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Architecture of System Design of E-verification and E-authentication of Driver in Saudi Arabia in Covid-19 using Bluetooth,fingerprint, Maps Technology

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ABSTRACT
Rising number of COVID-19 cases has led the Saudi government to implement various containment strategies, such as lockdown, curfews, closure of schools/colleges, religious places etc. In addition, social distancing was made mandatory to be followed and unnecessary travel was restricted for containing the spread of virus. However, it may be essential that people need to travel for essential commodities, and in case of emergencies. Accordingly, transport for essential needs was permitted during curfew timings for people with Temporary Traffic Permit (TTP). TTPs were initially granted on paper, which were identified to be misused by the people. As a result, police checkpoints were established in streets for monitoring the movements and verifying the TTPs of the people. However, policemen at checkpoints cannot check the face of women drivers due to the women wearing "Niqab" (covering face with cloth), and the cultural norms do not permit women revealing their faces to other people except family and close relatives. In addition, coming in close contact with travelers may place both policemen at checkpoints and travelers at risk of contamination. Focusing on this issue, this study proposed smartphone technology intervention (PIPS) for ensuring safe and secure travel and reducing the spread of COVID-19 in Saudi Arabia. The application design using Bluetooth LE communication technology (for verifying TTP details) and fingerprint biometric module is explained in this study and a porotype model is presented in this paper.

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I. INTRODUCTION

Saudi Arabia developed its own health strategy in managing epidemics such as the Middle East Respiratory Syndrome (MERS-CoV), Severe Acute Respiratory Syndrome (SARS-CoV). MERS-CoV was transmitted from camels to humans in Saudi Arabia in 2002, and the country has successfully controlled it [1]. However, the recent infectious disease COVID-19 caused by novel coronavirus (SARS-CoV2) has different symptoms and different treatment and precautionary methods compared to MERS-CoV and SARS-CoV, as a result of which the country has to update its strategy in containing the spread of COVID-19. Various countries across the globe have been adopting different mitigation and suppression strategies such as social distancing and lockdowns respectively [1, 5]. However, social distancing is one of the most widely accepted and implemented preventive strategy to protect people from getting infected [5].

Saudi Arabia has implemented both mitigation and suppression strategies since the discovery of COVID-19 cases in the country. All schools, colleges, and universities were closed from 8th March 2020 [13]. Operations across most of the government agencies were stopped except emergency and essential services from mid-March. A royal decree was issued on 23rd March, restricting the movement of people from 7 p.m. to 6 a.m. In addition, the curfew order for 21 days was issued in cities with two holy mosques, Mecca and Madinah [9]. The Interior Ministry closed down the city of Jeddah on 29th March, followed by cities Mecca and Madinah on 2nd April, and closure of all major cities including Riyadh, Dammam, Tabuk, Jeddah, Dhahran, Khobar, Hofuf, Al Qatif, and Taif on 6th April [5, 9]. In addition, all domestic and international travel through all modes were suspended [11]. The country was under complete lockdown by the first week of April to contain the spread of novel coronavirus. However, operations related to food and essential commodities supply, medical emergencies, and media agencies continued to operate from 9 a.m. to 7p.m [11]. In addition, emergency operations could be operated during specific timings. Accordingly, for ensuring safe and

secure travel operations related to the above-mentioned operations, TTPs were issued by the government. Police checkpoints were installed at various locations to implement curfew and track the unauthorized movement of people. However, few issues have been identified with police checkpoints, which have been affecting the implementation of curfew and risk of spreading the infection. As the TTPs were issued with stamp on paper, the police at checkpoints may need to come in close contact with travelers and touch the permits for verification, it could increase the risk of infection. In addition, there is no mechanism to identify if the permits are fake or original, as they were issued on paper. As a result, police at checkpoints were having difficulties in 1) verifying the authenticity and validity of the TTPs; 2) identifying if the permit belongs to the person who is actually travelling; 3) if the driver is following the correct and safe travel route; 4) maintaining social-distancing norms during verification.

Major technology interventions such as use of mobile applications, drones, and robots were being implemented in different countries to combat the spread of infection. Accordingly, in the context of issues faced by police at checkpoints in Saudi Arabia, mobile technology can be one of the effective technology interventions, for facilitating safe and secure verification process. Focusing on these issues, this paper proposes and develops a smartphone-based technology intervention referred as Police Investigation Point system (PIPS) for verifying TTP, traveler's identity, and purpose of travel. The mobile technology is further integrated with Bluetooth LE technology, Global Positioning System (GPS) or maps technology, fingerprint and facial recognition technologies for improving the secured level of verification. However, facial recognition approach can have serious cultural implications, as women drivers may not be allowed for facial recognition as it conflicts with Niqab (covering face) tradition in Saudi Arabia. Considering these factors, this paper proposes a design for a system that ensures safe and secure verification by adopting technology interventions including Bluetooth LE, fingerprint biometric, and maps technology, and following social distancing norms at police checkpoints in Saudi Arabia.

II. LITERATURE REVIEW

This section introduces COVID-19, how it has spread across the world and in specific Saudi Arabia. In addition, Bluetooth LE, maps, and fingerprint technologies were reviewed in the context of their application in this study.

Novel Coronavirus and COVID-19

Unlike other viruses, Coronaviruses (CoV) are a large family of viruses with spike proteins which facilitate their entry in to host cells, and may cause various illness ranging from the common cold to acute diseases such as Severe Acute Respiratory Syndrome (SARS-CoV) and Middle East Respiratory Syndrome (MERS-CoV), multi-organ failure, and may sometimes lead to death [1]. The coronavirus (SARS-CoV) was first discovered in China in 2002, which was transmitted from civet cats to humans and MERS-CoV in Saudi Arabia in 2012, which was transmitted from camels to humans [1]. The novel coronavirus (SARS-CoV2), which caused COVID-19 pandemic was believed to be transmitted from bats at seafood and animal market in Wuhan city, China [1].

The Chinese government informed World Health Organization (WHO) Regional office in China that there is a rapid increase in the pneumonia cases with unknown cause in Wuhan city, Hubei province of China on 31st December, 2019 [1]. This incident was followed by announcement from Chinese government on 7th January, 2020 announced that they have discovered which has been the transmitting among the people in Wuhan city, resulting in increasing number of pneumonia cases, which was later termed as COVID-19 disease causing acute pneumonia and even death in some critical situations [1]. Since then the novel coronavirus (SARS-CoV2) started spreading across the globe, being first detected in Thailand (outside China) on 23rd January, 2020 [2]. The Chinese government immediately locked down the Wuhan city, and placed 11 million people under quarantine, and isolated COVID-19 patients for treatment [3]. Accordingly, WHO declared COVID-19 as pandemic with 71,249 confirmed COVID-19 worldwide cases, out of which China accounted for 70,365 confirmed cases, and 25 other countries accounted for 794 confirmed cases and 3 deaths [4]. As a result, countries across the globe have started to implement various containment strategies to slowdown the spread of novel coronavirus by closing schools/colleges, industries, businesses, and all community places [6].

Saudi Arabia

The country reported first confirmed case on 2nd March, 2020, who was identified to be a Saudi national arriving from Iran via Bahrain [6]. As a result, restrictions on international travel was placed, such as temporary suspension of flights from GCC (Gulf Cooperation Council) countries, and other countries including China, Japan, Italy, Singapore, Kazakhstan, and Malaysia for fourteen

days, as there is high risk of virus transmission [15]. The total number of cases rose to 103 by mid-March as announced by the Ministry of Health [14].

The KSA has adopted various strategies and approaches for reducing the spread of infection. From 16th March, operations were suspended across all the government agencies, except those which were essential, such as municipalities. In addition, allschools/colleges/universities were closed and operations were carried out using E-Learning and virtual learning platforms [10]. A royal decree was issued on 23rd March, restricting the movement of people from 7 p.m. to 6 a.m. In addition, the curfew order for 21 days was issued in cities with two holy mosques, Mecca and Madinah [8]. The Interior Ministry closed down the city of Jeddah on 29th March, followed by cities Mecca and Madinah on 2nd April, and closure of all major cities including Riyadh, Dammam, Tabuk, Jeddah, Dhahran, Khobar, Hofuf, Al Qatif, and Taif on 6th April [5, 9]. In addition, all domestic and international travel through all modes were suspended [10]. The country was under complete lockdown by the first week of April to contain the spread of novel coronavirus.

Interior Ministry announced that the lockdown/curfew would continue till further notice, which will be taking to consideration of the rate of transmission and the zones of contamination. However, few restrictions were eased to permit essential and emergency activities. Accordingly, TTPs were issued for essential services travel such as food sector (transport of food and essential commodities), the health sector (hospitals, pharmacies, laboratories, research and pharmaceutical industries etc.), the media sector, and others. Police checkpoints were installed in every street to monitor the curfew norms such as social distancing, wearing of masks etc. by the people with TTPs [11]. However, issues such as social distancing could not be practiced as the TTPs were issues were paper-based, which need to be touched by the police for verification by coming in close contact with travelers. In addition, police may need to check the face of the travelers for verifying the identity. But, women in Saudi Arabia had to follow certain cultural restrictions such as wearing Niqab and showing face only to family and relatives. In addition, as no women police were deployed at checkpoints, as a result it was difficult for police in the process of verifying if the right person is using the TTP. However, there are few issues identified with respect to the operations at checkpoints, which included increase in fake TTPs as it was issued on paper; increase in the verification time, as there are more number of documents to be verified, such as Saudi nationality, car permit, driving license etc.; increase in risk of contamination as the police officers come in close contact with passengers during verification; long queues at checkpoints, affecting people with emergency transfers (ambulances/patients etc.).

Mobile and Bluetooth Technology

Countries have been using various technology interventions such as mobile applications for contact tracing; robots for healthcare services, drones for monitoring and contact tracing in the context of COVID-19 outbreak. Mobile technology in this context can be one of the effective technologies in facilitating the access and delivery of various services remotely. In addition, mobile technology, which can be used for communication through phone calls and messaging, can be integrated with other technologies such as GPS navigation VoIP (Voice over Internet Protocol), internet access etc. Mobile technology can allow multiple transmitters to transfer data over a single channel of transmutation signal [12]. The integration of 4G/5G technologies on to mobile platforms has revolutionized the modes of communication and accessibility of services at high speed and low costs. In addition, communication technologies such as Wi-Fi, Bluetooth have enabled the wireless connectivity among the devices facilitating faster data transfer [12].

Wireless communication has become one of the common modes of data transfer between devices including smartphones and laptops by using various applications and technologies such as Bluetooth and Wi-Fi [16]. Personal Area Networks (PANs) can be established by using Bluetooth technology using the Internet gateways [17], enabling safe and secure data transfer. The range of these technologies is usually covered up to 100 meters depending on the functional capabilities of the devices used [16], and can be used in various other areas such as mobile payment systems [18], audio and video streaming [19], and gaming [20].The recent development in Bluetooth technology, BLE (Bluetooth Low Energy), which is also considered as a smart extension of Bluetooth standard version 4.0. supports low-powered short-range wireless communication [Bluetooth.com]. It is a low-cost communication technology, which has a potential to run BLE devices for months or even a year on a single coin cell battery [Bluetooth.com]. It is considered to be a perfect application for devices which requires periodic short-range communication with devices that are able to work for long durations without requiring frequent charging. One of the unique features of Bluetooth LE is that communication between devices can be enabled without an explicit pairing operation and authentication used in earlier standards of

Bluetooth,that require manual pairing. [21]. This communication technology can be effective for establishing communication link between the travelers at checkpoints and police by maintaining a distance of more than one meter (Social distancing norms).

Fingerprint

Fingerprints reflect various patterns or graphical ridges on the fingers of humans, which are considered to be unique for each individual, as a result of which they are considered as one of the most effective solutions in biometric verification [320]. Biometric verification system uses natural features (chemical, physical, and/or behavioral features) such as retina scan, fingerprint scans, facial recognition etc., which can be considered as an effective alternative to security mechanisms such as using passwords or paper-based verification [22, 24]. Both physiological and behavioral characteristics can be used in the automated verification using biometric systems [25]. The two major [24] implications of using biometric systems include the following.

- For verifying the identity of the users by comparing the provided biometric information with stored biometric information, every time an individual requests an access.
- For identifying the individuals from a large section of biometric data of people, which is identified to be effectively used in forensic operations.

As most of the smartphones are integrated with various biometric sensors such as cameras, fingerprint scanners, voice recognition, and other tracking technologies using GPS, they can be used in various multi-media interactions in security verification process [22]. Accordingly, more than 50% of the smartphones sold in 2019 were integrated with fingerprint sensor for authentication [marketresearch.com]. As a result, various issues such as forgetting password, risk of data theft on lost phones (by guessing the password) can be addressed by using highly secured finger-print scan for authentication [23]. Accordingly, fingerprint scans are used in various operations for authentication, such as unlocking devices, personal identification, opening banking applications etc.; however, issues such as privacy was one of the major concerns identified with its usage.

As the risk of contamination of COVID-19 is very high by touching the contaminated surfaces and then touching eyes or nose without sanitizing hands or properly washing hands. During verification at police checkpoints, there is a high risk of surface contamination which may significantly contribute to the virus spread, as many travelers access the checkpoints daily. However, using fingerprint scans on personal devices can ensure safe and secured authentication at checkpoints by following social distancing norms. In addition, fingerprint scans may be more effective for verification in Saudi Arabia, as facial recognition is not possible for women, given the cultural norms. Accordingly, this technology can be used for verifying the person's identity with TTP in the proposed PIPS, where the data can be transferred through the communication link established by Bluetooth LE. The transferred biometric information (fingerprint scans) from traveler in vehicle to police at checkpoint ensures verification of person using the TTP at a safe distance.

Traffic Maps.

GPS and satellite imaging have been using in various applications and devices enabling personal navigation, tracking of goods, and many other applications in various fields. Sensors can be attached to various units such as transport vehicles, aircrafts facilitating real-time tracking. Mobile mapping refers to the collection of geospatial; data using sensors on mobile platforms [27]. In addition, the Internet, and mobile device are increasingly utilizing geospatial information, either in the form of mapping, or georeferenced imaging. Companies such as Google (Google Maps), Apple have used aerial photographs and satellite images to develop online navigation systems, which are more accurate and reliable [28]. Accordingly, many companies and systems utilize GPS location information through customers mobile in order to streamline their services according to the location preferences and enable live tracking of various services such as products delivery [26].

The use of GPS in traffic management systems is highly adopted in various countries. Conventional traffic systems rely on transport officials, drivers on phone, and traffic reporting companies for managing traffic movement [26]. However, with the use of GPS and navigation applications such as Inrix traffic, real-time traffic movements can be monitored, such as traffic jams, congestion routes, which can help transport officials in managing the traffic [29]. Approaches such as User-generated traffic reports, real-time mapping of peoples' movement through their mobile device locations have been adopted by companies such as Inrix Traffic, Google Maps for updating traffic information. In addition, Google Maps is one of the premium partners in Saudi Arabia and other GCC countries, which is authorized to monitor and updated traffic jams, accident, hazards, road closure,

and other travel related information in real-time [30].

The proposed PIP system uses the TTP details from the traveler's smartphones, where the information about destination, travel routes can be accessed by the police at checkpoints. Using the maps, police can verify if the travel route permitted in TTP is followed by the travelers. Mobile Bluetooth location can be used to verify these details in PIPs. The proposed PIP system uses Bluetooth LE, primarily for establishing safe and secure point-to-point communication channels between travelers and policemen at checkpoints. Accordingly, the purpose of selecting Bluetooth LE technology is to ensure effective and efficient communication with acceptable response-times, power-consumption and transfer data. Thus, Bluetooth LE can be used for transferring data related to fingerprint scans, TTP information, and location-based information through a secured and safe communication channel.

III. OVERVIEWPIPS SYSTEM OPERATION

The aims of the proposed PIP system include the following.

1. Verification of TTPs at police checkpoints without violating social distancing norms
2. Verification of person using the TTP at checkpoints.
3. Verifying and ensuring that the TTP is being used for the right and valid purpose
4. Facilitate paperless verification process and save time and cost in the process

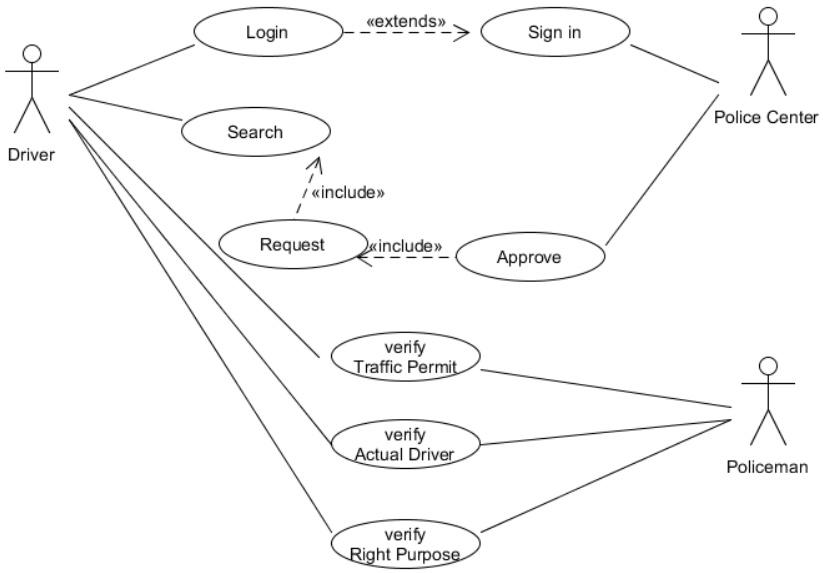

Figure 2: Use case of PIPsystem.

As shown in figure 2, the proposed PIP system has three components, including Driver Module, Police Center Module, and Police Investigation Points Module, which are explained in the following sections.

Police Center

Police Center is the initial component with which the driver establishes communication for application of TTP. Firstly, drivers have to register with Police Center. for submitting the TTP application. Drivers are verified using the One-Time-Password (OTP), received on the driver's mobile number, which is to be entered using PIP system. This would verify the driver's device communication, which they would be using at police checkpoints. Then driver has to make an online application for requesting the TTP using a mobile number. They need to enter the details of their travel route such as round trip/one-way trip; arrival and destination; travel route; date and time of travel; vehicle number; photo; mobile number etc. in the application, along with the purpose of travel. The police center has an internal system for verifying the details, and the identity of the driver. Accordingly, the decision of TTP is made according to the rules and procedures established by the Police Center. The decision on the application will be updated in PIPS stating 'Approved' or 'Rejected'. If the application is accepted, e-TTP will be provided, which can be accessed by the driver using PIPS mobile application. In addition, the Police Center

has the ability to update the TTP at any time according to the situations arising.

Drivers Module

From the drivers' perspective there are two modes of communication. Firstly, drivers are supposed to register on PIP system by providing the details as explained in the previous section. After verification, the police center may grant TTP for the drivers, which they can access from PIPS. The decision on the application will be received on the driver's mobile through SMS. Secondly, drivers communicate with police at checkpoints, where the driver's identity through fingerprint scans, the rightful purpose of travel, and validity of the TTP would be verified.

Police Investigation Point Module

The policemen at checkpoints need to verify the TTP of the drivers by following the social distancing norms, i.e. maintaining a distance of at least 1.5 meters from the drivers. Three functions for policemen are outlined in the process of verification. Firstly, the policemen need to verify the driver's TTP. In this process, the driver has to request Bluetooth LE communication through PIPS application with policemen mobile device, which will be accepted by the policemen. After establishing the communication, the information about TTP is accessed by the policemen from the driver's PIPS application. Secondly, the policemen need to verify the TTP details by establishing the communication with Police Center. Information from Police Center will be retrieved, and the TTPdetails are verified (by using GPS to track the drivers smartphone location). However, in order to identify if the permit is being used by the right persons, the policemen will use fingerprint application for verifying finger scans of the driver, which should match with the driver's fingerprint scans in register of finger print scans of the population. If the details do not match or fingerprint scan fails, the policemen would inform Police Center, which may cancel the TTP issued. However, if there is a need to update TTP details, such as change in route or other derails in case of emergency or any other situations arising, policemen can contact Police center, which will update the TTP details. Thirdly, the policemen need to verify if the TTP is being used for a valid and right purpose (by checking the driver's smartphone location using GPS). This can be assessed based on the travel route being used or by noticing anything doubtful. The policemen can also check the history of TTP if any doubt arises. Accordingly, if the TTP is identified to be being misused, policemen can request Police Center to cancel the TTP.

Design of PIPS system

This section details the procedures established, algorithms used in the design and development of PIP system. The UML flow chart is presented in figure 3. As shown in the figure 3, the process starts with driver's registration on PIP system.

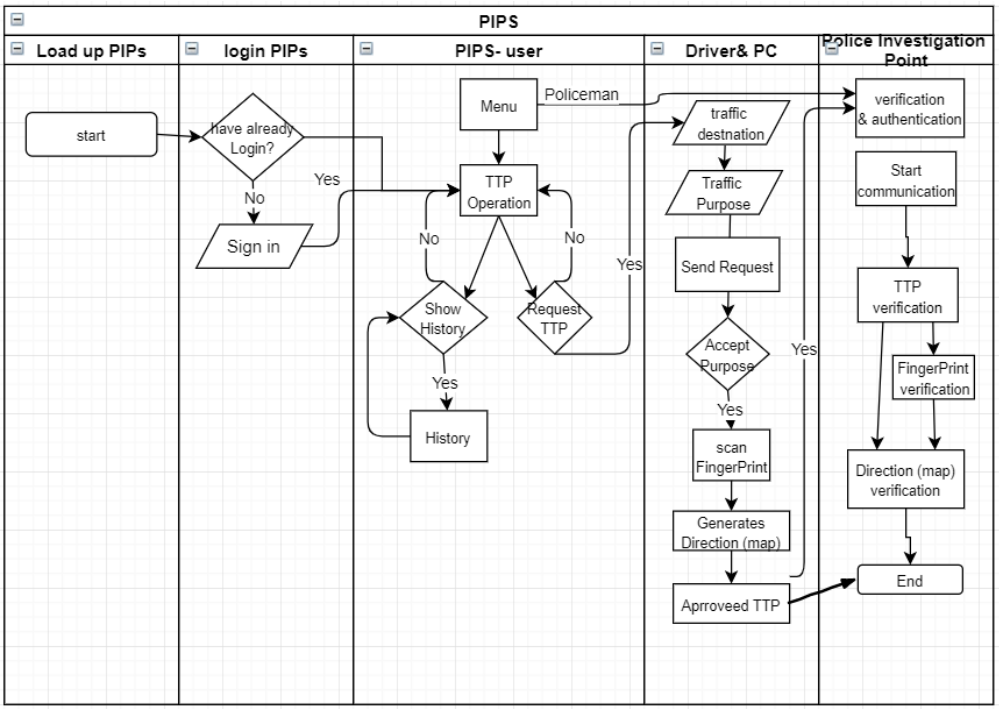

Figure 3: The UML flow chart of PIPS

*Load up PIPs:*The PIPS application is launched and loaded on the users' smartphones (driver or policemen), when they are supposed to share/ access TTP information.

*Starting PIPs:*First time users need to register by providing mobile number and their personal details. They would receive OTP through SMS, which will be used for verification. Once users are signed in, they need to sign in again if they are using same smartphone.The process is same for both drivers and policemen, except that policemen are supposed to get OTP from Police Center.

*PIPS User:*Users are divided in to two categories: Policemen and drivers. Drivers can browse their travel history and request TTP through PIPS; while policemen can access drivers TTP details and verify with police center.

*PIPs driver and police center:*Drivers need to enter information related to source and destination from the menu along with purpose of travel, and send a new request to Police Center. Police Center after verifying the details may either accept or reject the request. If the request is accepted, driver need to enter the fingerprint scans through the scanner on their device. The driver's fingerprints will be then verified by the Police center by confirming the identity by matching the scans with population scans register. After successful verification, PIPS will generate map with travel route between source and destination, with specific duration allocated for travel. The driver can access these details from PIPS application, and accordingly plan the journey.

*Police investigation Point:*The policemen uses PIPS for verifying TTP of the drivers by following social distancing norms in light of COVID-19 outbreak. Initially, policemen at checkpoints requests TTP details from the driver using PIPS application by establishing a Bluetooth connection. Drivers may send TTP ID details to policemen through established Bluetooth connection. Policemen would then verify TTP details with Police Center. If the details are correct, PIPS retrieve all information related to TTP including maps, travel route, and purpose, along with the driver details. Next, policemen may ask drivers fingerprint scan to verify the identity. Accordingly, driver may scan the fingerprints on the fingerprint sensors on their personal mobile devices through PIPS application, which will be transferred to the policemen PIPS application using Bluetooth LE connection. Policemen would request Police center, which would match driver's scans with population scan register to confirm the identity of the driver and the details are sent to policemen. In addition, for verifying the travel route or direction of travel, the policemen requests Bluetooth LE Position Point (BPP) via PIPS, which will be shared by PIPS from the driver's mobile. The drivers BPP will then appear on the TTP maps along with policemen BPP, which will be verified by PIPS, and verifies if driver's BPP is in the right direction to the source/destination.

IV. DISCUSSION

The purpose of this study is to design PIP system, which can verify the clients TTP details at police checkpoints ensuring that social norms are being practiced at police checkpoints during curfew timings. The motive behind the development of the system is to facilitate no touch contact during verification, in order to contain the spread of COVID-19. In addition, the system is also designed to identify the fake TTPs, and also, valid TTPs being misused. Use of ICTs have been increasing in the past few decades, which proved to be effective in developing innovative solutions in different scenarios. Accordingly, Bluetooth LE is one such technology solution, which has enabled wireless communication over a short-range distance between various devices. This technology can be used for various purpose. In the context of this study, Bluetooth LE is used for establishing communication between clients with TTPs and policemen at checkpoints, as it can facilitate data transfer without coming in to close contact. The travel data id is used for verifying the permit and at the same time to assess if it is being misused. In addition, to add an extra layer of security, fingerprint scan module is used for high level verification to identify if client who requested TTP and the person travelling using the permit are same. Both technologies are considered to be very effective in the process of verification by adopting social distancing norms through PIP system in light of COVID-19 outbreak.

The PIPS design accordingly included three components: clients, Police checking points, and Police Authorities Center. The PIP system can facilitate the TTP verification in a speedy manner, and secured manners without requiring the policemen to come in close contact with the travelers. In addition, online registration and application process can help people in getting TTPs in time, which can be very useful in times of need and emergency. Furthermore, it allows a systematic approach of travel to be implemented during the curfew timings. Focusing on the system features, two layers of security are provided in the process of verification, making it more effective design. Bluetooth LE can be used for verifying the TTPs; while fingerprint scan module, can be used by the policemen for more detailed verification if necessary.

V. CONCLUSION

The purpose of this study is to propose PIP system as a technology intervention in order to allow smooth travel operations with an effective monitoring system during the curfew timings in Saudi Arabia. Rapid increase in the COVID-19 cases has brough the healthcare systems and governments under stress. As a result, various containment strategies and technology interventions are being adopted to stop the spread of virus. In such challenging situation, it is essential that transport operations have to be continued systematically without affecting the people. Accordingly, the proposed system in this study is designed in such a way that it facilitates TTP verification at a faster pace while ensuring that social distancing norms are followed. In addition, it protects policemen at checkpoints from getting infected, as there is a high risk of transmission from policemen to various other travelers crossing the checkpoint. It can also help in contact tracing, as the travel routes of all the clients is recorded and saved. In addition, the police authorities can stop travelers from entering containment zones by modifying the travel routes online, which should be followed by the clients. Given the current situation in Saudi Arabia, with curfew being extended at regular intervals, the application proposed can be very useful in implementing containment strategies. In addition, the proposed design can add valuable contributions to the literature in developing technology interventions which can ensure safe travel adopting social distancing norms, which has become one of the essential activities in daily lives. Thus, the study has both theoretical and practical implications in relation to the use of technology interventions for containing the spread of COVID-19 pandemic.

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