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Conceptual Framework of Contact-less Consumer Products Industry during and Post-Pandemic Era

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Abstract. The COVID-19 era has reshaped the world regarding the contact-less economy, healthcare systems, remote work environment, people's lifestyle and their daily routines, etc. The consumer products (CP) industry is being impacted due to the behaviours of consumers during self-quarantine. This accelerates adopting digital transformation and upgrading the business models for the contact-less CP industry. Accordingly, this study provides a step toward the contact-less CP industry during and post-pandemic. First, we have proposed a conceptual framework for the contact-less CP industry that aims to bring together the key advanced technologies (e.g., Digital Twin (DT), blockchain, AI, cloud computing, 5G, and robots). The combination of the advanced technologies provides data monitoring, transparency, traceability, automation, and data sharing among consumers and CP partners. The proposed framework will enable a more contact-less personalized interaction that will work towards higher levels of consumer satisfaction while maintaining contact-less economy growth. Then, we have described how the proposed framework can be applied for contact-less delivery services for the CP industry during and post-pandemic.

Keywords: Contact-less · Blockchain · Digital twin · Consumer products industry · COVID-19 · post pandemic

1 Introduction

For more than two years, the COVID-19 worldwide pandemic has persistently continued to affect the lives of millions in several countries. Therefore, to combat the COVID-19 pandemic, the governments announced some restrictions such as self-quarantine, lockdown, and practising social distance. However, these restrictions have changed the way people live; people work, study from home and shop from home. Therefore, the COVID-19 restrictions cause a big challenge for marketing industries and force them to rapidly adapt to contact-less marketing to meet consumer needs while maintaining their expectations to achieve desired growth. Consequently, digital transformation for companies has been accelerated

by the COVID-19 pandemic [1,2]. Furthermore, during and post-pandemic era likely also come with some significant challenges, which leads the companies to rethink their business models [3,4].

The consumer products (CP) industry provides consumers with everything from food, beverages, toiletries, personal care, and small appliances. It is considered one of the industries which adopt digital transformation technologies. According to the Deloitte CP industry outlook survey at 2022 [5], the CP industry is one of strong financial performance, which has derived a more significant revenue in the last year. Most consumers are shifting from a go-to-market manner to a contact-less marketing manner during pandemic time according to the change circumstances [6]. Regarding consumer behaviour during the COVID-19 pandemic, the authors in [3] have addressed the impact of COVID-19 on consumer behaviour, strategic decision-making, and marketing policies for short-term and long-term actions. Also, the authors in [7] have proposed a methodological toolkit to assess the purchasing behaviour of online consumers during the COVID-19 pandemic. They have concluded that consumers have become more aware of shopping and more experts for making meaningful purchases. Crosta *et al.* [8] have focused their studies on psychological factors and consumer behaviour during the COVID-19 pandemic. They administered an online survey during the first peak period of the contagion in Italy. The authors have concluded that the consumer's behaviour is changed due to the pandemic, which raises marketing opportunities that contribute to economic growth. Also, there is more extensive study has been done on 55 countries in the first peak of the pandemic by Ulpiano *et al.* [9]. The study's empirical results have proved that exigency motivation is positively linked to purchasing essential goods.

Consequently, this shifting to the contact-less shopping paradigm raises challenges for the CP companies at the post-pandemic time to satisfy their consumers' needs and keep their business growth rate. Some CP industry challenges include supply chain (e.g., labour shortage, delayed delivery due to difficulties with international transportation, out of stock products), consumer preferences (e.g., personalized needs and privacy), transparency, offering online platforms for CP companies and so on. Furthermore, trust is critical since consumers won't engage and share data with companies they don't trust. Consequently, the changes during and post-pandemic contact-less society significantly need transforming strategies to combat the COVID-19 outbreak and deal with the new circumstances. In addition, these changes have required adopting new technologies that open the door for researchers to investigate different contact-less solutions during and post-pandemic.

Regarding adopting digital transformation technologies for online marketing during the COVID-19 pandemic, the authors in [10] have introduced a design of a resilient, transparent, and sustainable supply chain. The proposed design aims to develop localization, agility, and digitization characteristics using blockchain technology and circular economy principle capabilities during the COVID-19 pandemic. Also, Pratiksha *et al* [11] have proposed a blockchain-based framework to enable the traceability of products in the supply chain to help prevent

the spread of the coronavirus. The blockchain is used to track delivery personnel's medical test status and trace the travel history of delivery personnel to different locations. Alsamhi *et al* [12] have proposed a framework based on blockchain and multi-robot collaboration to provide a tactical solution for combating the COVID-19 pandemic. The blockchain network enables multi-robot to fight COVID-19 collaboratively and efficiently by sharing information autonomously and accessing each other's data. Furthermore, the authors of [1] introduced blockchain-empowered DTs to combat COVID-19 by supporting DTs collaboration for decentralized alerts during COVID-19.

The authors in [13] have addressed the management of delivery for the food supply chain in COVID-19. They have used blockchain technology to maintain data sharing and improve decentralized distribution among competing supply chain partners. Burgos *et al*. [14] have addressed the COVID-19 pandemic's impact on the food retail supply chain with the help of a discrete-event simulation methodology using the DT of the anyLogistix supply chain. The authors confirmed the importance of DT in the supply chain to provide end-to-end visibility for the food retail supply chain. Sahal *et al* [15] have proposed a framework to fulfill the DTs collaboration requirements for smart transportation. They have discussed how the framework is applied for logistics services during the COVID-19 pandemic for the consumers who prefer a safer and faster delivery method.

On the other hand, some research related to social manufacturing (SM) is related to the contact-less CP industry. The SM is a new business model to connect nearly everyone, and everything [16]. Also, the SM concept has been raised recently to support the sharing participation among individuals in the production of physical goods. Substantially, the SM concept comes to support the product personalized customization based on the customer's requirements [17,18]. In comparison, the contact-less CP industry concept empowers contact-less services to provide autonomous, secure contact-less solutions for the CP industry during and post-pandemic.

Because only a few publications exist in the CP industry regarding shifting to online marketing during the COVID-19 pandemic, the end-to-end contact-less concept has not yet been a focus in the literature to date. This motivates us to consider different emerging technologies to deliver an end-to-end contact-less framework for the CP industry during and post-pandemic. Consequently, combining the emerged technologies (e.g., DTs, blockchain, AI, cloud computing, 5G, and robots) empowers contact-less services for the CP industry. The data derived across the stages of the contact-less CP industry can be accessed and shared by stakeholders, retailers, organizations, or countries. The products could be tracked at every stage of the supply chain, meeting consumer demands with minimal wastage and contact-less. Figure 1 depict the high-level of contact-less remote applications for CP industry to combat COVID-19 and empower contact-less economy. To the best of our knowledge, there is no framework based on the contact-less CP industry proposed to deliver contact-less services to mitigate the unnecessary risk of people contacting during and post-pandemic. Therefore,

this research work introduces a conceptual framework for the contact-less CP industry. Our main contributions to this paper can be summarized as follows:

- We propose a conceptual framework for the contact-less CP industry that aims to bring the combination of advanced technologies (e.g., DT, blockchain, AI, cloud computing, 5G, and robots). Furthermore, the proposed framework aims to support the contact-less CP industry by providing data monitoring, transparency, traceability, automation and data sharing among consumers and CP partners.
- We describe how the proposed framework can be applied for contact-less delivery service for the CP industry during and post-pandemic.

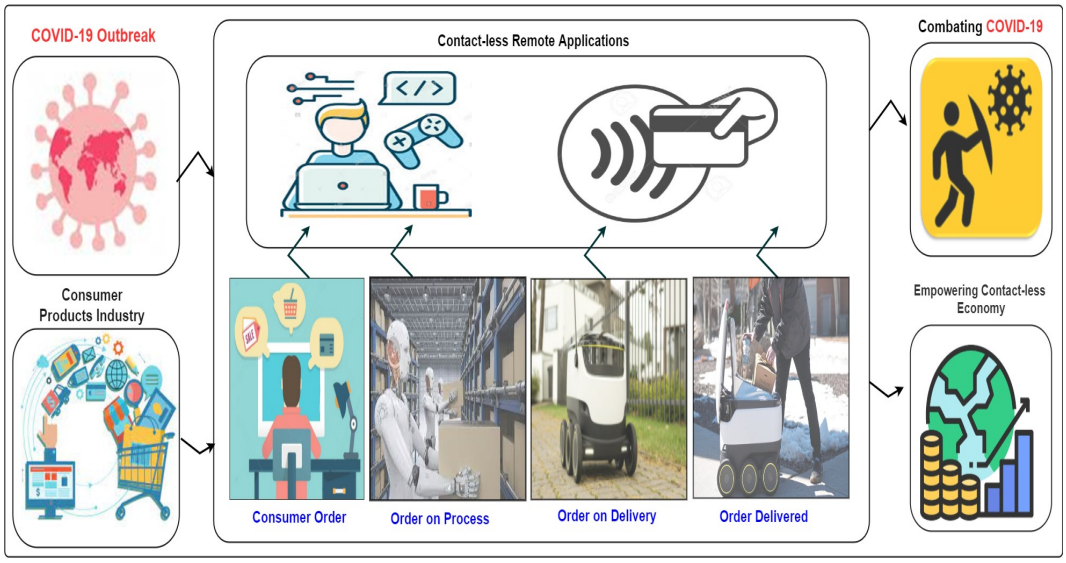


Fig. 1. The high-level of contact-less remote applications for the CP industry to combat COVID-19 and empower contact-less economy.

The remainder of this paper is organized as follows: The proposed conceptual framework of the contact-less CP industry is introduced in Section 2. Next, the description of the contact-less delivery service for the CP industry is provided 3. Finally, the open challenges, discussion and conclusion are presented in Section 4 and 5 respectively.

2 Conceptual framework of contact-less consumer products industry

A combination of the emerged technologies (e.g., DT, blockchain, AI, cloud computing, 5G, and robots) has the benefits of empowering a contact-less economy by supporting contact-less industries during the COVID-19 post-pandemic era. In Figure 2, we have described the proposed conceptual framework of the contact-less CP industry. The proposed framework's merit is exploiting the emerged industrial technologies' capabilities to provide autonomous, secure contact-less solutions for the CP industry during and post-pandemic. Four layers are used to equip the conceptual framework for the contact-less CP industry with the intelligence of marketing data. As seen in Figure 2, the four layers are the physical layer which contains the CP industry participants, the DTs layer, the driver industrial technologies layer and the applications layer. These layers will be elaborated flowingly. Further details of how these layers can work together to provide end-to-end contact-less delivery service for the CP industry are demonstrated in Section 3.

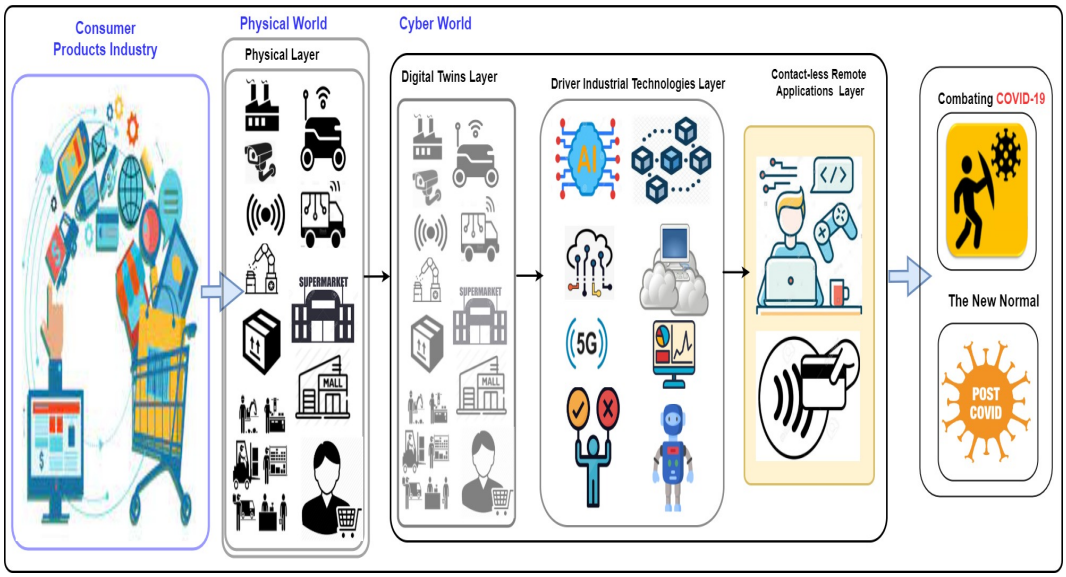


Fig. 2. The proposed conceptual framework for the contact-less CP industry during and post-pandemic.

2.1 Physical layer

The physical layer contains all nodes involved in the CP industry, ranging from the factory to the consumer. These nodes could be grouped into different categories, including supply chain, in-store and human participants. The supply chain participants can be factories, assets, warehouses, suppliers, products, monitoring devices (e.g., CCTV and sensor devices), robotic devices and auto-cars. The nodes for the in-store category are products on shelves, malls, supermarkets, and delivery robots. Finally, the human participants can be the people who can contribute by using their operational data (e.g., consumers, decision-makers, workers, employees, HR, security staff and so on).

2.2 Digital twins layer

The digital twins, digital models, and digital shadows are making the manufacturing revolution which makes our lives easier. These three concepts are used interchangeably in the digitization world. Regarding our work, we are using the DT concept to provide a virtual representation of products, processes, consumers, and other participants within the CP supply chain. Then, these DTs collaborate to automate the contact-less CP industry. The collaborative DTs of products, processes, consumers and other participants within the CP supply chain increase the speed of the contact-less CP industry. Furthermore, the DTs provide real-time data for the tracking stage of the products applicable to logistic companies, supply-chain managers, in-store processes, equipment sensors, purchasing, delivering, etc. Therefore, this layer is responsible for defining DTs within the CP industry at different stages (e.g., the products from being manufactured to being consumed) by providing multiple collaborative DTs with up-to-date operational and marketing data. The data-driven DTs collaborations help to understand the DT status, interact with other DTs at the edge level, learn from other DTs, and share common semantic knowledge within industrial manufacturing systems [19]. The DT-driven data are used as inputs for predictive models to predict the potential risks within the product lifecycle. The intelligence of DT-driven data help makes a timely decision to avoid product wastage and delayed delivery, reduce shipping cost and maximize profits of the contact-less CP industry.

2.3 Industrial technologies layer

This layer briefly highlights emerging industrial technologies' role in building a concert contact-less solution for the CP industry.

- **AI technology**: Pairing AI with DTs technologies creates new efficiencies for the contact-less CP industry. The AI technologies (e.g., machine learning (ML) and deep learning (DL)) could be applied using data-driven DTs. The ML/DL techniques provide predicted potential risks to the CP industry, such as product wastage, corrupted products, and estimated delivery [20,21]. Furthermore, AI technologies can build an intelligent experience engine based

on the consumer experience to provide more insights and personalised recommendations for consumer satisfaction. For example, the author in [22] has proposed a prediction model for anticipating the consumers' behaviour using ML methods during the COVID-19 pandemic. Also, the authors in [23] have conducted a comprehensive analysis based on evolutionary computing. Then, they have proposed a dynamic algorithm for gaining valuable insights into semiconductor manufacturing processes.

- **Blockchain**: The blockchain network connects multiple DTs of the participants within the contact-less CP industry using distributed ledger technology (DLT). The DT-based blockchain network increases traceability capability to monitor products by affording end-to-end flow of information about the products. Also, the DT-based blockchain network offers distributed operational data management and secure data sharing across contact-less CP industry participants [24,15]. Blockchain technology has been used to combat COVID-19 by supporting decentralization for multi-robot collaboration [12]. Also, blockchain technology is used to enable the traceability of products in the supply chain and help prevent the spread of the coronavirus [11].
- **Cloud/edge computing**: Due to large volumes of CP industry data generation, the operational data analysis is performed on computing paradigms such as cloud and edge computing. Furthermore, both remote cloud resources and local edge resources leverage extra computing capabilities for real-time analysis within the contact-less CP industry [25].
- **5G technology**: The 5G technology offers many benefits for the contact-less CP industry by providing reliable, high connectivity private networks and real-time interaction with consumers that open the doors to online business models within the contact-less CP industry [26]. Moreover, online shopping based on powerfully connectivity empowers personalized interactions that make consumers' lives easier and more convenient. It also helps combat pandemics by limiting people's contact and virus spread. The 5G and B5G technology capabilities may be successfully used to address COVID-19 difficulties both now and in the post-COVID-19 period. The authors of [27] highlighted the utilization of 5G e-health and digital services during and post pandemics.

  On the other hand, the authors of [28] highlighted the role of 5G networks in empowering AI in the prediction of future pandemic outbreaks and enhancing the digitization to develop a pandemic resilient society. Substantially, because AI approaches are often data-driven, providing support for significant device connections and IoT networks via (Massive Machine-Type Communications) mMTC services in 5G networks would give enough data for AI model training and deployment. Furthermore, AI technologies are often computationally heavy. Therefore, advancements in memory and processor technology and the inclusion of caching and edge computing in 5G would aid in adopting and using AI technologies. Moreover, the software-defined nature of 5G networks and associated architectures like network slicing, network function virtualization, data-control plane separation, and so on would

make AI approaches for intelligent and dynamic network management and orchestration easier to implement.

- **Data visualization**: The industrial data visualization tools provide useful dashboards to visualize and track the products based on the DTs operational data in real-time. Also, the visualization tools allow the decision-makers within the contact-less CP industry to conclude insights more quickly for reducing costs and achieving maximum cash flow.
- **Robot technology**: Robot technology plays a vital role in combating COVID-19 by reducing human interaction, monitoring, and delivering goods within in contact-less CP supply chain [12]. Furthermore, the multi-robots collaborate to achieve a contact-less CP industry by integrating with other technologies within the proposed framework, such as DTs, decentralized blockchain networks, efficient 5G connections and powerful AI engines. The authors of [29] introduced the role of robotics in healthcare domains for combating COVID-19. Moreover, the space robots and ground robots collaborations play a vital role in combating COVID-19 and reducing the outbreak with the help of blockchain technology [30]. Furthermore, the authors of [31] proposed the hospitality industries treat the uncertainties by using service robots. Therefore, the service-based robots will support the contact-less CP industry by providing better and more efficient service than humans.
- **Decision making**: Good decisions make great products and competitive services, save time and maximise profit which delivers value for consumers and the business within the CP industry. In the case of the contact-less CP industry, distributed decision-making algorithms are needed to empower contact-less services and prepare for the new changes of the post-pandemic world. In particular, the consensus algorithms are used to improve the contact-less CP industry by utilising the agreement of most nodes regarding the potential risk to notify the decision-makers within the CP supply chain. Some examples of the use of the consensus algorithms include Proof of Work (PoW), Practical Byzantine Fault Tolerance (PBFT), Proof of Stake (PoS), Proof of Burn (PoB), Proof of Capacity, and Proof of Elapsed Time.

2.4 Contact-less remote applications layer

The contact-less remote applications can be used in all CP industry solutions at different levels, from the product being manufactured to being delivered and consumed (e.g., online shopping, contact-less payment, zero-touch delivery, remote tracking and so on). Furthermore, the contact-less remote applications pave the way for the post-pandemic future and contribute to contact-less economy growth.

3 Contact-less delivery service for consumer products industry during and post-pandemic era

The contact-less delivery service describes how the proposed conceptual framework could be applied to provide a complete delivering service to the consumer

from the beginning to the end. In particular, the goal of the contact-less delivery service is to deliver the contact-less CP industry's services efficiently with high quality and security to satisfy the consumers. The contact-less delivery service can also serve people in the quarantine areas and residential areas by utilizing the intelligence of data generated by the participants (e.g., malls, medical suppliers, people, robots, drones, etc.) [15,12]. In the contact-less delivery service, a consumer (e.g., quarantined person) makes an online order for delivery, e.g., food, beverages, medicine, toiletries, personal care, .etc. Figure 3 depicts the high-level of mapping our the proposed framework to the contact-less delivery service. Further details are elaborated following. Then, a detailed mapping of our proposed framework to provide end-to-end contact-less delivery service for the CP industry is discussed.

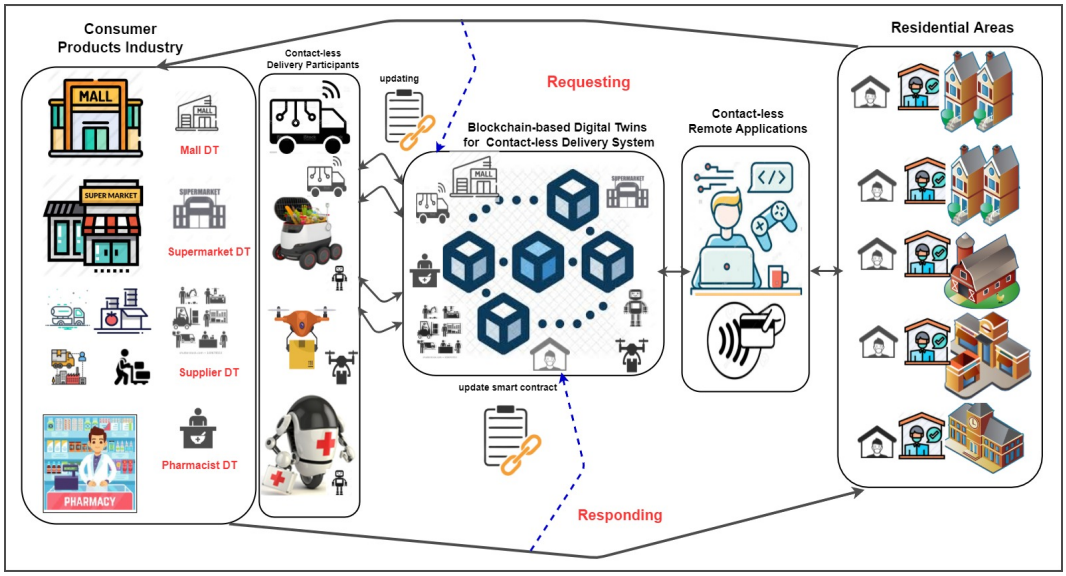


Fig. 3. The contact-less delivery service for CP industry during COVID-19 and post-pandemic era.

Digital twins collaboration in contact-less delivery service DTs represent the participants collaborating to provide a complete, efficient, high quality and secure delivery service in the contact-less delivery service. The core participants of the contact-less delivery services include malls, suppliers, supermarkets, people, robots, auto-driver cars, drones,.etc. These participants could be represented in interoperable and collaborative DTs to show high visibility of the contact-less delivery service without physical interactions to limit contacting and coronavirus outbreaks. In addition, the DTs are collaborating to track the

contact-less delivery service among the participants. The DTs' collaboration can understand each DT's status, interact with other DTs, learn from other DTs, and share common semantic knowledge across geographically delivery services. Furthermore, the DT-based data is used to allow data visualization. For example, the visualized contact-less delivery products enable consumers to track their orders. Also, it will enable the managers and decision-makers to conclude insights for actionable decisions.

On the other hand, there are different data models for the DTs in contact-less delivery services based on the requirements of each participant. In particular, the DTs for the contact-less delivery service are represented the data generated from sensors attached to products containers, robots, and drones to capture real-time data about delivered products and report on-time data about environmental changes. For example, the DTs of the warehouse are used to monitor the weather, e.g., temperature and humidity in the warehouse for storing safety products. For physical assets such as malls, suppliers, and supermarkets, DT models represent information about them, such as their locations and product storage. For example, the product's availability is updated in real-time to help the management department in-store to request the products from the nearest supplier in case of the product is out of stock. Also, the DT model represents the delivery robots used to serve the consumer by transporting ordered products. The models of the delivery robot DT have information about the robot status, the product condition, the location, and so on [12].

Blockchain and operational contact-less delivery data sharing Blockchain technology is required to provide high quality, secure connectivity, decentralized, traceability, and tracking transactions for safe communication between delivery robots, food suppliers, and in-stores [12]. In particular, DLT is needed to provide high-quality, secure connectivity to improve the security and safety of the communications between the participants of the contact-less delivery service. For example, DLT is used to acquire secure real-time data exchange and analysis across multiple participants, such as detecting attack vectors for stealing robots. In addition, DLT can implement collaborative DTs that allows data of delivery service sharing among multiple DTs in a decentralized contact-less delivery system. Therefore, sharing DTs-based data among DLTs can offer high data reliability in product delivery, faster access, high availability, and collaboration among contact-less delivery participants.

Data-driven digital twins based predictive analytics In such a contact-less delivery service, the examples of the potential risks within the decentralized delivery service include faults with robots and drones, lack of products, etc. To avoid the potential fault risk of the movable assets, including auto-cars, robots and drones, monitoring DT-based data is required from these assets, including location, speed, and sensing environment. The real-time collected data from DTs of the auto-cars, robots and drones could be fitted into the data-driven DTs-based predictive analytics to predict the potential fault to perform early maintenance for these movable assets and avoid any delay in the delivery service. DT-based

data acquisition can also identify any spoof attack vectors during the robots travelling to deliver products to the quarantine/residential areas. On the other hand, to assess the potential risk of lacking products, products available within the retails are evaluated based on the locations and the real-time demand. The decision-makers can direct the request to the closest in-stores to avoid delayed delivery services. Furthermore, these potential risks of lacking products can help decision-makers better supply plans and increase money flow within the contact-less CP industry.

Decision making in contact-less delivery service A consensus is a decision-making process in the contact-less delivery service to avoid the potential risks, including fault diagnosis and lack of products. Using collaborative DTs provides a better understanding of potential risks for the delivery system and facilitates consensus-building among participants involving the decision-makers. Multiple participants represented in DTs are divided into various consensus sets. The consensus mechanism is chosen based on the potential risk scenario (e.g., hijacking and theft of robots, faulty auto-cares, robots, drones, harmful products, expired food, and so on). The consensus algorithms will then be used to agree on the potential risk provided by collaborative DTs to notify the decision-makers about the potential risk that could delay the contact-less delivery service.

4 Open challenges and discussion

Right now, the contact-less CP industry is still a vision for the future of the contact-less economy. However, many challenges stand in developing a concrete contact-less CP industry. Therefore, we will explore some of those challenges and ways of addressing them.

Privacy and regulation The security and privacy associated with consumers are challenging within the contact-less CP industry because of the risk of sensitive marketing data created from consumers' preferences. Therefore, the contact-less CP industry should analyze consumers' data locally using federated learning and then share only the model to the blockchain instead of sending the raw data. Thus, the issue of security can be solved by using blockchain technology, while privacy can be solved by using federated learning. Combining both techniques can significantly enhance the security and privacy of the contact-less CP industry.

Security Data security is crucial for the contact-less CP industry due to hacker attacks. Consumers must be confident that their data is secure, transparent, and accessible. Blockchain technology can be applied to the contact-less CP industry to protect consumers' accounts access. However, blockchain technology faces various security and trust issues, such as attacks against consensus mechanisms and propagation processes [32].

Timing, speed, and response Timing and speed are tricky for delivering products. Also, time enhances decision-making and reaction times for consumer demands requiring high accuracy to avoid long delivery delays.

Data modeling Standardization is essential for designing a contact-less CP industry system. The fully connected contact-less CP industry participants need to use standard models to define each participant based on the relevant schema. The schema is determined based on the corresponding physical assets and the communication behaviour within the CP supply chain. These standards are complex to facilitate DTs of CP participants for interactions and collaboration. Furthermore, these standards can range from the file format of the data storage to the details of how the DTs are communicating within the CP industry at different stages (e.g., the products from being manufactured to being consumed) [33].

5 Conclusion

This paper introduces a conceptual framework for the contact-less CP industry due to COVID-19 and post-pandemic. The proposed framework's merit is exploiting the emerged industrial technologies' capabilities to provide autonomous, secure contact-less solutions for the CP industry during and post-pandemic. Four layers are used to equip the conceptual framework for the contact-less CP industry, including the physical layer, which contains the CP industry participants, the DTs layer, the driver industrial technologies layer and the applications layer. Consequently, the CP companies can effectively execute their business functions for the post-pandemic through an efficient combination of technologies within the proposed framework. Furthermore, we have described a contact-less delivery service during COVID-19 and post-pandemic, together with a detailed mapping of our proposed framework. In future, more work is required to be done to improve contact-less services in different sectors (e.g., hospitality industry) by utilizing the improvement in the robot, 5G, blockchain and so on.

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