A Survey on MCT vs. DCT: Who is the Winner in COVID-19

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***Abstract*—Coronavirus disease (COVID-19) is a contagious disease appeared in late 2019 and caused by a virus called SARS-CoV-2. It is a pandemic spreading across the whole world and impacts millions of people and sadly causes death. There are two main Contact Tracing Methods (CTMs) to limit and slow down any chance of transmission of it: Manual Contact Tracing (MCT) and Digital Contact Tracing (DCT). The MCT abides by the guide to World Health Organization's guidance (WHO) on COVID-19 in terms of properly applying social distancing, wearing masks, washing hands, using sanitizers, etc. while the DCT abides by the digital contact tracing applications developed by several countries. This survey is mainly focused on these CTMs and the recent proposed solutions in this field, in order to highlight their drawbacks that negatively impact on both of satisfaction and feasibility in using them. The findings in the survey will be beneficial to understand the effectiveness of CTMs and current proposed solutions, in order to develop a comprehensive smart tracking system able to cooperatively contribute with both of MCT and DCT in extremely detecting, preventing, and slowing down the spread of COVID-19 or even any other similar pandemics in the future.**

Keywords*—COVID-19; coronavirus disease; manual contact tracing; digital contact tracing

I. Introduction

Coronavirus disease (COVID-19) has been emerged for the first time in Wuhan [1-9], where the first reported cases were found in Huanan seafood market [10-12]. It has been reported by the World Health Organization (WHO) that there are 318,648,834 confirmed cases of COVID-19, including 5,518,343 deaths [13]. To slowing the spread of COVID-19 and protect family and community, Contact Tracing Methods (CTMs): Manual Contact Tracing (MCT) and Digital Contact Tracing (DCT) play a vital role in this respect, The MCT is a manual method [14-20] strives to [21]:

1) Support COVID-19 patients to stay home and self-isolate.

2) Alert and help people who have been in close contact with COVID-19 patients.

3) Follow-up them in testing, quarantine, and wearing a mask properly.

The DCT is a dynamic method [22-34] based on smartphones' applications which strives in tracking people diagnosed with COVID-19 to notify mobile users whether they have been exposed to the virus or not. The DCT utilize several technologies to collect data [35]: cell tower location data, Quick Response (QR) code, credit card/public transit card, videos surveillance, Global Positioning System (GPS), and Bluetooth.

There are three main approaches to store users' sensitive data [36]: Centralized Approach (CA) where the data is stored on centralized servers, Decentralized Approach (DA) where the data is stored on individual mobiles, and Hybrid Approach (HA) which is combination between CA and DA. The DA aims to protect users' sensitive data where a central server plays a small role in this respect by keeping very little data [37]. The CA is more efficient [37] and more secure compared with the DA, while it is considered a single point of failure [38].

To the best of our knowledge, existing related works have not fully considered CTMs and recent proposed solutions. Therefore, this paper thoroughly surveys both of CTMs and recent proposed solutions to highlight their drawbacks that negatively impact on both of satisfaction and feasibility in using them. The rest of the paper is organized as follows: In Section II, an overview of CTMs and proposed solutions is presented: DCT and MCT. In Section III, a comprehensive comparison of CTMs and proposed solutions is presented: MCT vs. DCT, DCT approaches, and DCT proposed solutions. In Section IV, a discussion is presented. Finally, a conclusion is given in Section V.

II. Overview of CTMs and Proposed Solutions

To provide a comprehensive comparison of CTMs, this section presents lots of vital recent related works either theoretical or practical: surveys, overviews, and proposed solutions for DCT and MCT.

A. DCT

In [22], the authors have introduced a Self-Sovereign Identity (SSI) model based blockchain to address the following issues in DCT applications: privacy leakage, efficiency, and energy consumption. The effectiveness of the proposed solution has been validated by theoretical analysis.

In [27], the authors have proposed a blockchain enabled privacy preserving contact tracing scheme: BeepTrace. Numerical analysis has shown higher security and privacy, battery friendly, and globally accessible.

In [34], a framework of a blockchain, Artificial Intelligence (AI) and Internet of Things (IoT) based system for the detection of COVID-19 and distancing has been proposed. It has aimed to offer real time data sharing, security, and transparency. However, no implementation or testing provided about the framework.

In [35], an overview of several DCT applications has been conducted. It has been concluded that the DCT have had the following issues: limited Internet access in poor countries, people without smartphones, lack of signal, transparency, privacy and security.

In [39], a cross national online survey has been conducted in the UK, Republic of Ireland, and the US, in order to discover public attitudes and the acceptability of DCT. It has been concluded that that trust and privacy have been the main concerns for the adoption of DCT.

In [40], 41 countries and 23 US states have developed a total of 64 DCT applications, where they have sampled eight applications in European countries between British Isles, and mainland Europe equitably. Using various analysis (e.g., quantitative analysis and qualitative coding), it has been concluded that the DCT has required updating regularly due to governmental policies and guidelines, there have been issues in the devices, applications and their features, high battery consumption, usability should be enhanced, and users have been generally unhappy with the applications.

In [41], a detailed analysis of DCT applications for 32 countries has been presented. The proposed architecture using blockchain Hyperledger Fabric (HF) has addressed the following inherent issues related to contact tracing: security, privacy, authentication, access control, flexibility, scalability, interoperability, and efficiency.

In [42], the authors have proposed COVERT blockchain HF for COVID-19 contact tracing with keeping user's privacy. The results have proved its scalability, robustness, and efficiency in protecting privacy leakage.

In [43], the authors have proposed a blockchain platform for contact tracing with keeping user's privacy, using a Generative Adversarial Network (GAN) application. It has shown that the privacy has been addressed by iterative deleting older data from the database.

In [44], the authors have proposed a prototype of blockchain and SSI-based digital contact tracing platform, using Mystiko blockchain cluster. A performance evaluation of the platform has been conducted, where it has shown addressing issues in security, privacy, scalability, and transaction throughput features.

In [45], the authors have proposed a framework used off-chain scaling mechanism of Interplanetary File System (IPFS) for contact tracing. There a performance evaluation using Ethereum application has been conducted of the framework in terms of security, privacy, and scalability.

In [46], the authors have proposed and implemented a blockchain based system called COVID-19 Contact Tracing System (CCTS), to verify, track and detect new cases of COVID-19, using Ethereum application. However, user's privacy and accuracy in detecting contacts of COVID-19 have not been investigated.

The DCT provides several features: accurate, fast, and low cost [47].

B. MCT

It is a traditional contact tracing method manually managed by health care providers to identify the contacts of infected individuals, interview, alert them to quarantine, and to seek a test [47]. However, the MCT has become difficult to be used due to rapid spread of COVID-19 [48], as it has been some drawbacks: relying on human memory, taking time [49], requiring trained human resources [47], [50], inefficient [51], costly, highly error prone, and not scalable [14].

The recent studies in [52] and [53] shows that the combination of MCT and DCT is more efficient for contact tracing.

III. Comparison of CTMs and Proposed Solutions

In Section II, plenty of recent related works have been considered: surveys, overviews, and proposed solutions of CTMs. To provide a comprehensive comparison of CTMs, in this Section, three types of comparisons are presented: MCT vs. DCT, DCT approaches, and DCT proposed solutions.

A. MCT vs. DCT

Ten factors are considered to distinguish between CTMs (MCT and DCT): time, efficiency, accuracy, cost, diagnosis, failure, scalability, reliability, dependency, and investigation. This is shown in Table I. In this competition, the DCT obviously has a full advantage over the MCT.

B. DCT Approaches

Five factors are considered to distinguish between the DCT approaches (CA, DA, and HA): data storage location, efficiency, privacy, security, and point of failure. This is shown in Table II. In this competition, the HA obviously has dominant features over the CA and DA.

TABLE I. MCT vs. DCT

Comparison	**DCT**	**MCT**
Time	Less	More
Efficiency	More	Less
Accuracy	More	Less
Cost	Less	More
Diagnosis	Fast	Slow
Failure	Low	High
Scalability	High	Low
Reliability	High	Low
Dependency	Technology	Human memory
Investigation	GPS, QR code, Bluetooth cell tower location data, credit card/public transit card, videos surveillance	Self-assessment survey

TABLE II. DCT APPROACHES

Comparison	CA	DA	HA
Data storage location	Server (S)	Mobile (M)	S & M
Efficiency	High	Low	Average
Privacy	Low	High	Average
Security	High	Low	Average
Point of failure	High	Low	Average

TABLE III. DCT PROPOSED SOLUTIONS

Paper	**Year**	**Type of Research**	**Implementation**	**Concern**	**Addressing**	**Solution**
[22]	2021	Theoretical	Analysis	n/a	Privacy, efficiency, energy consumption	SSI model based blockchain
[27]	2021	Theoretical	Analysis	n/a	Security, privacy, battery friendly, globally accessible	BeepTrace based blockchain
[34]	2021	Theoretical	n/a	Not developed	Real time data sharing, security, transparency	Framework based blockchain, AI and IoT
[35]	2020	Theoretical	Overview	Limited Internet access, people without smartphones, lack of signal, transparency, privacy, security	n/a	n/a
[39]	2021	Theoretical	Survey	Trust and privacy	n/a	n/a
[40]	2021	Theoretical	Analysis	Updating DCT regularly, issues in the devices, applications and their features, battery consumption, usability, user satisfaction	n/a	n/a
[41]	2021	Practical	HF	-	Security, privacy, authentication, access control, flexibility, scalability, interoperability, efficiency	Architecture based blockchain
[42]	2021	Practical	HF	-	Scalability, robustness, privacy	COVERT based blockchain
[43]	2021	Practical	GAN	-	Privacy	Platform based blockchain
[44]	2021	Practical	Mystiko	-	Security, privacy, scalability, transaction throughput features	SSI model based blockchain
[45]	2021	Practical	Ethereum	-	Security, privacy, scalability	Framework based blockchain and IPFS
[46]	2021	Practical	Ethereum	Privacy, accuracy	Verify, track, detect new cases of COVID-19	CCTS based blockchain

C. DCT Proposed Solutions

Five factors are considered to distinguish between the DCT proposed solutions [22, 27, 34, 35, 39-46]: type of research, implementation, concern, addressing, and solution. This is shown in Table III.

As for the type of research, it can be seen that the related works have been equitably conducted between theoretical and practical research works. This is shown in Fig. 1.

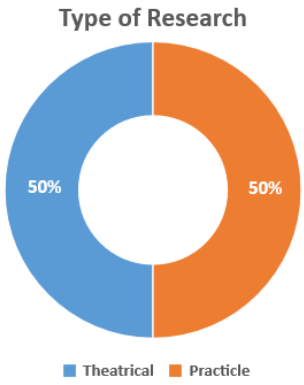

Fig. 1. Type of Research for DCT Proposed Solutions.

For the implementation, three related works are used analysis, followed by HF and Ethereum with two research works each; lastly, overview, survey, GAN, and Mystiko. This is shown in Fig. 2.

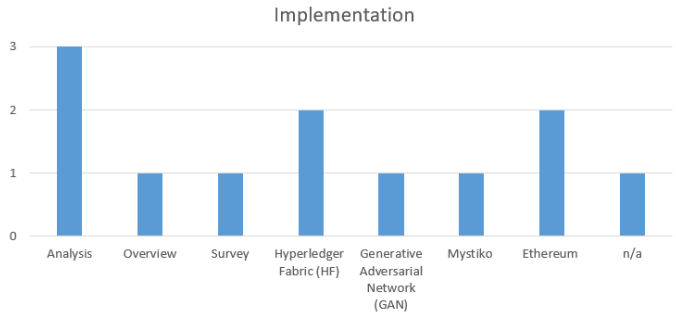

Fig. 2. Implementation for DCT Proposed Solutions.

In terms of the concern, fifteen common issues are arisen and divided into two main categories: IT's issues and user's issues. This is shown in Fig. 3.

In the addressing, eighteen common issues are arisen. It has been noticed that all the addressed issues are related to IT issues. This is shown in Fig. 4.

Finally, the most DCT proposed solutions based on the blockchain, as shown in Fig. 5.

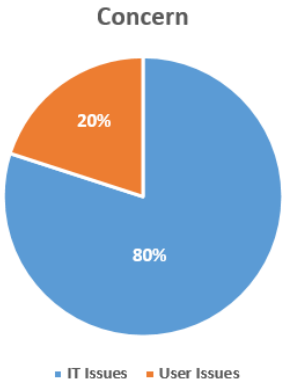

Fig. 3. Concern for DCT Proposed Solutions.

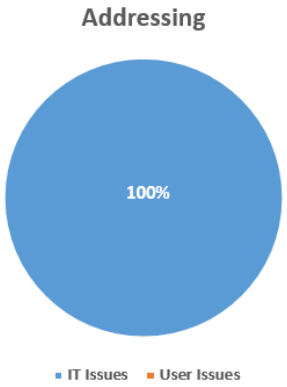

Fig. 4. Addressing for DCT Proposed Solutions.

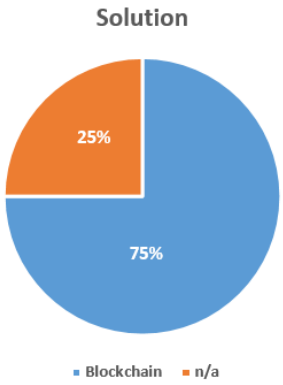

Fig. 5. DCT Proposed Solutions

IV. Discussion

In Section III, a comparison of CTMs has been conducted, where three types of comparisons have been presented: MCT vs. DCT, DCT approaches, and DCT proposed solutions.

For MCT vs. DCT, the DCT has shown a full advantage over the MCT in terms of time, efficiency, accuracy, cost, diagnosis, failure, scalability, reliability, dependency, and investigation, as shown in Table I.

For DCT approaches, the HA has shown dominant features over the CA and DA in terms of data storage location, efficiency, privacy, security, and point of failure, as shown in Table II.

For DCT proposed solutions, twelve research works have been conducted [22, 27, 34, 35, 39-46]. It has been noticed that all these works have been confined in introducing, enhancing or proposing DCT applications related to IT issues and user issues, as shown in Table III.

Therefore, in addition to the combination between DCT (HA approach) and MCT, it would be more effective to propose, implement and, distribute a comprehensive smart tracking system located in public places, universities, schools, hospitals, banks, airports etc. This obviously will extremely limit and slow down any chance of transmission of COVID-19 or even any other similar pandemics in the future. This is shown in Fig. 6.

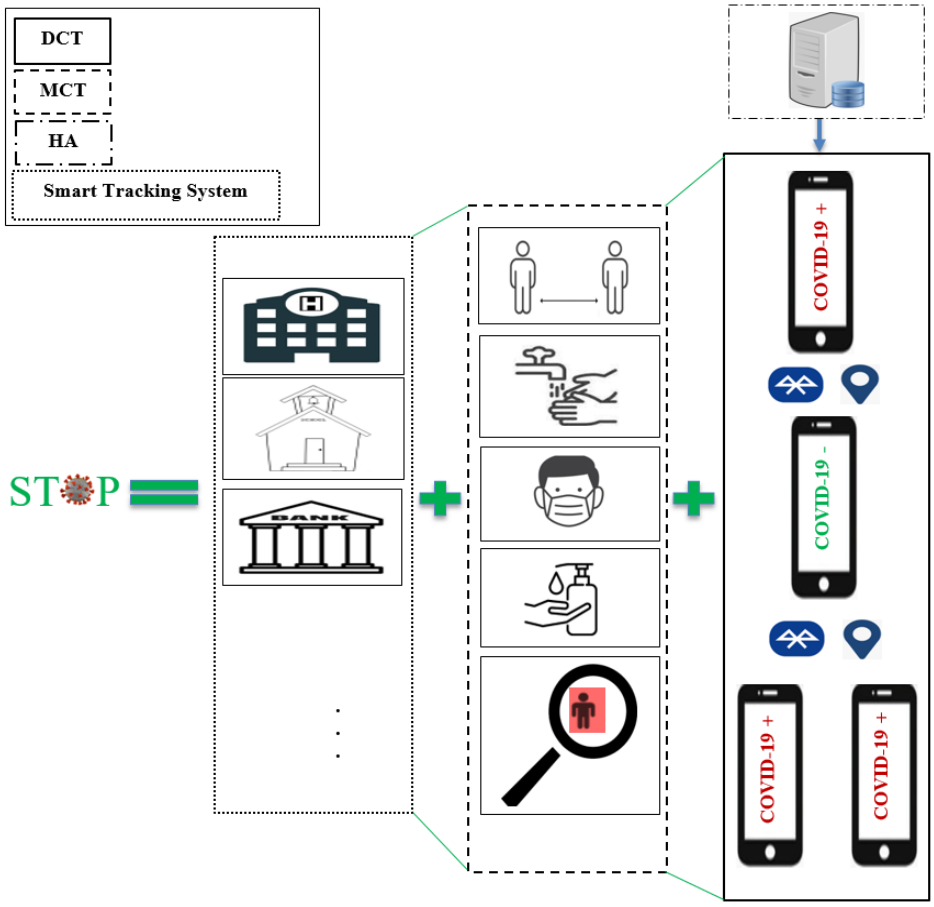

Fig. 6. Comprehensive CTM.

V. Conclusion

In this paper, the CTMs and the recent proposed solutions for COVID-19 have been surveyed thoroughly, where a fair comparison has been presented: MCT vs. DCT, DCT approaches, and DCT proposed solutions. For DCT proposed solutions, twelve research works have been conducted. It has been concluded that all these works have been confined in introducing, enhancing or proposing DCT applications related to IT issues and user issues.

Therefore, the competition in this paper has shown the importance of using both of MCT and DCT (HA approach), and come up with a comprehensive smart tracking system able to cooperatively contribute with them in extremely detecting, preventing, and slowing down the spread of COVID-19 or any other similar pandemics in the future.

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