Detailed Project Report (DPR)

National Mission on Interdisciplinary Cyber-Physical Systems (NM-ICPS)

On

Technologies for Financial Sector (Fintech)

Indian Institute of Technology Bhilai

GEC Campus, Sejbahar,

Raipur-492015(C.G.)

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Indian Institute of Technology Bhilai
GEC Campus, Sejbahar, Raipur 492015
Chhattisgarh, India
Phone # 9957561026

CERTIFICATE

Name of the TIH: TIH, IIT Bhilai

Technology Vertical: Technologies for Financial Sector (Fintech)

1. This is to certify that the Detailed Project Report (DPR) on the Technology Vertical of Technologies for Financial Sector (Fintech) is prepared and submitted to Mission Office, NM-ICPS, DST as part of implementation of Technology Innovation Hub (TIH) at Indian Institute of Technology Bhilai, GEC Campus, Old Dhamatari Rd, Sejbahar, Chhattisgarh 492015 under National Mission on Interdisciplinary Cyber-Physical System (NM-ICPS).

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3. The DPR will be implemented as per the Terms, Reference and Clauses stipulated in the Agreement signed on 29th January 2021 between Mission Office, DST, IIT Bhilai and IIT BHILAI INNOVATION AND TECHNOLOGY FOUNDATION (IBITF)

Date: 16th Sept. 2021

Place: IIT Bhilai

Prof. Santosh Biswas
Project Director, TIH IIT Bhilai

Dr. Prashant Agnihotri
Project Director, TIH IIT Bhilai

1. Executive Summary

The financial technologies and tools are nowadays undergoing a quantum leap at both micro and macro levels, keeping pace with the enormous advancements happening in the domains of Information technology and data sciences, further turbocharged by the easy access to various Internet and mobile platforms, as never seen before in the history of mankind. These changes will, to a great extent, impact all forms trading and financial activities, and are demonstrating great promise to benefit both the government and industrial stakeholders, as well as the retail sector merchants and consumers, in their day-to-day business dealings. FinTech is one of the fastest-growing areas with influence on all forms of financial services encompassing, inter alia, direct and indirect debit payments, handling of loans and credits, credit scoring, e-commerce transactions, stock trading and insurance, to name a few. As per the reports of KPMG India and b ! { { / h a Σ ƛ y ű K Ŝ ∃ f ƻ ō l f LJ l NJ f l y Ŏ Ŝ Σ largest Fintech l ă technology hub (trailing just after the US) reaching about USD 2.4 billion in 2020. Driven by factors like innovation-based start-ups, large market base, along with favorable regulatory policies and government-led initiatives, India is witnessing more than 2000 start-ups operating in the space of financial technologies. Financial technologies in India, though at a nascent stage, are increasingly becoming an indispensable part of everyday transactions thereby making a shift from traditional to digital payments.

The TIH at IIT Bhilai strives to provide the finest and the state-of-the-art research and engineering solutions for diverse FinTech products mainly in the following four verticals, Payment systems, Blockchain Technologies, Artificial Intelligence and IoT. To elaborate, under the umbrella of E-payments, projects aiming at development of products facilitating minimal physical human intervention, enhanced security, low cost, unification of different modes of transactions on a single device/platform, functional under low bandwidth or even intermittent Internet connectivity (i.e., for rural and remote areas), applicable for a wide range of utility services like water supply, electricity, waste management, transportation etc. will be at priority. On the Blockchain angle, projects will focus towards applied research wherein techniques like Consensus algorithms, Powerful smart contracts, Permissioned and permissionless hybrid platforms, Integration of hardware modules in Blockchain architectures etc. will be carried out that will enhance the

effectiveness of Blockchain technologies in the FinTech arena. Application areas would be Micro-payments, energy trading, secure digital identity management etc. The grand challenge problem of the TIH that aims to create a landmark technology in the Fintech arena in global parlance would be based on such Blockchain technologies and would comprise development of Peer-to-Peer Networks, the Artificial Intelligence, the focus is on development of efficient models for FinTech applications, for example, evaluation models for predicting client risk in terms of mortgage, loan, health policy and investment; algorithmic trading models to provide stock market related suggestions like when to sell, hold, or buy stocks etc. The fourth vertical is based on IoT paradigm, which is mainly responsible for sensor-actuator based interface to the FinTech applications. The focus in this vertical comprise development of IoT enabled FinTech products like Smart ATMs, reliable authentication devices, wearable gadgets to collect client related information etc., enhancing the security environment for IoT devices, and testing of IoT based systems.

Entrepreneurship and innovation are relevant in many different sustainable business contexts, specifically in emerging technical fields like FinTech. As a part of the TIH, one of the foremost plans is to establish a strong support system for entrepreneurship and start-ups in the Fintech arena.

Hand-in-hand with the applied research and entrepreneurial related activities in the FinTech area, focus will also be to drive HRD and Skill development. The major heads in endeavor comprise short term programs like Certification courses, Workshops, Train-the-trainer courses etc. Formal Education in Fintech comprising Electives courses in UG/PG degree courses, Postgraduate programs for Fintech, Fellowships for PG and PhD students etc. is also an important part of HRD activities of the TIH.

To augment the capabilities of the in-house team of the TIH, a strong collaboration mechanism in place Collaborations with academia both at national and international level have been established in terms of exchange programs, joint projects and student mentorship. To incorporate the accepts of real life market needs in the projects, access the productization viability of the on going projects, help in productization and marketing the promising prototypes, collaboration with industry and GoI organizations working in the FInTech area have been established.

The execution of the activities of the TIH will be through a Section-8 Company. Overall governance of the company will be through the board of directors. In addition, the TIH will be managed by a Hub Governing Body (HGB), which is the Apex body for overall supervision, control, directions and mid-course correction of the activities of the TIH. For execution and management of technical activities like evaluation of project proposals, evaluation of on-going projects, mentorship, HRD and skill development etc. committees comprising experts from academia and industry will be involved.

This TIH on financial technologies is a perfect match to most of the recent GoI initiatives namely, cashless India, digital India, Industry 4.0, SMART Society 5.0 etc. and the benefits of these schemes have shown up very prominently in the COVID times when most of the important business activities are happening on-line. As the main goal of the TIH under the overall CPS program is facilitating the entrepreneurship and start-up parlance in the Fintech area, it will be feeder to GoI initiatives like Make-in-India, Skill India and Start-Up India. The key beneficiaries from the products and solutions targeted by the TIH include, Fintech service providers, End users of digital economy (with special emphasis on rural economy), entrepreneurs and academia comprising faculty members and students.

The goal of the TIH is to foster an ecosystem that starts with basic research of CPS and then translates to the applied domain in the broad area of financial technologies. The outcome of the research would be reflected in terms of IPs, patents, research publications, white papers, book chapters, PhD and Y l· ă útîSNJS2ătc. The application of the research would be translated into prototypes/products and the impact will be in terms of successful start-ups, marketed products, turnover of the start-us, job creation etc. To make the TIH self-sustainable, after five years of funding by MNI-ICPS DST, fund raising will be through initiatives like certification programs, workshops and training programs, consultancy services etc. In addition, another major source of funding will through the successful start-ups incubated from the TIH. As an example, the startups incubated at the TIH and successfully running as a MSME (or large scale industry), will be required pay a minimal percentage of the profit for a period that is equal to the time they were incubated in the TIH.

2. Context and Background

The financial technologies and tools are nowadays undergoing a sea change at both micro and macro level, keeping pace with the enormous advancements happening in the domain of IT facilitating easy access to Internet and mobile platforms. These changes are, to a great extent, impacting all forms of trading and financial activities, and are demonstrating great promise to benefit both the government and industrial stakeholders, as well as the retail sector merchants and consumers, in their day-to-day business transactions.

Financial technologies have emerged as one of the most thriving sectors in terms of business growth, adoption among the customers, employment generation etc. As per the reports of KPMG India and NASSCOM, India is the largest financial technology hub (trailing just after the US) reaching about USD 2.4 billion in 2020 [1]. Driven by factors like innovation-based start-ups, large market base, along with favorable regulatory policies and government-led initiatives, India is witnessing more than 2000 start-ups operating in the space of financial technologies. During the Union Budget-2020, it was announced that businesses with an annual turnover of more than INR 50 crore would have to use digital modes of payment, namely, Aadhaar Pay, NEFT, BHIM etc. [2].

Financial technologies in India, though at a nascent stage, is increasingly becoming an indispensable part of everyday transactions thereby making a shift from traditional to digital payments. The digital payments or e-payments have proven to be rewarding for both at the individual level and for businesses, including the self-employed, rural entrepreneurs, small borrowers, etc. Considering the huge unbanked population, financial technologies is playing a critical role in breaking barriers such as lack of access to financial institutions, high-cost of traditional banking services and policy gaps that prevent a large percentage of Indians to be a part of the formal financial landscape.

Once dominated majorly by start-ups, this sector is now witnessing active participation by established public and private sector banks. Awareness of financial technology has also increased, with a huge base of consumers now familiar and ready to use financial technology platforms to

make transactions. This indicates a positive shift, and presents huge growth potential for the industry as a whole.

One of the major changes witnessed with the advent of financial technologies, is the customer centric model, where companies have recognized the dire need for increased customer orientation. By providing customized, targeted products and services, financial technology companies are not just acknowledging, but also catering to the evolving consumer demands by offering convenience, personalization, transparency, accessibility and ease of use, factors that empower customers to a great extent.

Financial technology companies, in a word, are those that facilitate all forms of financial services, consumer and enterprise, by utilizing software and hardware technologies running on a broad range of electronic devices, ranging from a simple desktop application, to a smartphone, even to an advanced smart watch. The usage of various IoT devices for mobile banking, and for lending and borrowing of services and goods, are a few examples where cutting-edge technologies are being put to use to make financial services more accessible to the general public. More examples of new-age technologies being increasingly used by Fintech applications are IoT, AI, Blockchain, data science, etc. The ultimate goal is to augment or replace the traditional functioning of the financial sectors, in order to improve user experience, and to make transactions more secure, accessible, faster and efficient. Financial technology companies are one of the fastest growing areas in almost all domains of financial services i.e., encompassing, but not being limited to, direct debit payments, handling of loans, credit scoring, e-commerce, stock trading and insurance etc.

Entrepreneurs are key to develop important innovative solutions for complex societal challenges. Entrepreneurship and innovation are relevant in many different sustainable business contexts, specifically in emerging technical fields like Fintech. Entrepreneurs need a strong support and advisory system in order to turn their start-up ideas into valuable businesses. Modern society needs innovations and effective solutions for existing problems. The bright and ambitious minds of entrepreneurs are to turn their breakthrough ideas into successful companies with purpose, driven by their vision. As a part of the TIH at IIT Bhilai, one of the foremost plans is to establish a strong support system for entrepreneurship and start-ups in the Fintech arena. Specifically, the TIH

will facilitate the transformation of innovative ideas to product by taking a holistic approach and providing required support at every stage of ideation, implementation and proper progression.

The vision of the TIH at IIT Bhilai is as follows.

Vision

1. Cutting-edge research and development in financial technologies
2. Scouting for young professionals and students with entrepreneurial skills, and nurturing them to grow
3. Capability and capacity building using HRD and skill development at various levels
4. Contribution towards India occupying the leadership position in the area of financial technology revolution
5. Building a sustainable ecosystem with national and international collaboration

3. Problems to be addressed

There are innumerable set of problems in the Fintech arena that can be addressed through the application of cyber physical systems. The TIH at IIT Bhilai focusses on Fintech solutions in four major verticals, namely, e-Payment systems, blockchains, artificial intelligence and Internet of Things. The targeted problems will be handled using transitional research and products pertaining to financial technologies applicable at local, regional and national level especially in the Indian context. The broad methodology that is planned be applied to solve the problems will involve mapping the problems to projects and the implementation to production phase would be through entrepreneurs and start-ups. This section elaborates the prominent set of problems and projects to be implemented through the entrepreneur and start-up ecosystem.

Alongside the projects to be implemented, the background survey is also presented in brief to highlight the importance and relevance of the projects being targeted by the TIH. The background focuses on the prominent schemes, technologies and products already in use in these areas. The major challenges and drawbacks in the existing schemes are presented and finally we discuss the outlines of the projects aimed at by the TIH to address those challenges.

The set of projects presented in this section are indicative and during execution of the TIH, new problems and projects will be considered based on relevance and merit.

3.1 Background

3.1.1 E-payment systems

E-payment system (or online payment system) is one of the fundamental components underpinning any Fintech application [3]. An epayment system allows financial transactions or payments for goods or services to happen through the electronic medium, without the use of physical cheques or currencies. Credit and debit cards based online transitions are some of the most popular epayment systems available nowadays. Besides them, there are also alternative payment methodologies; some of the prominent ones are discussed below.

- Electronic Funds Transfer (EFT) is a system that is used for transfer of money from one bank account to another without any involvement of cash. Some of the EFT based payment systems include the following.
  - *Direct debit* is a transaction where the account holder instructs the bank to credit the required amount of money from his/her account electronically for payment against goods or services.
  - *E-cheque* is a digital version of the traditional paper based cheque.
  - *Electronic billing* is another form of EFT that is used by merchandise to collect payments against goods or services electronically.
  - *Electronic cash (e-Cash)*: e-Cash facilitates the transfer of funds anonymously using the concept of blind signatures. A blind signature is a digital signature where the message's content is not visible before signing. Therefore, no one can create any transaction link between the withdrawal and spend.
  - *Stored value card*: Cards of this type contain an amount of money that can be used to undertake the required e-transaction, e.g., gift cards.
  - *E-wallet*: A digital wallet commonly known as "e-wallet" is an electronic gadget or online software service that facilitates electronic transactions with another user (may be merchandise) bartering units of digital currency for goods and services. Generally, money is deposited in the digital wallet before any transaction. Further, it is possible that an individual's bank account or credit card etc. is linked to the digital wallet.

Amidst the enormous impact of e-payment systems on Fintech solutions, there are several issues as namely, mandatory requirement of Internet, lack of availability of skilled operators, low exposure and training to students and entrepreneurs in the financial technology domain, low digital literacy, mandate of smartphones and devices for e-payment, difficulty in accessing rural areas, security concerns etc., elaborated as follows [4,5,6].

- *Lack of widespread availability of physical spots for e-payment*: POS devices, Barcodes, QR codes etc. that are used for e-payment by cards and mobile apps, respectively are available

readily in most of the merchandise. However, it may be noted that in many third world countries like India, the number of such spots for e-payments is less compared to the size of the population. Further, in many cases like POS devices, there is a requirement for manual intervention causing delay. Therefore, for applications, where the number of users making e-payments is very large and response time should be low (e.g., gates of a metro station), e-payments by cards or apps is not feasible. To address this issue, use of pre-paid cards with tap points are used for such types of applications, like metro station gates etc. However, in India, at present, such pre-paid cards with tap points are used only for very few applications. Further, in case of any e-payment system, continuous Internet connectivity is required for identification, authentication and authorization of payment. Even in case of pre-paid cards with tap points, if the Internet is not available, it may result in long queues and waits.

- *Multiple cards issued to an individual from different financial organizations, like bank issuing debit and credit cards, merchandise issuing membership cards and pre-paid cards:* In the current e-payment setup, an individual needs to carry a number of cards based on different financial organizations he/she has an association with, as an account holder or member. Similarly, for each merchandise or service provider there are individual loyalty cards or pre-paid cards. In recent times, the number of cards being used by an individual is substantial and for debit and credit cards, there is an extra requirement of remembering the PINs. This may be cumbersome, because different PINs (for security reasons) are to be remembered for different cards.
- *Difficulty of e-payments in rural areas:* The population of rural areas is not very literate and many are not able to independently operate computers or smartphones. So the online payment systems are not widely accepted in the rural areas. Further, still a significant percentage of the population in rural areas use feature phones due to budget constraints. In addition, lack of good Internet connectivity (i.e., having proper bandwidth, suffering from intermittent connectivity etc.) in many rural areas also make e-payments a difficult alternative to the traditional system.
- *Phishing attacks:* t Ƙ ƛ ă Ƙ ƛ ƴ ∃ ƛ ă Ɨ ƴ ˜ Ɨ ű ű Ɨ Ŏ ļ ø Ƙ Ŝ N J Ŝ ű Ƙ Ŝ Ɨ Ř information through luring e-mails or SMSs directing them to spurious websites that claim

to be legitimate. The users provide vital information that include usernames, passwords, credit card, or bank account numbers in the spurious website that are later used for transactions by the attacker on behalf of the genuine user without his/her knowledge, leading to financial thefts.

3.1.2 Fintech and blockchains

Payment systems (or medium of exchange of wealth) have evolved over hundreds of years, beginning with the barter system (introduced by the Mesopotamia tribes in about 6000 BC) to the various sophisticated 21st century e-payment systems that underpin the fancy e-commerce transactions (e.g., Amazon and Flipcart). The highly popular e-commerce system is still not the end of the story. Our conventional payment systems have also been turned on its head by the very recent phenomenon called the Bitcoin cryptocurrency based on the Blockchain technology. Cryptocurrencies (such as Bitcoin and Ether) have shown enormous potential to bring sweeping changes to all our financial transactions as used by the government, industry and the general consumers. Some of the major benefits that the cryptocurrencies have over the conventional fiat currencies are the following [7,8,9].

- More transparency,
- Supporting seamless micropayments (e.g. paying to employees for a fraction of a month or for even a fraction of a day),
- Strengthened user and data privacy,
- Traceability and trackability of goods, services as well as payments,
- Ease of retail trading even with low volume transactions,
- A platform which is difficult to hack,
- Seamless integration of all forms of asset transfers with the existing payment systems without compromising security,
- Less vulnerable to inflation and deflation, if regulated well,
- Smart contracts.

The philanthropy of blockchains in the Fintech parlance is summarized below.

- *Economic output and GDP.* It is noted that a major percentage of Indian economic output comes from the unorganized sectors. The transactions that happen in this sector are highly unregulated, ad-hoc and undocumented, most of the times leading to exploitation and often victimization of the service providers or the retailers. This remains a major source of poverty and a loss of GDP for the country. There is also another similar issue. Although demands and supply exist in these sectors, they do not get converted into concrete and tangible financial transactions due to the absence of a viable computing platform, ultimately resulting in loss of GDP to a great degree. Fintech solutions use advanced cryptographic techniques and protocols and can potentially automate and integrate all kinds of processes involving trading, supply chain management, wealth and asset transfers, insurance, direct money transfer, online auctions and bidding as well as various complex financial instruments such as trading in stock and bonds.

- *Supply chain management.* ! Ŏ Ŏ ƻ NJ Ř ƛ ƴ Ǝ ú ƻ I I· NJ Ø I· NJ Ř . dz ă ƛ ƴ Ŝ ă ă w company could transform global supply chains: Financial technology companies that act as intermediaries in facilitating transactions between a company and its suppliers. They enable both the buyer and supplier to improve their working capital by making it possible for the former to extend its payables and at the same time accelerate payment to the latter. This provides both sides with benefits, including greater liquidity and less variability ƴ ú Ƙ Ŝ ú ƛ Y ƛ ƴ Ǝ ƻ Ŧ Supply chains exist through the collaboration and partnerships of many different companies, which make payment solutions a growing importance. This is where Fintech steps in. Fintech enterprises in the supply chain management play the role of a digital procurement broker. The digital broker uses a network of banks to offer the most favourable trade financing terms to the buyer or supplier. There are many structures for supply chain that a Fintech company can choose, and in most of the cases the process starts with a purchase request from a buyer and terminates once the supplier is paid. Traditionally speaking, supply chain management comprises sourcing, Y I· ļ ƛ ƴ Ǝ Σ I· ƴ Ř Ř Ŝ f ƛ Ø Ŝ NJ ƛ ƴ Ǝ Φ L ƴ ú Ƙ Ŝ pply chain management comprises sourcing, of inexpensive capital.

- *Central Bank Digital Currency (CBDC).* Implementation of the concept of Central Bank Digital Currency (or CBDC for short) is now one of the top priorities of various governments, after the remarkable Chinese efforts and enthusiasm along these lines came to light. The CBDC, if successfully launched, will be able to support collecting and paying various forms of taxes, payments of salaries, handling health insurance related transactions, manage peer to peer lending, railway reservation, payment gateways and retail banking, among others.

- *Deriving credit score.* The current credit management system uses various financial and non financial information of a person to compute the credit score. Such a system therefore has limited scope in terms of retrieving the information from various sources and therefore is cumbersome. Managing credit score using blockchain could not only enable centralization by having all necessary data stored in a common ledger but also bring transparency to the system. Additionally, the blockchain platform will allow lenders to access the immutable records of financial transactions to understand the credit worthiness of a person. Smart contracts ensure the personal information of an applicant is never compromised or revealed.

- *Streamlining government expenses.* By storing the public funds related expense data in a public blockchain, citizens can get all the information on the various heads under which the expense was carried out, thereby enabling transparency in the system. Additionally, funding information of a political party can also be stored in blockchains thereby offering transparency to voters and helping them make better decisions about the political parties.

- *Loan and credit services.* With the help of smart contracts, borrowers can directly deal with the lenders on the rate of interest, installments, and duration of the transaction. Borrowers and lenders can negotiate terms on the smart contracts. If borrowers are not able to abide by the terms of the smart contracts, then smart contracts may add late payment fees to the actual amount to be paid to the lender. In this way, blockchains can make the entire lending process seamless by bringing transparency in the system.

In spite of the tremendous potential of blockchain technology towards Fintech solutions, there has been

only a limited application in real life solutions, especially in India due to factors like, high expectations but low understanding of the technicity and trust, unclear roadmaps, trusted execution environments [10,11,12] etc. The major challenges of applicability of blockchain technology towards Fintech in India comprises the following aspects.

- *Prohibition of use of cryptocurrencies* – RBI and tax authorities in India are not in favor of cryptocurrencies and ICOs due to the issue related to tax evasion and also lack of control of the regulators over the digital currencies. Startups and projects based on blockchain technologies are skeptical about going forward due to the battle between Indian authorities and cryptocurrencies.
- *No clarity in terms of rules and regulations related to blockchain adoption in Fintech* – Blockchains eliminate the need of traditional intermediaries who have played a major role in verification and attestation processes involved in any financial transaction. The use of smart contracts results in a significant deviation from the conventional way of establishing written contracts between two or more parties who meet and discuss the terms and conditions. Such a deviation requires the GoI to set clear rules and regulations on the use of blockchain technology for all financial transactions before they can be adopted by the masses. Such regulations will ultimately result in quick adoption of the technology.
- *Difficulty in integration with legacy systems* – While it is clear that Blockchains can certainly solve some of the complex problems in the Fintech sector, its implementation and subsequent deployment would mean replacement of some of the conventional processes which have been in place for quite some time. Such legacy systems are quite extensive and have several modules working alongside each other. With the advent of blockchain based digital platforms, such legacy systems will need to interface and communicate with the blockchain platform to emulate the end-to-end business logic. This process is not only hard but also incurs huge cost in terms of development and subsequent integration with the existing legacy systems.
- *Lack of human resources* – Any new technology such as Blockchain, requires champions from across industry to support its early adoption. Due to lack of regulations, investors and evangelists have not been able to promote Blockchains in the right spirit. Further, lack of talent to help with

the technical implementation of Blockchain applications, is also another reason for slow adoption of Blockchains in the Fintech domain. In order to enable blockchains in several financial use cases, we need to educate the youth of India in this domain thereby creating more blockchain ŘŜØŜ f ƻLJŜNJă ű ƻ lȄ ă ă ƛ ă ű ƛ yˇ ō f ƻŎ ļ ŎK lȄ ƛ yˇ LJ f lȄ ű ₮ ƻNJYˇ à

3.1.3 Fintech and AI

Artificial Intelligence (AI) is now heralded as the harbinger of the 'fourth industrial revolution'. In fact, it is transforming every industry, just as the invention of electric power did a century before, and most recently the Internet did. According to Gartner, AI is expected to generate $13 trillion in global economic activity in the next couple of decades [13]. The rise of AI presents before enterprises and institutions an opportunity to differentiate themselves and gain strategic advantage over the market.

While AI is not a new invention, the increase in the scale and speed of the existing computing infrastructure and the widespread availability of new computing resources such as cloud, has made it cheaper and faster to tackle problems of significant scale using AI, such as those in the Financial domain. In addition, new emerging technologies now allow handling of large distributed datasets generated by Financial applications and systems for faster processing, making better AI solutions feasible. These factors, coupled with the availability of large volumes of data generated from Financial platforms as well as social media and government agencies are bringing greater reliability to predictions generated by machine learning and bringing AI to the forefront to solve real-world problems quickly and efficiently.

Some of the important problems in the financial domain that can be solved with AI comprise the following.

- *Performance analysis [14,15,16,17,18]*: For financial institutions, the ability to predict or forecast outcomes such as bankruptcy and perform analysis such as credit scoring is crucial, as incorrect decisions can have direct financial consequences. Over the past decade, several financial crises observed in some emerging markets enjoying financial liberalization showed that debt financing Ŏ ƻdz f Ř NJŜ ădz f ű ƛ yˇ f lȄNJ∃ Ŝ lȄ yˇŘ ădzŘŘŜ yˇ Ŏ lȄLJ ƛ ű lȄ f ƻdz ű experience made banking authorities such as Bank for International Settlements (BIS) learn a

number of lessons, among which they all encourage commercial banks to develop internal models to better quantify financial risks (Basel Committee on Banking Supervision, 1999). The main impacts of such research are in lending decisions and profitability of financial institutions. Before extending a loan, banks need to predict the possibility of failure of the potential counter party. Thus, predicting bankruptcy timely and correctly has become great importance for financial institutions. With the rapid growth in the credit industry and the management of large loan portfolios, credit scoring models have been extensively used for the credit admission evaluation. The credit scoring models are developed to classify loan customers either as a good credit group (accepted) or a bad credit group (rejected) with their related characteristics such as age, income and marital status or based on the data of the previous accepted and rejected applicants The benefits of using credit scoring include reducing the cost of credit analysis, enabling faster decision, insuring credit collections, and diminishing possible risk. A slight improvement in credit scoring accuracy might reduce large credit risk and translate into significant future saving. Financial decision-making such as bankruptcy prediction and credit scoring described above, can be regarded as the binary classification problem of classifying an observation into one of the two predefined groups (in the bankruptcy prediction case, bankruptcy or non-bankruptcy). Related studies have shown that machine learning techniques, such as neural networks, outperform many statistical approaches to solving this problem type, and advanced machine learning techniques, such as classifier ensembles and hybrid classifiers, provide better prediction performance than single machine learning based classification techniques.

¶ *Corporate strategies and stock market prediction [19,20]:* Big companies like KPMG, Delloite, PWC, McKenzie group work in the field of corporate strategies where they assist other companies with strategic decisions like mergers, acquisitions, etc. All these activities are driven by huge financial implications that require analysis of past data of performance of companies involved for effective planning, and prediction. These tasks are a natural candidate for applying AI where complex and large models need to be built which cannot be done by existing statistical approaches. For instance, analysis of corporate financial stress is an important complicated property that is usually solved using non trivial statistical measures such as SBM (slack based

models), etc. Similarly, another very important factor which plays a deciding role in governing the corporate strategies is accurate predicti of the stock market trends. Stock market prediction is basically the act of trying to determine the future value of company stock or other financial instrument traded on an exchange. The successful prediction of a stock's future price could yield a significant profit. However, predicting how the stock market will perform is one of the most difficult problems to solve. Intrinsic volatility in the stock market across the globe makes the task of prediction extremely challenging. Investors and mediators working in this field have been traditionally dependent on the experience and relatively crude statistical approaches such as pane regression, z-score, etc., for making informed choices about buying or selling of stock. The rise of AI has revolutionized the domain by building accurate models of stock behavior thereby minimizing the risk to a bare minimum. Using features like the latest announcements about an organization, their quarterly revenue results, etc., machine learning techniques have the potential to unearth unforeseen patterns and insights, and these can be used to make unerringly accurate predictions. The movement of the stock price is classified into three different Ŏ f l· ă ă Ŝ ă NJ Ŝ LJ NJ Ŝ ă Ŝ y˝ ű ƛ y˝ Ǝ ű Ƙ NJ Ŝ Ŝ Ř ƛ Ŧ Ŧ Ŝ NJ Ŝ y˝ ű Ř ƛ NJ Ŝ Ŏ ű Ayesian text classifier is widely used to predict the direction of the movement of the stock price by deriving a set of indicators from the textual data retrieved from various financial news articles. Advanced techniques like Random Forest model, Support Vector Machine approach, Dirichlet Process Mixture etc. have been applied towards the prediction of stock market trends based on historical data, financial news articles, sentiments of Twitter feeds etc. for improved accuracy. Clearly, AI and ML techniques have shown multiple novel avenues to estimate future stock market behaviour and thereby decide the corresponding corporate strategies and prove to be quite efficient in doing so.

¶ *Security for Fintech solutions [21,22,23,24]:* Fraud is a massive problem for financial institutions. Fraud losses incurred by banks and merchants on all credit, debit, and prepaid general purpose and private label payment cards issued globally amounted to $21.84 billion in 2019, according to a Bloomberg report. For decades, financial organizations used rule-based monitoring systems for fraud detection. These legacy solutions were deployed in SQL or C/C++. They were attempts of the engineers to transfer the knowledge of domain experts into SQL queries, which would

typically end up being long, convoluted, and extremely brittle. Further, whenever they tried to change parts of these fraud detection systems later, to update a threshold or something, it led to the breaking of the entire codebase. This prevented banks from fighting fraud effectively as the criminals would just come up with new ways around alert triggers in their weak, rule-based platforms. So now many financial firms have abandoned their legacy tools to try and solve fraud detection with new-age machine learning solutions, and more still are planning to follow this suit in the future. Machine learning is ideally suited to combating fraudulent financial transactions as these models can scan through vast datasets, detect unusual activities, anomalies, and flag them instantly. Similarly, these algorithms can also be trained to detect a large number of micro payments and flag such money laundering techniques. Researchers have successfully used hybrid models combining deep neural networks and genetic algorithms for some selected problems in the domain. Still there is a documented inadequacy of application of AI in many more existing problems in this domain, which indicates a pressing need for better AI based models. Credit card fraud is one such critical problem. For frauds, the credit card is an easy and friendly target because without any risk a significant amount of money is obtained within a short period. To commit credit card fraud, fraudsters try to steal sensitive information such as credit card number, bank account and PIN. Fraudsters try to make every fraudulent transaction legitimate which makes credit card fraud detection a challenging problem. The problem gets more complex as typically, every credit card dataset is highly imbalanced, i.e., carrying more legitimate transactions as compared to the fraudulent ones. There exist few machine learning techniques to handle this kind of problem such as sampling minority classes where class training examples can be increased in proportion to the majority class to raise the chance of correct prediction by the algorithm.

While the area of AI has stated contributing immensely to the area of Fintech, there is quite a large spectrum of issues where research and technology initiatives are required, synopsized as follows [25, 26]:

- The AI and ML techniques need more digital data. The financial data may be imprecise and ambiguous, unstructured and unlabeled. Thus, methods need to be developed for curation and preparation of large datasets in an anonymous fashion for a given financial task. Also, datasets

are made available to the public, then many startups can come up with better solutions for the financial sector. For instance, the time series data that gets generated in financial transactions can be exploited using AI and ML approaches for doing time series forecasting and predictive analytics. AI and ML methods may also be developed for the curation and preparation of datasets.

- Digital transactions have brought a lot of ad-hoc, imprecise and unstructured data originating from heterogeneous sources in the financial sector. The data is also fairly complex in nature with several derived attributes that may be difficult to interpret and analyze because of the non-trivial nature of dependency (if any) among them. Here, the Natural Language Processing (NLP) of digital data from the financial sector has huge scope to disambiguate and add transaction details. NLP using AI and ML approaches will provide good solutions at reduced cost. However, there are several critical challenges in NLP too. For instance, named entity disambiguation is a huge challenge in processing any real world text data as the same entity (say, company name) can be referred using many different forms (different abbreviations, different cases, or different spellings) and requires manual supervision.

- Another major issue on the data and training are confounding and hidden variables. This is especially true for complex scenarios such as pictures. There may be connections we do not consciously notice as humans but a computer might notice. With neural networks, these connections manifest in the hidden layer, and we do not even know that there is a problem, because we do not know what the hidden network contains. Biases also creep into the data, either institutionalized and social biases, like racism, or statistical biases. The latter occurs when the training sample is not expansive enough to represent the real world. This is a major concern both in AI and statistics in general, as finding sufficiently randomly sampled data is not so easy, partially due to the hidden and confounding variables mentioned above.

- Although the ML models have proved to be effective in predicting stock market trends there are still several limitations. The stock models lack taking into account various contextual parameters of dynamic and abstract nature that are hard to quantify in a traditional sense. Factors such as political scenario, economic crisis situations, global events, environmental factors need to be

taken into consideration while building a fairly accurate model. This remains an open problem where AI and ML researchers are still trying to make inroads.

- One of the main issues where the number of solutions is less is fraud detection and prevention. AI and ML can play a significant role in automating many steps for fraud detection and prevention. Currently what happens is, there is human involvement at different levels of transactions to detect and / or prevent fraud. In place of this, existing digital, manual and semi automatic methods may be studied and replaced them with fully automated methods using AI and ML approaches.

3.1.4 Fintech and IoT

The Internet of Things (IoT) is one of the emerging technology trends that are widely being adopted by modern industries, including retail, automotive, smart devices etc. Further, there is a wide range of IoT applications in the Fintech field as well. Some of the promising applications of the IoT in the Fintech solution area are enumerated below [27,28,29,30].

- *Intelligent asset monitoring.* IoT paradigm allows banks to keep vigilance on their equipment like ATMs, lockers etc. facilitating security and the collected information can be used for intelligent business decision making. Some examples include, collecting data on ATM usage to determine the efficiency of usage in terms of location in a favorable site, amount of cash to be stored per day etc.

- *Deeper customer insight.* As businesses are becoming more consumer-centric, it is necessary to offer personalized solutions to the clients. IoT paradigm has helped Fintech companies to ŏ ƨ f f Ŝ ŏ ű ŏ f ƛ Ŝ y ű ă Ω Ř l· ű l· f ƛ ţ Ŝ ō Ŝ K l· Ø ƛ ƨ NJ Σ f ƛ ţ Ŝ ă earning pa ű ű Ŝ NJ y ă Ŝ ű Ŏ Φ ű ƨ Ŝ È ű NJ l· Ŏ ű ƛ y ∓ ƨ NJ Y l· ű ƛ ƨ y ƨ dz l· y l· f è ă ƛ ă dz ă ƛ y ∃ L ƨ ¢ ă è ă ű Ŝ Y ă ƛ y Ŏ f dz Ř Ŝ Σ ű NJ l· Ŏ ţ creditworthiness, navigation help to the clients to find a branch within their reach, providing real-time customer data to consultants and helping them to provide better quality, faster and focused customer support.

- *Wearable banking services*. Augmented with wearables, the impact of the IoT on the Fintech industry has started growing. This technology facilitates the Fintech service providers to allow clients pay the bills, speed up transactions, and enhance quality and security. Some potential manners, the wearable technology is being used in Fintech include, announcements and news related to finance to the wearable device, thereby fostering a meaningful and to the point connection with its customers, provisioning of contactless-e wallets to allow customers to instantly check their account status etc.

- *Authentication and security*. Since the advent of biometric technology, IoT devices with biometric sensors like fingerprint scanners, iris scanners, face scanners, heart beat pattern Y˝ƨ y˝ƛ ű ƨNJ ă Ŝ ű Ŏ Φ Ɨ NJ Ŝ ō Ŝ ƛ y˝ Ǝ dz ă Ŝ Ř Ŧ ƨNJ ά ø Ƙ Ɨ ű è ƨ authentication requirements in the Fintech sector have become quite stringent since clients can now use IoT-enabled mobile apps, make payments, etc. with their fingerprint.

- *Risk assessment for insurance and loans*. Identifying and eliminating risks in the area of insurance and loans has been a manual process till date. With the advent of the IoT paradigm, crucial pieces of information about a client behavior are collected which are then used by insurance companies. Ŧ ƨNJ Y˝ƨ y˝ƛ ű ƨNJ ƛ y˝ Ǝ Ɨ y˝ Ř Ɨ y˝ Ɨ f è Î ƛ patterns relating to health, driving, etc. This allows the companies to distinguish the candidates that can qualify for the insurance based on the data collected by the IoT device, access the probability of repayment of loans etc. A suitable example is, medical insurers wi ō Ŝ Ɨ ō f Ŝ ű ƨ LJNJ ƨ Ø ƛ Ř Ŝ Ŏ dz ă ű ƨ Y˝ ƛ Î Ŝ Ř LJNJ ƨ ű Ŝ Ŏ ű ƛ ƨ y˝ L exercise timings, smoking or drinking habits etc.

While the arena of IoT is quite a recent trend, however, it has found a deep penetration in the Fintech products, especially the ones dealing with customer interface. As the IoT devices are low power, heterogeneous and resource crunched, they pose a unique set of challenges for the Fintech domain. In addition, there is a lack of standards of cyber security of IoT devices, problems due to plenty and variants of communication standards for IoT etc. Some of the IoT challenges are elaborated below [31-40].

- *Security and privacy [31,32,33,34]:* IoT devices continuously communicate and collect information on a network. Further, as the communication occurs over the wireless medium a variety of attacks are possible on the IoT framework that can affect the critical IoT deployment leading to severe consequences and losses. As IoT seeks detailed information about individual users e.g., bank credentials, travel details etc. there is a risk of
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- *Complexity failures and non-trivial testing [37,38,39,40]:* Another factor that also raises questions with regard to reliability of IoT driven services is increased complexity. IoT framework comprises a complex and diverse network of heterogeneous devices, resulting in frequent failures. Application software integrates with IoT devices, issuing commands to the device and analyzing data gathered by the device. Since there are so many variants of software and hardware for the IoT devices, it is non-trivial to test all possible combinations of hardware and software. To define a reasonable subset of test cases for acceptable fault coverage, information from end users to understand which devices and software versions they are using are to be gathered and analyzed. On one hand, a large set of test cases may provide greater failure coverage but test time will be prohibitive. On the other hand, selecting a small but efficient test suite is a non-trivial problem because of the heterogeneity of the system.
- *Lack of standards [35,36]:* There is no well accepted standard for IoT framework, particularly in the Indian context. Therefore, interoperability between the components from different manufacturers is a major challenge
- *Limitation of adaptation of existing security and privacy solutions [33,34]:* For ensuring security and privacy, techniques like intrusion detection system, intrusion prevention systems cryptography etc. are deployed. The literature and techniques for ensuring security and privacy for traditional Internet based systems are matured and have proven their efficacy. However, such techniques can be seldom applied for the IoT paradigm because of low power availability, low resources in terms of compute and memory, heterogeneous nature etc. of the IoT devices. Hence, there is a requirement of lightweight security and privacy solutions.

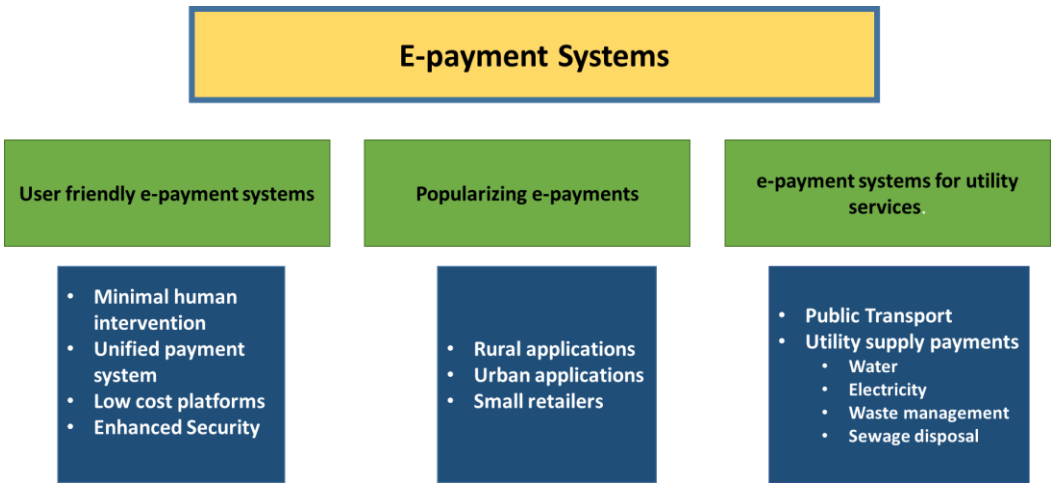
3.2 Problems, Applied research and product prototypes

Apropos the existing systems in the arena of financial technologies and the major drawbacks and challenges therein, we present a representative set of problems and solutions to address the challenges

3.2.1 E-payment Systems

Electronic commerce payment systems (e-commerce) constitute the most fundamental layer in the hardware architecture, over which all FinTech applications function. Although various e-payment applications have already been there for quite some time (e.g. debit, credit cards, PoS devices, etc.), massive deployment of mobile devices and associated platforms has turned the classical e-payment architectures on its head, and has opened up new avenues to push its reach further down the line. The focus of the TIH in the e-payment vertical is to investigate how to expand and fine-tune the existing e-payments systems to achieve the following.

- Make the services available to a much wider spectrum of customers, (e.g. rural, urban and retailers operating at small scale etc.).
- Improve the user experience (e.g. contact-less payments, unified platforms, usability on low cost mobile devices, intermittent Internet connectivity etc.), since ultimately it is the user experience that makes a technology acceptable;
- Provide platforms for seamless e-payments applicable to a variety of applications (e.g. utility services, public transport etc.)



Below, we discuss the problems more elaborately.

- P1: *User friendly e-payment systems*

  a) *Minimal human intervention and physical access based automatic e-payment systems*

  The traditional epayment system using cards on POS devices or mobile app (e wallets) using barcode/QR code, require human intervention. After the purchase is complete, the staff at the counter prints the bill, followed by swapping the card by the staff on the PoS device or scanning of the barcode on the mobile by the customer. Finally, payment is made after authentication (i.e., PIN) and authorization (i.e., amount billed by the staff) by the customer. In the current Covid-19 times, human intervention and requirement of physical access to the PoS devices is to be minimized.

  b) *Unified payment system:*

  Unified payment system is basically based on single card epayment system. Instead of providing multiple cards, the customer can be provisioned with a universal smart card. The universal card can be programmed with add on card details. While making an e-payment on a PoS device the customer can be asked for the option of which particular card to be used and accordingly the payment from that card can be initiated (which then follows the procedure similar to traditional multiple card based payment).

  In India, National Common Mobility Card (NCMC) is in use, which is an inter-operable card used for toll collection, public transport payment and retail payment. However, still there is a need to provide flexibility to customers to select payment service providers, which can actually provide interoperability between the banks.

c) *e-payment systems on low cost mobile platforms:*

E-payment systems can be developed based on Kiosk and SMSs on feature phones. Due to lack of literacy and capability of using smart phone based Apps, Kiosks can be set at the rural areas (shops or post offices) where customers will be assisted by trained personals to make the transitions and security would be ensured by SMSs delivered to the phones of the customers. It may be noted that in rural areas, people may not be literate enough to make payments using smart phones, but are capable of reading and understanding simple SMSs in their native languages. In addition, due to budget restrictions, many users in India are unable to afford smart phones.

d) *Security for e-payments*

Penetration of the Internet and mobile phones have brought convenience of digital banking and easy payment mechanisms to the end users. Several applications like UPI based payment systems and other similar banking solutions are available for different mobile platforms. These applications face cyber security threats from various sources. Reports suggest that more than 70% users use mobile phones without any security mechanisms installed and this brings the risk of the device itself being compromised which has an implications on security and privacy of these mobile applications. Other issues of these systems include:

- Malicious clone applications of their legitimate counterparts which can harvest sensitive user data.
- Misuse of these payment and banking applications for sourcing funds to illegal activities like money laundering, terrorism, etc. which have implications on national security.

Hence comprehensive mechanisms are required for monitoring these mobile based payment applications both from a regulatory perspective and also from

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population being illiterate and semi-literate can easily become victims of these malicious activities.

- *P2: Popularizing e-payments*

With increase in digital payments using Paytm, Google Pay, Bhim etc., small retailers found themselves grappling with the new problems e.g., emergence of clone apps that show payment Y l Ř Ŝ ō dz ű y 2 LJ l è Y Ŝ y ű l Ŏ ű dz l f f è l Ld1Ŝ aUJ1 hgV3 nowy ű K provided retailers with a machine that announces loudly whenever a payment has been made. This solves payment related issues of retailers, but brings in another issue of high percentage of cut of the transactions. This project aims to examine such issues using Game Theory and Platform-Mediated Networks.

The game of dominance has always been present in electronic commerce. The project wishes to see how it affects the small retailers when so many companies, such as Airtel, Jio, Ola, Paytm and P etc. are trying to capture the small pie of earnings of these retailers. There is a need to survey small retailers who use e-payment apps like Airtel, Jio, Ola and Paytm etc. to understand the issues they are facing. In addition, the project would also analyse the strategies of the payment app companies in alluring the small retailers.

- *P3:* e-payment system for utility services

a) *Public transport*

E-payment in the Indian public transport is rarely applied (restricted to metros, e ticketing for moderate to long distance travel etc.). In the recent time of CO-VID 19 infections, lots of travel regulations are becoming mandatory namely, limited number of passengers in a single transport, minimal physical contact etc. Most of these requirements can be achieved using an e-payment system that can be deployed in most of the modes of transport like bus, auto, cars etc. In the Indian context, due to the extremely high number of vehicles and the passengers, the e-payment system should have extremely fast response time, a requirement of

continuous Internet, transactions possible through credit/debit/prepaid cards, and there should be universal acceptance of most/all kinds of cards.

In this COVID-19 pandemic, the above-proposed payment system for transport will also be useful for tracking passenger travel history. By using the proposed e-payment system in the public transport, data about passengers like from where he/she has traveled, which mode of public transport is used, how many passengers traveled etc. can be gendered and used for contact tracing.

b) Intelligent billing and e-payment systems for utility supplies

¶ *Water supply*

In most of the traditional water billing system, a single analog water meter is installed in a building and the total bill amount is equally divided to each home/office in that building, irrespective of what amount of water that home/office has consumed. This method of billing is unfair and the meter can be eventempered. This project targets development of remote water quantity usage measurement system with digital billing and payment solution.

To create a fair system for charging in accordance with the usage of water, the proposed solution aims to develop a cost-effective sensor network that can be installed in each house or office (i.e., a unit) in the building complex. The sensors are connected to the Internet and sends the water usage data to the server. A web-based dashboard or mobile application displays the usage of each unit and automatically generates a bill and send a digital copy to the user. The user can view usage statistics and pay the bill via a web platform or mobile application.

Another problem with most of the traditional systems is that, as water usage is not reflected in the bill, people tend to recklessly use water which leads to wastage. Charging based on usage will lead to saving of water by the users as it will be reflected as financial saving. The benefit of this system is that users are charged as per usage and saving of water.

¶ *Electricity*

In the traditional system, the electric meters at the deployed locations are manually read and based on consumption of power, the bills are generated. Recently, electronic payments of the bills are provisioned by most of the electricity distribution companies of India. The online payment of electricity bills has reduced much of the manual efforts, however, still the system requires automation in terms of reading of the meters and data transfer to the central billing units. Further, the meters are prone to tempering leading to economic loss to the power distribution companies.

Real time data acquisition and monitoring of smart meters can be utilized to establish a bidirectional communication between the customers, distribution companies, and the utilities. At the consumer end, smart meter data can be used to monitor the energy consumption in a household/office, and distribution companies can provide incentives to consumers for any reduction of energy consumption during the peak loading. Moreover, seamless and secure communication of smart meter consumption data can allow distribution companies to generate utility bills, which can be paid by the customers using an e-payment system. At the utility end, it can be used to monitor the load consumption and thus can facilitate the control of generation through various renewable and non-renewable resources. At the distribution end, the smart meter information can be used to estimate the load peaks and therefore design the tariff rates. Furthermore, smart meter and distribution transformer data can help to solve the load balancing issues and improve the reliability of the system. Additionally, smart meters can be equipped with special sensors which can issue an alert signal to the distribution companies in the event of any physical tampering with the meters.

- *Waste disposal*

  As the population of India is on the rising curve, especially in the urban areas, the garbage also is growing at a high rate. As a result, garbage management is a problem that is quite hectic issue to solve. The waste disposal management agencies like, municipal corporations etc., sometimes fail or incur long delays to collect the garbage due to factors like lack of real-time knowledge of the quantity of accumulation of garbage and the location, improper scheduling of collection vehicles etc. The existing system involves collection of garbage arbitrarily, thereby making priority based garbage collection in case of a crisis of resources, as difficult solution to implement. Finally, there is no proportionate billing on the quantity of garbage being generated by an individual and the payment incurred.

  The proposed intelligent waste disposal management system will facilitate an end-to-end solution i.e., from monitoring of the status of the garbage bins to e-payments by the users based on quantity of the garbage. The bins will be augmented with IoT based solutions that will monitor the garbage bins, send the notification to the monitoring center about the level of garbage filled and schedule the movement of the collection vehicles based on the status of the bins. In addition, the quantity of garbage being disposed by an individual can be computed and billed directly (with display on a mobile), that can be paid using e-payment system. The garbage being disposed can be tagged to the user by techniques like scanning of a QR code by a mobile app (before disposing), or RFID tagged garbage packets etc.

The transportation, water supply, billing, waste disposal etc. discussed above are sample application areas for which the e-payment solutions will be developed. Expansion of such digital payment systems will be attempted for other application areas as well.

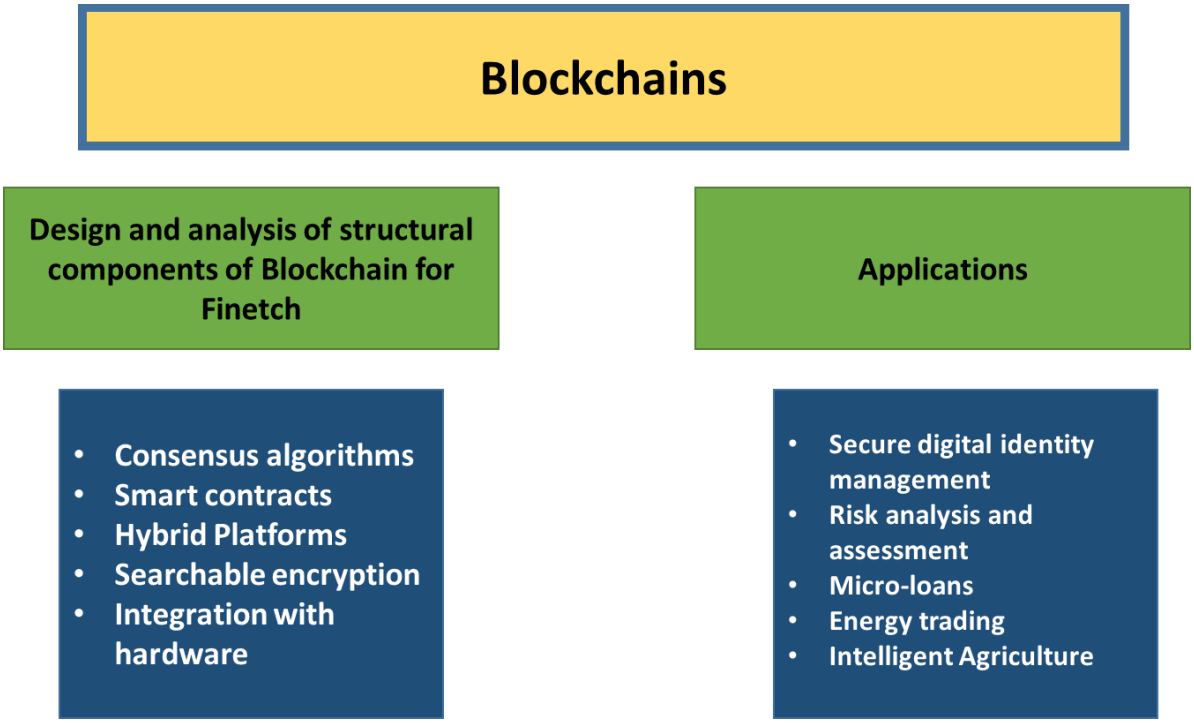
3.2.2 Fintech and Blockchain

Blockchain is a powerful and fascinating technology emerged in recent times which is perceived to have the potential to bring radical changes to the ways our financial systems (e.g. lending, mortgage,

retail payments, stock exchange, leverage, risk assessment and underwriting, etc.) work. The features that make blockchain a critical factor in current attempts to revolutionize the conventional notions of transfer (and management) of financial assets are as follows.

- It is underpinned by an integrated currency transfer mechanism;
- It can simplify and make faster a financial transaction by removing intermediaries;
- It uses modern cryptographic techniques to support security and privacy which are understandably the most crucial issues in any financial system;
- It can support financial transactions on a scale that can be both small (micro) and large (macro)

In the TIH at IIT Bhilai, we shall engage in working in the following areas in Blockchain supported Fintech, where fundamental research may potentially unearth several new applications and help develop technologies more powerful than the existing ones.



P4:Design and analysis of structural components of Blockchain for Fintech

a) *Consensus algorithms*

This forms the major building block of a Blockchain platform. There are mainly two types of consensus algorithms: Proof-of-work (PoW) and proof-of-stake (PoS). Bitcoin runs on Satoshi consensus which is PoW. There are various tradeoffs between PoW and PoS based consensus algorithms. It is an interesting open problem how to build consensus algorithms suitable for various Fintech products and solutions.

b) Powerful smart contracts

Smart contracts are application-specific. Based on the Fintech solutions at hand such as stock trading, insurance booking, credit swapping, the TIH will emphasize to build and optimize smart contracts.

Smart contracts is a powerful tool in the ambitious plan of the TIH to revolutionize the way the financial transactions are handled in our country. To put it in perspective, smart contracts are *authenticity verification mechanisms* that no rogue parties, inside or outside of the protocol, cannot tamper with. Thus, they become the Holy Grail for constructing automated dispute resolution apparatuses in the business ecosystem. It has already been discussed earlier about many different financial processes involving retail as well as enterprise customers. If there is one single bane in all these complex financial processes, then this is a fair dispute resolution system. The need for such a platform is most pronounced in processes such as insurance, underwriting, etc. The main target will be to design tailor-made smart contracts keeping in view the specifics of the aforementioned financial processes.

c) Integration with hardware modules:

Blockchain platforms are no longer limited to software-oriented modules. Hardware devices (e.g. Intel SGX) are also used these days to enhance security or replace expensive software modules such as zero-knowledge protocols. A major part of the research will go into building Fintech architecture using hardware-software co-design for Blockchain client machines.

A possible direction is to employ classical databases in combination with blockchain, not to mention building secure hardware modules and wallets. One of the major focuses in the line of research will be to eventually set up a system that is tamper-resistant in the sense that, even in the event of our client machines falling into the hands of the attackers, no information could be extracted out of it.

A viable blockchain platform will be able to make use of the best of the available technologies, be it in the form of software or hardware. In this context, the project will concentrate to hammer out the best possible software-hardware co-design to make the products/prototypes execute faster for a better user experience.

d) Building permissioned and permissionless hybrid Blockchain platforms

Blockchain can no longer be categorized as purely permissioned or fully permission-less; rather it is expected that a robust and suitable platform will be somewhere in between. A well-known technique for designing a hybrid platform is to have an authentication server for the purpose of user access control (this part being permissioned) and keep the remaining components working like the permissionless Bitcoin modules. The TIH shall delve into this matter to arrive at a more optimized co-design possibly with the help of traditional databases.

e) Searchable encryption platform:

The produced data in the IoT applications for Fintech is of huge volume and all the data are private and confidential. Therefore, the data should be stored securely. However, IoT enforcement becomes most effective and more scalable if and only if the big data analytics and cloud accessibility are integrated with the IoT structures. In addition, due to this pandemic situation (i.e., COVID-19) most of the bankers prefer to work from their homes and most of the financial sectors need to operate remotely. Furthermore, many users prefer to outsource data to the cloud to mitigate the burden of local storage. However, storing sensitive data on remote servers poses privacy challenges and is currently a source of concern. The cloud server is not fully trusted, and security of the data in the financial sector becomes a major concern. As a result, the cloud services

have not been fully realized due to users concerns about data privacy and security. To overcome these challenges, instead of the traditional database in cloud, the data can be stored in blockchain form in cloud as the traditional database has several security threats (for instance, SQL injection attack). The data (also called transaction) can be stored in encrypted form in a block into the blockchain. Once the encrypted data in form of block is committed into a blockchian to the cloud, an unauthorized person (also called adversary) cannot delete, modified or inject malicious data into blockchain, because the blockchain maintains the immutability property as well as it uses cryptographic algorithms such as elliptic curve based public key encryption and digital signature.

¶ P5: *Secure Digital Identity Management*

Banks, insurance, and other financial sector institutions employ a sophisticated identity management protocol to verify the identity of the customers before allowing them access to their services. Know Your Customer (KYC) processes are employed by private and public sector banks of all sizes for the purpose of ensuring that their customers are actually who they claim to be. The existing online KYC scheme is not secure in terms of data being stored at remote data storage servers which are susceptible to various risks of internal as well as external attacks. A secure digital identity is the need of the hour. Blockchain's encryption, decentralization, and immutable properties eliminate the need for a third party verification.

In the security aspect, a blockchain based digital identity creation and management framework will be developed that creates a secure network which can store the digital identity, financial and non-financial information of an individual. The identity information can be further used by banking and financial domain institutions to enable customers to carry out transactions such as personal and retail banking, retrieval of credit scores, apply for loans etc.

Another outcome of the proposed study will be development of a centralized block-chain based KYC system wherein banks can be linked to a centralized KYC repository along the lines of the existing KYC registry system. In this arrangement, customer data and documents are stored in the distributed ledger, and the bank that performs the KYC stores all relevant details and generates a unique KYC number. When another bank wants to perform due diligence on

the same customer, it can use the unique KYC number to search the central registry and download customer details.

- P6: *Risk analysis and assessment*

  The goal of any risk assessment and management process is to identify and mitigate all risks to an acceptable level to protect sensitive financial data and information from being harmed and compromised. However, there are some glaring deficiencies in the current risk assessment and management system and processes that are widely deployed and used. Firstly, data to be processed can be easily overlooked. Secondly, data can be easily tampered with leaving no trace behind. In other words, data integrity can be compromised. Finally, security at the data level is usually low, as a result of which finance related data is subject to greater security risks. The goal of this project is to develop blockchain based risk assessment and management system to address the aforementioned deficiencies. This system will have support for irreversibility, traceability, and backtracking and as a consequence will greatly improve the credibility of financial systems and applications. The project will also address constraints imposed by blockchain technology on scalability and privacy.

  The project comprises three broad steps as follows.

  - Detailed study of blockchain in the context of finance domain specific risks will be carried out.
  - Development of a blockchain based risk assessment and management framework to ensure that sensitive financial information can be tracked and cannot be tampered with.
  - Implementation of a prototype for the proposed framework.

- P7: M*icro-loan platform*

  Microloans are quite common in rural areas as against urban areas where banks disburse loans in large amounts. Indian banks find it prohibitive to conduct banking activities in the rural areas. Mostly gramin/agricultural banks provide financing facilities to rural

people. Villagers seek microfinancing from local lenders who offer loans at an excessive interest rate. On the other hand, government bodies provide loans at low annual interest rates, but are not readily approached by villagers for low amounts of money. Though the purpose of rural financing is not merely economic, ensuring proper economics of lending is necessary to sustain such financing. A simple microloan platform is to be developed for rural people whereby they can transact at competitive rates. The microloans can be transferred to the bank accounts of rural people and be linked to their other details available with local Patvaris. Local lenders and loaners can join this platform as its two sides, and the locals themselves govern the platform.

¶ P8: *Architectures for enterprise applications*

An architecture defines the blueprint of the platform and provides scalability to the platform. A common enterprise architecture is essential for deploying a country-wide scalable blockchain architecture. At present both central and various state governments are experimenting with blockchain in different ways. The end result would be a potpourri of legacy solutions that would not be able to interact with each other and thus, lead to another set of technology related problems. In this project, there will be a study of different architectures adopted by various state governments and central governments and try to come up with a unified architecture that would be useful for further adoption and proliferation of blockchain.

Blockchains are still under experimentation by various public and private sector companies. There is no unified architecture. This research would thus add by bringing a fool-proof architecture that would facilitate implementation and further adoption of blockchain.

There is a need to examine the blockchain adoption by public and private entities in the country and examine the issues they are facing in its adoption or implementation. These issues will further help us understand whether a feasible enterprise architecture can be

built for the implementation of blockchain.

- P9 : *Energy trading*

Traditional energy markets were mainly dominated by the large utilities owning centralized fossil fuel based energy generation, transmission and distribution network due to which there was very less scope of liberalization in the energy market. The customers had no choice to choose their supplier of energy. However, an increase in the oil prices, and global temperature rise due to pollution from large fossil fuel based power plants have pushed the world to explore clean sustainable sources of energy. An increase in Distributed Energy Resources (DER) such as Solar Photovoltaic (PV), Windfarm, Biogas, and Combined Heat and Power Plant (CHP) can create virtual power plants which can significantly reduce our dependency on the fossil fuel based energy production. World is witnessing a tremendous increase in the number of prosumers who can not only consume energy but can also produce it using sustainable energy options such solar PV and feed any access power generation back into the grid. Furthermore, with an improvement in the hardware technology in smart grid such as smart meters allow accurate monitoring of the power supply by the prosumers (to the consumers) and earn incentives in the form of net metering credits. Blockchain can play an important role in such energy trading, where energy can be treated as a digital asset that can be traded using various transaction. Blockchain tokenizes such assets and eliminate the requirement of centralized authority to connect the consumers directly through peer to peer energy trading and thus making the transaction more secure, transparent, and accurate. Apart from peer to peer energy trading, the blockchain can be applied across the value chain of the energy supply as shown below.

Blockchain coordination throughout the power system		
Generation	*Transmission & Distribution*	*End User*
Secure Power generation and supply data using blockchain	Wholesale power trading through smart contracts	Blockchain managed instant payments and power monitoring
Renewable Energy Credit (REC) awarding	Blockchain enabled sensor and control for improved	Smart charging for Electric Vehicle application with

and trading through blockchain	grid resiliency	seamless transactions Smart home appliances coordination and control through blockchain

Despite modernization and technological advances, our country is still facing the challenge of electricity access to each household in India. With the increasing demand of electricity, the stability of the electric grid is also a concern. The major grid failure in July 2012 was an alarming signal on how crucial it is to maintain the grid stability. Centralised fossil fuel based generating stations are generally used to provide electricity to the consumers, however due to the inherent centralized nature of generation, any failure at these stations can leave lakhs of people without electricity.

Recently, with the development of the technology in the renewable sector, Indian market has seen tremendous growth in solar PV and wind energy based generation. According to a recent report from Indian Brand Equity Foundation, as India looks to meet its energy demand on its own, which is expected to reach 15,820 TWh by 2040, renewable energy is set to play an important role. As a part of its Paris Agreement commitments, the Government has set an ambitious target of achieving 175 gigawatt (GW) of renewable energy capacity by 2022. These include 100 GW of solar capacity addition and 60 GW of wind power capacity. Government plans to establish renewable energy capacity of 500 GW by 2030. This tremendous growth in distributed generation can solve the problem faced by our nation to the access of electricity. However, this growth also poses few challenges such as lack of energy trading platforms and secured payment options for the customers. One more aspect, is that traditionally the flow of energy used to be unidirectional in nature, i.e., generation, transmission, to distribution. Therefore, it was easier to maintain the grid stability (load generation balance), however, with the ǻ y˝ ű NJ ž Ř dz Ő ű ǻ ž y˝ ž Ŧ 5 9 w Ω ă ă dz Ő K l· ă NJ ž ž Ŧ ű ž LJ ă ž nature. Any customers with excess energy (prosumer) would like to supply the excess energy into the grid. However, as of now India does not have any peer to peer (P2P)

energy trading platform where the information regarding the distributed generation can be facilitated to balance the grid and enable the customers to trade any excess energy.

This research aims to introduce the Blockchain Enabled Energy Trading (BEET) solution with the following benefits.

- The proposed solution will allow customers to generate income by selling their excess electricity.
- The proposed solution will allow microgrids to operate in a mode of decentralized distribution management system, which would ensure a better grid stabilization and control.
- Utility, prosumers, and customers will be connected to the p2p trading platform for seamless trading of energy.

Salient Features of BEET:

- The proposed solution will be based on an open platform with compatibility to any third party hardware such as sensors, and smart meters.
- It can be integrated into an existing microgrid solution and can easily adapt with the increasing size of the network.
- Provides real time management and monitoring of the grid stability, energy flow, and billing solutions.

¶ P10: *Intelligent Precision Agriculture (IPA)*

IPA uses smart sensor devices deployed in an agricultural farm to read the surrounding environmental parameters and connected together as a network and send the data via the Internet to a centralized server that can perform some processing before sending it to the blockchain-based cloud storage system. This collected sensor data can be used to activate an automated action on the field in order to maintain favourable conditions over the field. This collected data can also be analyzed further to allow improved decision making such as the type, quantity and quality of fertilizers, type of soil, amount of

irrigation to be used.

² ƛ ű Ƙ ű Ƙ Ŝ NJ Ŝ Ŏ Ŝ ƴ ű l· Ǝ NJ ƛ Ŏ dz f ű dz NJ Ŝ LJ NJ ƛ Ø l· ű ƛ Î l· ű ƛ 2 (Promotion and Facilitation) Bill, Farmers (Empowerment and Protection) Agreement on Price Assurance and Farm Services Bill and Essential Commodities (Amendment) Bill in September 2020 that allow the farmers to enter into contracted trades of agricultural commodities with private agricultural firms, it becomes imperative for the farmer to keep track of the delivered produce in order to obtain the Minimum Support Price. On the other side, the firm that enters into contract with the farmer also requires to keep track of the quality, quantity of produce and other requirements along with their business implications. In order to ensure fair trade, the research proposes the development of an l· dz ű 2 Y l· ű Ŝ Ř á t NJ ƛ Ŏ Ŝ L ƴ ƴ 2 NJ Y f ű ƛ 2 ƴ Ŏ Ŝ registered ű NJ [Ŝ ű ű involved traders, collect, maintain and disseminate all required information for complete transparency in the trade between the farmer and the firm, and also to ensure the buyer has access to this information that can enable him/her in decision making during the buying process. Such a system would also enable the central government to oversee the usage of food produce which will be an add-on help during extreme situations like flood, famine etc

This research proposal intends to focus on the security implication of authentication in such an intelligent system for IPA using blockchain technology. The scope of authentication goal to be achieved in the Price Information and Market Intelligence System would be as follows.

- IoT based smart agriculture: An intelligent precision agricultural system should first be based on an IoT architecture using clustered networks of sensors communicating through the internet.
- User authentication: Authenticate the involved traders (farmers and firms) to ensure the trading takes place between the right trading partners.
- Mutual authentication: Authentication between the sensor devices placed in the

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- Secure session management: For every transaction, a specific session is created between the two entities currently trading such that all information is secured using a session key.
- Blockchain security: After a transaction is completely committed, it is secured in a blockchain-based cloud system that prevents any kind of tampering on the transaction data

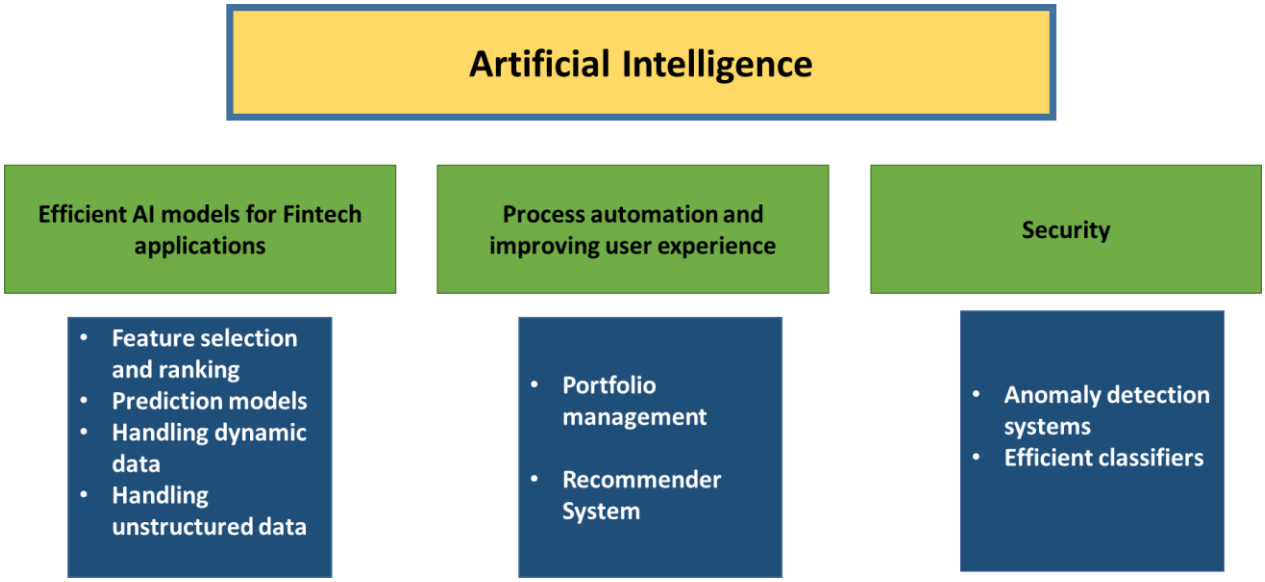
Since the information regarding a farm belongs to the owner of the farm, the data is considered confidential and hence private blockchains will be more relevant in the context. Certain information such as the type of fertilizer used, the type of soil on which the product is grown, the level of freshness of product, the chemicals used for keeping the produce fresh during storage etc., should be available to the public so that the end consumer can refer to them in order to decide to buy the product. Hence, it is understood that certain information is to be stored in encrypted form while some other information needs to be available to the public for the transparency. Thus, hybrid blockchains are also very relevant to the secure intelligent precision agriculture system. Depending on the specific end goals of the system being developed, it may be required to use blockchains not only for storage but also during authentication procedure before data storage. Further, smart contracts may be used to enforce the criteria agreed upon in the agreement between the farmers and traders.

3.2.3 AI in Fintech

AI and data analytics is arguably the most remarkable and disrupting scientific discipline of recent times. The main goal of the AI techniques is to automate processes, analyse and forecast their outcomes using fine-grained and complex mathematical models. Therefore, it is understandable that AI methods, if adjusted well, should also be adapted to our financial systems, especially in predicting volatilities, and uncertainties arising in various financial markets (both primary and secondary). Not only this, AI techniques can also provide an additional layer of security to our systems by adding, for example, security auditing mechanisms such as for detecting suspicious

activities.

In the following, we provide details of problems that will make use of AI in an impactful way for enhancing the Fintech products. The TIH mainly aims to apply AI and data science techniques to build prediction and forecasting models, enhancing security etc. for Fintech applications.



¶ P11: *Efficient AI and ML based models for Fintech applications*

a) *Feature selection and ranking*

First, feature selection is one of the most crucial tasks in data preprocessing which drastically improves the performance and accuracy of the prediction of financial anomalies. Machine Learning is the most popular approach followed by researchers in feature selection. It is the process of choosing a minimal subset of features from a given original dataset of a large number of features so that the dimensionality of the feature space is considerably reduced. It has been noted that there is a lack of general consensus among researchers regarding an agreed upon set of financial variables that are the most representative features for financial analysis. Hence collected variables must first be analyzed and their relative significance and explanatory power with respect to the selected dataset must be evaluated. The feature selection stage selectively filters out

noisy features that reduce dimensionality, and improve the effective performance and accuracy of classifiers. A large body of related studies clearly that feature selection has clear benefits of producing better models, improved accuracy and performance in financial prediction.

b) Generation of prediction models for complex Dataset

The second important pain point in financial analysis is the generation of prediction models. A host of prior research articles have documented the superiority of machine learning based solutions over statistical methods in producing prediction models. Hence it is imperative to consider machine learning based classification algorithms to obtain better results in the analysis and prediction of financial outcomes and crises. Such prediction models can especially be useful in tasks related to underwriting and credit scoring as well as algorithmic trading. In case of underwriting, the machine learning model assesses and evaluates the risk of whatever their particular client party wants (mortgage, loan, health policy, investment, etc.) and whether or not it is worth it for their company to assume that risk. Similarly, in case of algorithmic trading, the learned model monitors the news and trade results in real time and detects patterns that can force stock prices to go up or down. It can then act proactively to sell, hold, or buy stocks according to its predictions.

c) Maintaining accuracy with dynamic structure of data

The next most crucial problem in this domain is that the datasets are constantly changing in nature. A host of prior research articles have documented the superiority of ensemble or online machine learning based solutions in producing better prediction models with dynamic datasets. Hence it is imperative to consider such algorithms to obtain better results in the analysis and prediction of financial outcomes and crises.

d) Interpretation of unstructured data using Natural Language Processing and its application to Fintech

Tackling a firehose of information is a familiar problem in the financial services industry.

Traders and investment managers have numerous sources to comb through, such as research reports, company filings, and transcripts of quarterly earnings etc. The amount of this kind of unstructured content is accelerating at an unprecedented rate, making it time consuming to analyze. As a result, unstructured content is underused as a source of insight. It may contain hints that would quantify a trading strategy, but the overwhelming volume of data makes it impossible to spot the nuances that could drive a decision making process. Natural language processing (NLP) offers opportunities to uncover meaningful insights from underused content. The key benefits of using NLP are the following: (a) Efficiency: automating the analysis of volumes of unstructured content in real-time, (b) Speed: the value of information declines rapidly so insights need to be harvested swiftly, (c) Consistency: a single model achieves consistency that is not achievable if performed by a number of human analysts, each of whom may interpret aspects of text slightly differently and (d) Accuracy: unstructured documents can be lengthy, and human analysis can potentially miss or misinterpret information.

¶ P12: *Process automation and improving user experience*

Process automation is one of the most common applications of AI in finance. The technology allows to replace manual work, automate repetitive tasks, and increase productivity. As a result, AI enables companies to optimize costs, improve customer experiences, and scale up services. Such ML powered solutions allow finance companies to completely replace manual work by automating repetitive tasks through intelligent process automation for enhanced business productivity. Chatbots, paperwork automation, and employee training gamification are some of the examples of process automation in finance using ML. This enables finance companies to improve their customer experience, reduce costs, and scale up their services. Further, ML technology can easily access the data, interpret behaviors, follow and recognize the patterns. This could be readily used for customer support systems that can work similar ű ž l· NJŜ l· f Ќdz Y˜ l· y˜ l· y˘Ř ă ž f ØŜ l· f f ž Ŧ ű ЌWells Ŏdz ă ű ž Fargo using ML-driven chatbot through the Facebook Messenger to communicate with its users effectively. The chatbot helps customers get all the information they need regarding their accounts and passwords. One of the other rapidly emerging trends in this context is

Robo-advisors. Working like regular advisors, they specifically target investors with limited resources (individuals and small to medium-sized businesses) who wish to manage their funds. These ML-based Robo-advisors can apply additional data processing techniques to create financial portfolios and solutions such as trading, investments, retirement plans, etc. for their users.

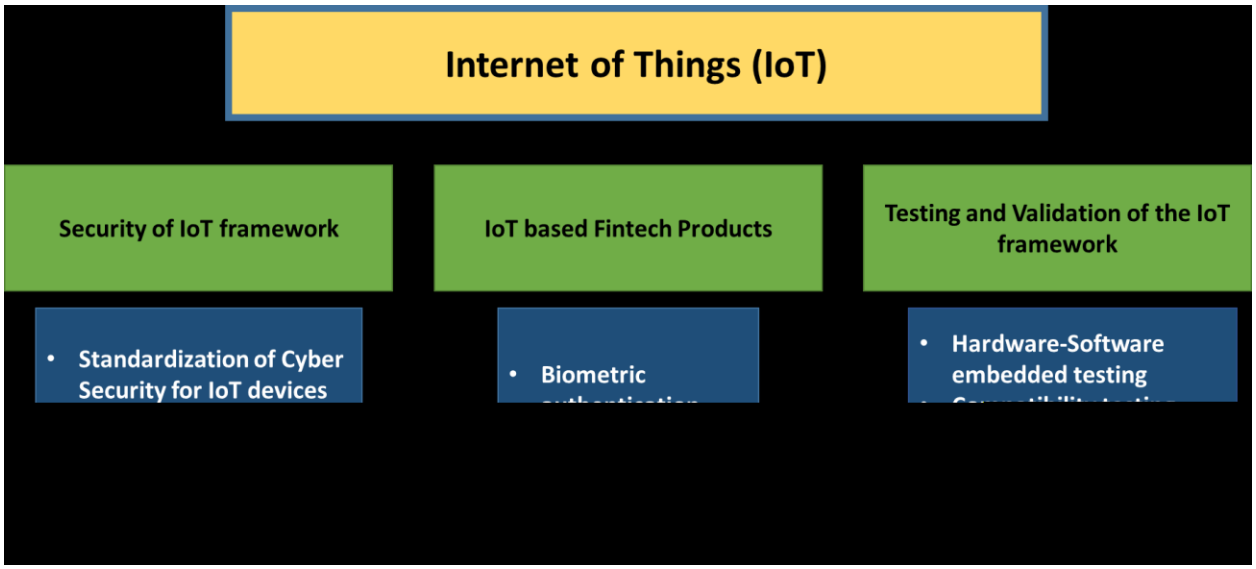
¶ P13: *Constant monitoring and security*

Security threats in finance are increasing along with the growing number of transactions, users, and third-party integrations. ML algorithms are excellent at detecting frauds. For instance, banks can use this technology to constantly monitor thousands of transaction parameters for every account in real time. The algorithm examines each action a cardholder takes and assesses if an attempted activity is characteristic of that particular user. If the system identifies suspicious account behavior, it can request additional identification from the user to validate the transaction or even block the transaction altogether. ML algorithms need just a few seconds to assess a transaction. The speed helps to prevent frauds in real time, not just spot them after the crime has already been committed. Financial monitoring is another security use case for ML in finance. Data scientists can train the system to detect a large number of micropayments and flag such money laundering techniques as smurfing. ML algorithms can significantly enhance network security, too. Data scientists can train a system to spot and isolate cyber threats, as ML is second to none in analyzing thousands of parameters and in real-time..

3.2.4 IoT framework for Fintech applications

With the advent of IoT paradigm, as in the case with many other industries, the financial sector is also witnessing the enormous impact of the technology in terms of features like immediate support and personalization of service, smart bank branches and ATMs, improved spending visibility, enhanced security, risk assessment for insurance and loans etc. In the Fintech market the concepts such as Bank of Things have started becoming popular.

The TIH at IIT Bhilai will focus on development of IoT based Fintech solutions. Some of the tentative problems are highlighted below.



¶ P14: *Security of IoT framework for Fintech solutions*

a) *Cyber security standardization and solutions for the IoT framework in Fintech applications*

IoT based paradigm is revolutionizing the Fintech industry. However, as the systems in an IoT platform are connected by wireless networks and the devices are resource constrained, they are subject to vulnerabilities at each layer of the network architecture as follows: *a) Perception layer* vulnerabilities like node capture, fake node and malicious data, denial of service attack and replay attack; *b) Network layer* vulnerabilities like heterogeneity, scalability issues, and data disclosure; *c) Application layer* vulnerabilities like mutual authentication and node identification, information privacy, data management and application specific vulnerabilities.

Heterogeneity and high resource constraint of IoT devices (in terms of memory, energy, and computing capacity) make development security solutions a real challenging task.

On another angle, with an envisioned unprecedented penetration of IoT devices in Fintech, significant effort is required in understanding the aspects around *governance standards* related to *privacy and security* considerations of the finance sector. Governance considerations implies questions like how to implement and evaluate security standards in IoT based systems, which involve issues like multiple stakeholders around the globe,