE
cardID = 0         # var cardID
lastCardID = 0         # var lastCardID
state = 2 # waiting         # var state


def setup ():

    # Registration Server Setup

    IoEClient.setup({
        "type": "RFID Reader",
        "states": [{
                "name": "Card ID",
                "type": "number",
                "unit": '',
                "controllable": False
```

```
Starting RFID Reader (Python)...
```

Figure 62. Programm run on ID reader (Python language example)

What I would also consider a drawback was the time the Cisco Packet Tracer took as a tool for all the architectures to be completed and the simulations be performed.

The CPT Packet Tracer was characterized by a complexity, that oftenly required regaining of information in order to troubleshoot and solve the problems appearing in it.So in other words the technical/practical part of the thesis was not underestimated at any time.

The expansion of the usage of IoT devices in the environments tended to be created is a great possibility of development in the future, which will make the network more complex and create an even more intelligent environment. The network will also require extra components for it to function regularly.

The last but not least addition to the infrastructure would be the usage of microcontroller. Although many examples,one of each smart environment there are still more simulations where it can fit in and make a more complicated but interesting architecture. Its function would be to control the smart devices while programming it would be a beneficial experience.

CHAPTER 5

RESULTS AND CONCLUSIONS

Regarding the conclusions of the thesis, in the previous chapters we have seen many of them but it is clear to say that overall, every simulation of the Smart Environments was achieved and the term of the Internet of Things not only was introduced but was easily comprehensible through the practical side even to the reader. Both the evaluations tended to be delivered and the methodology including results are expressed below.

After completing every simulation and creating all the infrastructures needed to perform them using the CPT Packet Tracer Tool, the goal of creating Smart Environments was reached while also answering the thesis questions and unclear informations.

The IoT simulations including devices and servers wer built and presented to the readers of the thesis for them to understand the creation of these smart environment using technlogical means to derive to the conclusion other than physical ones, but with the infrastructure being easy to imitate by real life components. The readers are also introduced to a tool that may help them with similar project simulations and a detailed explanation on its usage.

As mentioned in the previous paragraph, the usage of the Cisco Packet Tracer is the basic knowledge the readers should obtain by considering this thesis while the simulations done contain a bit of advanced knowledge that the reader may obtain in various studies and courses. They are an introduction to the practical side of networking while more complex simulation examples are also proposed in the future work section.

The expansion on the usage of the CPT tool and all the available options it comes with, all which can be gained from networking studies can result as in this thesis case in much more complex simulations which add even more components and devices that make the architecture loaded and detailed. The examples including microcontrollers and other smart and non-smart components, sensors delivered some of the best automations for a Electronics Engineering student while also expanding the knowledge in its requirements on programming and many other fields.

Another conclusion derived is that the Cisco Packet Tracer eventhough flawed and sometimes troubling was the best overall tool to simulate environments and networks with unlimited possibilities and ways of constructing your scheduled architecture. Updates in it make it even more likeable to be used on further studies and developments in the technological field.

There are also conclusions made in this paper regarding the methodology used and the result it provides, the implementation.

In order for this project to be executed, a lot of information and knowledge was gathered beforehand, the right tools to derive to the simulations were used, experiments regarding many subject fields were done, results were presented while feedback will derive from the readers.

In order for the thesis to be completed, each section of it was given its necessary time and undivided attention. This division made it possible to give everything into making each part perfect and I would suggest the same work method and ethic to users focusing on the future work ideas.

Regarding the simulation phase, or the implementation of each component a thing always to be considered before doing so is the pre-scheduling and planning of the scheme which will help a lot in these types of thesises. Practical knowledge should be obtained before thinking of starting a thesis whose concept is close to this as it would require an awful lot ammount of time and it would be hard to complete.

A beneficial situation which has a large contribute to this thesis is the help which came from the field specialist when difficult problems came to existence.

Future works and studies regarding these thesis are proposed as a way of heading the attention towards the Internet of Things field study and experimentation as it is the future of the technology.

To paraphrase and do a conclusion on the thesis, we can say that it is a very successful one regarding both theoritical and practical side. All the steps are explained and displayed in details while the results were documented and the future work was presented to initiate further studies.

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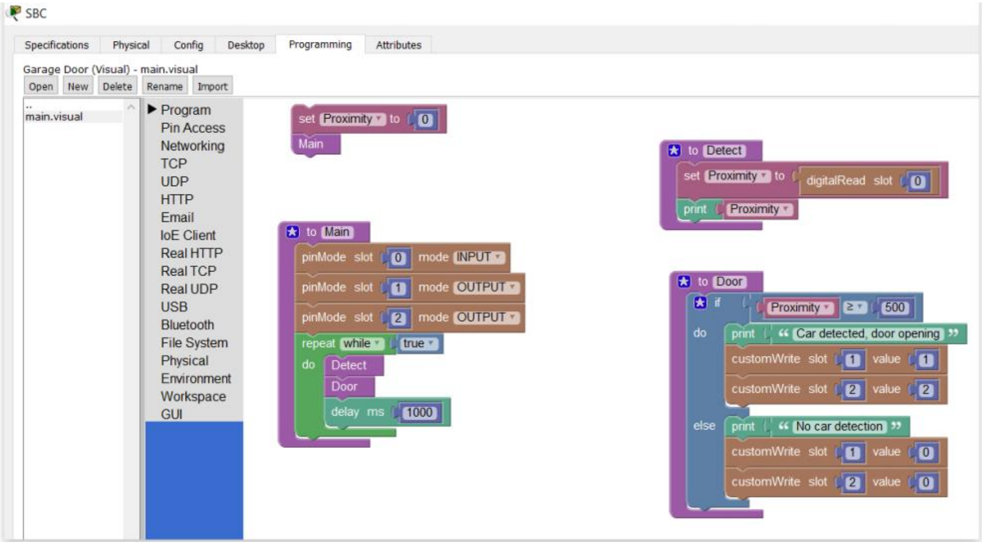
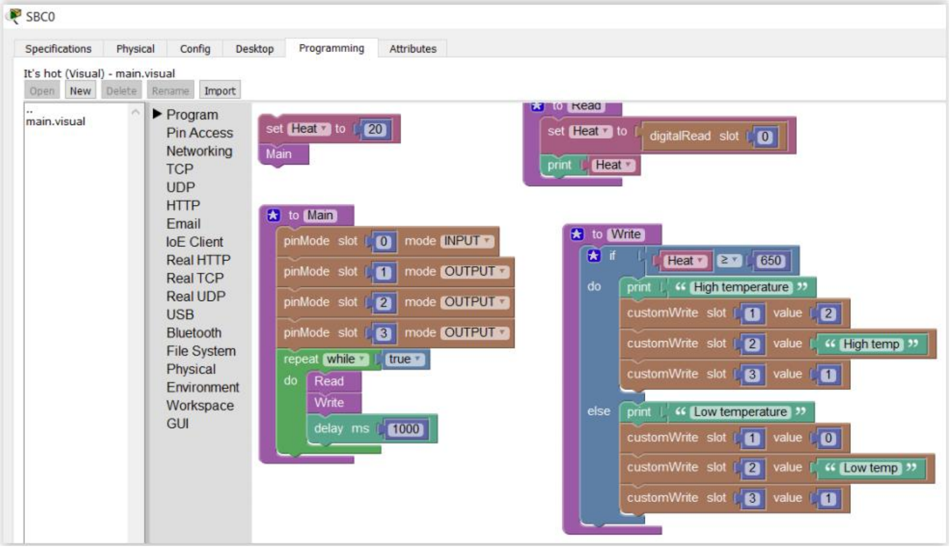
APPENDIX A



```
set Proximity to 0
Main

to Main
    pinMode slot 0 mode INPUT
    pinMode slot 1 mode OUTPUT
    pinMode slot 2 mode OUTPUT
    repeat while true
    do  Detect
        Door
        delay ms 1000

to Detect
    set Proximity to digitalRead slot 0
    print Proximity

to Door
    if Proximity ≥ 500
    do   print “ Car detected, door opening ”
         customWrite slot 1 value 1
         customWrite slot 2 value 2
    else print “ No car detection ”
         customWrite slot 1 value 0
         customWrite slot 2 value 0
```

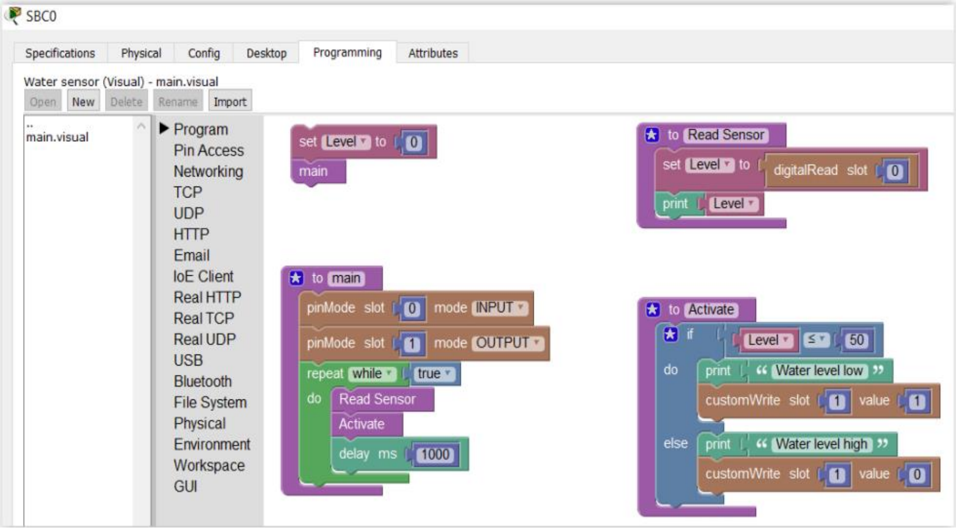
Figure 63. Blockly Programming (First Smart Home Simulation)



```
set Heat to 20
Main

to Read
    set Heat to digitalRead slot 0
    print Heat

to Main
    pinMode slot 0 mode INPUT
    pinMode slot 1 mode OUTPUT
    pinMode slot 2 mode OUTPUT
    pinMode slot 3 mode OUTPUT
    repeat while true
    do  Read
        Write
        delay ms 1000

to Write
    if Heat ≥ 650
    do   print “ High temperature ”
         customWrite slot 1 value 2
         customWrite slot 2 value “ High temp ”
         customWrite slot 3 value 1
    else print “ Low temperature ”
         customWrite slot 1 value 0
         customWrite slot 2 value “ Low temp ”
         customWrite slot 3 value 1
```

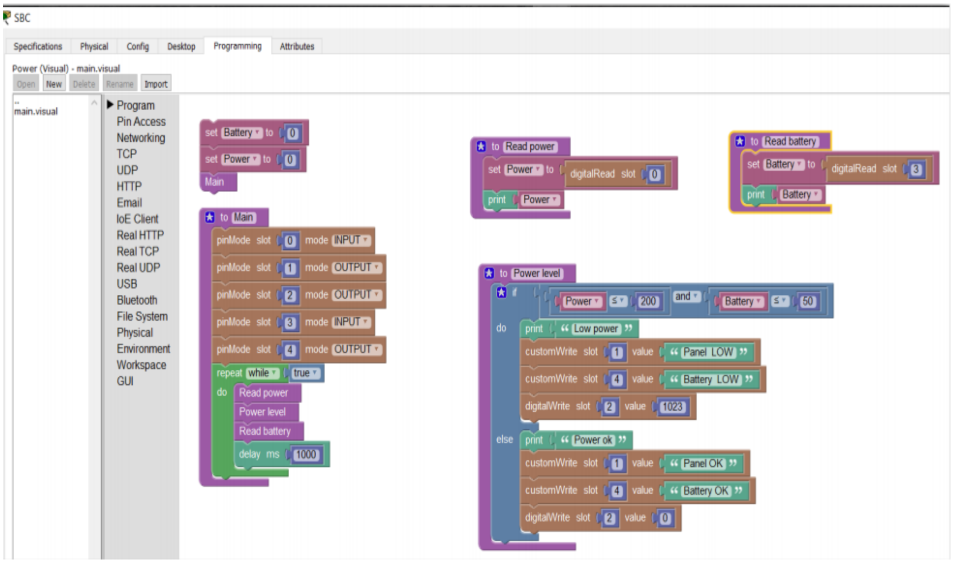
Figure 64. Blockly Programming (Second Smart Home Simulation)

APPENDIX B



```
set Level to 0
main

to main
    pinMode slot 0 mode INPUT
    pinMode slot 1 mode OUTPUT
    repeat while true
    do  Read Sensor
        Activate
        delay ms 1000

to Read Sensor
    set Level to digitalRead slot 0
    print Level

to Activate
    if Level ≤ 50
    do   print "Water level low"
         customWrite slot 1 value 1
    else print "Water level high"
         customWrite slot 1 value 0
```

Figure 65. Smart UNI Simulation



```
set Battery to 0
set Power to 0
Main

to Main
    pinMode slot 0 mode INPUT
    pinMode slot 1 mode OUTPUT
    pinMode slot 2 mode OUTPUT
    pinMode slot 3 mode INPUT
    pinMode slot 4 mode OUTPUT
    repeat while true
    do  Read power
        Power level
        Read battery
        delay ms 1000

to Read power
    set Power to digitalRead slot 0
    print Power

to Read battery
    set Battery to digitalRead slot 3
    print Battery

to Power level
    if Power ≤ 200 and Battery ≤ 50
    do   print "Low power"
         customWrite slot 1 value "Panel LOW"
         customWrite slot 4 value "Battery LOW"
         digitalWrite slot 2 value 1023
    else print "Power ok"
         customWrite slot 1 value "Panel OK"
         customWrite slot 4 value "Battery OK"
         digitalWrite slot 2 value 0
```

Figure 66. Smart Work Environment Simulation

APPENDIX C

Network characters used in the Cisco Packet Tracer

First Smart Home Simulation

Home Net SSID : HWifi

Password : 1234

IP address : 10.1.1.1

Subnet address : 255.1.1.1

IOT server IP address :10.1.1.10

DNS functionality : IoTHomePage.com

User : USER

Password : 1234

Second Smart Home Simulation

Home Net SSID : HWifi

Password : 1234

IP address : 10.1.1.1

Subnet address: 255.1.1.1

IoT Server IP: 10.1.1.10

DNS functionality : IoTSmart-home.com

User : USER

Password : 1234

Celullar network : Vodafone

Smart UNI Simulation

Class IP address : 10.0.0.0

Subnet address : 255.255.0.0

DHCP server: 255.255.0.0

Apartment SSID: AppWifi

Password : 1234

IP address : 10.1.1.1

Subnet mask address : 255.255.0.0

IoT IP address : 10.1.1.1

Subnet address : 255.0.0.0

DHCP server: 10.1.1.1

IoT IP address: 10.1.1.1

DNS functionality : IoTHP.com

User : USER

Password : 1234

Smart Work Environment

Office IP address : 160.140.10.0

Subnet address: 255.255.0.0

DHCP address : 160.148.12.2

Panel IP address: 140.125.15.0

Subnet mask address : 255.255.0.0

DHCP address: 160.140.12.0

Cellular Net IP address : 160.140.12.0

Subnet mask address : 255.255.0.0

DHCP address : 160.140.12.10

IoT work SSID : IoTNET

Password : 1234

IP address : 160.140.12.0

Subnet mask address : 255.255.255.0

IoTCon SSID : ConWifi

Password : 1234

IP address : 180.160.15.0

Subnet mask address : 255.255.255.0

IoT IP address : 140.120.30.0

DNS functionality : IoTConPage.com

User : USER

Password : 1234