Quantum Homomorphic Encryption

By

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1. Introduction

1.1 Overview

Owning a computer was the new thing in the world. Everyone wanted to have one. The first computers were very large in size but as the years passed by the size decreased. We now have portable laptops. Computers crash and we lose all our data, or the computation we want to perform, our computers cannot handle, hence a need arose to store and process our data elsewhere in addition to the local storage. This was characterized by Cloud Computing. Cloud Computing can be described as using the cloud (we can imagine is some server stored somewhere anonymous) to carry out our tasks like storage and data management over a network rather than doing it in our own computers.

We enjoyed cloud computing for a while but then the issue of security arose. We don't have control of who could access our data while in the cloud. Some people could just be curious or you may have made enemies somewhere, other times, it would be just accidental that someone gets hold of your data. Imagine a leakage of a patient's examination results or diagnoses. It started by using for example a symbol to represent a patient. Yes the patient's name maybe anonymous, but if someone has access to the hospital's data they would know how many people are suffering from a certain disease among others. This person can decide to cause unnecessary chaos or theft in case of a bank where a customers personal information is exposed. It became possible to encrypt data and send it over but performing computations on this encrypted data was not possible. Homomorphic Encryption shows that it is actually possible to perform computations on encrypted data.

1.2 Background and Motivation

In April 2011, a Play Station's network owned by Sony was hacked. There was exposure of customers information like credit card and passwords. The responsibility for this incidence was accepted by Sony. They realized they had not done enough to ensure security of their customers' data. They would have encrypted it before storage. In this same period researchers also discovered that files in Dropbox were stored unencrypted. This lead to users leaving and closing their accounts with Dropbox since they felt insecure (Ogburn et al., 2013).

According to Pfleeger and Pfleeger (2002), ensuring security would be done in different levels. Securing the hardware (this is the physical system), software (set of instructions executed in the system) and the data itself. In the hardware, locks were put to limit access to unauthorized persons. Systems to detect an intrusion and devices that verify persons identity were put into place. In the software, programs that limit access to database and protect one user from other users were developed. Also software programs were written in such a way that their weaknesses could not be easily exploited. Password checkers and virus scanners application programs were also developed. The solution to the data was encryption. Data is only useful to parties if it can be readable and interpreted. Encrypted data is only useful if one can decrypt it. All this assured

the user of security. At the instances where the user needed to use the data then a problem arose. The data needed to be decrypted before any form of computations. This raises a security issue again. We needed to develop a system that allows computations on encrypted data. This is known as Homomorphic encryption. This assured the user of total security.

Previous works have been done trying to explain how Homomorphic Encryption can be implemented on various platforms using different types of data. In 2013 (Ogburn et al., 2013) tried to explain a model which encrypts hospital data. After the computations are done the number of patients suffering from a certain disease is returned in an encrypted format. The hospital's management then decrypts it. Yokoo and Suzuki (2002) shows a system where different people are using it to perform an optimization problem among themselves. An optimization problem is a problem where you want the output to be the maximum based on certain inputs, for example maximum profit. The task is to find the inputs. These people work without revealing any information about their inputs to the server. Using a similar approach to these works, we will discuss an application of Quantum Homomorphic Encryption in the airport. This model is used to detect unauthorized personnel accessing different points of the airport.

1.3 Aim and Objectives of the Study

Imagine you own a business whereby you want to charge different prices for different people based on their financial capabilities and customer loyalty. Your resources are limited thus you have to outsource resources such as storage. You do not want this information to leak to the public since this may make some customers to withdraw. You want to maintain the privacy of these information. The system should be able to determine the financial status and loyalty of the customer then charge accordingly. No information about the customer is revealed or the prices charged to other customers.

The aim of this essay is to show the current state of security while requiring services from an untrusted server. The objectives include explaining vividly the security concerns and showing steps taken to counter these issues.

1.4 Purpose of the Study

The purpose of this essay is to show why one would consider a Quantum Homomorphic Encryption over a Classical Homomorphic Encryption and how Quantum Homomorphic Encryption can be implemented by showing an example. This is done by discussing about classical computing with its limitations compared to quantum computing. We will also see the different ideas quantum computing brings about which makes it attractive compared to classical computing. The process of Quantum Homomorphic Encryption in details and an application example.

1.5 Organization of Essay

This essay has been subdivided into different chapters. In chapter 2 we will discuss about classical and cloud computing with their limitations compared to quantum computing. In chapter 3, quantum computing is vividly discussed. Different types of encryption in quantum computing and why one is chosen over the other. Chapter 4 talks about an airport example which is an application of quantum homomorphic encryption and its implementation using Python. Chapter 5 is a conclusion with recommendations.

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