FinTech enablers, use cases, and role of future internet of things

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ABSTRACT

In the current global trend, financial organizations strive extensively towards smartening finance to derive the benefits of digitalization. In such an effort, Financial Technology (Fintech) involves usage of several contemporary disruptive technologies such as AI, 5G/6G, Blockchain, Metaverse, IoT, etc., in financial industry to add value to the customer services. By the inception of technology, several major financial services and processes such as lending, verification, fraud detection, quality maintenance, credit scoring, and many more will be simplified and augmented. However, there is a need for research and innovation of disruptive financial products and the enabling ecosystem of technologies. Consequently, several tech-giants have focused their attention on Fintech to introduce Information and Communication Technology (ICT) solutions. In this manuscript, firstly, we envision the future trends and driving applications of Fintech that would emerge during 2030. Further, we attempt to provide a high-level framework of the enablers of Fintech including IoT, 5G, Digital twins and Metaverse for certain use cases. In addition, we provide directions for future Fintech research while anticipating the challenges ahead.

1. Introduction

Financial Technology (Fintech) has seen a tremendous upward growth since 2018 with the influx of global investments reaching a sum of nearly 60 Bn USD (Arslanian and Fischer, 2019). It is also anticipated that the financial transactions through smart wearable gadgets exclusively will reach 75 Bn USD by 2025. Fintech offers innovative methods of financial transactions and banking services through adopting modern computer communication, data science, networking, and Artificial Intelligence (AI) technology. Fintech mainly relies on the Internet of Things (IoT), blockchain, AI, data analytics, and 5G and Beyond (B5G) in making financial services more user friendly, secure, and efficient. These ecosystem of technologies what we termed as *future internet of things* in this manuscript.

Now, there are two main reasons for the sudden rise of Fintech namely, the evolution of new computing and technological paradigms such as the Industrial Internet of Things (IIoT), Smartphone Apps, Cryptocurrencies, digital twins, 5G, Virtual Reality (VR), Augmented Reality (AR) and AI. They act as a catalyst in the growth of digital finance. Secondly, these technologies empowered the financial institutions to address the customer demands in a newer and most efficient way than the conventional methods (Butler, 2020). For instance, with traditional banking, knowing customers' investment preferences was a tedious task. However, with the assistance of data analytics and AI, it has become too trivial to learn and respond to a variety of customer needs instantaneously and to provide them suitable suggestions through chatbots and Smartphone Apps (Nicoletti, 2017). In addition, one of the key benefits of Fintech is automation; while comparing to traditional financial services the customers will have a greater freedom to operate and control their account autonomously by the integration of financial data with technology. As an example, one shall query the account details by digital assistants such as Alexa or custom built Apps with ease and shall use quick response codes (QR) for instant payments (Arslanian and Fischer, 2019). In China, the online payment

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giant Alibaba and Tencent have initiated several mobile, online payment avenues to facilitate money transfer, loans, and customize the future offerings as per the spending pattern and by considering customers' transaction data (Arslanian and Fischer, 2019). In another instance, the TD bank in USA has targeted to have 90 % of its transactions through self-serve mode where customers use technology for banking (Arslanian and Fischer, 2019).

However, the true implementation of Fintech requires highly reliable and secure internet connectivity, device to support multi-modal data, network scalability, storage, processing, precise localization, intelligent decisions, and energy efficiency, analytics, to name a few (Tyagi and Boyang, 2021). The existing mobile broadband like 4G, 5G have been offering these features to a major extent, yet not to its entirety. For instance, payments using QR codes for online payment works well with 4G; connecting tens of thousands of mobile phones, and IoT devices in a locality for financial data transaction would require 5G's massive device connectivity feature and location services. Nevertheless, virtual transmission of holograms to enhance user experience during banking or trade will require extremely high data rates. Consequently, technologies beyond 5G (B5G) such as 6G will be necessary. Further, blockchain, and quantum computing have been the ideal candidates to enforce security into the financial transactions over the conventional cryptographic encryption schemes (Gai et al., 2017). The vast Bigdata generated due to a variety of financial applications have made to incorporate AI for better data management and to assist in decision making process (Trelewicz, 2017). In the recent trends, distributed data collection at the localities and later processing the data at edge computing facilities has attracted the attention of Fintech firms that cares about network latencies. For instance, subscription to live video streams to access uninterrupted video during online gaming, live online auctions, high-speed trading systems, etc., requires fast transmission of the trading data from the market place to servers. In that context, it will be wise to process data locally from the regional markets and trading centres in a distributed manner than managing at a central data centre. These applications of Fintech require extremely low latency, jitter, and high reliability (Paper, 2019).

On the other hand, there exists several challenges while we try to introduce advanced technology features to the classical financial services. For example, when we expect to acquire the precise location information to authenticate the financial transactions, we need highly precise technologies (beyond GPS) such as mm-wave, THz communication for precise indoor localization. Moreover, high-speed networking technologies, extremely reliable security through quantum communication, fast and accurate AI algorithms for risk-prediction, digital twins for data analysis, etc., requires further exploration, and maturity of the existing technologies (Cao et al., 2020).

In this manuscript, the main intention is to discuss the key information technology enablers of Fintech. Our *contributions* are as follows:

(i) We provide a categorised literature survey on Fintech enablers to underline their research directions.
(ii) We envision the scope and need for Fintech research.
(iii) Further, we discuss the key driving Fintech applications and trends.
(iv) Moreover, we narrate the key Fintech enablers and proposed frameworks and use cases with Metaverse, digital twins, IoT and 5G.
(v) Next, we provide directions for future research while envisioning the challenges ahead.

Organization of this manuscript: In Section 2, we discuss the related works on Fintech. In Section 3, we highlight the driving trends, technologies and certain Fintech use cases. In Section 4, we narrate the technologies used to promote Fintech. Later, in Section 5, we highlight the challenges and future research directions and in Section 6, conclude the manuscript.

2. Related work

2.1. Procedure for the selection of papers:

In this study, we considered the key enablers of Fintech by performing an exhaustive survey of relevant literatures published in the reputed international conferences and journals by the major publishers such as IEEE, Springer, Elsevier, Science direct, Wiley, etc. including the book chapters. To be specific, our search included the studies in the past 5 years, with the keyword search on "IoT and FinTech", "Blockchain for Fintech", "Next generation Fintech", "Fintech and AI", "Fintech and 5G", resulted in numerous (100's) results. However, funnel analysis of these results based on our agenda of the current research lead us to only a few (as in the reference) literatures. Whereas, the rest of them leaned towards IoT, blockchain, AI, etc., or towards only Fintech in general (not focusing the theme of the current research).

2.1.1. Literatures on Fintech and its enablers

As the Fintech services mainly depend on the data, at present it is crucial for financial institutes such as banks, insurance companies, online traders, etc., to drift towards data driven technology for financing. Besides, as a disruptive technology of the future, Fintech should consider three aspects such as ubiquity, security, and strict regulations to offer financial stability (Maiti and Ghosh, 2021). Further, (Nakashima, 2018) restates that Fintech should support two factors namely, service and product, aiming at sustainability and survival of mankind.

There are several works that have discussed the trends, and challenges of Fintech. In (Ramachandran, 2019), the author has evaluated five technologies namely, IoT, Blockchain, AI, Unmanned Aerial Vehicle (UAV), and Robots as the key enablers of future Fintech in the context of UK. Let's discuss few of them briefly here.

IoTs in Fintech: For instance, the earlier model of Pay As You Drive (PHYD) could receive passive feedback from the vehicle. However, the model in (Marafie et al., 2018) utilizes the dynamic information obtained from IoTs in the vehicle (monetary rewards, penalties, alerts) to evaluate driver's behaviour and report the same to the insurance company as well alerts the driver to adjust the driving. This method proactively helps to avoid the risk by analysing the vehicle and road conditions. This is an instance of use of IoT in insurance sector (Marafie et al., 2018). In (Arora and Kaur, 2020) authors proposed a framework for intelligent banking using IoTs. The proposed architecture consists of three layers, where all sensors that sense the data forms the physical layer. Further, cloud, edge, AI analytics that receives the data, processes them and altogether forms the process layer. Finally, the applications (banks, insurance) and their service models such as alerts, recommendations, feedbacks, etc., forms the part of service layer. In (Maiti and Ghosh, 2021) authors have envisioned the rise of Neurotech enabled IoT (NIoT) in Fintech, that integrates man, machine, and memory. In this context, sensing, decision making and processing will be largely through IoT, AI, and embedded chips in human brain, respectively. Similarly, AI enabled IoT has been used in financial crisis prediction using metaheuristic algorithms (Tyagi and Boyang, 2021). This framework seems highly useful to classify and predict crisis in financial institutions.

AI in Fintech: Use of AI techniques for various financial applications has been evaluated in (Cao, et al., 2020). The authors investigated insurance, wealth and asset management, and payments. It

suggests that use of robotics in customer service will be beneficial than the conventional methods of determination of insurance premium or penalty. Further, we need more sophisticated methods of financial document verification and fraud detection such as computer vision, advanced pattern recognition when we deal with new customers and during the KYC procedures. Next, AI can involve more complicated financial services which otherwise had required intense human involvement to attract new customers and in customer retention. Moreover, at the moment AI is the only efficient tool for the organizations to detect the varsity of data generated by multiple sources such as sensors, news feeds, and tele consultations. In addition, when financial matters depend on the market demand, political factors, govt., policies, and customer emotions, AI shall predict and market trends. An interesting AI model for banks have been proposed in (White Paper: Building the AI bank of the future and Company, 2021), suggests that AI banks will facilitate faster innovation, efficient and diverse customer support through digital platforms. Therefore, the incumbent banks must become *AI-first* to become competent.

On the other hand, market prediction and analysis has been another complex issue in Fintech due to variety of data from heterogeneous sources. In this context, an adversarial network training approach using reinforcement learning has been adopted to improve the efficiency of market predictions (Khuwaja et al., 2021; Ghahramani and Qiao, 2020).

Traditional financial services evaluate the static data (age, gender, occupation, pre-existing health, etc) to decide the health insurance premium for instance. In addition, most of the earlier generation insurance services were in-person, or web-based without consideration to personal requirements. Nevertheless, the future financial services are anticipated to be highly personal and context based. For example, in the future, by adopting Fintech, the health insurance service shall offer recommendations to the customer by considering the healthcare data from sensors. These data shall be sent to the user's Insurance App to recommend the suitable diet, exercise, medications. Besides, it helps the insurance company to adjust the instalments by analysing the future risk factors associated with the customer.

Blockchain in Fintech: Fintech security mainly relies on blockchain. The key feature of blockchain is its transparency while offering distributed nature of financial transactions. The blockchain is the most suitable solution for monitoring the cryptocurrency transactions (Paul and Sadath, 2021). It is totally a peer-peer network where the participating users themselves does verification (or mining agents) of transactions, leading to faster and transparent Fintech ecosystem. Further, the Bitcoin allows users to anonymously join and trade, hence offer flexibility (Arslanian and Fischer, 2019). However, Bitcoin wallets may also become subject of hacking attack due to its cryptography based personal key concept. Hence, multi-signature concepts are essential in preventing such attacks (Vazquez et al., 2019). Despite the benefits, blockchain faces challenges such as scalability issues as the no. of peer node increases, regulatory laws as different countries have conflicting opinions, maturity of technology enablers to incorporate low latency, robustness, and ubiquity. The futuristic developments in quantum computing will lead to enhanced cyber-security, and speed of transactions (Mosteanu and Faccia, 2021). Moreover, supply chain finance, interbank joint loan business, cross-border transactions will become the key use cases of blockchain in Fintech (Hendershott et al., 2021). On the other hand, the challenges include enforcing regulatory mechanisms to channelize the Fintech as similar to regular banking practices. In addition, Fintech must adopt agile risk management schemes to demonstrate confidence among its customers (Mehrotra and Menon, 2021). Similarly, Non Fungible Tokens (NFT) which are the certified digital assets will boost the blockchain paradigm of future financial transactions.

Digital Twins in Fintech: Inclusion of digital twins to monitor and management has been the recent trend. However, in such scenarios, automation and regulation of the financial transactions from these twin-based cyber physical systems is the major task. In (Obushnyi et al., 2019), the authors have used digital twin models for the transfer of property rights with the aid of blockchain. Similarly, in (Kanak et al., 2019), the authors used blockchain for the decentralization of the digital twin including financial transactions and other transmitted information among the twin ecosystem. When we have distributed nodes (say IoTs) that sends financial data to the cloud, there involves a tremendous delay. Therefore, edge computing has been proposed to minimize the delay. Specifically, in (Munusamy et al., 2021), the authors have classified the financial tasks and assigned rank (priority) to these data to be analysed at the edge of the network by integrating AI models.

Fintech has another challenge of dealing with number of transactions per unit time (say per second). Typically, the amount of Big data generated by 10,000 transactions per second needs fast processing, and deletion of data (cleaning) where such algorithms may get a very short time to work on such huge data. Thus, a demand setting procedure has been proposed using K-means and FADO algorithms to efficiently handle this situation (Pelckmans et al., 2020). Similarly, asymptotic meta learning algorithms such as AML-Lin and AML-Xiang have been used to cross validate the financial big data (Xiang et al., 2020).

Lastly, (Mehrban et al., 2020) extensively surveys the recent trends in Fintech, emphasises security issues and measures, future challenges associated with various enablers of Fintech.

2.1.2. Scope and need for Fintech

In this section, we narrate the factors that underline the scope and need for Fintech research which motivated our study. Primarily, when we consider Fintech, we ponder upon the following questions: (i) why financial services must embrace digitalization and ICT (ii) how do the financial industry will look after the technology inception, and (iii) what are the challenges involved in the transformation into become a Fintech.

The studies have envisioned that Fintech will attain the business peak during 2025 (Report: Global Fintech Market, 2021). Nevertheless, we anticipate that the real peak will emerge once we actually witness the challenging use cases and the technology that drives Fintech becomes mature. For an instance, when we consider the United Nation's Sustainable Development Goals (UN-SDGs) targeting 2030, we foresee additional challenges with regards to use cases to fulfil SDGs such as no poverty, economic growth, sustainability by the inception of Fintech. Furthermore, the future internet applications will demand tremendous support from the technological ecosystem to meet user service requirements. Consequently, revenue generation from those users will entirely rely on the support of technology that meets their service requirements. Considering these factors, Fintech will have the opportunity to grow further until 2030 and even beyond as well by adopting the latest technology.

i) *Rise of new trends in financial transactions*: Compared to the conventional way of trade, Fintech involves extensive exploration of technology to bring changes in the way the institutions would serve customers. Mobile banking, Insure Tech, Robo advisor, Digital currencies are some of the new exemplary trends of financial transactions. They motivated us to explore the possible techniques to achieve the same.

ii) *Need for automated services*: Today every customer expects to have complete control over his transactions, access to banking resources, and retain the freedom of choosing services flexibly. Further, data generated by a variety of

financial transactions will be massive. Thus, processing the data to automate the services require an extensive support from programmable and intelligent systems.

iii) *Need for high security and privacy of user data*: In the future, along with the humans, IoTs, Digital twins, and robots will be in the loop of financial transactions. Therefore, determining the identity, protecting the data, maintaining end-to-end privacy of the user will become the prime parameters for banking.

iv) *UN-Sustainable Development Goals*: By 2030, all human being should be able to experience economic growth leading to eradication of poverty (SDG 8 & 1) as ambitioned by UN SDGs. In this regard, it is essential to exploit technology for the growth of financial sector. For instance, IoT enabled agriculture and weather prediction could help farmers to obtain better yield. Moreover, IoT's and mobile Apps will even guide the farmers in marketing their crops for the best value leading to economic growth and eradication of poverty.

v) *Resource utilization and cost reduction*: Use of technology in finance will facilitate automation of the process flow (eg. Smart Banking) which in turn will reduce the cost by efficient resource management and minimize the errors. Further, technology can assist in personalization of user services, thus attract more customers to enhance the revenue. For example, during the pandemic, inception of remote healthcare services in hospitals has benefitted many patients. Consequently, it influenced the income generated by the hospitals. In another instance, the banks can use AI to personalize the customers' need, that will popularize banking experience and boost the revenue.

The above mentioned factors lead us to the following conclusions, which motivates this study. The conventional banking services will not be of any use in the future when several new verticals emerge; and will be replaced by tech-driven financial services. Therefore, it is essential to explore and invent new technologies to assist inclusive and efficient economic activities and services.

Next, in the following sections (i.e. in section III) we provide a general framework of Fintech trends, applications and enablers (Fig. 1). Later, in section IV, we mention the key technology enablers of Fintech (Fig. 2), and describe them in details in the later part of the section through Fig. 3-Fig. 6.

3. Fintech driving applications, trends, and enablers

In this section, we discuss a few Fintech applications that will utilize the future technology and its trends while delivering customer service. For instance, two different applications i.e. mobile banking and VR- based financial recommendations will demand on an entirely different set of parameters (ex: data rate, bandwidth, resolution, location information) to offer the best service. In other words, how finance and workflow are handled with regard to any specific application will have a tremendous impact on the quality of service and monetization. The overall service model of Fintech is as shown in Fig. 1. It is divided into three levels, at the bottom we have the technology enablers that include sensors, actuators, communication modalities, data analytics, and security tools which includes collection of user's financial data, storage, transmission, analysis, and prediction. The middle layer lists the technology trends which are the performance indicators of the data received from the bottom layer and facilitate the easy functioning of the applications mentioned at the topmost layer. Finally, the top layer includes applications that dispense financial services. Altogether, for any specific application the bottom layer provides

data in the suitable format, the middle layer assigns the performance metric, accordingly the data will be presented to the application at the top for visualization which summarizes the Fig. 1. The following paragraph narrates the detail.

3.1. Driving applications

Soon the traditional financial applications will be replaced by smart financial management in the area of banking, insurance, and city management, entertainment, healthcare, etc., as shown in Fig. 1. For instance, an insurance company serving the agricultural sector shall use IoT to obtain real-time environmental data from the farm and evaluate the actual cause for crop failure. This will not only enhance the efficiency of reimbursement, compensation and adjustment of the premium, but also optimise resource utilization. Overall, the smart insurance scheme will improve the customer satisfaction by fair evaluation of the scenario, and reduce the chances of loss to the financing company. Similarly, the entertainment applications such as online games, on demand video, will require different video data rate, latency, resolution based on the type of the device (LED TV, Smartphone, Notebook), expected QoS, and location. The extent to which these metrics have been fulfilled at the user end will impact the revenue generated by the service provider. In summary, the entertainment applications require high bandwidth, data rate, security, and the lowest latency while billing (tariff) the customer for the services.

Furthermore, in the future, when we design financial strategies for entertainment applications one should consider the demand for multimodal data (AR, VR, Holograms) which decides the revenue (Gai et al., 2017; Cao et al., 2020). Additionally, in this context, there will be technical challenges from the point of device and network functionalities. To elaborate, we need a sub-millisecond latency and Tbps data rate. It is obvious that 5G's network capacity will fall short of these requirements of multimodal data transmission. As a consequence, 6G will be the potential candidate to introduce the new financial models for the entertainment industry as it could support extremely high data rate, ultra-low latency, etc., In addition, even the sensors and actuators must be highly sensitive to capture and represent all these inputs from the surroundings which necessitates an immersive user experience. We know that the existing technology has not matured to that extent which is one of the challenges. Along the same lines, the smart city application involving smart metering, smart home, and so on will also require massive connectivity and data analysis capabilities from the underlying layers as shown in the Fig. 1.

The other application i.e. smart healthcare may involve services ranging from telemedicine to remote robotic surgery, where healthcare providers use technology to monitor, serve and bill the patients. In the case of remote robotic surgery, the Fintech organization (i.e. insurance company) should monitor the surgical procedures and confirm that the patient will be able to afford the medical expenses (i.e. paying the overheads); ascertain that the specific treatment has been delivered to the patient. Such a revenue model will enhance trust and service satisfaction (Butler, 2020).

3.2. Driving trends

The new trends that drive Fintech intertwines the application requirements and the technological advancements. Let's discuss the driving trends which are fundamentally the performance indicators of the future Fintech applications.

i) *Low latency and extreme data rate*: The mission critical applications like healthcare, and autonomous driving that adopts Fintech in deciding their financial service model and choices

FinTech Driving Applications

Insurance   Banking   Smart City   Smart Health   Entertainment

FinTech Driving Trends

Low Latency   Extreme Data rate   Super Security   Multi mode Data   Energy Efficiency

FinTech Enabling Technologies

AI   IoT   Block Chain   5G   6G

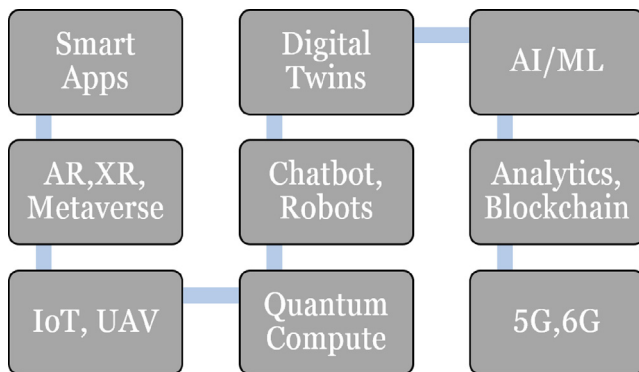**Fig. 1.** Key driving applications, trends and enablers of Fintech.

Fig. 2. Key technology enablers of Fintech.

will require response from the source (i.e. patient monitoring sensors, on-board sensors in a car) for every command sent by the controller (i.e. a remote doctor, insurance company) within fraction of a time. For instance, to implement remote robotic surgery, the end-to-end response time should be nearly 0.2 ms-0.3 ms and would require a data rate of Tbps (Bhat and Alqahtani, Jan. 2021; Dang et al., 2020). Similar will be the case with autonomous driving to avoid traffic disasters. To achieve low latency, and extreme data rate, the candidate technologies such as 5G, 6G, edge computing, THz communication would be required.

ii) *Multimode data*: To envision the true tactile internet and provide an immersive experience to the customers, the sensors, actuators, and communication network ecosystem involved should be capable of carrying touch, motion, sense, taste, and many more over the internet to remote locations. That means, we move from existing text, image, video,

augmented reality data to mixed reality and 3D hologram transmission. Especially, entertainment industry, remote-site trainings, and online games will heavily depend on these multimodal data in the future. These new modes of data will attract new financial pricing and subscription models to generate revenue.

iii) *Super security*: One of the fundamental requirement of financial transactions is the security of communication to maintain trust between the stakeholders irrespective of the type of application. To be specific, smart healthcare, banking requires utmost data security (nearly zero security breaches per transaction). To introduce super security, Blockchain, and Quantum Computing are the two potential disruptive technologies at the enabler level.

iv) *Energy efficiency*: Due to the nature of operation of IoT devices that brings data to and from the financial models, the entire network operations, and resources should adapt their functions intelligently to make the network self-sustainable. The self-sustainability stems from efficient energy-conserving models such as harvesting energy from the environment, proper spectrum selection, etc. For instance, an intelligent reflecting surface (IRS) is one such promising technology that would assist to build smart green communication networks and interfaces (Bhat and Alqahtani, 2021). In addition, embracing wireless energy transfer will also improve energy efficiency.

v) *Network Intelligent*: It is anticipated as one of the hot trends that future internet applications will demand. Since, millions of IoTs send data, analysing it followed by decision making requires a high degree of network intelligence. Therefore, the collected big data will be handled by AI models to assist in prediction and decision making. In some cases, the intelligence will reside at a central location such as a cloud, and in some other cases where data is to be processed locally, the
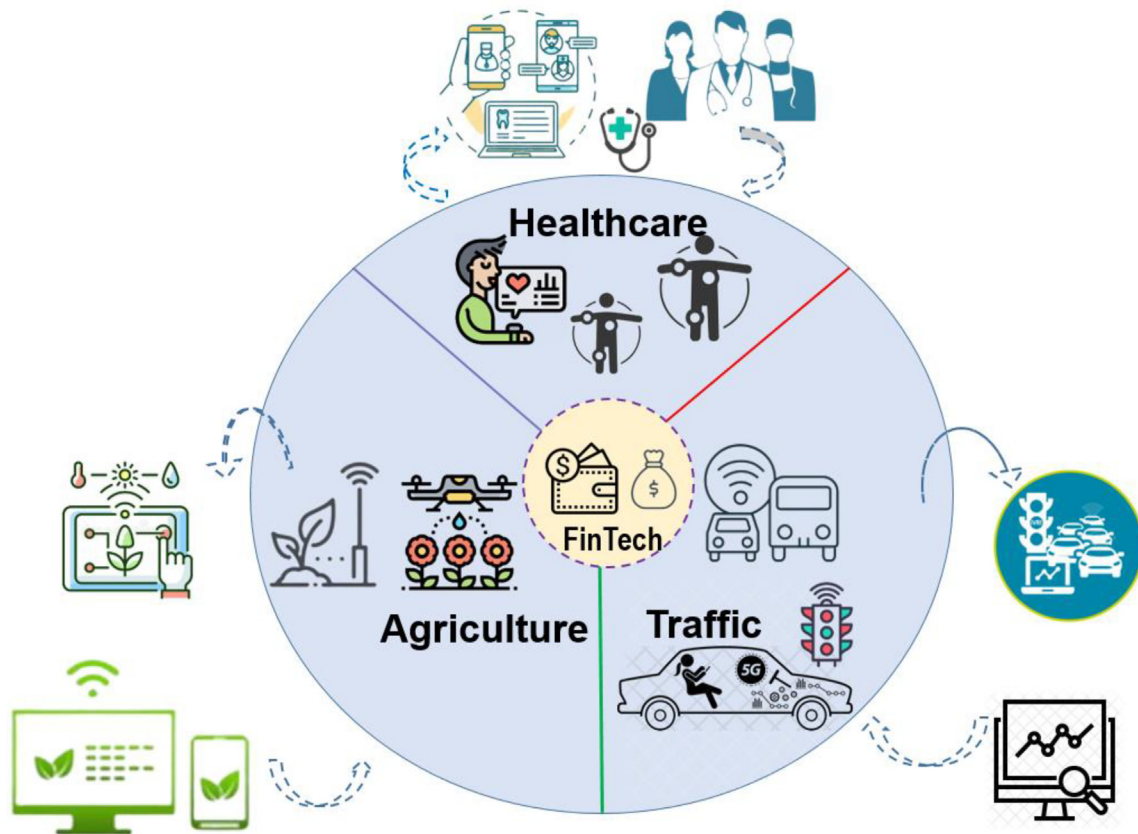
Fig. 3. Use case of FinIoT in healthcare, agriculture, and vehicle insurance.

intelligence will be present as a distributed entity, spanning from the device level to the application level at varying capacities (White Paper: Building the AI bank of the future and Company, 2021; Mehrban et al., 2020; Ghahramani and Qiao, 2020).

3.3. Enabling technologies

The bottom most layer in the Fig. 1 consists of a few technologies that forms the integral part of the Fintech. Overall, it could be categorised as data collectors (IoT, UAV), data transmitters (5G, 6G, and other wireless technologies), data analyser (Bigdata, AI, deep learning, digital twin), data storage, processing, and compute (edge, fog, cloud computing), data security (blockchain, quantum computing), and data visualizers (Mobile Apps, holograms, tactile internet). These technologies when combined in certain pattern will enhance the users' experience of using financial services (Arslanian and Fischer, 2019; Paper, 2019; Mehrban et al., 2020).

Let us consider an example of a financing system for smart healthcare. In this context, wearable sensors could collect vital signals from the patient and send it to the next data processing level (edge computing facility) through wireless interfaces (Wi-Fi, Bluetooth, or 5G) and from there reaches the cloud. The received and stored data will be processed at the edge, cloud computing level using various AI algorithms. The financing Apps collect the data from the cloud to decide subscription charges or the service pricing. In this case, edge computing, and cloud both shall run AI algorithms to analyse user health data and provide feedback. Comparatively, edge computing will offer a lower latency service due to its proximity to the client. Further, in the case of remote surgery, 5G/ 6G will be necessary to offer the required data rate,

bandwidth, energy efficiency, security, and localization. In the following section, we discuss these enabling technologies in detail.

4. Technologies for Fintech

Now, let us take a detailed overview of the potential technologies that drives the future Fintech applications and advancements. As mentioned earlier, IoT, AI and deep learning, robotics, blockchain, mobile Apps, cellular networks such as 5G, 6G, digital twins, quantum computing, are the key technology enablers of Fintech which is also depicted in Fig. 2. These enablers can be broadly classified as data collectors (IoT, UAV, Smart Apps, robots), data communicators and storages (5G/6G, robots, cloud, blockchain), data processors and presenters (AI, ML, XR, Metaverse, Quantum compute, Digital twins) as listed in Fig. 2.

Further, we initially describe the role of AI, followed by IoT, Metaverse, blockchain, 5G/6G, Smartapp, and digital twins in the sequential order.

4.1. AI and deep learning

AI is anticipated to be an essential part of banking in the future to provide distinctive services to users on a massive scale in real-time. Fundamentally, AI does the three following actions in finance. (i) AI helps in the personalization of services and enhances the revenue by attracting more customers. (ii) Facilitates operational cost reduction through increased automation, and better resource utilization. (iii) Introduces new business opportunities by effective utilization of customer data (Huawei Bank of Things White Paper, 2020).

Specifically, by the use of AI in investment analysis, market prediction, survey, and customer service, it becomes easy to increase

work efficiency and process automation. Next, analysing investment data, and market trends using deep learning models will play a significant role in building solid risk-prediction systems (Marafie et al., 2018). Now, AI has been extensively used in Fintech to assist in more informed decision making. For instance, when a user buys a product online or pays online, the user data from online shopping including the type of product, purchase time, location of credit card usage at the point of service (PoS), social media recommendations, posts etc., will be collected by the financing agency or third parties. This information shall act as a key source of data in deciding a new customers' financial usage pattern, and interests. An AI system can systematically analyse all these data to provide recommendations to the financial company about future purchases by the customer.

The AI chatbots will play a critical role in promoting service-oriented remote banking at an affordable price while offering a customized user experience. In addition, AI-enabled humanoids shall serve customers in the branch by the usage of machine vision and language translation in processing documents.

In the context of the personal loan scenario, AI has been used to estimate the credit score and perform an evaluation using big data mining. This feature actually brings credibility and fairness while deciding the potential of the customer to pay back the loan. Similarly, AI is useful in the case of peer-peer (P2P) trade, evaluating the borrower from multiple perspectives in an online lending system, and instant detection of fraud and cyber threats (Cao et al., 2020). As per the McKinsey survey, three key AI technologies used in finance are (i) robotics for task automation, (ii) virtual assistants for customer interactions, and (iii) detection of fraud, and cyber-attacks through machine learning methods. Further, it will add 1 trillion USD every year by the inception of AI in banking (White Paper: Building the AI bank of the future and Company, 2021).

Let us see a use case of AI in banking: The banks of the future will undoubtedly integrate technology, networking, and intelligence. The first step towards such an approach will be to transform the existing functioning model of a bank into an IoT model, where customers, banking processes, and data elements could interact over cyberspace. Consequently, it facilitates the easy discovery of financial and non-financial requirements of customers or underlying banking processes and thereby addressing their needs. Further, integrating AI into the Bank of Things (BoT) will enable expansion services and orchestrate the management process (Huawei Bank of Things White Paper, 2020).

We envision three disruptive technologies that have the potential to rule the banks of the future, namely, digital twins, IoT, and AI at different levels, yet, intertwined. For instance, a twin of a banking process helps in evaluating a new intended business model including risk and resource requirements at scale without disturbing the normal operation of the bank. Similarly, IoT based banking services will use IoT/ smart devices to offer financial or non-financial services regardless of temporal and special limits. Finally, AI integrated with IoT services will enable to offer services to customers through smart devices where those devices could function autonomously. In a recent trend, AI has been extended by Metaverse to enhance the quality of banking services while offering the highest level of virtual immersive participation in financial transactions.

4.2. Internet of things (IoT)

IoT will play a pivotal role in banking, financial planning, insurance, automobiles, and healthcare to improve the way by which these sectors provide services. The smart sensors in insurance industry, RFID at the shopping terminal, mobile banking, industrial sensors, wearable devices in healthcare, etc., are some examples that collect and connect data to the internet for storage, process, and analysis. These IoT will collect a variety of data from users,

such as location, time of usage of credit card, health data, driving styles, etc., which are highly useful for organizations to promote their business. Insurance, banking, and financial firms shall develop new financial products by involving IoT.

For instance, understanding the shopping behaviour (i.e. usage of debit card at a PoS) will help the marketing companies to promote their products better. Further, for the user with smartphone banking, the account details, advertisements, and other notifications can be sent directly to the registered smart device to promote further shopping. A recent trend that involves IoT is a remote financial estimation. Here, an on-spot inspection of road accident sites, or ships will be done with the assistance of UAVs that are mounted with integrated cameras and live video streaming capabilities. In another instance, the finance company shall deploy UAVs for aerial survey of the farm, and crop status and send the real-time status of the scenario under consideration back to the insurance company. In this context, UAV as a smart connected entity collects video or photographs, processes it on board, and communicates data over the internet using wireless links, similar to any other IoTs. This information received from regions of limited human access shall be used by the insurance company in the deciding the crop insurance value in real-time. This provides great assistance to the insurance companies in early release of funds based on the impact of accidents, evaluating the reasons, and thereby making the process autonomous.

Similarly, when we consider IoT inception, starting from ATMs to connected vehicles in the insurance industry, smart health monitoring for risk analysis, mobile banking, billing, remote skill transfers in a service industry etc., all come under the umbrella of the Internet of Financial Things (IoFT). These IoT networks carry data which stimulates financial activities. In another scenario, VR-based payments allow users to experience virtual money transfer to experience the visual feel of money transfer. Further, AR smart glass shall scan QR codes at shopping malls and perform the payment just in the blink of an eye.

4.3. Use case of IoT in Fintech (FinIoT)

In the Fig. 3, we depicted 3 scenarios where IoT has been used as an integral part of financial services. A car embedded with proprietary sensors to monitor speed, engine temperature, lubrication, wellness of tyres, etc., will continuously monitor the corresponding parameters and communicate them wirelessly to the financial organization that provides vehicle insurance. All these financial transactions depend on the data sent by the sensors and the connectivity to the internet (i.e. FinIoT). In case, the threshold value of any of these parameters drops below the permissible level, the company can alert the driver or penalize, forfeit the insurance coverage as shown in lower right part of Fig. 3. In another use case of smart agriculture, the drone which is controlled through the internet shall monitor the crops, irrigate, dispense pesticides during the flight based on the soil condition, moisture level, air quality at the field. In another words, these connected sensors shall update the farming information to the traders, or customers directly. As a result, competitive prices could be fixed to these crops based on the quality of the environment where they have been growing. For instance, organic crops, crops grown in certain weather conditions will have high demand in the market; however, without IoT implementation, tracking such data is difficult. Moreover, customers shall order these agricultural products through mobile Apps. In addition, the crop insuring agencies, and banks that provide loans to the farmer can adjust the premium by considering the data available by the sensors. For instance, during a drought, the banks shall provide higher financial assistance by monitoring the real-time data.

Similarly, the third use case of Fintech through IoT is remote healthcare. This scenario describes how IoT facilitates remote healthcare and management of medical expenses, health insurance. Here the hospitals will provide wearable sensors on rent or patients may use their own sensors to connect to the hospital's cloud-based healthcare services. For instance, the doctors shall provide consultation by monitoring the sensor data recorded at the cloud server, remotely. Next, the doctors' recommendation can be used by the health insurance company to offer customised health insurance plans, and even the hospital can bill accordingly based on the actual data from the sensors. Thus, by providing an avenue for object evaluation of the scenario through data from IoTs (against the subjective evaluation), more reasonable decision is possible.

However, there must be suitable privacy regulations while using these data. Improper management of data would lead to a breach of privacy, identity, financial loss, etc. In some cases, an IoT device such as fitness equipment might be used by multiple people in a gym or at home. Then, it is essential to have a proper data management system while collecting the data from specific users. Such devices must have personalized identification systems (eg: biometric identity) while making the data pervasive. Further, when relying on such IoT data to customize the services, it is possible to adjust the schemes or premiums at regular rates than conventional annual plans based on the fluctuations in the user data. This could lead to efficient revenue collection by carefully monitoring the user data and maintaining the history. In addition, it enables prompt customer assistance, service, and satisfaction.

IoT in Banking: IoT has been used by banks in guiding their customers during their financial needs. For instance, customers' mobile phones with location information shall be configured to know their location (with privacy) when they enter the bank premises and display advertisements on the bank's new financial services near the customer by using smart display surfaces. Further, smart boards, QR codes and assistive bots shall assist them in finding the right counter based on the need to enhance their satisfaction and save time. Similarly, IoT will allow customization of bank transactions based on clients' needs and usage patterns by acquiring and analysing massive data from the personal and social settings of the clients.

It is anticipated that a strategic business model, the inception of IoT and AI technology will revolutionize financial transactions in the future (Arslanian and Fischer, 2019). Further, AI bots shall replace some of the financial advisors.

4.4. Amalgamation of AI and IoT

Now, let's see a scenario in which we describe the way Fintech could offer three different services by integrating AI with IoT. One such amalgamation is the Huawei's model of Bank of things (Huawei Bank of Things White Paper, 2020). Based on the discussion in (Huawei Bank of Things White Paper, 2020), we generalize the areas where AI and IoT shall collaborate to offer services to the customer.

(i) *Ingenious service*: Intelligent devices shall evaluate the customer's requirements in a specific scenario and introduce suitable financial policies. For instance, during the onset of natural calamities (drought, floods) IoTs will proactively gather environmental data, and the intelligent agents will use the data to estimate the consequences and provide recommendations based on the customer's financial history.

(ii) Customer-specific service: Using the IoT data and the context information, the AI agent will be sufficient to make personalized decisions on financing the individual customers based on their situation.

(iii) Uninterrupted services: IoTs will provide real-time data. Thus, financial services shall provide immediate and dynamic assistance by considering the varying scenario. For example, the rain during the flood may vary, resulting in different amounts of destruction to the property or crop. Thus, finance policies should support 24x7 by analysing the varying situation to enforce relief measures.

4.5. Metaverse

In Fig. 4, we present the Metaverse model of banking to provide a *meta*-world experience for the customers' interaction. Recently, after the trends such as the bank of things (Huawei Bank of Things White Paper, 2020) and AI-first bank (White Paper: Building the AI bank of the future and Company, 2021) became too popular, we look forward to further enhancing the user experience of banking services via an immersive real-virtual world intertwined model of the Metaverse. After COVID'19 gripped the world, customers demand multi-way online engagement for banking-related activities. Thus, Metaverse seems to be the right candidate. Nevertheless, use cases of Metaverse are not just limited to banking and shall be extended to any field of life and beyond. For instance, to buy a cloth, one shall use his avatar to search for a cloth that suits the style in a global virtual shop, wear, and pay virtually using crypto when the shopkeeper appears with his avatar. Thus, a truly immersive, holographic environment where everyone will be interacting virtually; yet, experience a reality. Further, leading banks like HSBC and JP Morgan have initiated their virtual branches in the Metaverse to offer the best user experience (ex: cash withdrawal, deposit, storefronts, etc) to customers. In this context, the users and banking staff could use their avatars to have seamless, beyond spatiotemporal virtual transactions (Wang et al., 2022).

Inspired by these instances, as shown in Fig. 4, we proposed the Metaverse banking model consisting of four layers. At the bottom, we have the hardware and networks layer that comprises enabling technologies for Fintech in general such as IoT, chatbot etc., to provide customer data by mobile phones, credit cards, ATMs, etc., and security of transactions through blockchain, cybersecurity along with networking modalities such as 5G and 6G to provide bandwidth, reliability, etc., for the financial data transmission. In the next layer, the model offers computational and intelligent services to the customer data acquired through the lowest layer. As the data comes through various devices in variety of formats, AI is necessary to evaluate such massive data. A few of the intelligent services include providing loan evaluation assistance to a new customer who has a high potential to repay, yet has no credit score by predicting their spending pattern. Similarly, by embracing AI in banking, we shall achieve better market prediction, risk analysis, etc. Altogether, the two layers at the bottom offer data, networking, pre-processing, security, analysis, and prediction services. We know that use of Metaverse in financial transaction will facilitate better user experience, optimize cost of operation, and so on. Therefore, we have the upper two layers offering the Metaverse experiences. The upper two layers provide Metaverse experience by generating Extended Reality (XR) content, avatars, holograms and so on to offer services to the top layer. These avatars, and XR data forms the key elements that translate the user data from banking processes to be ported into the virtual Metaverse locations. Finally, the Metaverse user services layer will offer services such as immersive seamless banking, online trading using virtual objects and currency, remote training and skill transfer for improving the QoS, etc. For instance, collaborative remote work using AR/VR platforms shall be enhanced by switching between the workspaces virtually while chatting, screen-sharing, etc., with the help
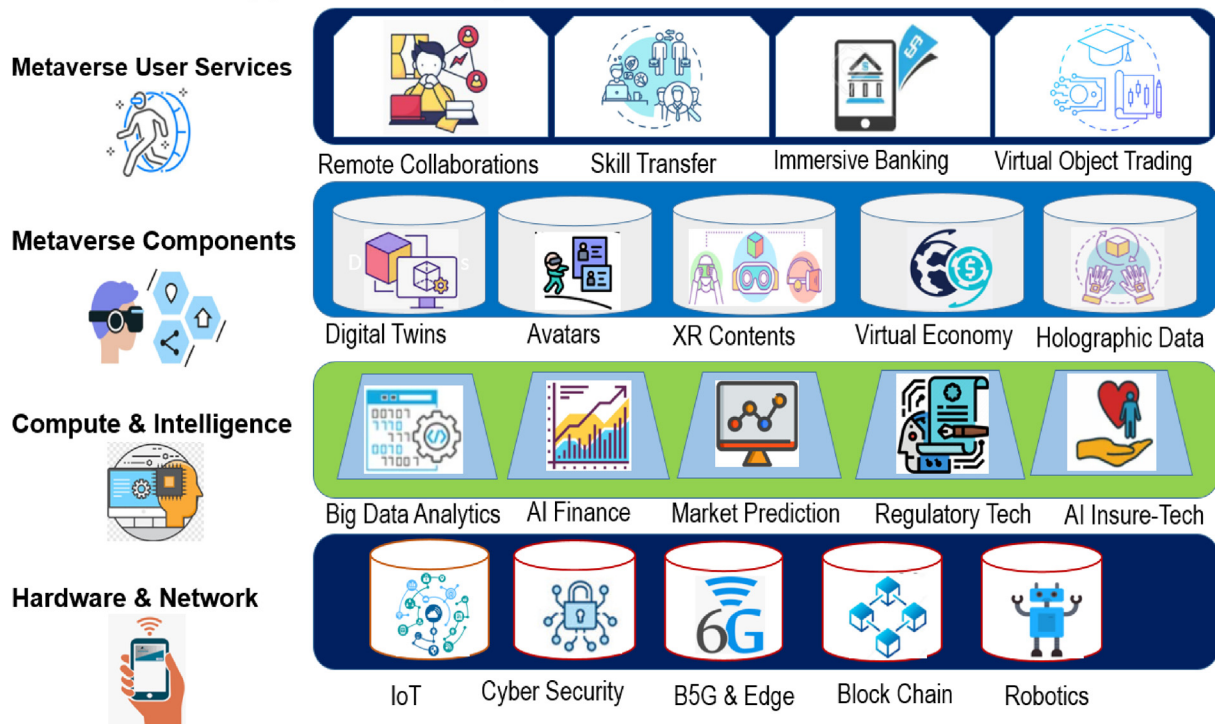
Fig. 4. Framework of a Metaverse enabled bank.

of Metaverse to bring in seamless transitions between collaborating parties. This brings new revenue and business models.

4.6. Blockchain

The rise and popularity of cryptocurrency has led to decentralization of financial transactions beyond the borders. At the same time, the risk involved with such transactions has multiplied. In this context, we see blockchain as facilitator which will enforce secured financial transfers. blockchain plays a vital role in Fintech due to the following features, namely immutability of data, decentralized operation allowing modification by all participating users and updates based on mutual agreement (Obushnyi et al., 2019). Further, as a distributed ledger, blockchain offers security and decentralized operation, which makes it an ideal candidate to enforce security of cryptocurrencies.

Moreover, when we connect millions of user devices and processes to internet and remotely access, the financial data generated in each step of the financial process could be recorded in a transparent way for verification in the future. Moreover, the distributed ledgers are applicable in tracking of assets during mortgages, digital identity, smart contracts, and online trading.

Another use case of blockchain in finance is smart contracts. Most of the financial transactions are a contract between two parties who oblige for a service. For instance, bank loans require to verify the credit scores of the borrower, ability to repay, continuous account management, etc. Thus, every proceeding of that contract should be transparent, and if automated, it should be trustable. The blockchain has the potential to automate the contracts and provide security. Several banks and financial services have integrated chatbots that analyse user's data access pattern, shopping interests, and even history of transactions while providing suggestions on investments and future shopping. As a practical model, Samsung has embedded Stellar blockchain wallet into the phones that uses secured cryptocurrency technology to store the

private keys to offer security for financial transactions done through the mobile phone.

4.7. 5G and Fintech

5G promises to offer high data rates, and low latency while offering massive connectivity for IoT. Consequently, one shall exploit high data rates for financial applications such as VR based mobile apps for advertising, high graphical (3D) investment charts, and promotion of monetary discounts through Device-to Device (D2D) communications when users are near the shopping mall, bank, etc. In general, 5G will enable faster adoption of AI, IoT, deep learning, quantum computing, and blockchain in Fintech (Bhat and Alqahtani, Jan. 2021). Further, 5G will enable banks to scale up in terms of financial data and enhance user experiences.

Let us consider a scenario of a Fintech that includes a common household requirement of operating a IoT enabled coffee machine which doesn't have critical requirements. On the other hand, an emergency medicine dispenser that requires low latency. Both the devices operate under a common 5G network. Now, due to 5G's network slicing features the services could be offered to both during the payments to automate the services as shown in Fig. 5. These we termed as smart home financial services. This example considers the financial transactions for the food and medical supply delivery system. For instance, as shown in Fig. 5, in the lower part, we have an emergency smart medicine vending machine. It is capable of communicating wirelessly (5G) with an access point or edge computing facility to indicate the status of emergency medicine in the machine. In case, if the machine is out of medicine, the edge computing facility located in the proximity (say at the access point) of the machine shall order the medicines from the nearby suppliers by sending a notification to them. The intelligent algorithm in the edge computer will compute the price and perform online payment to the supplier as soon as the medicine has been refilled into the vending machine. Since the computations
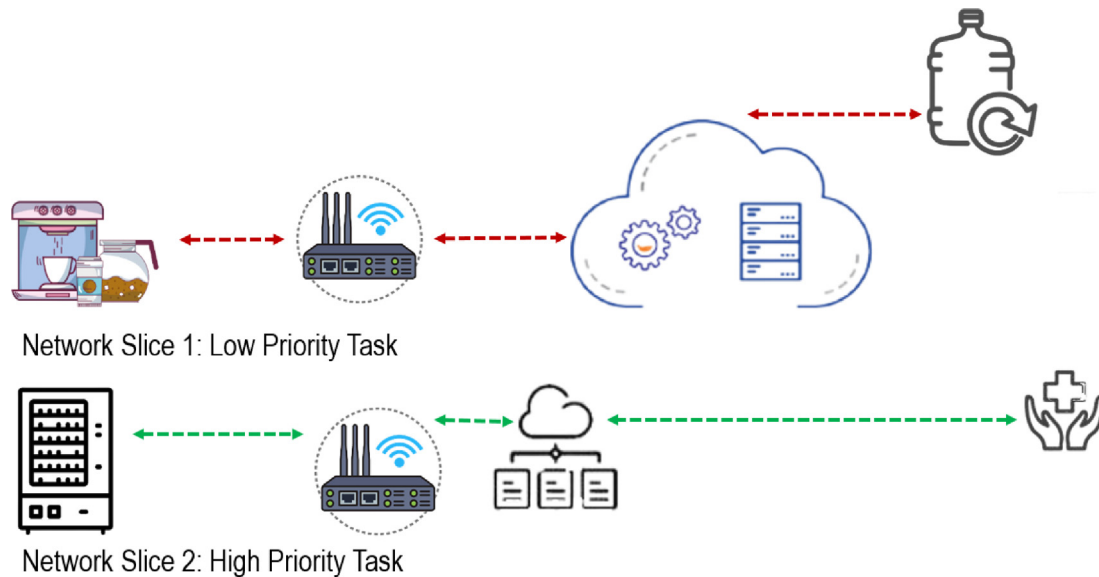
Fig. 5. 5G's latency aware use cases for Fintech.

take place at the edge computing facility, we shall avoid the delay associated with the cloud systems. On the other hand, for a non–critical service, a coffee vending machine may indicate its status through cloud services which shall compute the charges, pay through cloud service Apps and communicate it to the service provider to refill the coffee beans or water to the machine. This model integrates the financial services using 5G's use cases of critical or non-critical instances. Altogether, communication technologies such as 5G and beyond are essential to provide QoS in every aspect of data transmission either it maybe within a short distance or in long distances.

Next, we have D2D communication which is one of the technology components of 5G promising financial services. Through D2D communication, the shopping malls could advertise their products, and promotion codes to the potential customers in the proximity (say 1 km). Consequently, the users could see the product details and respond instantaneously through D2D links. This is a new paradigm of business promotions.

4.8. 6G the next gen network

Certain technical aspects of immersive financial experience require extremely high data rate (transmission of financial holograms), lowest latency (authentication, access control messages in financial tactile internet), localization (cm level precision of location information of financial IoTs), privacy and energy efficiency (longevity of user device) that 5G could not support. Future Internet applications including digital finance necessitate an amalgamation of control, communication, computing, storage, intelligence, and sensing characteristics. For instance, during fraud detection, learning the location of the financial transaction (device), analysing the authenticity of the user, evaluating the fraudulent operation, and communicating the control messages to the bank and to the device necessitates a convergence of several network characteristics as mentioned earlier. The existing 5G would face challenges in the above context which requires sensing, intelligence, reliability all at once. Further, the studies on 6G have anticipated that 6G shall bring in the above mentioned features that could be easily extended to Fintech to offer a wide range of services (Bhat and Alqahtani, Jan. 2021).

Key features of 6G: (i) 6G will utilize a wide range of frequency spectrum spanning to 300 THz and more while offering 100 GHz of

bandwidth in order to make the Tbps data rate possible. This is essential to host tactile banking effects in Metaverse banking models. (ii) Secondly, extremely low latency and high reliability of data transmission feature will introduce a tolerable end-to-end delay of nearly 0.1 ms and reliability up to 99.9999999 %. These figures of very low latency (sub-ms) and reliability (up to nine 9′s) (Dang et al., 2020), will be essential to enforce no loss of financial information during any data transactions including XR- based gaming, Metaverse online content delivery, etc., The extremely low latency aspect stems from the optimization of the cross-layer design of the communication stack, integrating intelligence at the sensing, mobility management, resource allocation, and so on. (iii) Thirdly, 6G will incorporate AI in every aspect of the network architecture which is essential to analyse a variety of financial big data and make optimal decisions. (iv) Next, 6G will enforce high security through quantum computing and blockchain algorithms, which is another key requirement of Fintech.

Edge Intelligence: Edge computing is one paradigm that allows processing and computing activities at a facility near to the user where data is required or generated. Thus, reducing the overall latency. In the case of financial transactions not all data are time-critical. Nevertheless, the time-critical information such as login credentials (ex. facial scan), virtual tellers, verification of subscription, etc., should be processed at the earliest to send feedback to the user. In this context, employing AI algorithms at the edge of the network i.e. Edge Intelligence (EI) that could analyse and make the decision will lower the latency and energy consumption than processing at the centralized cloud platforms (Munusamy et al., 2021). It also saves bandwidth, enhances privacy, and reduces the need for data aggregation. However, there are challenges with respect to running resource-hungry AI algorithms on constrained edge devices to make them edge intelligent. Thus, further research is necessary in this regard.

4.9. SmarApps

The mobile Apps really speed-up the financial services while comparing them against the web-based payment services. Moreover, integration of financial services with the social networking Apps is one of the disruptive factors and has the potential to drive the future of digital banking. For instance, WeChat a popular messaging App has integrated food, transportation, entertainment, and

money transfer services. Similarly, WhatsApp users also shall use it for financial services. Moreover, the smart Apps enable users in investing their money in various financial projects on a predetermined term and adjust the investments based on the liquidity of the funds. These Apps shall even educate them with regards to the various terms and conditions of such investments (Gai et al., 2017).

Next, few Apps provide access to instant loan on certain commodities. In some cases, (ex: AliPay in China) the App will facilitate easy purchase of goods by the customers directly from the seller's website in the local currency at a minimal service charges. This, eliminates the need to have a multi-currency credit card, or conversion of currency. One of the heavily used smart phone App for financial transactions is the banking App. It provides avenues for loan, investment, fund transfer, account details, risk analysis, contactless payment, etc., where the user only needs a mobile phone and internet connectivity or Nearfield Communication (NFC) to access these services. In some cases, the pre-paid QR code vouchers and SMS (cell-phone text messages) will also enable fund transfer without the need of internet connectivity (eg. e-RUPI in India). Overall, we anticipate that in the future the even the non-banking mobile Apps will emerge as *all-in-one Apps* by incorporating multiple services besides managing financial requirements. This phenomenon will challenge the way in which the traditional banking Apps function, especially, when the Apps become intelligent, capable of monitoring the user's activities and recommend avenues for better services at a reduced cost. A popular use case of NFC is as pre-paid cards to avail cashless services in various sectors such as transportation, shopping, etc (Mehrban et al., 2020).

4.10. Digital twin for Fintech

Let us discuss how the digital twin model could assist to build financial services for different verticals. With the digital twin, first, we represent the physical model of a specific vertical, say smart agricultural, smart vehicle insurance, etc., in cyberspace by acquiring all types of major inputs (data) and continuous synchronization. Further, the acquired data can be subjected to simulations which helps in better modelling of the overall physical process being monitored and modelled as a digital twin at the digital level.

For instance, in case of smart agriculture, the data obtained through sensors helps to build the digital twin of the farm. Such a digital twin will integrate intelligence, analytics, prediction agents with respect to finance and the specific vertical (i.e. environment in case of agriculture). The model will offer feedback to the physical world (i.e. agricultural process) to adjust the process. As an example, the digital twin of a farm may recommend the irrigation system to sprinkle more water to prevent yield loss, accordingly the sensors would control the value. In another case, suggest the farmer to sell the crop at an outlet that offers the best price on that day to the crop by analysing its quality. These services will enable financial analyst or Fintech to introduce competitive prices to customers for the offered services.

Similarly, when we build the twin for vehicle insurance system, the twin will collect data from sensors in the vehicle, analyse the fuel efficiency, determine the distance to the destination and available routes, no. of toll centres, nearest fuel refill station, fuel prices, etc., to decide the cost efficient routes. By using the current and historical data, the twin model will issue predictions. In this way, digital twin enables financial solutions using data and technology. Overall, the digital twin model helps to introduce attractive financial services to customers as the data from the digital twin model can be processed and analysed based on the customer's expectations and service demands.

In the Fig. 6, the digital twin model consists of four layers. At the lowest level, the sensors related to a specific sector (banking and vehicle insurance) gather data. To be specific, in case of vehicle insurance data will be collected from sensors located at the steering, wheels, engine temperature, etc., Similarly, in case of banking system, data from cell-phones, credit card usage, payment pattern,
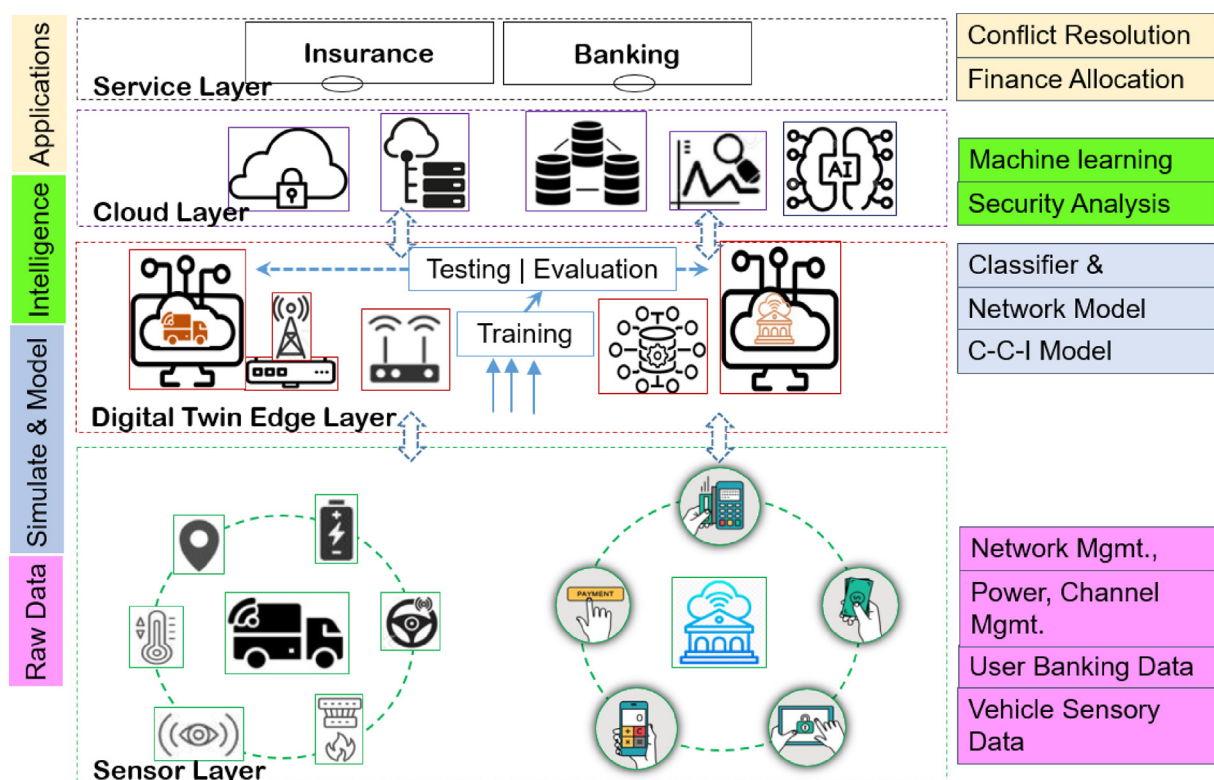

Fig. 6. Digital Twin framework for Smart banking and Insurance.

Table 1

Summary of literatures on various Fintech Enablers.

References	Enabler Technology	Application Area	Research Direction and Key Contributions	Trade-off
(Marafie et al., 2018)	IoT	Insure Tech	• Method of determining the optimal insurance cost and feedback using real-time driving pattern has been proposed. It uses IoT based monitoring and feedback device, the fog analytics engine, real user data (MapBar Auto Guard), and the cloud server to achieve the task.	(+) The proposed model offer an attractive service value and customer satisfaction (-) Requires only real-time data which may not be feasible all times.
(Arora and Kaur, 2020; Huawei Bank of Things White Paper, 2020)		Banking	• Proposed a framework for intelligent banking (vehicle loan management) different from conventional mainframe based storage. It used banking data from RFID, barcode tags, mobile phone, GPS to collect user data and applied machine learning at the cloud storage to determine the risky driving patterns. In (Huawei Bank of Things White Paper, 2020), the author proposed a new term 'bank of things' to highlight that how banking processes shall be enhanced by the use of IoT.	(+) The framework is economical, energy-efficient, and scalable for the given scenario. (-) Delay sensitive cases are not addressed due to cloud based model.
(Maiti and Ghosh, 2021)		Business	• This study highlights that current Fintech services use IoT in a limited sense; however, there exists enormous potential in business process by adopting mobile network, blockchain, and data. The study proposed a new paradigm of IoT (i.e. Neurotech) by incorporating IoT sensors in the brain to perform efficient business decisions.	(+) Brain initiated communication will be the key technology of the future IoT as proposed here. (−) Brain-implantable sensors and actuators requires further research.
(Khuwaja et al., 2021)		Stock market	• The authors proposed a framework for stock market price analysis using adversarial training strategy (adversarial learning network) and reinforcement learning. The study used modified newton-divided difference polynomial (NDDP) for missing data imputation, long short-term memory networks for market volatility prediction.	(+) The adversarial learning network provides the best result compared to the candidate procedures. (-) The heterogeneous database is limited.
(Pelckmans, Feb. 2020)	Bigdata	Online payments	• This study proposed two methods of analysing the financial transactions involving massive data. Authors investigated K-means and FADO schemes and concludes that FADO scheme (single cluster) out- performs K-means (multiple clusters) as against the conventional beliefs.	(+) The proposed K-means anomaly detection in financial data out-performs the existing schemes. (-) semi-supervised methods will be better than the proposed un-supervised one.
(Xiang et al., 2020)		Finance audit	• The authors proposed a method for cross validation of financial data using *meta*-learning algorithms. Specifically, two asymptotic meta learning algorithms (AML-Lin and AML-Xiang) in the article have limited complexity and high efficiency on real time large financial data.	(+) Better computational cost by asymptotic meta learning, despite noisy financial data. (-) Proposed algorithm requires improvement in terms of credit risk modelling and block-chain approaches.
(Obushnyi et al., 2019)	Blockchain	Real estate	• The article proposed a protocol for transfer of property rights to values between digital twins that act as notary. The proposed theoretical model envisioned various economic agents like robot or other machines and their digital twin for validation of the property values.	(+) Transfer of values ownership is made simple and at zero cost blockchain. (−) The twin model requires extreme data rate for synchronization.
(Dustdar et al., 2021; Zhang and Zhou, 2020; Vazquez et al., 2019)		Smart contracts	• (Dustdar et al., 2021) Proposed a reference architecture for Elastic Smart Contracts as suitable for multi-platform IoTs for Fintech. (Zhang and Zhou, June 2020) This state-of-the art manuscript discussed the security and trust for Fintech using blockchains along with the challenges.	(+) Proposed solution is efficient and adaptable. (−) real-time traffic analysis is missing and shall be investigated (Dustdar et al., 2021).
(Cao et al., 2020)	AI	Business	• This review paper discussed the businesses and challenges, data repositories, business decision and optimization methods using AI. The neural computing, evolutionary computing, deep and reinforcement learning, and hybridization methods will be the key directions in AI for future Fintech, as per the proposition in the paper.	(+) Survey address the broad picture, potentials, and challenges of AI-enabled smart FinTech.
(White Paper: Building the AI bank of the future and Company, 2021)		Banking	• This white paper discussed an end-to-end view of an AI bank's full stack capabilities. It highlights the need, obstacles, and scope of transforming from a traditional bank to an AI-bank. Further, obstacles such as regulatory requirements, security standards, and lack of innovation are the key hindrances in establishing the AI-banks of the future.	(+) Proposed a detailed framework of AI for banking. (−) These frameworks requires extensive validation before the actual implementation which is missing in the study.
(Munusamy et al., 2021)		Edge networks	• The authors proposed a mathematical model for financial data analysis at the edge of the network by AI-based task classification and rank estimation. It implements support vector machine at the network edge for delay sensitive financial applications.	(+) Addresses the latency issues of Fintech through edge deployment through SVM. (−) However, there is network overhead which requires data aggregation.

Table 1 (*continued*)

References	Enabler Technology	Application Area	Research Direction and Key Contributions	Trade-off
(Hou et al., 2021)		Stock market	• This paper discussed the stock market dynamics using deep learning analysis on the financial data. The data is tailored using variational auto-encoder, clustered and graph model was created using long-short term memory network.	(+) Most suitable for time series prediction with hidden spatial dependency. (−) Data set preparation and computational time are the limiting factors.
(Kanak et al., 2019)	Digital Twin	Industry	• This article proposed a framework for implementing secure financial transactions in industry 4.0 using digital twin and blockchain.	(+) The proposed model is simple to execute in terms of technology and computations. (−) The ecosystem requirements such as data rate, storage, and latency requirements have been not evaluated.

etc will be collected by the sensors. At the twin level of this sensor layer includes computations such as management of device and network properties namely, power level, interference, network density, transmission parameters. Upwards, the collected data enters the edge computing layer where actually digital copy of the data is stored and analysed to build the intelligent twin model of the underlying phenomenon. By building a digital twin at the edge layer, time critical responses shall be communicated to the sensors at the earliest. However, due to limited computing facilities and local data, building a complete model at the edge will be a real challenge. The twin edge layer mainly builds the Compute-Communicate-Intelligence (C—C—I) model. As per the C—C—I model, data from the sensors will be pre-processed, trained, tested, evaluated and transmitted to offer predictions for the services which requires timely services. Altogether, the edge layer processes local data to offer quick predictions at edge. Later, the remaining data will be processed at the upper cloud layer for delay tolerant applications. At this layer of the twin, i.e. cloud computing level, data from lower layer (i.e. raw data) will be temporarily stored, processed, represented appropriately. In addition, intense machine learning algorithms are used to create a training data set for predictive models which run at the edge layer, and develop classifiers for financial analysis.

Moreover, certain processed data (i.e. cleansed data) also comes to cloud layer from the edge layer for further processing and sent to the applications. The layer also builds a security model for the twin. It could include blockchain, or advanced crypto methods. Altogether, AI models will enhance the functioning of the twin by playing a major role from the cloud layer. All non-critical computations shall be performed at the digital twin at the cloud level. Finally, the service layer has the user interface or App to the specific service sectors (insurance, banking, Agri-tech, etc). The service layer sends feedback based on the received data from the underlying layers, or by considering the user requirements. The said feature facilitates adjusting user requirements and enhancing the customer's experiences. The other main functions involve allocation of financial resources, resolution of conflicts in case of mortgages/ banking to the appropriate applications using AI data from the lower layers.

Further, from the sustainability point, digital twins should consider the infrastructure's health as well. the data centres that compute and process user data requires maintenance to avoid power failures and other errors. In this context, digital twins could model the overall operation of a data centre on a cyberspace and predict outages to reduce service disruptions.

5. Technological challenges and future directions for Fintech

In this section, we discuss the key challenges w.r.t implementation of financial solutions and provide directions for the future research on Fintech. There exist several Fintech solutions using IoT, smart Apps, blockchain, AI, digital twin., etc as mentioned in Table 1. However, in the context of next decade (say 2030), there would emerge several financial use cases that require advanced technology, specific performance metrics, and innovations. Because, the existing technology may not be able to serve those requirements.

i) *Digital divide*: Since most of the financial data depend on internet, the internet connectivity at different regions across the globe will challenge the inception of Fintech services. The current mobile Apps could not provide offline financial services at scale (Gai et al., 2017; Mehrban et al., 2020). Thus, there is a need to wipe out digital divide by the network of communication satellites (i.e. low earth orbit satellites), offline financial services such as QR-codes and pre-approved fund transfer, etc. to promote ubiquity of financial services.

ii) *IoT challenges*: To offer excellent QoS to customers through tactile or haptic ways requires advanced sensor and actuators which could transfer haptic data. At the moment, such devices are far from technical maturity. Even though 5G is anticipated to provide tactile effect, it will fall short of its capabilities (Paper, 2019). Further, carrying tactile effects requires tactile internet with extremely low latency or perfect synchronism. We reckon that 6G will be the key enabler of such services (Bhat and Alqahtani, Jan. 2021). For instance, time sensitive financial data arriving from large distributed synchronized networks requires extremely low latency. In such a context, in order to monitor the performance of such systems, data capture is done at regular check points with high precision time-stamping. Therefore, sensors, actuators, and network architecture needs to be developed to carry tactile data from end-to-end which is challenge ahead.

iii) *Cybersecurity*: One of the key threats to Fintech is cyber-attacks including fraud detection and prevention. The blockchain and distributed ledger seems promising to enforce security to certain extent (Obushnyi et al., 2019; Kanak et al., 2019; Mehrban et al., 2020). However, quantum key cryptography would offer an extreme security which requires further research (Aji et al., 2021).

iv) *Regulatory requirements*: Fintech will face challenges with respect to policies that deals with data handling and user privacy, distributed operation of virtual currency, regulation of interface for APIs and Fintech companies (Mehrban et al., 2020). This challenges could be handled by framing the efficient and inclusive regional (or global) techno-financial policies. Therefore, academia, industry, and other R&D organizations should develop the framework by 2030.

v) *Edge Intelligence:* for fast trade decisions, financing high-speed games etc., require the AI algorithms to be executed at resource constrained edge devices. As we know that most of the AI algorithms are resource hungry, it becomes a real hurdle to run those AI algorithms that deal with financial decisions on the edge devices (Munusamy et al., 2021). Therefore, we need to device an efficient and resource aware, lighter AI algorithms for these applications. In another instance, data training and inference shall be split and performed at cloud and edge layers, respectively to reduce the load on the edge. Similarly, data pruning methods should be devised to make these algorithms run efficiently at the edge.

vi) *Analysis of market behavior* is one area which includes analysis of customer behavior and life style (i.e. social and online attitudes), impact of public events such as fall of a govt., war, social sentiment, and so on are the highly challenging research areas due to the presence of dynamism and interdependency between the parameters. In this regard, fine-tuning of deep learning, data science, and data-genomics will be helpful.

6. Conclusion

Fintech has been evolving with disruptions in technology and innovations in data science, cybersecurity, computing and communications. In this paper, we discussed the key aspirations of the future financial applications and how the next generation of IoT, and networks will contribute towards reaching that technology driven financial requirements. Initially, this study provided a categorized survey of various technologies that facilitates Fintech operations and later discussed the future driving trends and candidate technologies to assist Fintech. Next, we proposed new use cases and frameworks for Fintech using IoT, 5G, digital twin and Metaverse. Moreover, we discussed the challenges of Fintech and recommend that involved collaboration between financial institutions, the tech industry, and academia is necessary for research, technology development and early inception of Fintech in the society.

From this study we infer that the ecosystem of next generation of IoT such as AI, IoT, 5G/6G, Metaverse, digital twin will be the cornerstones of large scale global finance and business by 2030 to attain the UN-SDG (1 & 8). However, we recommend constant and meticulous efforts while making financial regulations as neither hard to use nor easy to breach. Further, extensive research is necessary for secure, scalable, sustainable, zero-touch, and green Fintech practices.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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