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ORIGINAL ARTICLES

Innovative solution for SARS-COV2 epidemic management

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Abstract: *The SARS-CoV-2 pandemic challenged the authorities into taking measures that limit the spread of the virus in the community. TAMEC project (Advanced Community Approaches to Epidemic Management) developed a system that detects the contacts of patients infected with the SARS-CoV-2 virus and alerts them using mobile applications. It allows real-time analysis of confirmed patients and identified contacts, early detection of new outbreaks, and provides decision-making information to prevent viral transmission. The system uses its patent for homomorphic encryption, a method that allows to process and manipulate data in an encrypted format, without having access to the original data. Thus, the solution proposed in the TAMEC project fully respects the privacy rules of citizens imposed by the EU, using the concept of privacy preservation. Our solution offers the possibility to identify and validate a risk score that could become an extremely helpful tool in the stratification of COVID-19 patients. The TAMEC system is innovative in its simplicity and ability to facilitate the prevention of the spread of the SARS-CoV-2 virus in the community*

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The SARS-CoV-2 virus pandemic challenged the authorities into taking measures that slow and control the spread of the virus and limit the disease among the population. Prompt identification of contacts and possible outbreaks is essential so that normal activities could be resumed. Researchers from Google and Oxford [1] concluded that if 15% of the population would benefit from a digital alert system, the number of infections and deaths could be reduced by 8% and 6%, respectively. Their studies concluded that 90% of people alerted would voluntarily start quarantine for 14 days, with an abandonment rate of 2% per day. One could assume that the benefits would be even greater if the participating population in such a system were more than 15%.

Epidemiological research is crucial in limiting the spread of the SARS-CoV-2 virus. It aims to identify and alert people at risk who have been in contact with confirmed infected patients. Currently, these surveys are carried out by Public Health Care (DSP) employees and include interviewing each infected person. Data collected are used in compiling a list of people in contact with the infected person within a period determined by epidemiologists. Each possible contact is then alerted and informed of the following procedure by a Public Health Care employee (DSP). This is time-consuming and involves significant human resources. Also, the collected data are sometimes incomplete.

Thus, we have developed a system that detects the contacts of patients infected with the SARS-CoV-2 virus and alerts them using mobile applications [2, 3, 4]. It aims to help limit the spread of the disease among the population and to reduce the health care employees' epidemiological research. This system can be extended for use in other

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contagious diseases, such as seasonal influenza.

An essential part of the TAMEC project (Advanced Community Approaches to Epidemic Management) [5] is the TAMEC Mobile Application which enables the detection and rapid warning of people who had been in contact with patients infected with the SARS-CoV-2 virus. The application provides a high degree of confidentiality for all users' data, thus protecting their privacy [6, 7].

The TAMEC project developed two systems that limit the spread of the virus in the community in two different effective ways:

• TAMEC Mobile System is responsible for early detection and notification of people who have been in contact with an infected person and who are possibly infected with contaminants.

• TAMEC Map System which is a real-time display of the distribution of confirmed cases and possible infected contaminants according to different parameters such as age, gender, profession, geographical location. This system analyses case distribution in different geographical areas and the time evolution of cases in different subgroups. This analysis allows early detection and geographical location of new outbreaks and provides decision-making information to prevent viral transmission.

To date, many such mobile applications rely on collecting location data or interactions of Bluetooth users. These approaches have drawn much criticism and concern for the safety of users' privacy. To solve this problem, the TAMEC Mobile application has been designed using the concept of privacy preservation. Thus, CERTSIGN has used its patent for homomorphic encryption [7]. This is a method that allows a third party to process and manipulate data in an encrypted format without having access to the original data (unencrypted data). This method allows a server to directly evaluate the encrypted data and obtain a result that is also encrypted, without the ability to decrypt the result or initial data. Thus, users will be assured that private information will not be misused, nor accessed without their explicit consent. If a user of the TAMEC mobile application has contact with an infected person, it is entirely their decision to inform the health care employees and to follow specific procedures such as testing or treatment. Also, a user notified by the mobile application as being in contact with an infected person will not be able to identify the infected person, nor the time of contact.

With all measures to secure data and preserve privacy, we are confident that users will be convinced the application is safe. The way the application is launched and promoted might determine the number of people who choose to use it. In addition to alerting the population through a mobile application such as the TAMEC Mobile system, it is also necessary to inform them to increase awareness in combating the spread of the SARS-Cov-2 virus. By knowing the evolution of the virus, one can have feedback and be motivated in adhering to the epidemiological strategies issued by the authorities.

Researchers such as epidemiologists and specialists from public health departments need well-structured and detailed data to determine key factors of the epidemic trend in the community. Accurate, concise, and easy-to-interpret data available for health care specialists enable the identification of outbreaks and risk areas. Thus, the authorities will be able to adopt prompt measures to prevent the spread of the virus from possible outbreaks.

TAMEC Mobile device application uses a system for detecting and alerting the contacts of confirmed infected patients. The system can preserve data privacy, revealing both authorities and users only the minimum information required. The core of this solution is generated by a homomorphic encryption scheme patented by CERTSIGN partner [7], the only Romanian patent of its kind. The system also includes existing digital contact tracing solutions already in use worldwide [8, 9].

The developed system is a modular one that includes six important components, namely:

• TAMEC mobile application. The TAMEC mobile application prototype is dedicated to Android operating system devices with 8 or newer Bluetooth mode versions. The detection of the contact was done using only Bluetooth technology, not GPS location, following the European Commission recommendation published shortly after drafting the project. The mobile app TAMEC is intended to be used by citizens, whom we will also call users. The application allows identifying contacts with confirmed infected patients, with sufficiently good precision in terms of distance and exposure time, using Bluetooth technology available on users' devices. The list of identified contacts that meet the case definition criteria is stored in the phone's memory (14 days for each contact). Periodically, this list is compared to the list of infected people from the Public Health Care System (DSP), using the backend components for anonymization. If a person is identified on both lists, the user is notified, without knowing who the infected person was or when the contact occurred in the last 14 days.

• The DSP web service is a backend component that has the role of ensuring the management of infected people and providing to the Computing Server component the list of

anonymized IDs of infected users. In the case of a production system, this component should be located and managed by the National Centre for Contagious Disease Surveillance and Control/Ministry of Health.

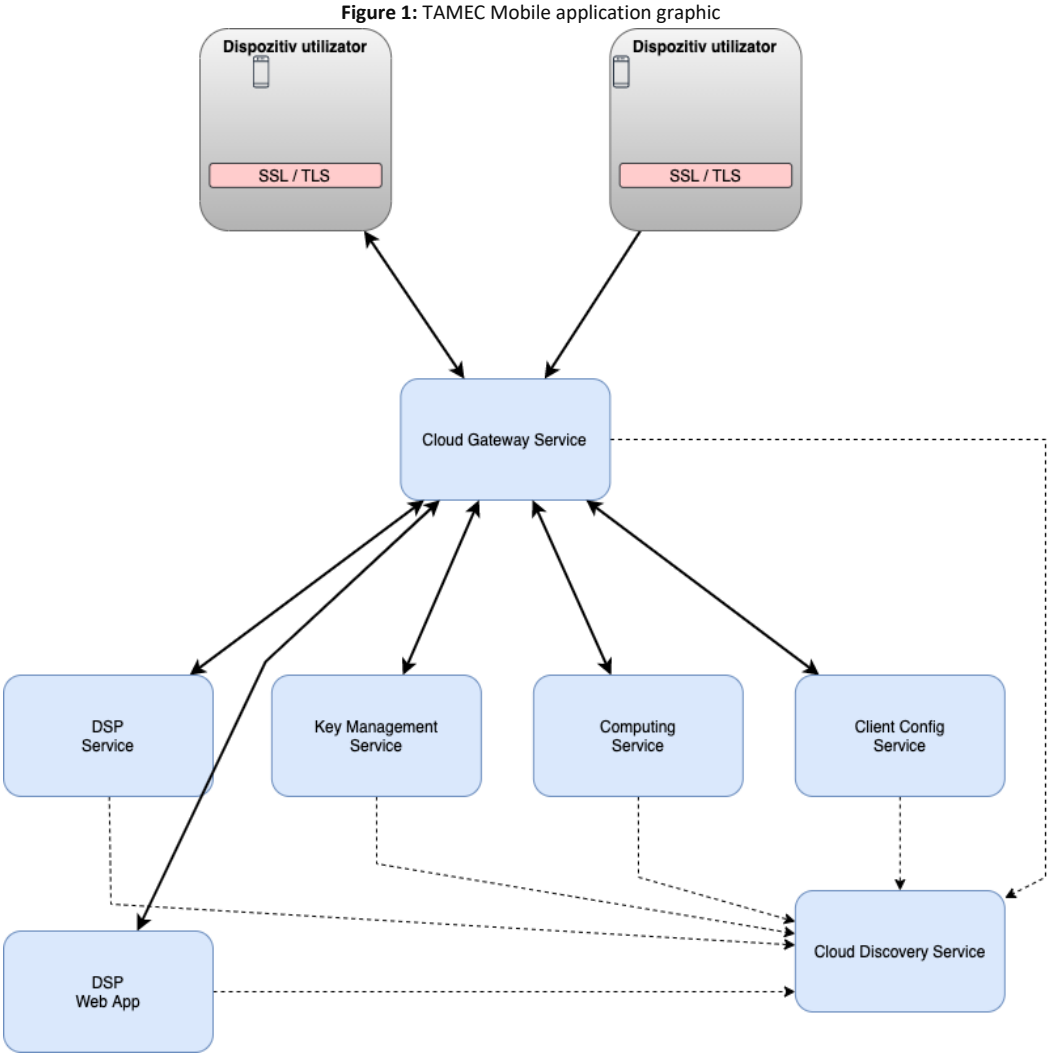
• The KMS web service (Key Management System) is also a backend component that has the role of managing the cryptographic keys necessary to ensure the confidentiality of the data from the system. In the case of a production system, this component should be located and managed by another state entity (e.g. STS);

• CS web service (Computing Server) is another backend component that has the role of performing the cryptographic calculations required by the system, for example, the intersection of anonymized mobile devices users list with the anonymized list provided by the DSP server to identify contacts with infected people. In the case of a production system, this component could be located and managed by a civil entity. This entity has also the role of giving trust to the users and ensuring that no state entity will be able to access, use, and manipulate confidential data of users.

• The CC web service (Client Configuration) is a component of the backend that has the role of centralizing mobile application configurations, depending on the phone type on which it is installed.

• The DSP-WebApp application is a web application that will be used by DSP employees in the territory for contacts management, respectively of the persons notified by the mobile application on the fact that they came in contact with an infected person, and report this and follow the necessary steps (isolation, testing, treatment, etc.). This web application can be hosted by the DSP, even on the DSP server that hosts the corresponding backend component (see the TAMEC Mobile application diagram in Figure 1).

Figure 1: TAMEC Mobile application graphic



• The management system of all confirmed cases and possibly infected contacts detected by the system for detecting and warning the contacts of patients confirmed with SARS-CoV-2, TAMEC Mobile, was named TAMEC Map.

• The developed TAMEC Map system uses the software infrastructure already created in the first phase for the TAMEC Mobile system. The main components of the system are:

• TAMEC Map system database required to present the detailed map with the real-time distribution of all confirmed cases and possibly infected contacts. For each confirmed case or contact this includes the location, form of disease and severity, comorbidities, age, sex, professional category, etc. External data sources are used for this database, such as data available in the Corona-Forms system for confirmed cases, as well as data stored in the DSA WebApp database for contacts. From a technical point of view, the TAMEC Map system database is an extension of the DSA WebApp database developed in the first phase of stage I.

• The graphical interface of the TAMEC Map system is a web application that extends the DSP-WebApp application previously developed with the components necessary for the management and real-time analysis of confirmed cases and contacts and the display of this information, both on a map and in other graphical formats as well. This graphical web interface includes a public area used for dissemination related to the evolution of the pandemic in Romania, as well as a private area used by DSP and MS specialists to analyze the geographical evolution of the virus according to selected parameters, early identification of potential new outbreaks and making the best decisions based on the local situation. This web application can be hosted by the DSP, even on the DSP server that hosts the corresponding backend component.

Geolocations for confirmed or potential cases are obtained from the addresses provided by the Corona-Forms application using a service provided by Google, the Geocoding API. https://cloud.google.com/maps-platform/ terms/maps- service-terms # 3.-geocoding-api.

This database is consumed by a graphical interface (called a dashboard) that allows real-time analysis of confirmed patients and identified contacts according to available criteria. Among the information available on this map, a series of necessary data will be identified and counted, such as the location of the diagnosed persons, age group, sex, comorbidities, occupational category, and severity of the disease. This database will not contain personal data of individuals, but only anonymized IDs that can allow only the relevant authority (DSP) to find the identity for a given ID, if necessary. From the graphical interface, it will be possible to easily generate and export reports regarding all the information from the database, depending on the search and reporting criteria. This information can be very helpful for the Public Health Care System to analyze the population epidemic impact for quick and adequate epidemiological measures initialization and to allocate the hospital resources where hospitalization and treatment are required according to medical recommendations.

Also, this type of representation allows real-time mapping of infected population characteristics in each territory, rapid triage, and classification into a risk category according to certain variables (age, sex, associated diseases, stage of disease, pathogenic type of the virus, biological and immunological status of the host). Thus, our solution opens a wide field of epidemiological and clinical research, offering the possibility to identify and validate a risk score that would become an extremely helpful tool in the stratification of COVID-19 patients.

The application also includes tools that allow the dissemination of certain types of reports on social media and indicators that measure their audience.

To conclude, the solution proposed in the TAMEC project is innovative in its simplicity and ability to facilitate the prevention of the spread of the SARS-CoV-2 virus in the community and fully respects the privacy rules of citizens imposed by the EU. The application will allow the development of statistical analysis components, adaptive filtering, and automatic prediction based on artificial intelligence. Starting from the existing information in the system database this can perform their automatic analysis, discover and predict critical developments (e.g. the emergence of new outbreaks), and generate alerts to epidemiologists, accompanied by intervention recommendations.

References:

1. Abueg M., Hinc, R., Wu N et al Modelling the combined defect of digital exposure notification and non-pharmaceutical interventions on the COVID-19 epidemic in Washington state. MedRxiv https://doi.org/10.1101/2020.08.29.20184135

2. EU Digital Solidarity: a call for a pan-European approach against the pandemic, https://edps.europa.eu/sites/edp/files/ publication/ 2020-04-6_eu_digital_solidarity_covid19.

3. Mobile applications to support contact tracing in the EU's fight

against COVID-19 Common EU Toolbox for Member States

4. Swiss National COVID-19 Science Task Force. SARS-CoV-2 contact tracing strategy: epidemiologic and strategic considerations, 26 April 2020

5. TAMEC-Tehnici Avansate de Management a Epidemiei in Comunitate. http://www.scumc.ro/tamec-tehnici-avansate-de-management-a-epidemiei-in-comunitate

6. Regulamentul general privind protectia datelor, https://eur-lex.europa.eu/legal-content/RO/TXT/PDF/?uri=CELEX:32016R0679&from=RO

7. ANNEX IV: INVENTORY MOBILE SOLUTIONS AGAINST COVID-19, https://ec.europa.eu/health/sites/health/files/ehealth/docs/covid-19 apps_annex_en.pdf

8. Barcuși M, Pașol V. Fully homomorphic encryption from monoid algebras, US10454668B2, Oct. 2019.

9. Hyunghoon C, Daphne I, Yun WY. Contact tracing mobile apps for COVID-19: privacy considerations and related trade-offs. CoRR, abs/2003.11511, 2020.

10. Oxford University Research. Quantifying SARS-CoV-2 transmission suggests epidemic control with digital contact tracing, https://science.sciencemag.org/content/early/2020/04/09/science.abb6936.full

11. http://www.healthdata.org/covid

12. https://www.nih.gov/health-information/coronavirus

13. https://www.cdc.gov/coronavirus/2019-ncov/index.html

14. https://www.escardio.org/Education/COVID-19-and-Cardiology/ESC-COVID-19-Guidance.