# 

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Secure Voting System

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Abstract

This report introduces a mobile application for automating the voting process for the Jordanian elections. An open-source JavaScript framework called AngularJS has been used for the development of the application because it reduces the time and cost of transforming the web application into a mobile application.

The developed application is easy-to-use and secure where a unique national number along with a unique password provided by the government are used as inputs, which facilitates the identification of the eligibility of voting by linking the application to the database of the government.

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dashboard.

**List of Abbreviations**

* SQL : Structured Query Language
* C# : C Sharp
* PK : Primary Key
* SHA : Standard Hashing Algorithm
* IDE : Integrated Development Environment
* ID : Identity Number
* IEC : Independent Election Commission
* Gov : Government

# Chapter 1: Introduction

## Elections in Real Life

As we know, democracy represents one of the most important pillars in the human rights essentials. The core meaning of democracy is the election, when a group of people chooses their leader.

Therefore, the election process is part of every community’s life. It’s what distinguishes the United States of America from any other country in the globe.

Fortunately, in our country, Jordan, we have a great democracy comparing the other countries in the MENA region, ran and managed by the Independent Election Commission which is independent from any ministry within the Jordanian government.

* + 1. Problems of elections in real life

However, this essential process has many obstacles, mentioned as bellow;

1. Cost of the procedure organization, like organizers wages, papers, and buildings.
2. Crowded persons will increase the COVID-19 cases,
3. Time consumption, waiting in the lines will make the persons late on their daily duties.
4. Generally, in our country, the voting process is held in the schools which in turn will impede the teaching procedure.
   * 1. Election Automation

Luckily, we are in the era of the fourth industrial revolution, most of the bureaucratic procedures can be automated using secure, fast and scalable technical tools.

Automating the election process as a mobile application is highly efficient comparing the ordinary process.

It will reduce the cost, time consumption and make the voting process much easier.

* + 1. Importance of Automation

In addition to previously mentioned benefits, it will give our country a great reputation as one of the first countries who automates the voting process.

Also, as the entire world is automating its procedures, we could be at the top countries who contemporary with revolution.

* 1. Top Features of the Application

This section illustrates the main functional features of the app.

* + 1. Security Concerns

In order to prevent any identity theft, authenticating will be done using the fingerprint.

Moreover, the data will be encrypted before the transmission using the threshold encryption.

* + 1. Scalability

The app will be implemented as multithreaded design pattern; each area is divided in a single thread.

So even if millions of users want to vote, the app will work as expected.

Besides, the data won’t be centralized; it will be stored in two servers, one for auditing and another for system information.

* 1. Goals

Designing such an idea as a mobile app is not an easy handled process but however, it’s doable and it will achieve many all the election process goals which clarified as below.

* **Time Efficiency:** Voters will not stop their daily activities to vote, only using the app.
* **Cost Efficiency:** Government will save wages, infrastructure, papers, etc.
* **Voting Motivation:** Ease of the voting procedure will ensure that most of citizens will vote for their favorite candidate.
* **Effort Reduction:** The government only has to insert the candidate’s information into the app database
  1. Summary of report structure

In this report, we will illustrate all sides of app and the development procedure as bellow.

* The work flow of the application
* Technical Tools
* Obstacles we faced during the development phase
* System Design Architecture
* Analysis of the app
* Comparing the app with other voting applications.
* Future Objective

# Chapter 2: Detailed Design

## 2.1 Technologies Used

* **Front End**: For the UI design we used IONIC *& Angular* frameworks which are technologies used for building a Hybrid Mobile App.

**Why Hybrid App ?**

The hybrid app is a web app that is converted to a mobile app, this mechanism provides many features

1. Cross-Platform: Meaning that only one-code based app works on both Android and iOS.
2. Cost-Effective: Instead of hiring Mobile development team and Web development team, you only need web developers to get the work done.
3. Time-Effective: One source code works as web and mobile apps.

* **Backend**: For the Server side implementation, we used ASP*.NET* technologies (Microsoft C#) which is considered a libraries rich and the most secure framework in the world.

It’s very compatible with our system requirements.

* **Cloud Storage**: Considering the compatibility with our .NET tools, using Microsoft Azure will be best choice in our implementation.

Azure is considered a leader in the cloud computing field which provides many cloud based services.

The most important service is the App Service that enables us to publish our backend code on the cloud.

* **Database**: In order to deal with highly scalable data, the database needs to be integrated and low storage cost. As we uses Microsoft stack, we figured that *SQL Server* meets our needs.

## App Details

**Authentication**

The app has two signing modes, one as Voter and the other as Admin.

The admin could be the *government* which controls the candidates

data, or he *ICE* which controls the Voters data.

The signing in will be using **ID & Password.**

**Voter User**

As the voters’ signs in, a list candidates will be displayed, each voter has only one vote.

**Governments User**

This account mode will view the candidates list. It has the authority to add, delete, or modify the candidates’ data.

In Addition, it contains a dashboard which views the voting processes and declares the winner.

**Independent Election Commission**

In this mode, user could add, delete or modify the voter data.

Functional Features

* **Mobility**

As the system is online, the voter should be able to vote from anywhere.

* **Convenience**

The voter will be able to cast his vote quickly and easily.

* **UI**

The app provides a user-friendly interface which enables the voter from displaying his choices.

* **Transparency**

The voting process is clear and simple; the voter only has to sign in by his ID and chooses his favorite candid to vote.

* **Accuracy**

The app embedded with a logging feature which will store each voting process data in the database.

* **Eligibility**

The voting process has a certain condition; user must be 18 YO, Jordanian and has only one vote.

* **Uniqueness**

The voter should only vote once and choose only one candid

* **Documentation**

For security reasons, the system must be well-documented and easily implemented.

* Technical Features
* **Voter Authenticity**

The voter should be authenticated by his ID and given password.

* **System Integrity**

The system should not be re-configured during the election process.

* **Data Integrity**

Votes cannot be modified during the election process.

* **Secrecy & Privacy**

The voter must not be aware of another individual vote.

* **Reliability**

The system must be robust; this is implemented using multithreads app.

* **System Disclosability**

The system must not be open source, it’s owned by the government.

* **Accountability**

The system contains a logging feature which logs every voting process in the database.

## **System architecture**

* **Backend**

The server-side code is built using N-Tier Architecture. This architecture consists of three layers:

* **Presentation Layer**: This layer is exposed to the http server that accepts the request from the client-side.
* **Business Logic Layer**: This layer performs all logical operations.
* **Data Access Layer**: This layer is responsible for accessing the database data.

**Diagram

Description automatically generated**

Figure 2.3.1: A screenshot of N-Tier Architecture

* **Database**

We have two main databases:

1. **Audit**: Stores every performed process
2. **System**: Stores the users and voting data

This division occurs to utilize the storage and prevent the data overflow and storage problems.

Audit:

**Location:**

columns: ID (primary key integer number), State, Country.

Store the location (State) belongs to voter.

**Logs:**

columns: ID, VoterID, CandidID, Time, Location.

storing information that belongs to voting System.

**Voter:**

columns: ID, Name, Email, NationalID, Password, Image,

Location, Nationality, Gender, Status, Age , is Voted, CandiID.

Persons allowed to vote.

**Admin :**

columns: ID, Name, Email, Password, Type

Represents the government to make sure who is allowed to vote and insert or delete candidates or voters.

**Candid(**Persons nominated for election**):**

columns: ID, Name, Email, Image, Bio, Location, NationalID, Nationality, Gender, Status, Age, Voters

* **Entity Relationship Diagram**

Graphical user interface, application

Description automatically generated

Figure 2.3.2: A screenshot of Relationship Diagram

* **Backend**

**ORM**

Instead of opening a connection between database and backend, which is a time-consuming process; we used the “Entity Framework” from Microsoft.

This framework allows database tables to be represented as classes in the code, thus we only deal with the classes instead of accessing database directly.

**Searching**

Using a high-performance searching algorithm will make the search process more effective and faster.

**Multithreads**

When the voter try to vote at the time, the server may go down, here comes the role of multithreaded app in hand.

We divided the voting process into a time slots, each slot with its own thread.

This will ensure the system reliability and scalability.

* **Front end**

**Native Performance**

As known, the native apps like Android by Java or iOS by Swift are the best apps in terms of performance,

Although the ionic is a hybrid cross-platform, but it has the native performance.

**Reduce Development Time**

Instead of hiring an Android development team and another one for iOS, we only code once using flutter which is very time saving process.

**Material Design**

Ionic supports material design which gives us user-friendly UI without any server-side rendering.

## **The Details of the Mobile Application**

There are two user modes in this application as shown in Figure 2.1, the first user mode is the voter mode, and the second user mode is the administrator mode. The administrator can be the Independent Election Commission or the government.

Figure 2.2 shows a screenshot of the application showing the page of the voter mode. When the user signs in as a voter, the required fields are the national number which is a unique number for each Jordanian national, and the password which is assumed to be assigned to each voter by the Independent Election Commission.

Graphical user interface, application

Description automatically generated

Figure 2.1: A screenshot of the application showing the user modes

To ensure the security of the voting process, a database containing the national number of each voter along with the corresponding password is uploaded to Microsoft Azure. When the user fails to enter the combination of the national number and the password correctly, the application shows an error message indicating that the ID is not found as shown in Figure 2.3.

When the user enters the combination of the national number and the password correctly, a page lists the candidates shows up. The page shows the name, electoral district, age, electoral statement, and photograph of each candidate as shown in Figure 2.4. Figure 2.5 shows an example of a candidate page, in which the number of voters who voted for the candidate is shown.

Graphical user interface, application

Description automatically generated

Figure 2.2: A screenshot of the application showing the page of the voter mode

The voter is required to be a Jordanian national, 18 years old or above, and his/her permanent residence is in the same electoral district of the candidate. To validate the eligibility of the voter to vote for a certain candidate, the data of the voter such as the residence, nationality, and gender are stored in a database. The data are stored as integers in which an integer is assigned to each entry. For example, a value of 0 in the column of nationality indicates that a voter is Jordanian national. The data is stored as integers instead of strings to optimize the data storage.

Figure 2.6 shows a test of the application in which the voter is ineligible to vote because the permanent residence of the voter is not the same as that of the candidate. When the criteria for a voter to vote for a certain candidate is met, the voter can vote successfully as shown in Figure 2.7.

Graphical user interface, application

Description automatically generated

Figure 2.3: A screenshot of the application showing the front-end validation when the user fails to enter the correct combination of the national number and password

Text

Description automatically generated

Figure 2.4: A screenshot of the application showing list of candidates

Graphical user interface, application

Description automatically generated

Figure 2.5: A screenshot of the application showing a page of the candidate details

Graphical user interface, text, application, chat or text message

Description automatically generated

Figure 2.6: A screenshot of the application showing that a voter is ineligible to vote

Graphical user interface, text, application, chat or text message

Description automatically generated

Figure 2.7: A screenshot of the application showing that a voter voted successfully

Graphical user interface, application

Description automatically generated

Figure 2.8: A screenshot of the application showing the option of deleting a vote

Graphical user interface, application

Description automatically generated

Figure 2.9: A screenshot of the application showing the option of replacing a vote

The application gives the user the flexibility to delete his/her vote and vote again for the same or another candidate as shown in Figure 2.8 and Figure 2.9.

Graphical user interface

Description automatically generated with low confidence

Figure 2.10: A screenshot of the application showing the page of the administrator mode

As mentioned above, the Independent Election Commission and the government can access the app and control the voting process such as updating the list of voters and candidates. As in the voter mode, a database that contains the list of the email addresses of the administrators along with the passwords is stored in the cloud.

Figure 2.11 shows the government portal in which the administrator can perform the CRUD (create, read, update, delete) operations on the data of the candidates as shown in Figure 2.12, 2.13, and 2.14.

Graphical user interface, text

Description automatically generated

Figure 2.11: A screenshot of the application showing the government portal

Graphical user interface, application

Description automatically generated

Figure 2.12: A screenshot of the application showing the page of adding a new candidate

Graphical user interface, text, application, chat or text message

Description automatically generated

Figure 2.13: A screenshot of the application showing the page of updating the data of the candidate

Graphical user interface, text, application, chat or text message

Description automatically generated

Figure 2.14: A screenshot of the application showing the page of deleting the data of the candidate

Similarly, the independent Election Commission can perform the CRUD operations on the data of the voters as shown in Figure 2.15.

A picture containing application

Description automatically generated

Figure 2.15: A screenshot of the application showing the Independent Election Commission portal

Another feature of the application is the dashboard, where the dashboard appears for the government and the Independent Election Commission. The dashboard shows the statistics of the elections as shown in Figure 2.16.

A picture containing bubble chart

Description automatically generated

Figure 2.16: A screenshot of the application showing the dashboard

# CHAPTER 3: ECONOMIC and ethical

## ***3.1 Final Cost Analysis***

**“**Cost: The total money, time, and resources associated with a purchase or activity”. Secure Voting Systemsoftware can cost anywhere from nothing to tens of thousands of dollars in licensing costs. Affordability is influenced by ease of use and assistance.

This project did not cost us anything, there were so many free online courses; Channels like: Kudvencat, Elzero web school,   
Tecno U, and Websites like: MDN, Udemy, w3schools. That helped us code professionally. The database was also free by using Microsoft Azure.

Main cost categories:

1. Software: We have been working on this part by ourselves, so there is no additional cost here.
2. Advertising: We could use social media and the leading companies in the field of information security in Jordan for advertising. All of these ways are free, so no additional cost here.

3.2 ***Relevant Code of Ethics and Moral Framework***

Like most things in life, change is inevitable. The same applies to the company's IT network and operating system. With this in mind, it is important to know who is making the change and why.

Secure voting system (as any application program) is needed to meet with many crucial regulatory ethics, such as :

1. Public: Software developers will act in the public interest.
2. Client and employer: Software developers will act for the benefit of their customers and employers consistent with the benefit of the public.
3. Product: Software developers shall make sure that their products and connected modifications meet the best professional standards possible.
4. Judgment: Software developers must maintain integrity and independence in their professional judgment.
5. Management: Software developers and managers must maintain and promote ethical methods to manage and promote software development and maintenance.
6. Profession: Software developers promote their professional integrity and reputation consistent with the public interest.
7. Colleagues: Software developers must be fair and support their colleagues.
8. Self: Software developers must learn for life to practice their profession and develop ethical methods in their profession.

And there are some qualities we have ensured in our secure voting system product:

● Flexibility

● Compatibility

● Friendly user interface

● Affordability

# Chapter 4: Results and Analysis

## 4.1 Comparing

* Hindawi Voting System

In this scheme, the system is designed as follows.

The voters must go to the government institute and register that they want to be involved in the election to get a private key for the security concerns.

Using this private key, the voters will be enabled to vote in the voting center.

As we noticed, this scheme is a hybrid scheme, half online and half regular, it has a system but still the paper involved, and it does not reduce the voting process in a significant way.

Comparing with our App, our app is much better than their scheme because it’s fully online as we showed. And it’s contemporary

Link of the project:

<https://www.hindawi.com/journals/scn/2017/3075210/>

* Civic Design Voting System

This scheme is fully online except that the voters will have certain information to be enabled to elect.

Yes it’s better than Hindawi’s system but still lacks the motivation because there is an effort on the citizen to obtain their required information to vote.

Our system provides this motivator because the citizen only has to sign in and vote easily without any obstacles.

Link of the project: **https://civicdesign.org/projects/rcv/**

# Chapter 5: Conclusions and Future Work

## 5.1 Conclusion

Finally, this application will help to provide a larger number of voters, in order to facilitate the election process and save us time and effort.

Elections without using the application will take a longer time to find out the successful among the elected, and there will be no mistake by the person, there will be no vote that goes to someone else, and there will be no loss of any ballot box in order to use the application, which ensures integrity in the election process.

Based on above, this scalable highly effective app will reduce cost, time, and efforts for the Jordanian government.

In the current period, with the emergence of the Corona virus and with more types of mutants, the use of an electronic application will help provide reassurance to the voters.

In addition, it will support the tendency of automating the governments’ transactions into fully smart processes.

## 5.2 New Skills Learnt

We became able to understand how applications work, how they are developed and how much time and effort it takes the developers to reach the state of proposing a complete, finished, functional and useful application.

We improved our team working skills by discussing ideas and deciding important things together, we also learnt time and project management and their importance in any project.

## 5.3 Way forward

As a way forward to improve our project in the future, we will upgrading our app by add fingerprint and face print and use two-factor authentication to increase security and overcome any issues we might encounter when implementing the app.

# References

[1]"Ionic"

<https://code.tutsplus.com/articles/best-ionic-app-templates--cms-28563>

[2]"Database definition"

<https://www.guru99.com/introduction-to-database-sql.html>

[3]"SQL SERVER"

<https://en.wikipedia.org/wiki/Microsoft_SQL_Server>

[4] "angular"

<https://www.tektutorialshub.com/angular-tutorial/>

[5] "c#"

<https://www.tutorialspoint.com/csharp/index.htm>

[6]"relational data base"

<https://www.oracle.com/database/what-is-a-relational-database/>

[7]"c# in Depth"

<https://www.amazon.com/C-Depth-Jon-Skeet/dp/1617294535/ref=as_li_ss_tl?keywords=C#&qid=1578407020&s=books&sr=1-2&linkCode=sl1&tag=laurebradf-20&linkId=4883f29b237dd0799ec0f433795a5547&language=en_US>

[8]"SQL Queries for Mere Mortals"

<https://www.amazon.com/SQL-Queries-Mere-Mortals-Hands/dp/0134858336?_encoding=UTF8&pd_rd_i=0134858336&pd_rd_r=0e6bd034-bf41-42ce-88f8-72a24800ab15&pd_rd_w=SIZfl&pd_rd_wg=Sa8Rk&pf_rd_p=337be819-13af-4fb9-8b3e-a5291c097ebb&pf_rd_r=Z3N1CKRKND57BNAAVZ79&psc=1&refRID=Z3N1CKRKND57BNAAVZ79&linkCode=sl1&tag=laurebradf-20&linkId=57daf15de4cbec685795b9aff693a5a1&language=en_US&ref_=as_li_ss_tl>

[9]" security login password"

<https://docs.netapp.com/ontap-9/index.jsp?topic=%2Fcom.netapp.doc.dot-cm-cmpr-980%2Fsecurity__login__password.html>

[10]"Lazy loading"

<https://www.codeproject.com/Articles/652556/Can-You-Explain-Lazy-Loading>

[11]"security authentication"

<https://frsecure.com/blog/what-authentication-means-in-information-security/#:~:text=In%20security%2C%20authentication%20is%20the,resources%20in%20an%20information%20system>.

[12]"learning ionic"

<https://www.goodreads.com/book/show/42529959-learning-ionic>

[13]"presentation layer"

<https://en.wikipedia.org/wiki/Presentation_layer>

[14] "Business logic layer"

<https://help.hcltechsw.com/commerce/7.0.0/com.ibm.commerce.developer.doc/concepts/csdbusinesslogicbase.html>

[15]"Data Access Layer"

<https://docs.microsoft.com/en-us/aspnet/web-forms/overview/data-access/introduction/creating-a-data-access-layer-cs>

[16]"normalization"

<https://www.geeksforgeeks.org/second-normal-form-2nf/>

[17]"multithread"

<https://www.c-sharpcorner.com/article/introduction-to-multithreading-in-C-Sharp/>

[18] [online] Available

[19] [Online]. Available <https://www.computer.org/education/code-of-ethics>