# CHAPTER 1 - INTRODUCTION

The internet which is a ‘global communication of networks consisting of thousands of other networks that are interconnected by fiber optic cables’, has become part of the daily life of our society. The use of the internet has become very popular and eLearning is reshaping the way education is being acquired. In essence, the purpose of the internet is making lives easier by connecting to one another and sharing important documents, files and other resources. The internet has its origins in the 1960s and have gone through transformation and somewhat revolution. People have been adding to the Internet ever since it was invented. However, no single individual, group or company owns or control all the hardware that connects to the internet. Anyone can use the internet provided they have a compactible device and connection. While this technology is made a free and neutral resource for individuals globally, it has fallen short in providing an efficient accessibility where data can be transferred, and where connectivity is required in some regions of the world.

To use the internet, an individual or institution must have a connection that is provided by the ISP – Internet Service Providers. The ISP company connects their customers to these global networks of networks known as the internet using a data transmission technology appropriate for delivering Internet Protocol datagrams such as dial-up, DSL, cable modem or dedicated high-speed interconnects. Often, the ISP companies charge their customers and are responsible for the speed and the efficiency of the internet. Since these costs can sometimes get too expensive, some schools are not able to fully integrate and serve their students with the internet access. They are boycotted resulting in the unavailability of connectivity in schools through the internet. And because of this problem of limited or no internet access for communication and transfer, the course documents are not sufficiently disseminated among students, eLearning is lagging in their institutions and the benefits internet has to offer is not accessible in these educational institutions.

The Internet connectivity in an educational institution plays a critical role in education and learning. Huge amount of information is passed through for learning enhancement and other educational practices, which demands more sophisticated and efficient medium of communication and connectivity. If we look at a university setup in the developed countries, we can see that an efficient internet connection is inevitable in their activities. In the developing and underdeveloped countries, it is often a typical problem of little or no internet connectivity for educational enhancement. This typical problem of inefficient internet access leads to a lack of help for students and teachers to perform the necessary activities that can be done online.

## Problem Statement

All institutions aim to provide the best and efficient way of schooling within the constraint of their available finances. This is also the case for schools mostly in the developing and under-developed nations. However, circumstances and resources vary markedly between countries and all these usually impacts the implementation of the efficient way of learning in schools. Because of the pivotal role that the ISP companies play on internet connectivity, the charges for this service often gets too unbearable for institutions and hereby causes the lack of internet connectivity between students and their teachers in many schools of the developing and under-developed countries. Although, sharing course document handouts among students and verbal method of communicating announcements is what is mostly used in these institutions. However, several problems can be itemized because of using this traditional method of schooling:

* The concept of Blackboard for educational purposes to view course materials, submit an assignment, create a forum between teachers and students and other benefits that the blackboard offers is not made available in the institution.
* Information is not sufficiently disseminated among students and most importantly, the students that are not available at the time the information was passed across gets little or no content of the information that was passed.
* Schools that can afford the internet services run them at higher costs.
* According to personal experience, when this internet service is available, they often run so slow.
* Distributing handouts is not an effective way of passing course documents because it is susceptible to misplacement.
* All these problems lead to ineffective communication in an institution.

## 1.2 The Purpose of the Research

For this project, the main purpose is to provide a solution that enhances education activities and solves the problem of inadequate internet efficiency for educational development in places that offer little or no internet access for connectivity and for communication. This solution can be considered a short term, but it depends on how fast and rapid the schools in developing and under-developed countries can catch up in terms of resources, development and technicality. Here, I propose a way to solve this problem by creating a network in a local area that every device can connect to, using a software application – mobile, desktop, web and these devices that are connected on the LAN can communicate and share resources of any file type without the need for internet. The medium of communication would be through a Wireless Networking Protocol using an access point router. Devices that are connected on the LAN would be able to drop resources on a file system and can retrieve these resources on the file system with proper authorizations. This solution for a no-internet network creation would solve most of the problems faced with connectivity and communication in educational institutions and thus, will transform the sharing of course documents manually into a computer based as a digital transformation hereby enhancing an effective way of efficiency, distribution, connectivity and communication.

The benefit of this project is to achieve the following objectives:

* Digital Transformation in educational institutions – Making all course documents in one central repository instead of having to distribute papers and handouts.
* Creation of a mobile application software as a client for Content Management System (CMS) – This CMS models a typical blackboard.
* Server creation for request and response purposes – This server fetches resources from the file system into the client devices.
* Local Area Network that models a peer-to-peer connectivity – Since the internet is not in the scenario of what the solution proposes, its only right to be creating a local area network having no doubt that internet is the most effective medium of communication in a wide area network.
* Reduced cost of internet bandwidth that will be purchased in an institution – Since most internal communication would be done on this local network, file transfer through the internet which may take a certain amount of bandwidth will be restricted to the network that is created.
* All these goals lead to a solution to the problem in most ramification and these forms the objective of the project.

# CHAPTER 2 – LITERATURE REVIEW

For this project, the literature review of the scientific references founded by many studies and research to be considered are in Networking, Application software and Database as described below:

## 2.1 Networking

Networks are a collection of computers that are connected with wires and wireless signals. It can also be defined as a:

* Group of interconnected things.
* Number of interconnected computers.

Networking allows computer users to share data and interact with each other, even though they are using two different computers. “When network first came into being, computers could only communicate with computers that were produced from the same manufacturer. For instance, a company can run an IBM solution or a DECnet solution but not run both together. In the late 1970, the Open System Interconnection reference model was created to break this barrier.” (Lammle, 2007)

Networking is useful because it allows a group of people to access a pool of resources. One of the most useful resources a network makes available is people. Collaboration has become expected in a workplace, schools and other institutions because of networks. People are now able to talk, chat or send an electronic mail with someone else who is literally miles away. But networking does have some disadvantages, there is an initial cost to set up a new network – such as cost of purchasing networking equipment, labor cost for trained network personnel. Other disadvantage can occur because of the cost of maintenance and threats like viruses and hacking. However, with proper maintenance and security measures, these disadvantages can be mitigated

Networks and internetworking have grown exponentially over the last 20 years with constant evolution throughout the years. Networks are made up of different protocols and standards. It is helpful to know that Networking Protocols are the guidelines that define the communication between two or more devices while the Networking Standards make sure that different networking products from different manufacturers are interoperable using some set of rules. The evolution of Networks and internetworking can be described below:

### 2.1.1 Time Sharing – the first online communities - 1960

According to a Wikipedia page, “In computing, time-sharing is the sharing of a computer resource among many users by means of multiprogramming and multi-tasking at the same time” (Wikipedia, 2017). By the early 1960s, many people can share a single computer, using terminals to log in over phone lines. Even though the computers were unable to connect to each other at the time, these idea is described as the first common multi-user systems, with many people online at the same time. It then gradually develops into many features of later networks, from file sharing to e-mail and chat.



#### Figure 2.1 A User on the Dartmouth Time-Sharing System. (Timeline of Computer History, 2018)

### 2.1.2 Multiplexers: Getting more users into the same line – 1968

The telegraph is typically a system for transmitting messages from a distance along a wire in the early years. People have had the utmost urge to have many more connections on a single wire. Then the concept of Frequency Division Multiplexing came up which allows 15 terminals share the same line. Along that same line of thought in 1968, comes a new generation of time-division multiplexers that radically expand the computer terminals that can share the same line from the initial 15 now until 45. This innovation advances helped more people go online.

**2.1.3 Networks come online – 1969**

In the late 1969, at this time created by the United States Defense Advanced Research Projects Agency (ARPA), the ARPAnet makes a debut as a large-scale, general-purpose computer network that connects multiple computers together. ARPAnet was a ground for experimental networks and satellite radios and the need to connect diverse systems led ARPA to begin its internet programs, which developed techniques for interconnecting networks, using this technique to connect other research networks forming the basis for today’s internet, a worldwide network of networks. (Abbate, 1996--1988)

### 2.1.4 Inventing the Internet – 1973

Before 1957, Computers only worked on one task at a time and this is called Batch Processing. The concept of batch processing was ineffective as Engineers and Programmers started developing a need to work remotely. Then the idea of Time sharing came up – The concept of sharing the processing power of one computer with multiple users. So, the next challenge must be creating the ‘networks of networks’, a process called internetworking or internetting. The foundation of the internet begins with the Defense Advanced Research Project’s ARPAnet for the concept of a military network, the National Physical Laboratory for a commercial network, and Cyclades for the scientific network. (Picolsigns, 2009).

In 1973, France’s Cyclades and the Britain’s NPL network were experimenting on a protocol that influenced the United States’ development of ARPAnet TCP/IP internetworking protocol, which was first designed by Vint Cerf and Bob Kahn. Given that, the Cyclades had fewer nodes and the focus was laid on the communication with other networks. In this way, the term Internet was born. The collaboration of this led to the development of NCP – Network Control Protocol and later, it was replaced by a much efficient Transmission Control Protocol (TCP). The specific feature of the TCP is the verification of file transfer. To avoid congestion of these files that are transferred, the files that are sent are divided into smaller packets and this technology was termed, Packet Switching. During communication and transfer, the computers serve as a transfer node, starting with electronic mail and adding file sharing, remote access and eventually the World Wide Web capabilities.

### 2.1.5 Linking the Ethernet and Local Networks

The IEEE is an institute of Electrical and Electronics Engineer that develops global standards for a range of technologies. The year 1973 marks the start of the standard that will eventually prevail: Ethernet (Timeline of Computer History, 2018). While the internet is comprised of multiple layers, among these layers is the Link layer where Ethernet is categorized. Ethernet uses both Data Link and Physical layer specifications. All network connected in a local area had to be connected to some type of cable. When these cables are connected in a network, they act as a medium that transfer resources from one computer to another. The Ethernet becomes a contention media access method that allows all hosts on a network to share the same bandwidth of a link.

Fast forward to the year 1999, the IEEE 802.11b is a Wireless LAN for short range radio networking standard that came into place as “Wi-Fi”. The IEEE 802 family of standards made publicly available the 802.11 as a standard format for the Wireless Networking. “The wireless networking uses radio frequency to send information between devices that are able to pick up the frequency and translate the radio signals back into information that the device user can understand and use”. (edx, 2018). Radio frequencies come around in different types. The 5 GHz frequency has a less interference with a higher speed, but it has a shorter range than the 2.4 GHz is the common and popular frequency because it has a bigger range that is not mostly affected by obstacles. Wireless networking is measured in Mbps.

## 2.2 Application Software

An application software and a software application can be used interchangeably. A software application is a written set of software codes that serves as instructions for the computer to carry out the purpose of the written codes. This purpose is typically to solve problems. A way to solve problem is to begin analysis and break down of such problems into smaller pieces we can handle. A key note is to first understand the nature and concept of the problem as not all human problems require computational solution. However, if need be, we can go ahead to use software technology for our solution. For this project, the analysis has shown that software application is desirable to solve this problem at hand.

According to Shari, the figures below describe the process of analyzing a problem and synthesizing a solution.

PROBLEM

#### Figure 2.2 The Problem Analysis. (Pfleeger, 1991)

SOLUTION

#### Figure 2.3 The Solution Synthesis. (Pfleeger, 1991)

Software application spans across multiple sections of modern technology in mobile phones, laptops and many more. Here, I categorize software application into two major types:

* System device application – Desktop, Mobile.
* Web design application – Website.

Software applications require a certain level of proficiency in a software programmer. Software programmers take designing and implementing a solution to a problem computationally and are responsible for quality software services. Just as product manufacturers aspire ways to make sure their products are of quality produce; software programmers too find ways to ensure their software is acceptable. The quality and acceptability of a software depends on how easy it is to use, learn and if in fact, it provides solution to the proposed problems. There are different types of programming languages for software creation. Examples of this languages are Hypertext Markup language (HTML), JavaScript, ASP.net, C#, Java and so on.

Literature review is a systematic summary of studies addressing a clear question, with an unbiased and valid method to identify, study and analyze data or other relevant topics (GET-IT, 2015). In the review of the relevant references founded many actual implementations of solution that solve problems of connectivity and digital transformation. The following is a summary of each research reference in terms of their goals and the solutions they provide.

### 2.2.1 Blackboard, 1997

Blackboard is a technology developed by the Blackboard Inc. This tool delivers a content management system allowing faculty to add resources for students to access online. The blackboard technology is mostly used to support effective learning process by providing an area to place information about courses in multiple learning styles and content formats – texts, images, pdf, audio, etc. Blackboard provides a software application that is web-based and may be installed on local servers. Its main purposes are to add online elements to courses that would have been traditionally delivered face-to-face hereby serving a digital transformation.

### Conclusion

* According to Forbes.com, blackboard is used by more than 70 percent of the colleges and universities in the U.S.A. (Peter Bradford, 2007, pp. 35:301-314).
* Blackboard has proved ultimately useful in distance learning.
* A course content feature allows professors to post course documents on the platform.
* Students can chat in real time with other students in the classroom section.
* Students are also able to send emails.

### 2.2.2 Skype, 2003

Skype is a telecommunication software application that specializes in connecting many people through video calls, voice calls and chat. With Skype, individuals can hold a meeting, learn languages and do just about anything that needs to be done together on their phones, tablets, computers or TV with skype on it. (Skype, 2003). Skype was created by Swede Niklas Zennstrom and Janus Friis, and it was originally a feature of hybrid peer-to-peer and client-server system (Tallinn, 2014), before it was acquired by Microsoft which transitioned the technology into a centralized Azure service. (Goodin, 2012)

### Conclusion

* The use of peer-to-peer and client-server formed the basis and beginning of Skype.
* According to a Wikipedia entry in 2012, about 35 million number of concurrent users are on Skype (Caukin, 2012). The implication of this is that more and more people are connected to each other on daily basis because of this software application.
* According to reports, Skype has been improved to make Voice over IP (VoIP) a real-time communication option for schools. (Branzburg, 2007, p. 36)

### 2.2.3 Facebook, 2004

Facebook is a social media and social networking company based in California, United states of America. It was co-founded by Mark Zuckerberg in Harvard University. While in Harvard, Mark and his friend, Adam D’Angelo identified the need for students to upload lists of their friends and compare these friend lists with others. To them, it was a problem of connectivity that they were seeing to provide solutions to. In 2003, Mark’s goal would be to create a software application that he named Facemash with a PHP programming language. To create Facemash, Mark broke into Harvard’s web systems and copied student ID images. In 2004, Mark finally created a website that is called Facebook that lets users create profile for themselves and connect with their friends. (Telegraph, 2017)

### Conclusion

* Facebook grew out to become a widely accepted solution to the problem of social connectivity.
* It has further become a marketing solution outreach to connect multiple people in business environments.
* A comprehensive database for individuals are stored that matches people from everywhere else.
* The Facebook system can store data that is necessary for people to keep in touch and connect with each other.

### 2.2.4 Gmail, 2004

Gmail is an email service that was developed by Google. A software application was the solution to this problem of transferring electronic mail from one individual or corporation to another. This solution typically mitigates the long time it takes to traditionally post a letter through the post office services. Even though Gmail is not the only email service available, it is a technology whose research is worthy of my study and whose innovation is worthy of emulation. Whenever possible, Gmail uses a transport layer security (TLS) to automatically encrypt emails that are sent and received on the web and on the devices. (Gmail, 2016).

### Conclusion

* Gmail stands out as a wide service for digital transformation.
* Gmail becomes the first software application to reach 1 billion downloads on android device.
* According to the verge reports in 2016, Gmail has 1 billion monthly active users, and this shows the rate at which this software providing digital transformation is widely accepted. (Miller, 2016)

### 2.2.5 GroupMe, 2010

GroupMe is just another mobile group messaging app that is owned and controlled by Microsoft. It works similarly like a regular text message app on a mobile phone and even with a real-time communication. GroupMe solves the typical problem of people trying to connect to each other in groups. It even offers group calling as a conference call which does not push a time limit on you. Some of the features on the app includes ability to share photos, videos, location, create events and so on.

### Conclusion

* By June 2012, GroupMe has also been widely accepted and over 550 million messages were delivered on GroupMe each month. (Shontell, 2011)
* GroupMe becomes a software that radically competes with top leading technology experts like Google with the launch of Google+.

### 2.2.6 GitHub, 2008

Started by Linus Trovalds, GitHub is a web-based version-control and a collaboration platform for software developers. Many people have alleged that GitHub is a social networking site for programmers. Here software codes and other programming materials are uploaded in a central repository and can be retrieved at anywhere on any platform. GitHub also allow multiple developers to collaborate on a project, update and track progress on the project. Three main terminologies serve as distinct features on GitHub – fork, pull request and merge. Forking is when a project is created based on another project that already exists. Pull Requests are the changes you’ve pushed to a GitHub repository. Merging is joining a project you modify to an existing project for purpose of update and changes.

### Conclusion

* A software application written in Ruby on Rails.
* GitHub provides a light-weight workflow for developers.
* It allows developers to share their codes for others to view, modify and update
* GitHub can be used for any type of files.

## 2.3 Database

The collection of factual data can be described as a database. The database can further be described as a repository for a collection of computerized data files (Date, 2000, p. 2). Today, most universities and colleges have a centralized place they store student information. The departments that store these data are a very important section in colleges and it is in fact, a level of management of the college. Many routines and burdensome works need accuracy and little or no errors such as the student information, courses undertaken by each student in the school, degree level of the students and so on. A database server typically contains all the tables and data that are required to be saved.

A Database Management System is required to connect to the database server. In a typical development environment, the database can be installed on one centralized machine and usually developers can connect to that using a database management system that is installed on the respective machines. The figure below shows the relationship between a database and a database management system.

DBMS

DBMS

DATABASE

SERVER

DBMS

DBMS

#### Figure 2.4 How a database management system and a database server relate.

## 2.4 Discussion

After critically looking at these technologies, one thing they all have in common is the internet connectivity. For these technologies to become optimal in a learning environment, they all require the internet to work. This is what has made a difference in my proposition. For this project, the main medium of communication would be done over a wireless networking protocol connected from a router and to the other devices. No internet is required, and no Ethernet is required for this technology.

For the Networking review, the Timesharing system formed the basis of sharing a computer resource among many users. This technology that has developed into modern features of file sharing, to email and chat can be agreed as what came on to the design and implementation of networking connectivity. However, with the Multiplexers, it can be agreed that transmitting messages from a distance along a wire is a head start for modern telecommunication, but it can be criticized in the limited range this technology is able to cover. The Internet remains the largest community of online connections as the connections of different networks with little to no limitations. The only shortcoming of the internet is its efficient availability in certain areas of underdeveloped and developing countries which has formed the scope of this research as to how connecting individuals can be made possible until the Internet finally arrive in these places.

In the Application Software review, it can be completely agreed upon that this software applications are a tool for efficient connectivity and a tool that can further make education much smoother for individuals. While the Blackboard is held in high regards for its innovation, the Blackboard has its limitations and according to a survey of 730 faculty staffs and students in Wisconsin who uses this blackboard found that course management systems are harder to learn to use than expected. (Carnevale, 2003, p. 49). Another limitation of the blackboard is that its options may be restricted to some operating systems. Even though the GitHub is regarded as the leading version control service and a social platform for developers, its technology requires more technical know-how and certain expertise to work on a master level.

Database File System is another common tool that these software applications have in common as they require a centralized place to store their information. Database utilizes authentication for administrators and the implication of this is to provide integrity to the information that is saved by ensuring the data is not manipulated by unauthorized individuals.

These reviews can be summarized as follows:

* The technology for connecting individuals in an institution require internet connectivity.
* Each application software allows students to communicate either individually or in groups.
* File sharing are made possible with this networking and software tools.
* There is a centralized file system for storage of data.
* Communication is mostly done in a wide area network.

From the above, it is considered ideal the need for communicating and sharing information among individuals. The above systems solve a mutual problem of accessibility and connections, not only in educational institutions but in all ramifications of life. The system I am researching goes in a similar route and it provide a solution to this imminent problem of inefficient connectivity in educational institutions too but using a different innovative strategy of communicating and sharing files without need for the internet access. The education system in developed and developing countries is in the process of development and with this solution, it raises a high level of education enhancement in their institutions.

# CHAPTER 3 – METHODOLOGY

# For the solution of connectivity and digital transformation to be effectively provided, a sophisticated piece of software must be used in conjunction and along with a hardware. The solution is designed in such a way that it carefully analyzes the problem faced in areas of low and inefficient internet connectivity and these analyses has shown that the desirable way to solve the problem at hand is by a successful design of a software application that will be user friendly meets with the requirements of beneficiary networking and hardware body. The application is designed to be modular and thus, required some packages to be installed at different ramifications of the development which will be detailed later in this chapter in their respective technologies. The solution is built upon different technologies and its methods will be described shortly but are itemized as:

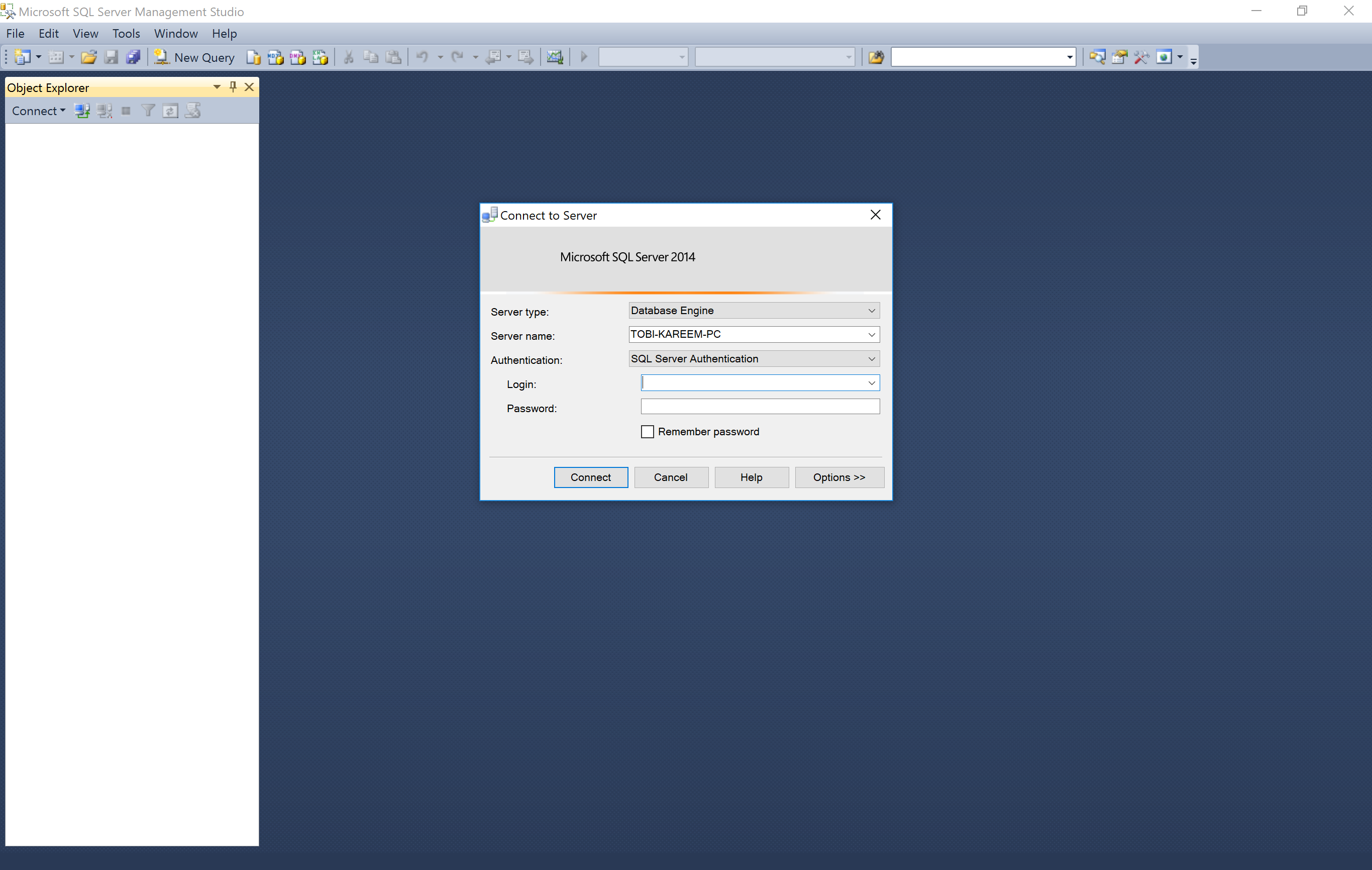
1. Sql Database File System
2. Raspberry Pi 3 Raspbian
3. Node. Js
4. Xamarin. Forms
5. DOTNET C#

## 3.1 Sql Database File System

At the heart of many organizations and institutions is the ability to collect, organize and manage data. This is precisely the focus of this sub-section. According to the Modern Database Management edition of Jeff Hoffer et al, over the past two decades, data has become a strategic assets for most institutions including education and libraries since database are used to store, manipulate and retrieve data in nearly every type of organization (Jeff, Ramesh, & Heikki, 2016). The understanding of database in financial, marketing and education can give clear understanding in answering questions almost as soon as they are asked. Database continue to become a more common part and central component of business and educational operations. For the rest of this section, it is helpful to describe steps taken to accomplish the database part of this project. Different technologies can be used to build a database system. For this project, SQL server technology is used to construct the database.

### 3.1.1 Connecting to SQL Server

To connect to the database server to construct a database information, SQL Server Management Studio was installed on a windows x64 bit machine. The sql server would be automatically installed in the default *\Program Files\Microsoft SQL Server\mssql14.<instanceID>\* path of the windows which is configurable. It can be started automatically from the start menu. The Sql server management studio opens and as seen below.



#### Figure 3.1 SQL Server Management Studio (SSMS)

On startup, the SSMS require certain authentication to connect to the database server. A database server typically contains all data and objects that are created to be stored on it. To connect to the database server, the client tool that is typically used is the Sql Server Management Studio, however, the SSMS is not the server itself but a client connection tool. This can be further illustrated below:

SSMS 3

SSMS 1

Database Server

SSMS 4

SSMS 2

#### Figure 3.2 SSMS connects to Database Server

### 3.1.2 Creating the Database

# Creating a database is done by writing database syntax known as queries. This database consists of tables that store records of the Students, Teachers, Courses and Departments. It was determined in the development of this application that the required information is needed to deliver the content management system for an educational institution. The information required for the database system are described as follows:

* Student’s main information.
* Courses Information.
* Teacher’s Information
* Department’s information.

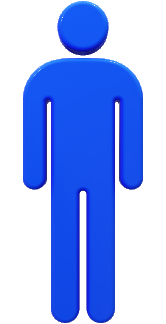
The student’s main information consists of student’s Id, first name, last name, middle name, department id, password. The course information consists of course id, course name, teacher id, department id. The Teacher information consist of teacher’s id, first name, last name, middle name, department id and password. The Department information consist of department id, department name, department administrator. This is further illustrated below:

*Figure 3.3 Requirements list*

### 3.1.3 The System Administrator Roles

The role of the system administrator covers all right of creating, updating and deleting records in the database. The administrator is tasked with adding students, teachers, courses and departments’ information into the database and performing other database operations on this information. The system administrator would be an employee of the institution and a use case for the role is described below:

ADD Students



ADD Student’s Courses

ADD Teachers

ADD Department

Administrator

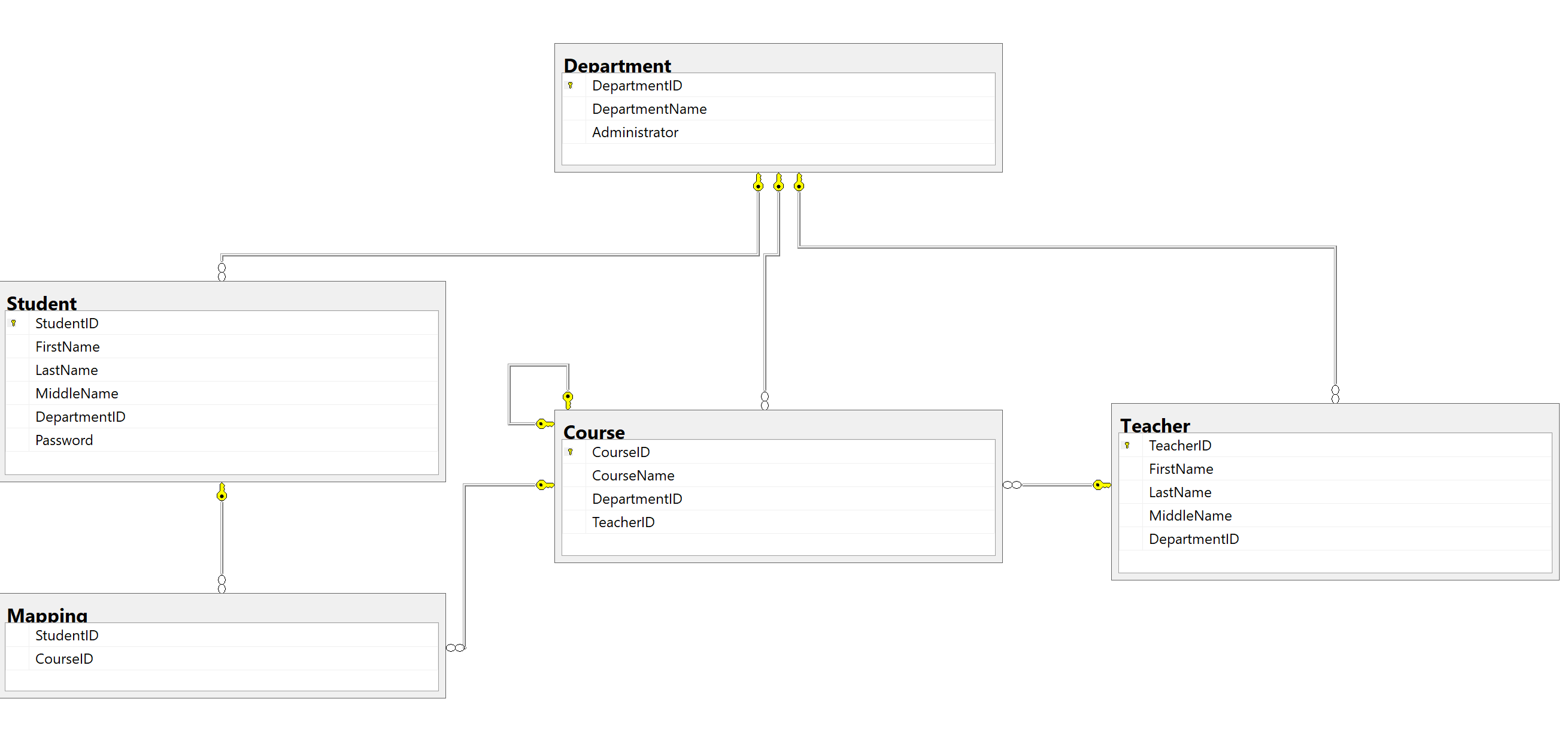
#### Figure 3.4 Use case for the admin roles.

### 3.1.4 Database Description

The description of the database covers the entities and their relationships. Entities and their relationships are a very important part of database architecture as they point us in the right direction and basis for the logical structure of our database. These entities are the records representing a noun in the database. The Entity-Relationship model is expressed in terms of entities in the institution, the relationships among these entities and the attributes or properties of both the entities and their relationships which is also referred to as an E-R diagram. A description of the relationship role can be in three parts namely:

1. One to One relationship
2. One to Many relationship
3. Many to One relationship.

The figure below shows the E-R diagram of the entities in our database and their relationships.



#### Figure 3.5 An E-R diagram for the database.

### 3.1.5 Database Logical Structure

During logical design, we transform the E-R model diagrams that were developed in the earlier section during the conceptual design into a relational database schema. This is a straightforward process as it only contains an additional well-defined set of rules. These rules describe the user input whether an alphabet is expected, or a numeric value is expected. The tables below describe the logical design of our database.

1. Student Table

|  |  |  |  |
| --- | --- | --- | --- |
| Column Name | Data Types | Allow Nulls | Description |
| Student ID | int | No | Student identifier (PK) |
| FirstName | varchar (55) | No | First Name |
| LastName | varchar (55) | No | Last Name |
| MiddleName | varchar (55) | Yes | Middle Name |
| DepartmentID | varchar (55) | No | Department ID (FK) |
| Password | varchar (55) | No | Password |

#### Table 3.1 Student table

1. Course Table

|  |  |  |  |
| --- | --- | --- | --- |
| Column Name | Data Types | Allow Nulls | Description |
| CourseID | varchar (55) | No | Course Identifier (PK) |
| CourseName | varchar (55) | No | Course Name |
| DepartmentID | varchar (55) | No | Department Id (FK) |
| TeacherID | int | No | Teacher Id (FK) |

#### Table 3.2 Course table

1. Teacher Table

|  |  |  |  |
| --- | --- | --- | --- |
| Column Name | Data Types | Allow Nulls | Description |
| TeacherID | Int | No | Teacher Identifier (PK) |
| FirstName | varchar (55) | No | First Name |
| LastName | varchar (55) | No | Last Name |
| MiddleName | varchar (55) | Yes | Middle Name |
| DepartmentID | varchar (55) | No | Department ID (FK) |

#### Table 3.3 Teacher table

1. Department Table

|  |  |  |  |
| --- | --- | --- | --- |
| Column Name | Data Types | Allow Nulls | Description |
| DepartmentID | varchar (55) | No | Identifier (PK) |
| DepartmentName | varchar (100) | No | Name |
| Administrator | varchar (55) | Yes | Dean |

#### Table 3.4 Department table

## 3.2 Raspberry Pi 3 Raspbian

The Raspberry Pi is a small widely used single board computer running on a Linux operating system (Rory, 2011). It has an HDMI interface on one end for a TV display, and a USB master socket on the other end for a keyboard, plus a mouse via an off-board hub if needed. The figure below shows what a typical raspberry pi looks like.



#### Figure 3.6 A Raspberry pi

The raspberry pi goes through many series of evolution in several versions with added features for functionality. The functionality of the device spans across many performances of computing and can be used for such things as a programming device, a hacking device and even a networking device. For this project, I have taken an advantage of the networking functionality of the raspberry pi to create a Local Area Network using the device to model an access point that is configurable to host DCHP servers, Dnsmasq and distribute IP addresses to every device that connects automatically. Below I describe the strategies that were used to make this happen.

### 3.2.1 Setting Up the Raspberry Pi as an access point for a LAN

The raspberry pi provides different functionalities and one of these functionalities is its used as a wireless access point router that can run a standalone network. To get this started, a fresh installation of Raspbian Operating System was made and booted into the device. Using *ifconfig -a* in the terminal, my raspberry pi model has three basic network interfaces namely *wlan0* for WLAN devices, *eth0* for basic ethernet and *lo* which presumably represents the localhost. Since I am using the model 3 that comes with an inbuilt wireless, I do not require a WIFI dongle. However, a WIFI dongle might be desired for a longer range.

### The Steps

It is always helpful to update and upgrade the operating system. The apt-get commands in Linux is used to find new packages, install and upgrade new packages and to clean the system (Abhishek, 2017). Updating and upgrading with apt-get requires the super user privileges.

*sudo apt-get update*

*sudo apt-get upgrade*

For software-wise, to use the access point functionality, an application package software is provided by hostapd which can be installed on the pi’s OS with apt-get (Fredrik, 2013). This software will act as the host access point.

*sudo apt-get install hostapd*

Dnsmasq is a free software that provides Doman Name System (DNS), Dynamic Host Configuration Protocol (DHCP) server and a network boot (Kelley, n.d.). Since, we require IP assignments from a DHCP server. I have chosen to use the Dnsmasq by installing it as shown below:

*sudo apt-get install dnsmasq*

IP Tables manager can be installed with the command below and its use will be described later in this section.

*sudo apt-get install iptables-persistent*

My next stop was to configure a DHCP server provided by the dnsmasq. First, I must open the configuration file at

*sudo nano /etc/dnsmasq.conf*

I would like to configure the wlan0 interface and provide an authoritative IP addresses in the range of 192.168.1.17 and 192.168.1.30 with a timeout of 24 hours using a subnet mask of 255.255.255.0 with the commands below:

*interface=wlan0*

*dhcp-authoritative*

*dhcp-range=192.168.1.17,192.168.1.30,24h*

*dhcp-option=1, 255.255.255.0*

*dhcp-option=3, 192.168.1.1 #dhcp-option =3 represents the gateway*

*dhcp-option=6, 192.168.1.1 #dhcp-option=6 represents the dns*

*dhcp-host=c6:9d:ed:18:0a:4b, Tobi-Kareem-PC, 192.168.1.20 #this is a static ip address that I am assigning #to a computer named “Tobi-Kareem-#PC” that was preceded with the mac address.*

# On my raspberry pi, I shall be setting up a wlan0 for a static IP Address 192.168.1.16 in the dhcpcd configuration file. Since we are configuring a standalone network to act as a server, it is only right for the device to have a static IP address. The configuration file can be found in

*sudo nano /etc/dhcpcd.conf*

At the top of the line put

*interface wlan0*

*static ip\_address=192.168.1.16/24*

At this point, I am all set to configure my access point by creating a new the hostapd configuration file at

*sudo nano /etc/hostapd/hostapd.conf*

# The information below is a configuration for the host access point. For this configuration, I am using channel 6 with a network name of KareemNet and password as describe below.

interface=wlan0

ssid=KareemNet

channel=6

hw\_mode=g

wmm\_enabled=0

macaddr\_acl=0

wpa=2

wpa\_passphrase=MYPASSWORD

wpa\_key\_mgmt=WPA-PSK

wpa\_pairwise=TKIP CCMP

Since I am using the raspberry pi 3 that comes with an inbuilt wireless, I do not need to provide the *driver=nl80211* parameter.

At this point, we need to tell the system where to find the configuration file that was just created.

*sudo nano /etc/default/hostapd*

On the line where *#DAEMON\_CONF* is, it should be replaced with:

*DAEMON\_CONF=”/etc/hostapd/hostapd.conf”*

The command above should also be added in the *DAEMON\_CONF* location at

*sudo nano /etc/init.d/hostapd*

The next step is to add a routing system. This can be done by setting up a Network Address Translator (NAT). The purpose of this is to allow multiple clients to connect to the WIFI and have all the data tunneled through the single IP. This process will also start IP forwarding on boot up. The file to edit can be found in

*sudo nano /etc/sysctl.conf*

We need to uncomment the line below or add this on a new line

*net.ipv4.ip\_forward=1*

to activate the NAT routing system immediately, I have ran the command below:

*sudo sh -c “echo 1 > /proc/sys/net/ipv4/ip\_forward”*

At this point, our ip\_table configuration is next in command. The command below adds a masquerade for outbound traffic and creates a network translation between the ethernet port eth0 and the wifi port wlan0

*sudo iptables -t nat -A POSTROUTING -o eth0 -j MASQUERADE*

*sudo iptables -A FORWARD -I eth0 -o wlan0 -m state –state RELATED,ESTABLISHED -j ACCEPT*

*sudo iptables -A FORWARD -I wlan0 -o eth0 -j ACCEPT*

To save the iptables rule and always make the rule available upon every reboot:

*sudo sh -c “iptables-save > /etc/iptables.ipv4.nat”*

To check the rules in the iptable

*sudo iptables -t nat -S*

*sudo iptables -S*

Another way to restore the rules on boot up is to edit the file

*sudo nano /etc/rc.local*

add the following command above the exit 0

*iptables-restore < /etc/iptables.ipv4.nat*

then reboot.

This works well and the KareemNet network that was created can now be visible on every device that searches for a wifi connection.

### The Test!

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#### Figure 3.7 using the raspberry pi to create a host access point.

## 3.3 Node.js

Node.js is a JavaScript framework for asynchronous server communication. The node.js software needed to be install on a raspberry pi for this project. Node.js has set of built-in modules and one of the most important module to be considered in this project is the mssql module. To download the newest version of Node.js on the raspberry pi, I used the following command (w3schools.com, n.d.).

*curl -sL* [*https://deb.nodesource.com/setup\_8.x*](https://deb.nodesource.com/setup_8.x) *| sudo -E bash –*

The command below installs the new downloaded node.js

sudo apt-get install -y nodejs

To confirm the successful installation and check the version of node, use

*node -v*

### 3.3.1 Remote Connection to SQL Server

To connect to the sql server, certain considerations must be taken into place. These are configuration settings and according to Marko Zivkovic (Zivkovic, 2016), the settings must be in place and they are so important that, without them, the connection to the remote SQL server would not be successful. These are:

* Allowing the sql server instance the protocol that is being requested
* Allowing the access through the firewall

To get the node.js server to connect to the remote database file server, a JavaScript packet manager – npm’s module called mssql was installed. With this, connection was made easy to the remote database. The command to install mssql from the packet manager is:

*npm install mssql*

Connect the raspberry pi hosting the node.js software to KareemNet. Open a new file from the terminal with a .js extension

*var sql = require(‘mssql’);* #this imports the mssql module

The next step is to define the remote database configuration for connection as described below:

*var dbconfig = {*

*server : ‘169.254.142.131\\MSSQLSERVER’, #this is the remote location of my database server*

*user : ‘username’,*

*password : ‘password’,*

*database : ‘TobChat’,*

*port : 1433 #default port for sql*

*};*

*(async function() {*

*Try {*

*Let con = await sql.connect(dbconfig)*

*Let result = await con.request().query(‘SELECT \* FROM Student’)*

*Console.log(result);*

*}*

*Catch (err)*

*{*

*If (err)*

*Console.log(err)*

*}*

*})*

*()*

*Sql.on(‘error’, err => {*

*Console.log(err);*

*})*

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