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Automatic control system for managing travel certificates and monitoring the spread of Covid-19 pandemic in Morocco

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ABSTRACT

The automatic control system for managing mobility certificates during the Covid-19 pandemic in Morocco "ACS-MMC", is a platform, developed so citizens can apply online for mobility and travel certificates during the curfew of health emergency, caused by Covid-19 in Morocco. The platform goal was minimising citizens' contact with agents of the law forces and the public administration by designing the application process on line and generating digital certifacates for mobility. Besides, "ACS-MMC" system proposed mobility control to be performed at the authorities' checkpoints since the certificate' QR code can be easily shared between smartphones. Moreover, the system summarized the spread of the infection through its dynamic dashboard that indicated infected cases and movements traceability at the national level, in order to take all necessary precautions to limit as much as possible a large contamination of the population. This project was funded by NCSTR (National Center for Scientific and Technical Research in Morocco) and Abdelmalek Essaadi University (Morocco).

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1. INTRODUCTION

In the context of the implementation of new protocols against the propagation of Covid-19 pandemic, declared officially by the World Health Organization (WHO) on 30 January 2020 to be a public health emergency of international concern and later, on 12 March 2020, as a global pandemic [1]. This project was developped in Morocco, to design a digital platform for requesting authorization for travel and mobility during the lockdown. Once the authorization is validated by the relevant authorities througth the platform, the system generates a digital certificate, sent to the citizen via email or SMS.

The platform allows avoiding physical contact in the public administration and at the checkpoints between citizens, agents and agents of the law forces. To avoid sharing certificate in the paper format, each authorization is identified by a QR code that allows reading remotely the data. Thus, we developped a mobile application for android smartphones, for agents at the checkpoints to allow scaning the code remotely for extracting the citizen data.

This procedure will not only minimize the risk of contamination of citizens by minimizing physical contact in the public administration, but also by eliminating any exchange of paper between control authority and citizen at the checkpoints.

In addition, the platform offers a dashboard allowing a traceability of the infected cases and a follow-up of the spread of the pandemic on a national scale. In this article, we present all the stages of development of this system, from the design phase and the description of the functional needs described in section 3, to the realization phase detailed in section 4, and finally we conclude with the perspectives.

2. Related Works

A study was conducted to identify national and international platforms with the same functionalities, or related to the management of people's movements during the Covid19 pandemic. At the national level "wiqaytna" [2], is the only Covid-19 contact detection application that has been developed by multidisciplinary teams from the Ministry of Health and the Ministry of Interior in collaboration with the National Agency for Telecommunications Regulation (NATAR) and the Digital Development Agency (DDA) and with the voluntary contribution of Moroccan companies and startups that are experts in the field.

Its purpose is to allow the Ministry of Health to inform the citizens that they were at a very short distance from a patient infected with Covid-19. It is a mobile application that once activated, uses Bluetooth technology to detect other smartphones using the application. Thus, once the person infected with Covid-19 is hospitalized, the department at the hospital retrieves all the contacts of the people who have been in contact with the patient, to ask them to take all the necessary precautions and to report to the emergency health services once the first signs of contamination are detected. The application has worked well, but such an approach requires an absolute commitment from all citizens, which was difficult to achieve. Internationally, several applications have been developed, either to detect people being close to a person with Covid-19, or to monitor people who were in quarantine for a certain period of time. Table 1 summarizes some of these applications by country and their different functionalities. To detect Covid-19 contacts, the proposed applications rely on Bluetooth technology or on location information from the activation of the citizen's position via his smartphone. Being prohibited in Morocco, this last approach is not possible since it presents a violation of the law on the protection of individuals with regard to the processing of personal data.

Table 1 : Summary of applications developed to control the spread of the Covid-19 pandemic

Covid-19 Application	Country	Programming Language/ Technology	Features
Wiqaytna [2]	Morocco	Kotlin / Bluetooth	Notification of exposure to Covid-19 (21 days' delay). Statistics of infected cases every day.
TousAntiCovid [3]	France	Kotlin / Bluetooth	Warning to people who have crossed paths with a person who tested positive for Covid-19. An anonymous alert will be sent to nearby users. The application takes into account contacts within one meter for at least 5 minutes, as well as contacts within two meters for at least 15 minutes.
COVID Watch [4]	USA	Vue.js Nuxt.js Node.js Kotlin / Bluetooth	Detect users when they are in close range to each other and anonymously notify them if they are in contact with someone whose test is positive.
TraceTogether [5]	Singapore	Kotlin / Bluetooth	Alert the user if they have been exposed to COVID-19 in close range. The application allows the Department of Health to provide care and advice quickly.
PeduliLindungi [6]	Indonesia	Kotlin / Bluetooth	Notify users if they have come across a person with a positive diagnosis.
StayHomeSafe [7]	Hong Kong	Kotlin / Bluetooth Wi-Fi location service	Ensuring that confined people remain in their designated location during the quarantine period, using Big Data and artificial intelligence technologies, in conjunction with the wrist band. If the mobile application detects a suspicious location of a confined, it tracks it according to government regulations.

3. Analysis and design of the propsed system ACS-MMC

3.1. Objectives and operating principle

The aim of the proposed ACS-MMC project is to allow on the one hand the detection of people infected with Covid-19, once scanned in a Covid-19 emergency checkpoint, during their first hospitalization. The itinerary of their movements will be easily retrieved, thanks to the different control points established at the level of large surfaces, public establishments, accesses to different cities and rural areas. On the other hand, this platform manages the requests for travel and mobility authorization, made online by citizens, then proposes a validation process as designed by the morocan authorities. Thereafter digital certificates are sent to citizens via email or SMS. Besides, the platform can respond to requests for verification of any citizen mobility at the authority control points, via a simple reading of the QR code.

The platform consists of a web application intended primarily for Moroccan citizens concerned with derogatory travel or mobility. A Citizen will be invited to fill in a web form and provide their information such as: Name, First name, ID card number, Address and reason(s) for travel or mobility. After the validation of this form by the adequate administration according to the citizen's place of residence, he will receive his derogatory travel/mobility certificate. The system consits also of a mobile application developed for authority agents at the checkpoints, to control citizens' mobility. In fact, at each checkpoint, the citizen must present his certificate with the QR code (on his smartphone). The control agent will let the citizen pass to the desired area once the status of his authorization is verified.

The proposed procedure permits a follow-up of the contaminated cases, and their travel or mobility history. Thus, determine and visualize the areas with high contamination index in a dynamic dashboard.

Figure 1 summarizes the three main functionalities provided by the ACS-MMC platform, firstly the sending of the online application requests of the citizens, secondly, the processing of these requests by the agents of the administrative annex, and lastly, the verification phase of these authorizations during the travel of the various citizens.

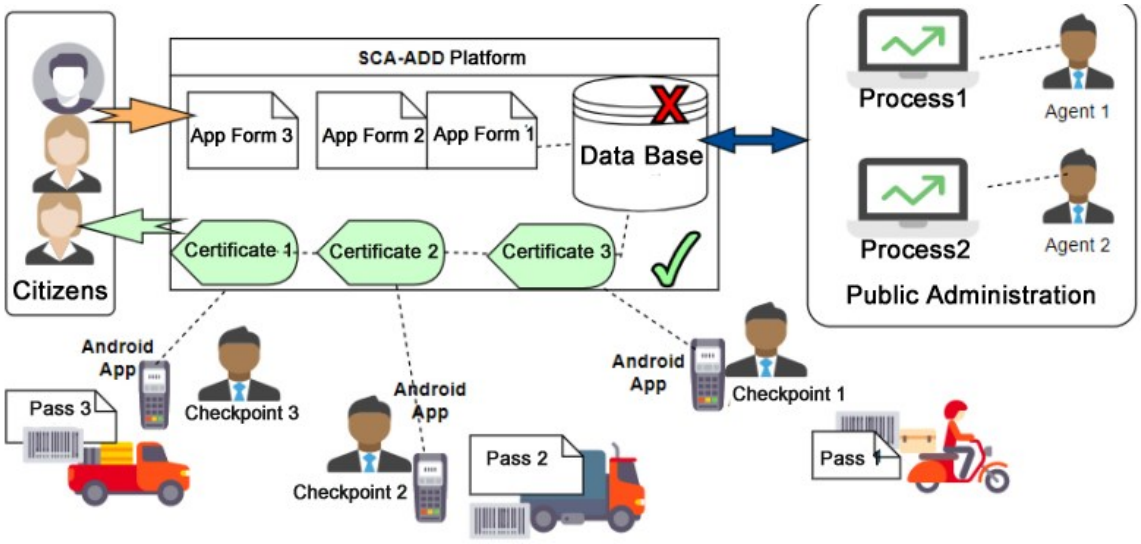

Figure 1 : Operating principle of the ACS-MMC system

3.2. Use cases and class diagrams

In this section, we present the textual description of the main use cases.

- Use case 1 – " Apply a request "
  - **Main actor:** Citizen
  - **Preconditions**: Internet access - Install Browser / Mobile Application - Have an ID and a Valid Tel Number.
  - **Nominal scenario**:
    1. The citizen enters his or her personal data in the form via the system's web application.
    2. The system displays the citizen's information and sends a verification code to the Tel entered.
    3. The system requests the verification code sent by SMS/Mail.
    4. The citizen enters the verification code.
    5. The request is registered in the system.

6. The citizen receives a request number via Mail/SMS.
7. Session ended.

- **Exceptional scenario:** E1: If no verification code is entered, the system closes the session, and asks you to reapply. 3. Go to 7: Session ended.

➢ Use case 2 – " Process a request"

- **Main actor:** Administrative Authority Agent.
- **Preconditions:** Internet Access and Browser - Registered Authority Agent.
- **Nominal scenario:**
  1. The agent authenticates via the system's web application system.
  2. The system checks the user's login and password of the user.
  3. The agent displays the home page containing the requests that concern his administrative annex.
  4. Agent accepts/refuses the request.
  5. The system saves the decision.
  6. The agent closes the session.
- **Exceptional scenario:** E2: If the Login or PWD are wrong the system displays an authentication error message.

➢ Use case 3 – " Validate a request"

- **Main actor:** Administrative Authority Officer 2
- **Preconditions:** Internet access - Browser - Administrative officer 2 registered.
- **Nominal scenario:**
  1. The agent authenticates via the web application.
  2. The system checks the user's login and password.
  3. The agent displays the home page containing the requests that concern his administrative annex.
  4. The agent validates the processing done.
  5. The system changes the status from "in the process of validation" to "accepted".
  6. The system creates the certificate and sends the link via SMS/Mail to the citizen.
  7. The agent closes the session.
- **Alternative scenario**: A1: 5. The system changes the status from "in the process of validation" to "Rejected" and sends via SMS/Mail, the rejection SMS/Mail, the rejection and the reason for the rejection to the citizen. Go to 7. Logout.
- **Exceptional scenario:** E2: If the Login or PWD are wrong, the system displays an authentication error message.

➢ Use case 4 – " Controlling a movement"

- **Main actor:** Controller
- **Preconditions:** Mobile + Internet Access + Mobile Application Installed - "Controller" registered
- **Nominal scenario:**
  1. The controller authenticates via the Mobile application.
  2. The system verifies the login and password.
  3. The controller displays the citizen's information and status of his certificate, and authorizes the trip.
  4. The system records the trip.
  5. The controller closes the session.
- **Alternative scenario:** A2: 3. The controller displays the citizen's information, the status of his certificate, and denies the move.
  Go to 5. Logout.
- **Exceptional scenario:** E2: If the Login or PWD are wrong, the system displays an authentication error message.

4. Realization of the ACS-MMC

4.1. Technical study

Before starting the programming phase of our system, it is essential to realize a technical study in order to identify the most adequate technologies in terms of libraries and framework for the development of our project. The technical study concerns Front-End and Back-End technologies.

Front End [8]: the study that we have realized in this sense is interested in three technologies among the most used, recent and powerful in the development of graphical interfaces of web applications. These are in fact: Angular, React, Bootstrap and VueJs.

- Angular [9]: an open source framework developed by Google. It is written in JavaScript.
- React [10]: a free JavaScript library developed by Facebook.
- Vue.JS [11]: an open source JavaScript Framework, created by Evan You.
- Bootstrap [12,13] : an open source Framework developed by Twitter social network team.

The main results are shown in Table 2. At the end of this study, we opted for the Bootstrap to develop the user interfaces of our system. This choice is mainly based on the ease of developping, and its performance as well as the multi-site compatibility [14-16]. A detailed study of these frameworks is presented in [17-18].

Table 2 : Advantages and disadvantages of the frameworks: Angluar, React and Vue

Advantages	disadvantages
Angular	
- A Complete Framework; A large community; - An elegant architecture allowing an easy evolution; A rich and detailed documentation; - A DI engine (dependency injection); - The advantages of Type-Script: static and operational verification of the input; Powerful input functions	- Cumbersome language and complex syntax; - Difficult to learn; - It leads to heavier and slower applications compared to React and Vue. - Upgrading is often difficult. - Difficult to change Framework during a project.
React	
- Easy to learn, Very detailed documentation. - Flexibility (easy integration to mobile due to React Native); Redux, the most popular framework to manage app state. - React uses the virtual DOM and improves the performance of applications requiring regular updates; - It is based on a unidirectional data flow which provides better control over the whole project.	- It is necessary to have in-depth knowledge for the integration of the library in the MVC framework. - The ViewOriented approach of the MVC is one of the drawbacks of React. It can lead to indexing problems for search engines. - Very little official documentation; - No engine for dependency injection.
Vue.JS	
- Easy to use; Performant; Very light; Simplicity of code; - The use of components allows you to do more things with less code to write; - Can be easily implemented in an application whatever the technology used.	- Used mainly for web applications. for mobile applications the use of the Vue Native remains unknown, and it still needs a lot of improvements. - A limited community compared to React and Angular.
Bootstrap	
Open source developed by Twitter. Uses HTML, CSS and JavaScript languages. Most popular to develop sites with a responsive design template, frameworks, which adapts to any type of screen sizes, and in priority for smartphones.	At a minimum, a basic understanding of HTML5 and CSS is needed — JavaScript is more likely to be required if you want to perform serious customization of a site.

Back End: regarding the programming of the back-end part (functionalities) of our system, we can in fact choose between several technologies. This is because the React.js library (for the development of development of user interfaces) does not require any specific technology for the back-end development. So, we have prepared a list containing a set of frameworks among the most used and known for their performance.

This list contains the following frameworks: Express (Node.js), Spring (java), Django (Python) and Laravel (PHP). we opt for the Spring framework in the development of the business part of our system. A detailed study of the most used back-end frameworks is presented in [19].

4.2. Software architecture

The general architecture of our system is presented in the following figure:

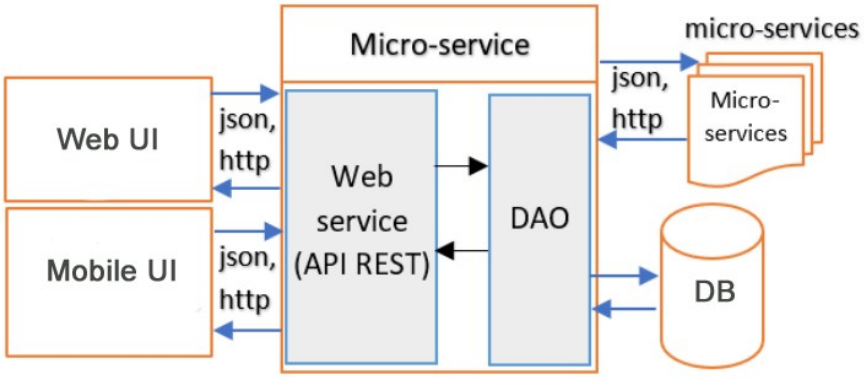

Figure 2: Micro-services architecture of the ACS-MMC system

The architecture of the ACS-MMC system is a micro-services architecture (MSA-Micro-Services Architectures) which splits the system into a set of small, completely autonomous services (microservices). In fact, each microservice can be designed, developed, deployed and tested independently. Each microservice exposes a REST API that other microservices can consume to communicate [20].

4.3. User Interfaces

The developpement phase of the project is completed, thus this section presents the platform inetrfaces. Figure 3 presents the system homepage of the citizen, which conataines two options, appliying for a travel certificate or verifying its status, if it has been validated or not yet.

Figure 3 : ACS-MMC System Home Page for the citizen

The application form of the authorization certificate takes four major steps, firstly the personal information of the citizen, implying name in both Arabic and French, identification number, date and place of birth, as described in figure 4.

The second step presented in figure 5, consists of chosing the place of residence and the nearest public administration according to the citizen' residence, so the authorities may easily recognize the citizen and his needs, such as the nearest supermarket, drugstore, etc. Then in step 3, the citizen is asked to choose the reason of his travel or mobility. Finaly he must fill in the contact information as demonstrated in figure 6.

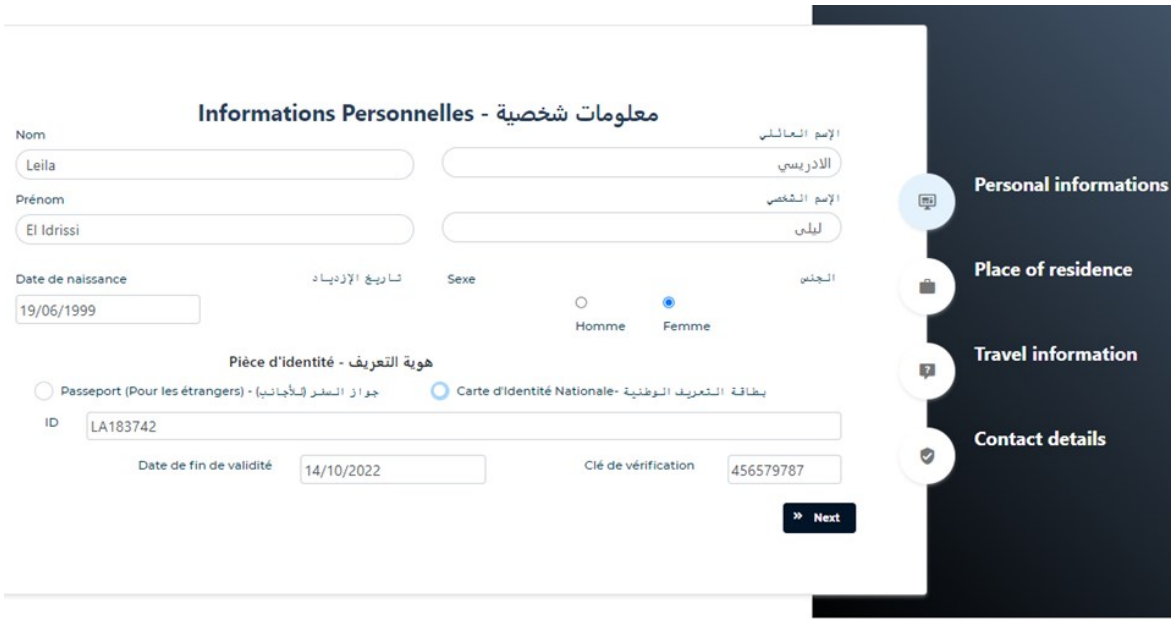

Figure 4: Step 1 of the Citizen Application form for travel and mobility certificate- Personal informations

Figure 5: Step 2 of the Citizen Application form for travel and mobility certificate-Place of residence

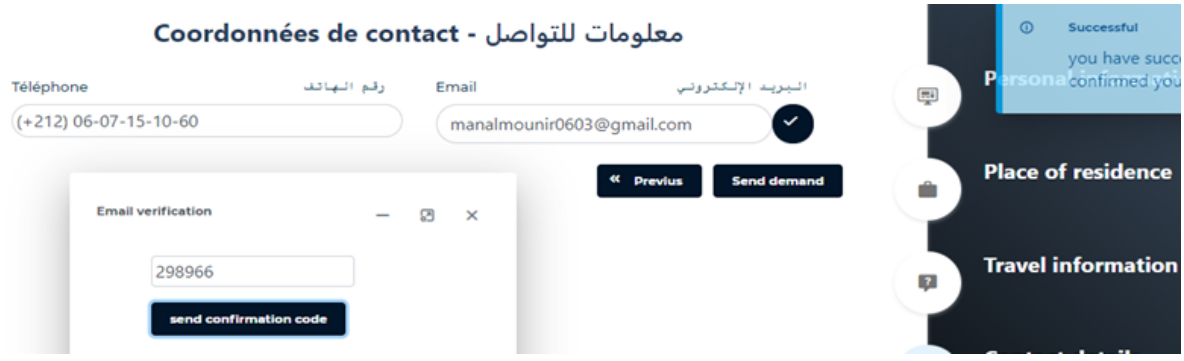

Figure 6: Step 4 of the Citizen Application form for travel and mobility certificate-Contact Details

The citizen can easily track the state of his demand through the demand-tracking interface and even make a complaint directly to the autorithies if his demand takes more than a week to be treated. One validated, the digital certificate as demonstrated by figure 7, is sent to the citizen via mail or through a

temporary link via sms. Thus, one can use only his smart-phone to present his mobility certificate at each control point he meets.

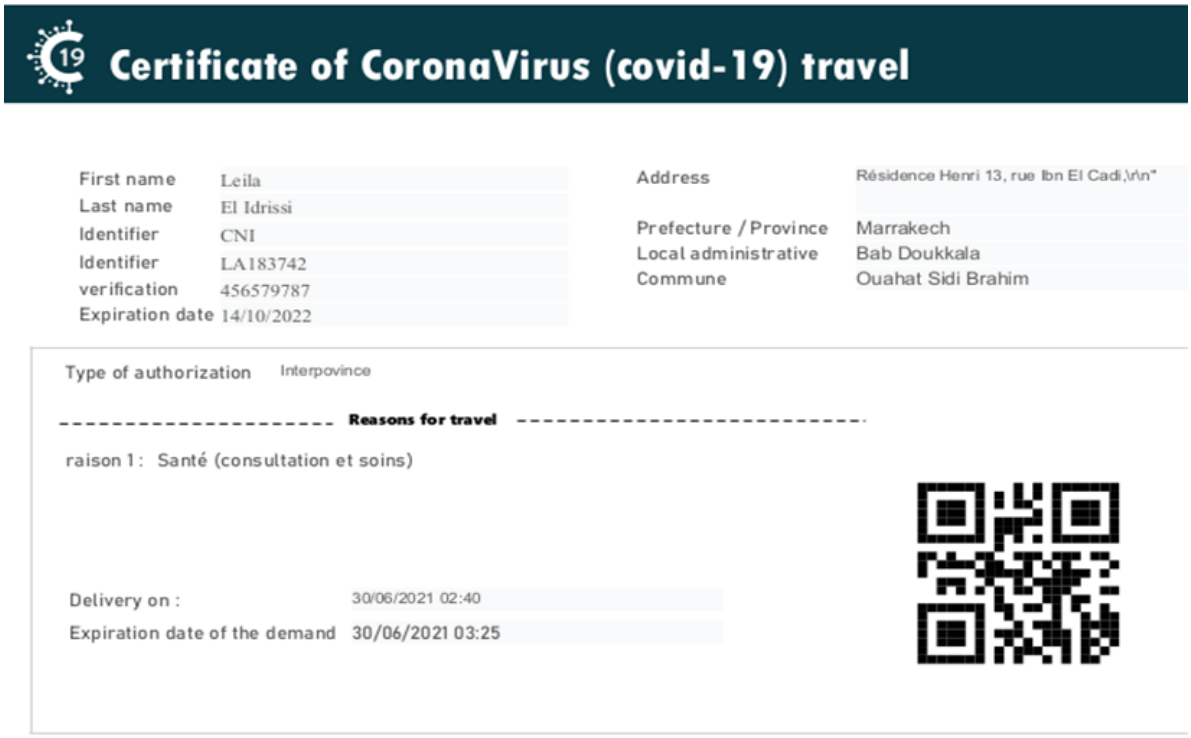

Figure 7: Travel certificate generated by the ACS-MMC system

Finally, each security control officer is invited to set the identification and the control point location, before checking the citizen certificate. Figures 8 and 9, describe respectively the first and the second features of the mobile application of the ACS-MMC system.

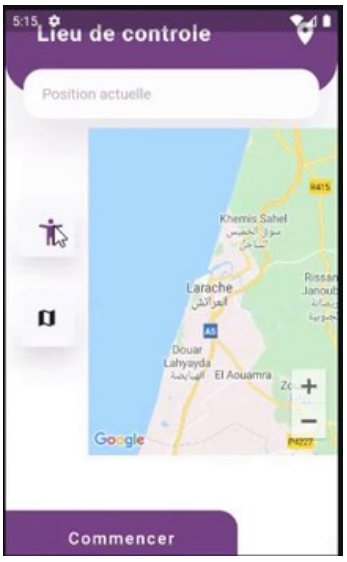

Figure 8: Setting the Identification and the location of the security control point in the ACS-MMC system.

Figure 9: The ACS-MMC mobile application interface to check mobility certificate.

5. CONCLUSION

The ACS-MMC system is a project proposed during Covid-19 pandemic to minimize the risk of contamination and to monitor the spread of the infection in Morocco. It presents a complete solution for

mobility certificate management and control, developed in accordance with the authorities' procedures and hierarchy. Finally, the platform was developed in a modular way, while taking into consideration the various administrative procedures and the hierarchical organization of the ministry of the Interior in Morocco, starting from the certificate application phase until the document validation process. Thus, the system could be customized to generate different kinds of digital documents such as the vaccination pass, the security form used at the airport or any other document needing to be digitalized, as part of the digital transformation strategy in Morocco.

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