Detailed Project Report (DPR)

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

On

Technologies for Financial Sector (Fintech)

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Contents

1. 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, in the global parlance, India has emerged as the world's second-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 2019-2020 announcement, Finance Minister Nirmala Sitharaman had declared 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, SMEs and MSMEs. In a country like India, that has the world's second largest 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 break-through 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 financial technology revolution
5. Building a sustainable ecosystem with national and international collaboration

2. 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.

2.1 Background

2.1.1 E-payment systems

E-payment system (or online payment system) is one of the fundamental components underpinning any Fintech application [3]. An e-payment 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 on-line transitions are some of the most popular e-payment systems available nowadays. Besides them, there are also alternative payment methodologies; some of the prominent ones are discussed below.

- Electronic Funds Transfer (EFT) is an e-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 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 smart phones. 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:* Phishing is an attack where the adversary gains access to one's personal 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.

2.1.2 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 e-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.* According to Harvard Business Review: "A new type of services 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 in the timing of payments." 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, making, and delivering. In the Fintech world it's about "funding" i.e., the supply chain as a source 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 issues related to tax evasion and also lack of control of the regulators over the digital currencies. Start-ups 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 developers to assist in blockchain platforms' development.

2.1.3 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 could result in large and sudden capital outflows, thereby causing a domestic 'credit crunch.' This 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 as either 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 type of problem, 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 prediction 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 classified into three different classes representing three different directions, namely “up”, “down” and “unchanged”. A naive Bayesian 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 – 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 data sets, 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, still 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. If such datasets

are made available to the public, then many start-ups 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 decode 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 replace them with fully automated methods using AI and ML approaches.

2.1.4 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 collect clients' data like behavior, likes, dislikes, places being visited frequently, expense and earning patterns etc. to extract information out of them. The benefits of customer's data analysis using IoT systems include, tracking creditors' behavior to precisely evaluate the 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 monitors etc. are being used for "what you have" based authentication. The security and 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 loan.* 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's behavior are collected which are then used by insurance companies for monitoring and analyzing one's habits and past 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 will be able to provide customized protection plans by reviewing customer's health habits like 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. they pose a risk of compromising an individual's privacy.
- *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.

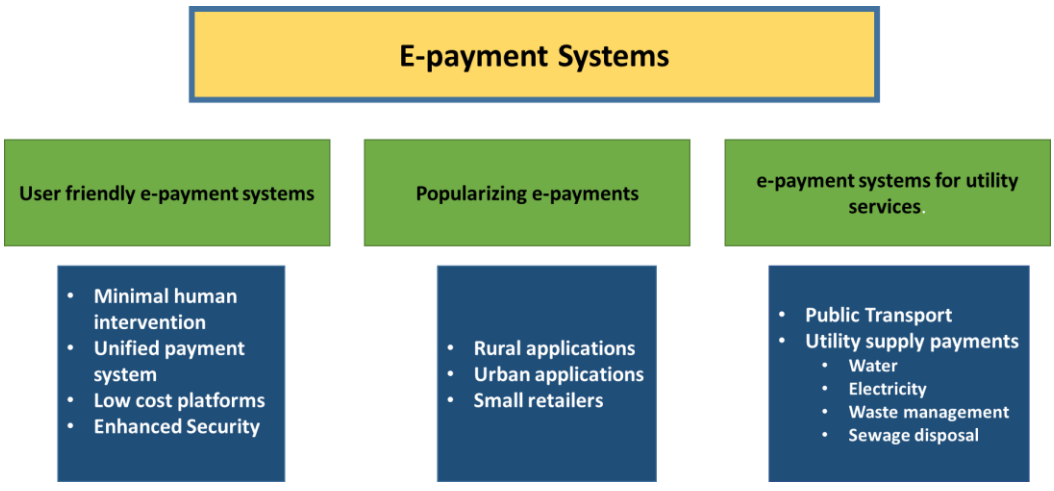
2.2 Problems: Applied research and product prototypes

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.

2.2.1 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 deep and wide. The focus of the TIH in the e-payment vertical is to investigate how to expand and fine-tune the existing e-payment 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 e-payment 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 e-payment 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 e-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 e-payments using smart phones, but are capable of reading and understanding simple SMSs in their native languages. In addition, due to budget restrictions, may 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 implication 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 end user's security perspective. In the Indian context, a large section of the

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 made but no payment actually appearing in the retailer's account. Some of these apps have now 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 and Paytm 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 COVID-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, non-requirement of

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

In this COVID-19 pandemic, the above e-payment system for transport will also be useful for tracking passenger's 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 co-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 the home/office has consumed. This method of billing is unfair and the meter can be even tempered. 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 savings. 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 electrical 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, a 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 any 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.

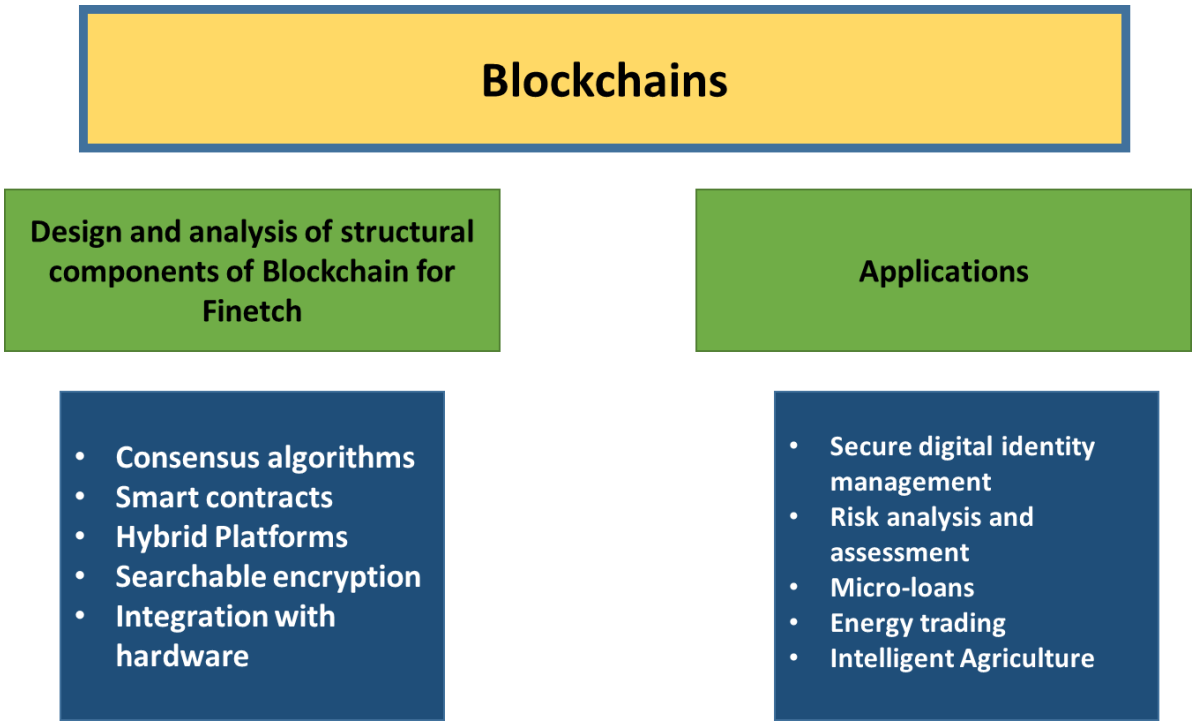
2.2.2 Fintech and Blockchain

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 our 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 an applications-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 e-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 permission-less 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 permission-less 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 e-KYC scheme is not secure in terms of data being stored at remote data storage servers which are susceptible to various kinds 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 blockchain-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 access the central registry and download customer details.

- **P6:** R*isk 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 cost-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 banking 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 and trading through blockchain	Blockchain enabled sensor and control for improved grid resiliency	Smart charging for Electric Vehicle application with 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 introduction of DER's such as rooftop solar and wind, generation is now decentralized in 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.

With the recent agriculture privatization bills : Farmers' Produce Trade and Commerce (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 automated "Price Information and Market Intelligence System" that can register the involved traders, collect, maintain and disseminate all trading 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 farm fields, the farmers' devices, and the firms' devices.
- 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

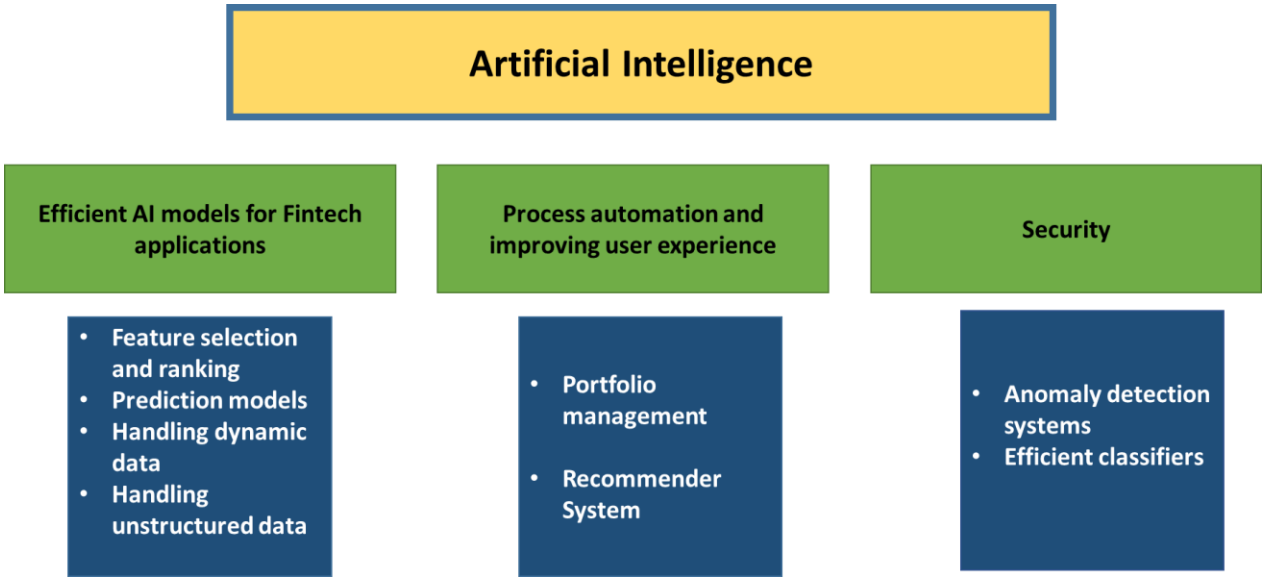
Since the information regarding a farm belongs to the owner of the farm, the data is considered confidential and hence private blockchains will be more relevant in the context. Certain information such that the type of fertilizer used, the type of soil on which the product is grown, the level of freshness 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.

2.2.3 AI in Fintech

AI and data analytics is arguably the most remarkable and disrupting scientific discipline of recent times. The main goal 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, a security auditing mechanism 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 show 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 has (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 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 under-used 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 to a real human and solve all of the customers' unique queries. An example of this is Wells 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 traditional data processing techniques to create financial portfolios and solutions such as trading, investments, retirement plans, etc. for their users.

- **P13**: *Constant monitoring and security*

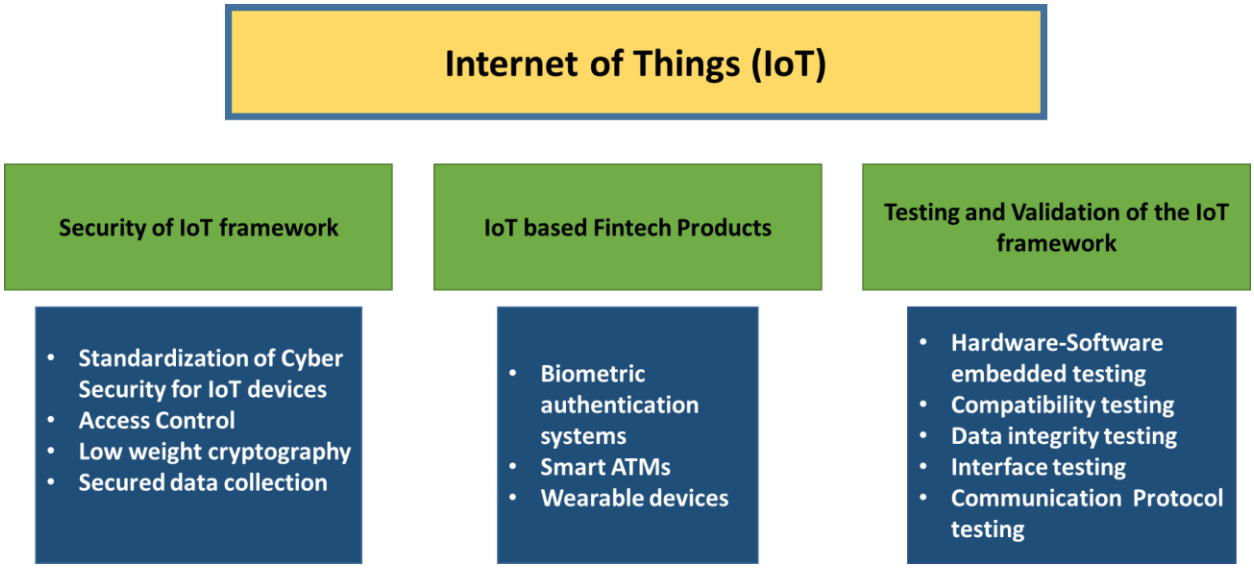
  Security threats in finance are increasing along with the growing number of transactions, users, and third-party integrations. ML algorithms are excellent at detecting frauds. For instance, banks can use this technology to constantly monitor thousands of transaction parameters for every account in real 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 train a system to spot and isolate cyber threats, as ML is second to none in analyzing thousands of parameters and in real-time..

2.2.4 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 loan 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 constraints 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, heterogeneous devices, varying network topologies etc.

As of now in the Indian context, aspects related to security standardization of such systems are governed by their legacy Internet counterparts, and do not have any regulatory authority. So, standardization of security requirements for such systems is itself nonexistent. Further, we do not have well accepted metrics to evaluate or validate the security solutions/standards. So, given the scale, diversity and heterogeneity of such systems, compounded by the inter-connections, we need standardization for security techniques and metrics to evaluate such techniques.

From the cyber security aspects of IoT in the Fintech sector the major challenges are the following.

- Challenges in development of security solutions due to issues like heterogeneity, low resource availability, fast change in technology etc.
- Lack of standards related to security requirements and solutions.
- Lack of metrics and techniques to validate security standards and solutions.

On the cyber security aspect of the IoT paradigm for Fintech, the TIH would focus on the following areas.

- Development of new security standards and solutions for IoT in specially emphasizing on the Indian Fintech context
- Development of metrics and methodologies to evaluate the security standards and solutions

b) *Fine grained access control framework for online financial applications:*

Financial applications can be accessed from different types of devices and through numerous channels. The goal of any financial organization is to protect financial applications from unauthorised access. A foolproof Access Control Framework to protect such applications is a

key requirement. Commonly used access control approaches such as Attribute Based Access Control (ABAC), Role Based Access Control (RBAC) and Capability Based Access Control (CBAC) do not, in isolation, provide a complete solution for securing access to such applications. They may, for instance, rely upon an overly centralised solution or an unmanageably large database of policies, both of which are not practical and scalable. To address these issues this project will propose a novel hybrid access control architecture which improves policy management while providing fine-grained access control to such applications. With such an access control system in place, financial institutions will be able to meet regulatory and statutory requirements as they will now have the ability to manage how data is being accessed and used. This is especially significant for such institutions, which must manage and safeguard large amounts of sensitive data.

c) *Efficient symmetric-key algorithms for use in IoT*

An IoT device for any financial application, must come with its own encryption method. Indeed, encryption is essential for protecting any sensitive data stored and transmitted by the device. As most of these devices are data, energy or power constrained, the most adapted encryption solution for them is symmetric-key algorithms, that are known to be more lightweight. Today, many good symmetric key standards for encryption exist (e.g. AES), however, most of the time they are not adapted for the IoT context. Choosing an adapted encryption algorithm, that would take into account the device's resources and constraints, while being resistant to all known attacks, is essential. In this problem domain, the TIH will aim at evaluating for each Fintech application that needs symmetric encryption, and develop/adapt a suitable solution, involving the following steps.

- Analyze the existing lightweight encryption algorithms and evaluate whether they could be adapted for the given IoT application.
- If no algorithm fits exactly the constraints, design a new symmetric encryption algorithm, which would take the new constraints into account (speed, latency, energy and power consumption, easy masking, etc.)

- Apply cryptanalysis to the newly designed algorithms to ensure that they are robust and provide proofs for resistance to all known attacks. Depending on the specificities of the new design, this can lead to the development of new cryptanalytic techniques.

d) *Whitebox cryptography for securing embedded devices*

The current society is becoming more and more connected and sensitive information including financial transactions, is being exchanged through the Internet. While adequate security measures have been taken to secure the transacted message, however if the device is captured by an attacker, then the adversary can extract the embedded secret by reverse engineering. To address this issue, the white box cryptography would be applied. Whitebox cryptography basically obfuscates the secret so that reverse engineering fails to extract the key. Specially, in this domain, the TIH will focus on development of whitebox implementation of AES that is secure and at the same time lightweight.

A very important use case of this application is protecting smart card's secret from physical attacks

- The usage of smart cards has been ever increasing and it can be seen as credit cards, access cards etc. Smart card has a small circuit which performs cryptographic operations while sending the transaction information. However, as the secret is embedded inside the smart card, it is possible to extract the secret by applying some physical attacks such as side channel or fault attack. To protect the embedded secret in the smart cards, counter measures against fault attacks that are effective and lightweight, i.e., does not incur too much overhead, would be developed.

e) Data driven approach to security forensics and trustworthy decision making in IoT networks

Cornerstone of (mobile) e-payments is anomaly or fraud detection in voluminous time series data collected through mobile apps, smartphones, and sensor-enabled IoT operating in smart cyber-physical systems (CPS) impacting our daily lives, such as smart city, smart home, smart healthcare, smart transportation, smart grid (energy), and water distribution networks. Such time series (big) data can be under low profile stealthy attacks hiding behind high randomness

of benign IoT data trends, thwarting analytics accuracy to aid trustworthy decision-making, thereby impacting operational reliability and safety in e-payments. The intertwined dependence on data analytics, potential civilian impact of wrong decisions, and competitive economic motivations make the underlying IoT and CPS domains extremely vulnerable to data integrity/availability attacks, among others, as to be addressed in this project.

The proposed research is ever more important in the current crisis like COVID-19 pandemic. With the worldwide outbreak of coronavirus and subsequent lockdown, there has been a surge in the dependence on mobile banking and e-payments. Although security is a serious concern, safety and health issues have outweighed security and hence the spike in mobile phone (or app) based transactions. This has also motivated adversaries (rogue individuals/organizations) to launch huge numbers of cyber-attacks on the banking and e-payment systems. This necessitates the need for enhancing security in IoT devices and offering seamless and safe user experiences.

f) *Secured Data collection framework using IoT :*

The Fintech industry has become one of the biggest consumers and producers of data. Big data in banking is growing astronomically big as the companies rush to collect more insights about their users to drive product development and make intelligent business decisions. Predictive analytics in banking and financial services, paired with AI is going mainstream and helping companies make decisions faster and be confident about the outcomes. The third vertical of the activities of the TIH aims at focusing on AI based data analytics to make intelligent business decisions.

As a part of the IoT based solution to Fintech, TIH aims to develop solutions for secured data collection framework using IoT.

- A secure cloud-assisted IoT data managing system
- Data confidentiality when collecting, storing, and accessing IoT data
- Maintaining scalability

- **P15***: IoT based Fintech product*

a) *Biometric authentication system:*

There are several authentication mechanisms like ID-Password (what you know), smart-card based (what you carry), and bio-metrics (what you have). Among these, biometric-based authentication is gaining wide acceptance in Fintech because of factors like unique attributes, difficult to forge, convenience (not required to remember PIN), accountability, etc. However, biometric solutions are susceptible to attacks namely, DoS, DDOS, replay, spoofing, and fake credentials, and tempering of credentials etc. The TIH will develop a biometric authentication solution for Fintech that encompasses attack detection and prevention techniques. The proposed biometric authentication systems will facilitate the following.

1. Tolerant to attacks using intrusion detection system and prevention systems
2. Easy integration to the required systems like access control, unlocking of computers, Aadhaar based authentication etc.
3. Remote access to systems by cloud-based or web-based biometric authentication that enables users to access services remotely using the mobile biometric scanner. Hence, there is no requirement of providing access to any third person for any urgent requirement in the absence of the user.
4. Use of AI/ML techniques to improve the accuracy of the biometric authentication devices.

b) Smart ATMs:

IoT based sensors and smart cameras can be deployed in the ATMs that would facilitate banks to optimize operational cost by reducing energy wastage (AC and light control), reducing the risk of theft of withdrawn money, helping customers e.g., ATM cards stuck in the machine, soiled/torn notes etc. With live monitoring, if a customer faces health issues when inside an ATM, help can be provided by a quick medical response team. In fact, if a person feels sick can enter a nearby ATM (for which he/she is a customer), and on detecting a medical emergency, a response team would be alerted. The customer details taken from the wearable IoT device would enable informing his family members, shifting to the hospital that he/she regularly visits etc.

Further, in the IoT managed ATMs, several checks can be maintained like cleanliness, staff adherence to bank's policies, monitoring the security staff of the ATM etc. With the ATM crimes on the rise, deployment of IoT based smart ATMs would increase the customer's confidence in the bank.

- **P16:** *Testing and improving reliability IoT framework*

For any systems including IoT, applicable to critical infrastructure like Fintech, there is an increasing need to deliver better, faster, secured and reliable services. In the IoT paradigm, due to the involvement of various integrated sub-systems namely, device, networks, processors, operating systems, platforms and standards etc. testing becomes an extremely challenging problem.

The proposed solutions for testing the IoT paradigm would involve testing the hardware of the devices, embedded software included in the devices, interconnectivity among the devices and with the backbone Internet etc. Further, special emphasis would be given for performance testing considering the resource considerations such as limitations in memory, processing power, bandwidth, battery life, etc. of the IoT devices.

3. Aims and Objectives

The TIH at IIT Bhilai entitled "**IIT Bhilai Innovation and Technology Foundation**" on Financial Technologies aims to provide state-of-the-art solutions with the following aims and objectives, specially targeting the Indian economy from massive upcoming trends of digitization.

Aims

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 financial technology revolution
5. Building a sustainable ecosystem with national and international collaboration

Objectives

1. R&D for Fintech Technologies
    - E-Payment Systems
        - User friendly e-payment systems
        - Popularizing e-payments
        - e-payment system for utility services
    - Blockchain for Fintech
        - Design and analysis of structural components of Blockchain for Finetch
        - Applications of Blockchain for Fintech products
    - AI for Fintech
        - Efficient AI and ML based models for Fintech applications
        - Process automation, improving user experience and security solutions for Fintech applications
    - IoT for Fintech
        - Security of IoT framework for Finetch solutions
        - IoT based Fintech products
        - Testing and improving reliability IoT framework

2. Entrepreneurship and Startup ecosystem

- To build a nation-wide innovation/incubation center that provides a platform for entrepreneurship
- Supporting students/Alumni and Faculty for startup in Fintech ecosystem
  - Connecting with the state-of-the-art technologies
  - Connections with organizations such as UIDAI, NPCI, GSTN
  - Connections with academics for best-in-class understanding in Fintech
- Entrepreneurs in residence programs
  - Start-while-you-learn: Prototyping as part of the education ecosystem
- Technology business incubation Collaborations

3. HRD and Skilling for Fintech

- High-end skill development
  - Certifications
  - Quality Improvement Programs
  - Skilling for Fintech technologies
  - Workshops
  - Train-the-trainer models
  - Self-Employment oriented training
  - Books and reference material generation

- Formal Education in Fintech
  - Courses for Electives
  - Postgraduate programs for Fintech
  - Fellowships for PG students
  - Project works for degree programs
  - Interface with the industry
  - Case Studies
  - State-of-the-Art studies

- Research Education in Fintech
  - Doctoral Programs for Fintech in EE and CSE
  - Masters program in Fintech
  - Joint research programs across institutes
  - Joint research programs with Industry

- Faculty Fellowships
  - Faculty fellowships for existing faculty
  - Inviting cross institutions faculty

- Visiting Faculty
- Chair Professor
- Chair faculty at other levels

4. Collaborations
- Academics
  - National and international educational institutes
  - Exchange programs
  - Mentorship for startups
- Government
  - Organizations like UIDAI, GSTN, NPCI, CDAC etc.
  - International labs such as NIST etc.
- Industry
  - MSME and Startups
  - Large Players such as Infineon, Intel etc.

The specific objectives/goals in terms of quantifiable measures are shown in the following table.

S.No.	Activity	Target
1	**Technology Development**	
	a) No of Technologies (IP, Licensing, Patents etc.)	15-20
	b) Technology Products	8-10
	c) Publications (Journals, conferences, Book chapters), IPR and other Intellectual activities	30-40
	d) Increase in CPS Research Base (White papers, Standards, RFP, concept papers, Technical reports etc.	40-50
2.	**Entrepreneurship Development**	
	a) CPS-Technology Business Incubator (TBI)	1
	b) CPS-Start-ups & Spin-off companies	20-25
	c) CPS-GCC - Grand Challenges and Competitions	2-3
	e) CPS-Promotion and Acceleration of Young and Aspiring technology entrepreneurs (CPS-PRAYAS)	3-5
	d) CPS-Entrepreneur In Residence (CPS-EIR)	11-15
	e) CPS-Dedicated Innovation Accelerator (CPS-DIAL)	1-2
	f) CPS-Seed Support System (CPS- SSS)	1
	g) Job Creation	5000 -7000

3.	**Human Resource Development**	
	a) Graduate Fellowships	160-200
	b) Post Graduate Fellowships	30-40
	c) Doctoral Fellowships	25-35
	d) Faculty Fellowships	1
	e) Chair Professors	1
	f) Skill Development (in terms of workshops and STPs)	250-300
4.	**International Collaboration**	
	(a) International Collaboration	3-5

4. Strategy

This section focuses on the broad strategies to be applied to achieve objectives of the TIH mentioned in the last section. The broad set of strategic points would involve the following.

- Launch of Section-8 Company
- Sub-Committees for technical streams from academic and industry
- Selection of projects through various competitive schemes like GCC, PRAYAS, EIR, Hackathons etc.
- Hub Governing Body as Apex Body
    - Overall supervision, control and mid-course corrections.
    - Key implementation/operation guidelines

The strategic details of initiation and operationalizing the TIH are enumerated below.

1. As the first step of the project, a section 8 company will be set up. The section 8 company will be entitled “IIT Bhilai Innovation and Technology Foundation” (IBITF). The documents regarding ARTICLES OF ASSOCIATION and MEMORANDUM OF ASSOCIATION of the company have been drafted and the BoG of IIT Bhilai has given permission for creation of the section 8 company.

2. **“**IIT Bhilai Innovation and Technology Foundation**”** will focus on areas related to Fintech in the four major verticals namely, E-payments, Blockchain, AI and IoT. The faculty members of the Electrical Engineering and Computer Science department of IIT Bhilai and academic collaborators of the TIH have core competence in these verticals in terms of applied research and product prototyping. The collaboration of the TIH with the best Fintech related companies of India will augment the academic expertise with industry skill set namely, incubation of start-ups, prototyping to productization, marketing etc. A core team of experts from IIT Bhilai, academic collaborators and industry personals will be formed that will be responsible for proposal initiation, selection of projects under the schemes of the TIH,

continued evaluation and end-to-end guidance from “spin-off to marketing”.

3. The TIH has already on boarded collaborators from the Indian and well as international academia of repute namely, ISI Kolkata, IIM Raipur, IIIT Hyderabad, IIT Dharwad, Macquarie University (Australia), University of Missouri (USA), Université de Versailles Saint-Quentin-en-Yvelines (France) etc. The faculty members from these universities have been selected based on strategic alignment of the objectives of TIH with their research interests. Most of the collaborators have extensive experience in terms of research and running stat-ups as well, that would help deliver synergies leading to enhanced results to meet the TIH objectives. Similar endeavor is ongoing to bring in more collaborators in the TIH.

4. On the other hand, the TIH has already taken on board the major government of India Fintech related companies namely, NPCI, UIDAI, GSTN, CDAC etc. As these companies implement most of the electronic commerce in India, their expertise will help to guide the projects in the TIH appropriately, so that the prototypes from the start-ups can be easily productized and made available to a large mass in the Indian context.

   At the same time, some of the global private sector companies working in the area of IoT based products to support Fintech namely, Infineon Tech., Intel, Tektronix etc. have committed to be the collaborators of the TIH at IIT Bhilai.

5. After shortlisting of the projects by the TIH for funding, relevant experts from the collaborating industry and academia will be asked to mentor the projects. This will ensure that projects are application oriented, requirements are real life need driven and final products are marketable. This industry-academia joint venture will ensure that there is a smooth synergy between academic focus of research and industrial targets of implementation.

   As an icing on the cake, support from the industries in the forms of In-kind or In-cash will ensure the self-sustainability of the projects and the TIH as well.

6. The selection of proposals for funding will be basically from two ends (i) TIH backed schemes

like Hackathons, GCC, PRAYAS, EIR, DIAL etc. will have the industry mentors from the starting and (ii) Through open calls, where high weightage will be given to the proposals having industry/start-up partnership as collaborators.

The list of tentative problems already identified in this DPR will be published and applicants interested to work on these problems will have the experts from academic and industry (as they are already identified) as mentors. In this case, the applicants for funding will be selected based on the merit of their proposal, productability of the deliverables, background of the team members, prior experience etc. Unless found exceptional, only one team will be allowed to work on a problem.

7. As a target to one of the most important objectives i.e., Human Resources Development, the TIH will focus on undergraduate, post-graduate, doctoral students and visiting faculty members (namely, faculty chairs, visiting faculty etc.).

    - At the UG level, elective courses and projects will be offered for in house students of IIT Bhilai. The TIH shall also offer internships, summer and winter schools for UG students (all across India) focusing mainly on short term innovative projects in the Fintech domain. Emphasis will be given such that the projects offered at the UG level are in-line with the ones already being funded by the TIH to the entrepreneurs, thus facilitating the outputs to augment a mainstream work of the TIH.

    - Regarding the projects at PG level, the same approach will be followed as in case of UG students, however, more involved problems will be given. Since, fellowships will be provided, the UG students will be given freedom to work with any of the start-ups under the TIH and contribute directly to a much larger goal.

    - For PhD, the TIH will recruit dedicated and motivated students to conduct applied research and development in the verticals under the TIH namely, e-payment, Blockchain, AI and IoT. The students will be encouraged to perform basic or applied research in the areas of Fintech however, keeping in mind to target a possible product as a direct or indirect output of the research. As in the case of PG students, the PhD

students will be given freedom to work with any of the start-ups under the TIH and contribute directly to a much larger goal.

The students whose research has shown a bright prospect of a future product will be encouraged to continue under the EIR program.

- The TIH will on-board chair professors who have shown exemplary experience in driving product oriented research, nurturing start-ups etc. in the Fintech domain. As chair professors will have a sufficiently long tenure (3 years), they will be engaged as expert advisors in one or more projects being funded.
- Faculty members from top tier Indian and foreign universities (with special emphasis to our collaborators) will be inculcated as visiting professors in the TIH to mentor the various activities in the TIH.

8. As IIT Bhilai has started only 4 years back, there will be very minimal overlap of the existing facilities with the ones targeted under the TIH. The institute will move to its permanent campus on 2022 and at that time, it will ensure that new facilities being created by the institute grants will augment the TIH and has minimal redundancy.

9. The resources of the TIH i.e., faculty members of IIT Bhilai, collaborators from academia and industry will mainly look at the technical aspects. For the managerial and administrative related activities, the TIH will recruit staff in the TIH. For marketing and publicity of the TIH, third-party agencies will be on-boarded.

10. It is understood that the main of the TIH is based on a non-profit system, however, while selecting proposals for funding it will recommend projects with a potential for commercial application and profits. If some project is for a large social benefit of the country, the commercial angle may be ignored.

11. Under the present pandemic situation, if some project is proposed to address the situation, special drives will be taken to fact-track the selection and funding of such endeavors. It may be noted that many proposed projects in the DPR fall in this category.

12. TIH will ensure accountability from all the stakeholders and maintain necessary checks and balances. All ongoing projects will be evaluated periodically and high performing ones may be awarded with top-ups and low performing ones will be warned and even dropped to maintain overall performance.

4.1 Entrepreneurship and start-up ecosystem

The entire set of activities starting from technology development to collaboration and research, will provide a fertile ground for entrepreneurship and start-up ecosystems. The strategy for inculcation of the startup ecosystem through various schemes of the TIH is detailed here.

4.1.1 Grand Challenges and Competitions for scouting innovations (GCC)

GCC is a pre-incubation activity targeted mainly to discover innovative ideas in the area of financial technology. Through different challenges like Hackathons, the TIH can invite people from different areas with innovative solutions for solving issues and challenges in the area of finance particularly to Indian context. The basic objectives of the GCC are

- Find and nurture innovative ideas for addressing major challenges in the area of Fintech and their solution with the help of technology.
- Find untapped sources and convert ideas into start-up.
- Provide a minimal risk entry point into the start-up ecosystem.
- Provide structured guidance, mentoring and funding for application of ideas.
- Generate awareness and build a vibrant entrepreneurship ecosystem.

4.1.2 Promotion and Acceleration of Young and Aspiring technology entrepreneurs PRAYAS)

At an early stage, a gap exists for young entrepreneurs to build a working prototype from their ideas before progressing to the next level. There are many challenges that are faced by entrepreneurs in

preparing the first working prototype. PRAYAS would be filling this gap by providing funding and guidance at this stage to help entrepreneurs and allow a large number of potential ideas into incubation programs. Specifically, PRAYAS aims at the following.

- Enable translation of ideas into prototypes
- Attract a large number of youth with innovative ideas for different types of problems.
- Provide a platform for faster experimentation and modify approach from idea to prototype.
- Provide a platform to test ideas.

The lab set-up to be developed in the TIH will provide all the required facilities to allow for fast prototyping of the ideas.

4.1.3 Entrepreneur in Residence (EIR)

The EIR program is envisaged to inspire best talents among PG and PhD graduates and provide ample support to minimize risk in pursuing start-ups. The program would provide enormous opportunity for innovative entrepreneurs to expand network and get critical feedback to promote their entrepreneurial goals and aspirations.

- Encourage students to take up entrepreneurship by providing fellowship
- Provide prestigious forum for deserving entrepreneurs to pursue their ideas without additional risks
- To make entrepreneurship related to financial technology an attractive option among available career options.
- Enable creation of new start-ups and allow them to make significant progress towards raising funding and investment.

4.1.4 Dedicated Innovation Accelerators (DIAL)

Accelerators are a post-incubation initiative linked with the existing incubators to supplement and complement the scaling up of a start-up. It aims to direct focused resources for a start-up to validate product ideas and engage with customers for scaling up and boosting the incubator's existing

activities. Accelerators also help in realizing and deciding whether to create a scalable start-up from a very nascent stage. The basic objectives of DIAL involve,

- Fast track growth of potential start-ups through monitoring and networking
- Attract mentors, expert, academicians and investors through structure accelerator programs

4.1.5 Start-up

A significant effort of the TIH is to innovate new ideas and technology for revolutionizing the financial sector. These innovations are incomplete if they are not brought forth for the use of common people. A way to do this is through creating start-ups based on the innovations made. Start-ups are the vehicle through which innovative ideas will not only be implemented, but also have substantial effect on the society around. The objectives of the startup program is to achieve,

- Take forward innovation to the commercialization stage.
- Promote start-ups by young Indians students
- Accelerate and guide the journey of an innovative idea
- Provide financial assistance for the initial stage of start-up.

4.1.6 Seed Support System (SSS)

The SSS will allow for funding promising ideas and incubate them till next funding is obtained from investors. The funding allows the innovators and entrepreneurs to develop their technology to a level, where they can attract investments from well-known investors. Thus, it acts as a bridge between ideation, development and commercialization of an innovation in a hassle free manner. The basic objectives of SSS involve,

- Ensure timely availability of seed support for deserving incubator
- Provide platform for innovative entrepreneurs to carry their idea to commercialization
- Widens the pipeline of incubators by attracting more innovators
- Allow entrepreneurs to carry forward their start-up with minimal risk.

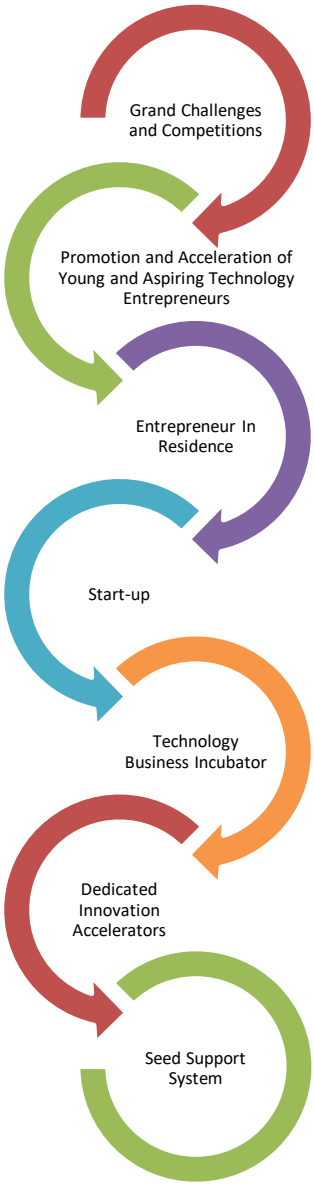
4.1.7 Technology Business Incubators (TBI)

The Technology Business Incubator will be primarily established with some academic, technical or management institution to bring in the innovations and technologies for venture creation by utilizing expertise and infrastructure already available with the host institution. The TBI initiative of the TIH will protect the institute to be funded, from the high risk involved in high growth ventures, to enhance the prospects of their success. The basic objectives of TBI involve,

- Job creation, prototype and product design, businesses etc. aligned with national priorities.
- To facilitate start-ups with cutting edge research mentorship, lab facility etc.
- To provide a platform for speedy commercialization of technologies developed by the host institution or the stakeholders associated with the institute.
- To build a vibrant network of start-up ecosystems facilitating mentorship, technical and R&D related suggestions, financial support etc., by establishing a network between academia and industries, mainly involving the collaborators of the TIH.

The figure below illustrates the strategic flow for traversing the roadmap planned for the "entrepreneurship and start-ups" in the TIH. Following that, target numbers to be achieved under each scheme of the TIH are tabulated.

PRAYAS enables entrepreneurs to convert their ideas into prototypes with minimal risk and thus eliminates a barrier to entry.



GCC will encourage discovery of new innovative ideas through different competitions and challenges.

EIR will enable entrepreneurs to have access to proper guidance and offset the cost of setting up a start-up. This will provide immense opportunity for correct start.

Start-up program will encourage students from various institute with appropriate guidance to start their journey as a start-up.

TBI will allow creation of job and wealth by promoting new technology/knowledge /innovation based start-up.

DIAL allows fast tracking growth of potential start-ups through rigorous mentoring and networking support.

SSS is there to ensure availability of seed support to the deserving start-ups.

Entrepreneurship Development at the TIH	Tentative Roadmap
CPS-GCC - Grand Challenges and Competitions	Organize typically two or three Hackathons in two years to find promising ideas in the Fintech domain and support them for incubation under various schemes of the TIH. Selected teams will be provided 5-10 Lakhs (in a period of two years) as initial grant and encouraged to open start-ups or develop prototypes.

CPS- Promotion and Acceleration of Young and Aspiring technology entrepreneurs (CPS- PRAYAS)	Set up PRAYAS unit at the TIH focused on Fintech technologies, facilitating fast prototyping of the ideas brought out by interested individuals/teams. Support around five promising ideas under PRAYAS scheme in Fintech based products/solutions development, with a fund support of Rs. 45 Lakhs (maximum), for a period of 1 year. Successful ventures will be encouraged for entrepreneurships and start-ups under the TIH umbrella.
CPS-Entrepreneur In Residence (CPS-EIR)	The students inculcated under the UG/PG/Doctoral fellowships in the TIH will be encouraged to work with a target to translate their research into Fintech related productable ideas. Promising candidates whose work can lead to marketable solutions in the Fintech arena will be encouraged to work under CPS-EIR scheme. The TIH will support around fifteen Individuals in Fintech based product/solution development with monthly stipends of Rs. 15-30K.
CPS-Start-ups & Spin-off companies	Support around twenty Start-up companies in the Fintech domain, with a grant of Rs. 10 Lakhs (maximum) for three years. The selection will be based on open calls and schemes of the TIH namely, GCC, PRAYAS, EIR etc.
CPS-Dedicated Innovation Accelerator (CPS-DIAL)	The TIH will set up a DIAL unit to monitor projects ideas that need fast tracking due to market needs e.g., products supporting to deal with the COVID pandemic. The DIAL unit will select about two projects for additional funding to acquire manpower, resources etc. to get the prototype to the market in a short time. The maximum period of funding will be 1 year and the funding will be limited to 100 Lakhs.
CPS-Seed Support System (CPS- SSS)	Based on performance in terms acceptability of the prototype and interest to market by after production by an industry (giving preference to the industries already in collaboration with the TIH) one of the start-ups inculcated by the TIH, will be selected under the SSS. Additional funding of a maximum 5 crore will be provided by TIH. Additional support may be provided by the industries already in collaboration with the

	TIH, if they are interested to market the product.
CPS-Technology Business Incubator (TBI)	Based on outstanding performance as a team by any academic, technical or management institute as collaborator of the TIH, one of them will be selected as Technology Business Incubator. The funding will be maximum of 7.5 Crores. Following that TIH will work jointly with the TBI to expand its activities.

5. Target beneficiaries and collaboration

This section identifies target beneficiaries of the TIH in terms of products and services to be churned out by the incubated companies, helping entrepreneurs to transform their ideas to products, manpower development etc. in the domain of financial solutions. Even in the current times, electronic commerce has limited penetration in the rural and weaker section of the society. Therefore, special emphasis has been given such that the outcomes of the THI majorly benefit such classes of the society. Further, contributions expected from the collaborators have been identified regarding problem formulation, mentoring the funded projects, joint research and development, continuous monitoring of the progress of the projects etc.

5.1 Key beneficiaries

The proposed 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 foremost verticals of the TIH in these national initiates are (i) development of Fintech related products specifically targeting needs of India (ii) creating an Innovation, Entrepreneurship and Start-up ecosystem in line with the migration towards digital economy of our nation; (iii) HRD in the financial technologies arena at the undergraduate, post-graduate, doctoral, postdoctoral level through mentorship and guidance from exerts of the academia and industry;

The following are some of the major sectors of beneficiaries from the products and solutions targeted by the TIH.

- *Fintech service providers*: The technologies, prototypes and products to be churned out of the TIH will benefit at the first tire to all organizations associated with finance e.g., banks, mutual fund management agencies, credit rating agencies, software and firmware design companies (e.g., e-payment mobile Apps, ATMS, PoS devices.), cyber security agencies etc.

- *End users of digital economy*: Even compared to the Fintech service providing agencies, the larger set of beneficiaries will be the customers. The products and the services from the TIH will have ample level of benefits for the customers namely, add-on features to gadgets to make digital payments seamless and easy, added security to e-transactions, fully contactless transactions in many practical applications like public transports, ATMs etc. to address the COVID-19 situation, tools for market prediction as a guide to financial investments, transactions with very minimal Internet requirements etc.

    - *Rural users of digital economy:* The real success of the GoI initiatives like cashless economy, digital India etc. would be successful only if the major benefits of the electronic economy percolates to rural India. Keeping this factor in mind, one of the aims of the TIH is towards development of systems that facilitate e-financial transitions using gadgets with minimal numbers of features, requirement of Internet connectivity as low as for a few minutes a day, use of local languages for transactions, use of voice based transactions in local language etc. Thus it is envisaged that a large mass of the Indian population of the rural part and only partially literate will be a major beneficiary of the TIH.

- *Entrepreneurs:* Among all the objectives of the TIH, the paramount is to provide an ecosystem for entrepreneurs in the Fintech domain. The TIH has collaboration with the best GoI organizations and private sector companies of India in the Fintech area to mentor the entrepreneurs, provide full support to productize the ideas and finally marketing them. In addition, the TIH has on-boarded best experts from academia in India and abroad to provide basic and applied research based mentorship. With a very rich set of experts from the academia and industry, the TIH will majorly benefit the young and budding entrepreneurs of the country.

- *Academia comprising faculty members and students:* Apart from the industries, start-ups and end users of the electronic economy, a more fundamental sector of the population that will be highly benefitted is the academia involving students and faculty members. With a rich portfolio of programs for the academia namely, fellowships for PG, PhD and chair professor positions, internships, summer and winter boot camps, short term courses,

faculty development programs, workshops, entrepreneur in residence program etc., the TIH is going to definitely inculcate the interest of working on Fintech related areas among the students. Further, a state of the art laboratory facility pertaining to the aspects of Fintech will be setup in the TIH.

5.2 Collaboration

To provide a genesis to the Detailed Project Report (DPR) apropos the missions of the TIH, inputs have been taken from the experts in academia, industries in the private sectors and government institutions having wide and long experience in the Fintech area, both from India and abroad. After getting an idea of the missions of the TIH they have agreed to be on-boarded as collaborators; the details are tabulated below.

Sl No	**Industry (GoI and Private)** **Faculty members from Academia**	**Nature of Collaboration**
1.	Prof. Sumanta Sarkar Research Scientist TCS Innovation Labs Hyderabad India	Formulated applied research oriented problems in the area of Information Security which includes cryptology, cloud security, under the IoT vertical of the TIH. Mentor for UG/PG/PhD projects. Mentor for the EIR scheme
2	Prof. Goutam Paul Associate Professor Cryptology & Security Research Unit (CSRU) Indian Statistical Institute, Kolkata	Formulated applied research oriented problems in the area of Cryptology, Security, Information and Coding Theory, Quantum Information, under the Blockchain and IoT verticals of the TIH. Mentor for UG/PG/PhD projects. Mentor for the EIR scheme
3.	Prof. Christina Boura Maître de conférences Laboratoire de	Formulated research oriented problems in the area of Symmetric-key cryptography and cryptanalysis under the IoT vertical of the

	Mathématiques de Versailles (LMV) Université de Versailles Saint-Quentin-en-Yvelines	TIH. Mentor for UG/PG/PhD projects.
4.	Prof. Yu Sasaki NTT Distinguished Researcher NTT, 3-9-11 Midori-cho, Musashino-shi, Tokyo	Formulated applied research oriented problems in the area of Cryptography, symmetric-key cryptosystem, blockcipher, design, cryptanalysis under the IoT vertical of the TIH. Mentor for UG/PG/PhD projects.
5	Prof Sajal K. Das Professor and Daniel St. Clair Endowed Chair Missouri University of Science and Technology, USA	Formulated product based research oriented problems in the area of Cyber-Physical, Systems and Smart, Environments, Mobile and Pervasive Computing, Smart City, Smart Grid, and Smart, Healthcare, Wireless and Sensor Networks; IoTs, Security and Privacy; Big Data Analytics, under the e-payments and IoT verticals of the TIH. Mentor for UG/PG/PhD Mentor for the EIR scheme
6	Prof. Rajan Shankaran Senior Lecturer, Department of Computing Macquarie University, Australia	Formulated product based research oriented problems in the area of D2D communications, medical implant security, network security and trust in mobile networks, under the e-payments and IoT verticals of the TIH. Mentor for UG/PG/PhD projects.
7	Prof. S. R. Mahadeva Prasanna, Professor, Department of Electrical Engineering IIT Dharwad India	Formulated product based research oriented problems in the area of AI, ML and NLP, under the AI based Fintech vertical of the TIH.

		Mentor for UG/PG/PhD projects.
8.	Prof. Sumeet Gupta Professor (Information Technology and Systems) IIM Raipur, India	Strategy design for execution of the various schemes under the TIH namely, Start-ups, EIR, DIAL, PRAYAS etc. Mentoring the TBI and ensuring collaboration of the TIH with TBI and other collaborators.
9	Dr. Ashok Kumar Das, Associate Professor Department of CSE IIIT Hyderabad	Formulated product based research oriented problems in the area of Cyber-Physical, Systems and Smart, Environments, Mobile and Pervasive Computing, Wireless and Sensor Networks;, under the IoT vertical of the TIH. Mentor for UG/PG/PhD projects. Mentor for the EIR scheme
10	Dr. Neminath Hubballi Associate Professor Department of CSE IIT Indore	Formulated product based research oriented problems in the area of Network Intrusion Detection Systems, Wireless and Sensor Networks and Biometric security etc. under the IoT vertical of the TIH. Mentor for UG/PG/PhD projects
10	Dr. Siba Narayan Swain, Asst. Professor, Department of Computer Science and Engineering IIT Dharwad India	Formulated applied research oriented problems under the Block chin vertical of the TIH. Mentor for UG/PG/PhD projects
11	Infineon Technologies 8, Kallang Sector, INFINEON, Singapore	Support in the form of equipment and expertise in the area of Smart Card Technologies, Bio-metric devices, IoT solutions etc.

		Access to existing industrial facilities (remote/on-site).
12	CDAC-Noida Anusandhan Bhawan, C-56/1, Sector-62, Noida - 201307 Uttar Pradesh (India)	Support for equipment for Embedded Systems Support for Software solutions in smart card and transit domain Support in the form of area expertise in Smart Card Technologies, Transit Domain, QR technologies Access to existing industrial facilities (remote/on-site).
13	Tektronix Salarpuria Premia, Survey No. 16 Kadubeesana Halli, Varthur Hobli Kaverppa Layout, Marathahalli - Sarjapur Outer Ring Rd, Bengaluru, Karnataka 560103	Sharing of advances in test and measurement technologies relevant for this TIH. Participation of Tektronix experts in organizing Measurement technology Workshops Engage the students under this program with Technical Experts from Tektronix for mentoring to make them industry ready.
14	ARM Bagmane World technology Center- SEZ, Citrine Block 5th and 6th Floor, Marathahalli Outer Ring Road, Doddanakundi Village, Mahadevapura, Bangalore -560048, Karnataka, India	Arm University donation program: Access to teaching material Access to online courses Access to e-textbooks SW tools
15	UIDAI Unique Identification Authority of India (UIDAI)	Support to the TIH will be in the form of guidance by the experts

	5th Floor, UIDAI HQs Bangla Sahib Road, Behind Kali Mandir Gole Market, New Delhi 110 001	
16	GSTN Goods And Services Tax Network, East Wing, 4th Floor, World Mark - 1, Aerocity, New Delhi - 110037	Support to the TIH will be in the form of guidance by the experts and availability of dataset Facilitate collaboration with relevant stakeholders of GSTN with the TIH
17	National Payments Corporation of India 1001A, B wing, 10th Floor, The Capital, Bandra-Kurla Complex, Bandra (East), Mumbai	Support to the TIH will be in the form of guidance by the experts and availability of dataset Facilitate collaboration with relevant stake holders of NPCI with the TIH.
18	AI foundry, First floor, Indiqube Orion, 24th Main Rd, Garden Layout, Sector 2, HSR Layout, Bengaluru, Karnataka 560102	Formulation of the mission, vision and targets of the TIH.

5.2.1 Collaboration with the Technology Innovation Hub in "Cognitive Computing and Social Sensing" at IIIT Delhi

The TIH at IIIT Delhi is focused towards cognitive computing, with emphasis on creating computer systems for different applications that behave, think and interact the way humans do. Cognitive information systems can proactively understand the incoming data (from a diverse set of sources), situations arising in the systems and reacting automatically by learning from patterns pertaining to these situations. To

elaborate, cognitive computing understands the psychology of end-users and how they are going to consume the information thereby facilitating immense amounts of personalization, precise profile mapping, accurate trend analysis and future prediction. From the perspective of end products, cognitive computing play a key role in human-centric computing driven personalized visualization tools, recommended interactions, adapt the user behavior and interaction patterns to improve context etc. The TIH at IIIT Delhi focusses on development of key cognitive technologies to develop intellective (cognitive) systems and different applications to solve society's most vexing problems.

One of the foremost focus of the activities targeted at the TIH of IIT Bhilai, is adoption of a customer-centric model for Fintech solutions. 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. IoT paradigm has helped Fintech companies to collect clients' data like behavior, likes, dislikes, places being visited frequently, expense and earning patterns etc. to extract information out of them. The benefits of customer's data analysis using IoT systems include, tracking creditors' behavior to precisely evaluate the 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.

The collaboration between the TIHs at IIT Bhilai and IIIT Delhi will be on use of cognitive computing techniques to develop customer-centric Fintech solutions.

6. Legal Framework

The TIH ***"IIT Bhilai Innovation and Technology Foundation (IBITF)-"*** Fintech will be registered as a Section 8 Company. The relevant documentation namely, ARTICLES OF ASSOCIATION and MEMORANDUM OF ASSOCIATION for the Section 8 Company have been drafted. The BoG of IIT Bhilai has approved the creation of a section 8 company to operate as a Technology Innovation Hub (TIH) in the Technology Vertical "Technologies for Financial Sector (Fintech)" in the meeting held on 6th August 2020.

Due to major corporate and business related activities that will take place in the TIH, a legal team will be formed for the TIH. A senior resource with legal background (i.e., corporate lawyer, IP Lawyer or CA) will be recruited, with one administrative staff for regular jobs. Further, the TIH will empanel with law / CA firms to get legal services as and when required.

A tentative legal framework proposed to execute TIH at IIT Bhilai is presented in the table below pertaining to the various schemes under the TIH. It may be noted that the legal framework is a draft and will be validated by the legal expert to be hired and modifications will be incorporated.

Sl No	**Stakeholders**		**Scope of the Engagement of the Stakeholders**	**Legal Documents and coverage**
1.	IIT Bhilai	TIH as section 8 company	Hosting and operation of the TIH	1. AOA 2. MOA 3. MoU of the TIH with IIT Bhilai 4. DPR of the TIH The documents will cover: Governance model, operational frameworks, details of support to the TIH, financial implications to IIT Bhilai, conflict resolution etc.

The section 8 company shall be governed by the Hub Governing Body (HGB) comprising the following members.

- Chairman: Director, IIT Bhilai
- Member: CEO of TIH
- Member: Institute coordinator of the TIH
- Member: Dean R and D of IIT Bhilai
- Member: One faculty member of IIT Bhilai associated with TIH (on rotation basis)
- External Members:
    - One representative from industry (from the collaborators)
    - One representative from academic (from the collaborators)
- Members (Finance): Deputy Register (F and A) of IIT Bhilai

The details are available in Section 9.

Various internal stakeholders of the TIH and the tentative set of documents involved are as follows.

Sl No	**Stakeholders**		**Scope of the Engagement of the Stakeholders**	**Legal Documents and coverage**
1.	TIH	Students	1. Internship for external students 2. UG project 3. PG and PhD degree 3. Fellowship	1. Internship: As per IIT Bhilai policy 2. Academic Handbook: Rules and regulations for academic related matters will be as per the academic regulations of IIT Bhilai (for UG, PG, and PhD students) 3. Financial Guidelines: Rules pertaining to the fellowships of the students and interns.

2.	TIH	Chair Professors and EIR	1. Engagement as visiting faculty member of IIT Bhilai 2. EIR engagement as project staffs	1. Faculty Handbook: Rules and regulations for chair professors will be as per the faculty handbook of IIT Bhilai (case of visiting faculty members): Leave rules, working hours etc. 2. Staff handbook: Staff Handbook: Rules and regulations for EIR will be as per the staff handbook of IIT Bhilai (case of project staffs): Leave rules, working hours etc. 3. Financial Guidelines: Rules pertaining to the salary of chair professors and EIR.
3	TIH	Start-ups (including DIAL, PRAYAS etc.)	Projects funded by the TIH	1. Criterion for selection of projects under different schemes of the TIH for funding 2. MoUs: TIH and the stakeholders funded. 3. Rules and regulations for the start-ups 4. Financial utilization guidelines for the startups 5. Monitoring and evaluation framework 6. Remedial measures in terms of non-compliance 7. IP ownership rules
4.	TIH	Collaborators (Academia and Industry)	1. Collaborations in terms of joint research and development with the stakeholders engaged with the TIH.	1. MoU with the collaborators (individual) or organization (based on need) 2. IP Ownership Rules 3. Academic handbook of IIT Bhilai: Joined student guidance

			2. Use of test bed at the collaborator's end for validation of the technologies developed	
5.	TIH	Participants (Grand Challenge)	Selection of project ideas to be funded by the TIH	1. Proposal for Grand Challenge and Admin Approval (similar to event organizing guidelines of IIT Bhilai) 2. Financial utilization guidelines (similar to event organizing guidelines of IIT Bhilai) 3. Selection criterion of the projects

7. Environmental Impact

The THI will involve activities related to financial technologies with special focus on e-payments, Blockchains, AI and IoT, which comprise development of software and small electronic gadgets. Hence, the TIH has NO impact on the environment in terms of land and water body acquisition, clearing of forest land, impacting wildlife, rehabilitation etc.

8. Technology

The TIH on Fintech at IIT Bhilai has a wide spectrum of activities ranging from fundamental research, to applied research and translation to cutting-edge technologies and products. The key emphasis will be development of a versatile environment for entrepreneurship and start-ups, which would initiate with the research ideas and finally lead to successful productization and commercialization. The TIH will focus on the four major verticals that would aid financial technologies in the modern age, viz. e-payments, Blockchain, AI and IoT. In this section we elaborate on major technology pipelines that are planned to be applied to the problems perceived to be worked upon (and elaborated in Section 2.2).

It may be noted that most of the projects are based on strong research fundamentals for which we discuss the tentative technology pipeline to be applied for implementation. During the actual execution of the projects, the technology options available will be studied in more details and the best option will be selected, subject to constraints like budget, availability of resources etc. At the same time some projects being perceived like Smart ATMs, Single smart cards etc. are based on known engineering techniques that would be integrated for implementing the system. Such projects are extremely important from the urgency of Covid-19 pandemic situation prevailing in the world. As the technology stack for such problems are well known, we do not discuss them in this section (but are covered in Section 2.2)

8.1.1 E-payment Systems

- *User friendly e-payment systems*
    - *Minimal human intervention and physical access based automatic e-payment systems:* Human interaction can be minimized by auto billing of the items, which can be achieved by attaching RFID tags to the items with the price information. Once the items are passed through an RFID gate, the accumulated bill can be prepared and printed/displayed. The customer can make the payment using a mobile app based e-wallet (by scanning the barcode using the mobile app followed by authentication and authorization); in this case there is no physical access required. However, if the customer needs to pay using a smart card, near field communication can be used to tap in the card (i.e., identification). Instead of using the keypad of the PoS device (requiring physical access) to provide the PIN,

information can be sent to the registered mobile, where the PIN can be entered via an App. Of course, system, hardware and software level security will be incorporated in the design.

- *E-payment systems on low cost mobile platforms*:

  To facilitate e-payments in rural areas GoI has formed an umbrella organization "NPCI" for operating retail payments and settlement systems in India. NPCI enables various modes for making payments like AEPS (Aadhar Enabled Payment System), Bharat bill payment system, BHIM Aadhaar pay etc. to encourage e-payments in rural areas. However, many challenges are to be addressed to encourage digital payments in rural areas like, intermittent and low bandwidth of Internet, requirement of interfaces in native languages, confidence of the users in terms of security and privacy etc.

- *Security in e-payments:*

  This project aims to develop mobile apps to secure mobile based e-payment platforms, using the following broad techniques.

  - Method for monitoring financial transactions and identifying suspicious activities by observing the user behavior and profiles.
  - Comprehensive backend system to monitor money trail aiding in detecting fraudulent activities like money laundering.
  - Standard signature detection systems.

- *E-payment for utility services--public transport:*

  A tentative design architecture for implementing UPI based e-payment systems, especially applicable to the Indian scenario is discussed as follows.

  During the entry, the passenger just needs to TAP the card at the entry point of the vehicle or the station. TAP in, stores the data at the public transport operator's local server. In case of a station, a server can store data from multiple TAP points located in the station entry points. However, in case of an individual vehicle, the data is stored in the TAP reader. If Internet connectivity is available, the data is sent to the central server. Otherwise, the local server or temporary storage holds the data till Internet connectivity

is available. The temporary storage is required to solve the problem of intermittent internet connectivity.

If the Internet connectivity is available, the identification would be done during the TAP in of the card. After successful identification of a passenger, the issuing bank will send an OTP on the passenger's mobile for authentication. Passengers need to enter that OTP during the journey for authentication and authorization of payment. A fixed amount of money (based on the policy) will be debited. After completing the journey passenger needs to TAP the card again (exit point) for actual fare calculation and payment settlement.

If the Internet connectivity is unavailable during the journey, the identification and authentication process would take place later when the Internet is available and the passenger can take the journey. Passenger needs to TAP the card for entry and the data is stored locally. During the exit, the card is tapped at exit point and the data is again saved locally. As soon as the Internet connectivity is available (even after the journey is complete) identification and authentication take place and passengers need to enter the OTP to complete the transaction. In this case, the exact amount of fare is debited and payment is settled.

In any of the cases, if the payment is not authorized (e.g., due to lack of balance), the customer needs to immediately add money in the account to complete the transaction. Otherwise, the card will be blacklisted and the passenger cannot undertake any future journey using that card. Information of the blacklisted cards are regularly updated on the concerned TAP points. So, the TAP points would ring an alarm when a blacklisted card is tapped in, denying entry to the passenger.

The Unified Payments Interface (UPI) offers the architecture and a set of standard Application Programming Interface (API) specifications to facilitate online payments. It aims to simplify and provide a single interface across all NPCI systems besides creating interoperability and superior customer experience. UPI provides a good combination of features like simplicity, innovation, adoption, security and low cost, that can be utilized to develop the proposed e-payment system for the Indian transport.

8.1.2 Fintech and Blockchain

- *Design and analysis of structural components of Blockchain for Fintech*

  - *Consensus algorithms:*

    Consensus algorithms play an important role in the successful implementation of Blockchain-based products or prototypes. Since, the project will mostly concentrate on Fintech related services such as lending, borrowing, mortgage, insurance, underwriting, tokenization-based transactions through national and international payment gateways, mainly using peer-to-peer networks, it is quite understandable that the conventional consensus algorithms such as Algorand, Satoshi's or Ethereum's would fail to make the cut. On the other hand, some of the modern algorithms such as Ekiden and FastKitten, although quite useful from the performances and efficiency points of view, may be quite off the mark for applications in various financial processes such as taxation, regulatory compliances, paperless authentication, loan underwriting and approval, etc. The research will mainly focus on investigating various new ways to design consensus algorithms to solve various financial processes. The main goal that will be pursued is to achieve various financial transactions that are secure, privacy-preserving and available to all round-the-clock, which is, last but not the least, fully transparent.

  - *Building permissioned and permission-less hybrid Blockchain platforms*:

    A sizable amount of time and energy of the research communities have been devoted to understanding and determining the most suitable blockchain platform, whether it is permissioned or permissionless, yet the community is still at the surface. The crux of the whole problem is the following: normally, business and financial applications need not be fully decentralized like Bitcoin or Ethereum. On the other hand, decentralization is an important feature that brings to the table all the "unhackable" properties. Therefore, the major goal to achieve here is to have the right balance of permissioned and permissionless features in protocols.

- *Searchable encryption:*

  For searchable encryption, the users employ the encryption techniques to mitigate the security concerns of the confidential financial data. However, once the data is encrypted, no processing (for instance, ordinary searching) can be carried out on the outsourced data. If anybody wants to process the encrypted stored data from the blockchain, in the worst case he/she has to decrypt each and every encrypted block in the cloud where the blockchain is stored. This technique is not efficient and takes huge time, and this way is not also reliable. To mitigate this issue, Searchable Encryption (SE) techniques need to be incorporated to allow searching on the encrypted data without leaking the information for the cloud domain. These techniques enable different kinds of search on the encrypted data and offer various levels of security. The searchable encryption scheme can be categorized based on the type of search and especially keyword search, “regular expression search”, and “semantic search”. In the following, the major steps of the project are enlisted.

  - Though the searchable encryption technique performs in various domains, such as financial sector, supply chain, health care, law-enforcement, and so on, but still there are lot of issues that would be addressed, such as the encrypted clustering data for improved search speed, searching over the multiple encrypted datasets, employing edge/fog computing and efficiency for the blockchain data.

  - Recently, various practical attacks have been reported on searchable encryption, which also raise serious concerns for security of searchable encryption. One of the attacks is forward privacy that implies inefficiency. In addition, the majority of the existing searchable encryption schemes do not withstand such kind of attacks. Intrusion detection systems for such attacks will be developed

  - Big data analytics will be applied once the blocks containing important information through encrypted search are identified.

  - A testbed experimental setup to validate the efficacy of the proposed schemes.

- *Secure Digital Identity Management:*

  The project will comprise research and development of a peer-to-peer blockchain network in which the user will submit his/her KYC information. This data will be recorded as one transaction and will be floated on the network. The miners will validate these transactions and calculate the nonce for the block and then add it to the blockchain. The user is now a part of the blockchain based digital identity network. The user can now either give the bank account details, if he/she has an account, or just fill in the non-financial parameters. The Know Your Customer (KYC), which is done by banks, takes a lot of time for authentication. This time will be reduced due to the trust built by the blockchain.

  The proposed blockchain based digital identity framework will be used to develop two separate models to enable intra- and inter- bank verification and update processes. This significantly reduces time and effort spent in repetitive due diligence processes. If a new service request requires additional customer information not found in the ledger, the model will allow the bank to update the ledger and get it revalidated by external agencies—which essentially translates into re-KYC. Additionally, the blockchain platform will also ensure secure inter-bank document transfer—enhancing process efficiency, standardizing KYC processes, and performing near real-time customer validations.

- *Risk analysis and assessment:*

  Numerous p2p lending platforms (such as lendenclub.com, paisadukan.com) are available in India. They cater to the urban population and have yet to see a big jump in business. For the rural community, the platform needs essentially be provided by the government because of the issues of trust and risk involved in such a platform. When Yes Bank's founder can siphon away a considerable amount of consumer wealth, then what to speak of private platforms which always look for ways and means of cutting into consumer's pie. The government's platform can overcome the problems of trust and risk among rural people and be more secure by linking to records available with Patvaris and information available on Aadhaar. The novelty lies in the platform being developed for a social cause and rural people.

  The scheme envisages developing a secure technology platform, the two sides of the lending

platform (lenders and receivers), and influencing rural people's adoption. The first step in this journey would be to conduct a feasibility study of such a platform among rural people and understanding their concerns about participation in Fintech. Technology can be built on a blockchain platform and linked to rural people through an app whereby they can conduct transactions among each other without any need of physical cash.

- *Energy Trading:*

  The methodology for blockchain based energy trading requires the use of smart meters. For any prosumer, these smart meters measure the amount of the power consumption and any excess power generated using the rooftop solar panels. Similarly, the information of the excess power from all the prosumers is gathered and fed into the ethereum based blockchain. The consumers who want to purchase the power from their neighbourhood can raise a request to purchase the power and the amount they are willing to pay for per unit of power. Thus, the information regarding the demand of the power is also fed into the blockchain. Now, based on this demand and supply at regular intervals, the blockchain determines the optimal price for the power sale and consumers will be supplied with the required power (charged based on the optimal price) and prosumers will get either the equivalent net metering credits or money credited in their accounts. Smart meters installed at the prosumers and consumer's side also keep track of the power flow through the transmission lines owned by the distribution companies and equivalent credits can be transferred to the distribution company based on the contractual price for per unit power flow through the lines.

- *Intelligent precision agriculture*

  Some of the major techniques to be applied to achieve the Blockchain-enabled authentication in IoT-based intelligent precision smart agriculture system are listed below.

  - Design of new efficient and robust user authentication protocols for the IoT based intelligent precision smart agriculture, specially emphasizing on the Indian Fintech context. Practical implementation of blockchain solution for the newly proposed user authentication protocols.

  - Incorporation of smart contracts to enforce the criteria agreed upon in the agreement

between the farmers and traders.

- Prediction on the collected data from agriculture fields that are stored in the blockchain for big data analytics.
- Testbed experiments for validation of designed protocols.

8.1.3 AI in Fintech

- *Efficient AI and ML based models for Fintech applications*

  - *Interpretation of unstructured data using Natural Language processing:* For interpreting the unstructured data using NLP the following techniques will be utilized.

    - *Speech recognition and intent parsing:* Speech recognition is a key piece of the analysis of companies' quarterly or semi-annual earnings calls. Corporate conference calls usually start with the company making a presentation on the performance of the previous quarter and the outlook for the following one, followed by a Q&A session in which analysts ask direct and specific questions to the company. Profiling the tone of speech, and converting it to text to quantify it across different key topics, such as revenue, are likely to help in gazing the company's stock price

    - *Content enrichment - retrieval:* NLP can also be used to retrieve information from unstructured text. This approach is known as Named Entity Recognition (NER), and is used to detect and label entities, that is, real-world concepts, such as people or companies. NER effectively overlays context on the content by tagging it with machine-readable metadata aligned with an ontology which leads to efficient and accurate information retrieval.

    - *Content enrichment - trends and relationships:* In the investment sphere, applying tags to highlight the main topics covered by text, or topic modeling, is valuable when analyzing earnings calls to establish a main theme, or to compare against previous, similar calls to identify trends. NER offers additional value, since it can be used to link entities and build a graph of relationships. For example, an entity-modelling system can pick out mentions of specific topics within a range of unstructured text and build new connections. It can help track relationships between entities, with the potential to detect money laundering

or fraud.

- *Sentiment analysis:* Another area of NLP is sentiment analysis, which can extract the subjective meaning from text sufficiently well to be able to determine its attitude, or sentiment. It is an ideal tool for reviewing unstructured content about a particular company to look for inconsistencies and anomalies. Sentiment analysis can help classify news stories based on positive and negative sentiment to indicate the likely impact on a stock price, but also has more nuanced uses. Similarly, banks and other financial institutions can use NLP to discover and parse customer sentiment by monitoring social media and analyzing conversations about their services and policies.

- *Process automation, improving user experience and security:*

  The projects on the AI parlance for Finetch planned in the TIH (i.e., process automation and improving user experience and security) can be broadly mapped into clustering and classification problems. For instance, monitoring and security for fraud detection can be represented as a binary classification problem with four possible classification outcomes: (1) true positive (a fraud firm correctly classified as a fraud firm); (2) false negative (a fraud firm incorrectly classified as a non-fraud firm); (3) true negative (a non-fraud firm correctly classified as a non-fraud firm); and (4) false positive (a non-fraud firm incorrectly classified as a fraud firm). The most commonly used techniques required to perform such tasks are the following.

  - Descriptive or Unsupervised Techniques: These functions do not predict a target value, but focus more on the intrinsic structure, relations, interconnectedness, etc. The unsupervised techniques that can be applied to these three projects are as follows.

    - Self-Organizing Map (SOM) is a neural network technique but uses unsupervised learning. SOM allows users to visualize data from high dimensions to low dimensions.

    - Group method of data handling (GMDH) is an inductive learning algorithm for modeling complex systems. It is a self-organizing approach that tests increasingly complicated models and evaluates them using some external criterion on separate parts of the data sample.

- Clustering algorithms such as Density Based Spatial Clustering of Applications with Noise (DBSCAN) will be used for filtering out outliers and discovering clusters of arbitrary shapes.

- Supervised Predictive Techniques: In predictive analysis, the purpose is to build an analytic model that predicts target objects/events of interest.

    - Logistic Regression (LR) is a type of generalized linear model especially useful when the dependency between the observed variable and features is not linear (happens commonly).

    - Decision Trees (DT) is a tree structure, where each node represents a test on an attribute and each branch represents an outcome of the test. In this way, the tree attempts to divide observations into mutually exclusive subgroups. Cost-sensitive decision tree (CSDT) an induction algorithm developed to identify fraudulent credit card transactions are given. In the well-known decision tree algorithms, the splitting criteria are either insensitive to costs and class distributions or the cost is fixed to a constant ratio.

    - Neural Networks (NN) is a mature technology with an established theory and recognized application areas.

    - Support Vector Machines (SVM) use a model to implement nonlinear class boundaries by mapping input vectors non-linearly into a high-dimensional feature space. In the new space, an optimal separating hyper-plane is constructed.

    - Naïve Bayes (NB) a classification tool that uses Bayes conditional probability rule. Each attribute and class label are considered random variables, and assuming that the attributes are independent, the naïve Bayes classifier finds a class to the new observation that maximizes its probability given the values of the attributes.

    - Bayesian belief network (BBN) allows for the representation of dependencies among subsets of attributes. A BBN is a directed acyclic graph, where each node represents an attribute and each arrow represents a probabilistic dependence.

- K-nearest neighbor (KNN) is used largely in detection systems. It is also proved that KNN works extremely well in credit card fraud detection systems using supervised learning techniques.

- Artificial and Computational Intelligence Techniques: These are nature-inspired computational methodologies and approaches, which are applied to address complex real-world problems to which mathematical or traditional modelling takes prohibitive time.

    - Genetic Algorithm (GA) is a search heuristic that is inspired by Charles Darwin's theory of natural evolution. This algorithm reflects the process of natural selection where the fittest individuals are selected for reproduction in order to produce offspring of the next generation.

    - Scatter Search (SS) is an evolutionary algorithm, which shares some common characteristics with the GA. It operates on a set of solutions, the reference set, by combining these solutions to create new ones.

    - Artificial Immune System (AIS) - the human biological immune system has a number of fundamental characteristics that can be adapted as design principles for AIS applications in various problem domains.

- Apart from these, Deep learning (DL) thrives in recent years as one sub-field of machine learning, which is mainly developed based on artificial neural network with complex framework. DL becomes increasingly popular because of its amazingly powerful performance, mainly due to the fast advancement of computing power of machines and better algorithms for training deep neural networks. It is observed that both auto-encoders (AE) and restricted boltzmann machines (RBM) are effective in feature reduction for financial series' trend prediction. Heaton illustrates that AE and Long Short Term Memory Models (LSTMs) can be put into use for many financial problems such as Factor Models, Default Detection and Event Study (Heaton, Polson, and Witte, 2016).

- Finally, multiple NLP-based approaches are used to explore the predictive value of various international accounting and finance-related text sources. For instance, POS (part of speech) tagging and TF-IDF (Term Frequency- Inverse Document Frequency) weighting, enhanced by

Gaussian-radial-basis-function-kernel and polynomial-kernel supervised SVM classifiers, are successfully applied to confirm correlations between the textual content of financial news articles and stock-price trends. Moreover, multiple topic modeling, keyword extraction, summarization and sentiment analysis approaches are proposed to predict Stock Index trading activity levels and stock prices.

- Packages - Most of the aforementioned machine learning techniques are well available in Python packages like NumPy, SciPy, Scikit-learn, Pandas and Matplotlib. Especially for Deep Learning, packages like Theano, TensorFlow, Keras and PyTorch are found to be very useful. For performing NLP tasks the most used packages are Natural Language Toolkit (NLTK), Genism, polyglot, TextBlob, CoreNLP and spaCy. Similar packages are also available in other languages like R.

8.1.4 IoT framework for Fintech applications

- *Security for IoT framework for Fintech solutions*
    - *Cyber security standardization and solutions for the IoT framework in Fintech applications:* The basic technology blocks to be applied in this project comprises the following.
        - Security solutions in terms of software prototypes i.e., Intrusion Detection Systems (IDS) and Intrusion Prevention Systems (IPS), targeting layer wise vulnerabilities in IoT paradigm. Attempts will be made such that the solutions have less resource overheads and cater to diverse types of cyber-attacks on varying types of devices in domains such as automotive, industrial IoT, smart home, smart cities, smart grids etc.
        - Development of standards for security requirements and solutions for IoT paradigm in the Indian context.
        - Development of metrics for validation of security requirements and solutions vis-à-vis the standards.
        - Development of scalable techniques for validation considering the large size and diverse nature of the network and its components.

    - *Fine grained access control framework for online financial applications:*

The major technology components of the project comprise the following.

- Development of models for expressing access control properties in a large-scale financial system.
- There will be use of a combination of different access control models employing attributes, roles, and capabilities.
- Further, a formal specification of the model will be developed and its application will be demonstrated through different use-case scenarios.
- Prototype implementation of the proposed model and evaluation of the effectiveness of the model through simulation studies

- *Efficient symmetric-key algorithms for use in IoT:*

  An IoT device for any financial application, must come with its own encryption method. Indeed, encryption is essential for protecting any sensitive data stored and transmitted by the device. As most of these devices are data, energy or power constrained, the most adapted encryption solution for them is symmetric-key algorithms, which are known to be more lightweight. Today, many good symmetric key standards for encryption exist (e.g. AES) however, most of the time they are not adapted for the IoT context. Choosing an adapted encryption algorithm, that would take into account the device's resources and constraints, while being resistant to all known attacks, is essential. The project aims at evaluating each Fintech application that needs symmetric encryption and determining the optimal solution. The following working plan will be adopted.

  - Analyze the existing lightweight encryption algorithms to evaluate whether they could be adapted for the IoT application in Fintech products.
  - If no algorithm fits exactly the constraints, design a new symmetric encryption algorithm that would take the new IoT related constraints into account (i.e., speed, latency, energy and power consumption, easy masking, etc.)
  - Apply cryptanalysis to the newly designed algorithms to ensure that they are

robust and provide proof that they can resist all known attacks.

- *Whitebox cryptography for securing embedded devices*.

  Conventional cryptography has over time evolved to systematically address most of the issues of privacy and/or integrity but the fact remains that classically cryptosystems have not been designed keeping in mind a resource-constrained environment. This makes it extremely difficult to use classical crypto algorithms on devices that are highly constrained in either chip-area, power sources and mostly importantly in terms of computational capabilities. Though one solution could be to adapt the current standards to fit in these small embedded systems, it has been found that this workaround often creates more problems than it solves. With more than 25 billion IoT devices to be connected by 2021 according to Gartner's report, this points in the direction of designing algorithms from scratch keeping in mind the devices that they will sit in.

  In recent years, the crypto community has made multiple efforts to design so-called lightweight ciphers: Present, Prince, Led, Skinny, Qarma, Katan, Ktantan and Gift to name a few. A clear definition of ``lightweight'' seems lacking in literature but it has been observed that the only unifying factor between the design of diverse lightweight cryptographic algorithms is the low computing power of the devices that intend to run them.

  The projects that are intended to be taken up under this broad and developing area of Lightweight Cryptography for Fintech, will primarily concentrate on analysis of existing standards when they are being adopted or deployed for financial applications.

- *Data driven approach to security forensics and trustworthy decision making in IoT networks:*
  To enhance security in e-payments, the proposal is to develop a data-driven, context-sensitive, multi factor authentication and security forensics model based on transaction log, device, location, etc., which will offer protection against vulnerabilities and fraudulent e-payment transactions. In addition to exploring the underlying research challenges, limitations, gaps and future scope of e-payments

from CPS and IoT viewpoints, the project will specifically develop a lightweight, data-driven approach towards security analytics across IoT domains in e-payments. An anomaly based intrusion detection method will be proposed that will capture linear and non-linear relationships in data from multiple IoT devices and ensure sharp deviation signatures under various stealthy attacks, yet remaining undisturbed under no attacks and hiding differences in skewness. A feedback response mechanism will help gather evidence on the presence, types, severity, and strategies of threats. Finally, evidence-based information theory will be used to propose a novel unified trust-scoring framework that will remain accurate under various stealthy attacks.

This project is expected to have tremendous impact. By developing a new science of security for emerging IoT applications including e-payments, the project will address stealthy attacks hiding behind randomness due to human behavioral differences of cyber-physical exploits, and codify a unique model at community scale to tackle various types of attacks. This will drastically reduce the number of concurrent cyber-attacks and corresponding cross coordination to secure IoT applications. Validation with real datasets will also make the proposed framework applicable to other IoT contexts, leading to potential technology transfer and incubation of start-up companies.

- *Testing and Improving reliability IoT framework:*

  Some of the major techniques for testing of the IoT framework, as perceived in this project are as follows.

  - *Hardware-Software embedded testing*: IoT is based on an architecture, which is closely coupled among various hardware and software components. It is not only the software applications that make the system but also the hardware, sensors, communication gateways etc. too play a vital role. Techniques for separate testing of the hardware and software are widely available and provide effective fault coverage. To address the issue of testing the closely coupled hardware and software components in IoT devices, embedded system testing will be applied to achieve fault coverage arising in the hardware alone, as well the effect of the software on the hardware.

  - *Compatibility testing:* There are lots of devices which can be connected though the IoT framework. These devices have varied software and hardware configurations. Therefore, the

possible combination is huge. As a result, checking the compatibility in the IoT system is important and would comprise a major component of the test suite.

- *Data integrity testing:* Since IoT involves large amounts of data and of widely varying format, data integrity testing will be a vital part of the test list.
- *Connectivity testing comprising multiple protocols:* Network connection plays a vital role as IoT is all about the data being communicated most of the time. IoT performance has to be tested in all kinds of network connectivity/speeds. In case of dis-connectivity i.e., offline period, it needs to be tested that once the system comes online, all data should get propagated and data loss should not be there in any condition.
- *Test of multiple communication protocols:* IoT devices today use many different communications protocols to interact with controllers, and with each other. Protocols such as Message Queuing Telemetry Transport (MQTT), Extensible Messaging and Presence Protocol (XMPP) and Constrained Application Protocol (CoAP) are common, and each has its own advantages and disadvantages. Sometimes even provisions for smooth hands-off in between protocols are also present in the devices. Test suites need to be developed to validate the proper communication and connectivity of the IoT devices under the supporting protocols.

9. Management

The TIH shall have multiple teams to look after the research, product prototyping, manpower development, start-up and entrepreneurship. The teams shall together cover the following aspects.

- Research: Team members from TIH (faculty members, visiting (chair) professors and EIR) and collaborators (national and international), Post-docs, PhD students and MTech students.
- Product prototyping: Team members from TIH (faculty members, chair professors and EIR) and industry collaborators, Post-docs and PhD students.
- Manpower development: Team members from TIH (faculty members, visiting (chair) professors and EIR), faculty members (Indian and collaborators from abroad), industry experts (from the industry collaborators).
- Startup and entrepreneurship: Team members from TIH (faculty members, visiting (chair) professors and EIR) and industry collaborators.
- Project selection and evaluation: Team members from TIH (faculty members, visiting (chair) professors), academic and industry collaborators.
- Administration of the TIH: CEO of the TIH, legal expert, administrative staff for managing finance, HR, academic activities.

To facilitate overall coordination, the following broad structure of the management is also envisaged.

- *Hub Governing Body (HGB):* The Hub Governing Body (HGB) will act as the apex body for all matters related to the TIH namely, administrative, financial, legal, technical, academics etc. This shall be the board of the section 8 company. The body shall resolve any issues that may require consideration so that the project execution is not impacted. The structure of the HGB will be as follows.
    - Chairman: Director, IIT Bhilai
    - Member: CEO of TIH
    - Member: Institute coordinator of the TIH
    - Member: Dean R and D of IIT Bhilai
    - Member: One faculty member of IIT Bhilai associated with TIH (on rotation basis)

- External Members:
    - One representative from industry (from the collaborators)
    - One representative from academia (from the collaborators)
- Members (Finance): Deputy Register (F and A) of IIT Bhilai

- *Project Coordination Group (PCG):* The project coordination group shall be responsible for coordination of the different schemes offered by TIH from time to time. The PCG will be responsible for activities like selection of projects for funding, form Project Review Steering Group (PRSG) for each funded project, approve PRSG recommendations etc. The PCG shall comprise the following and will be meeting as and when necessary for meeting the goals of the projects.
    - Institute coordinator of the TIH
    - Two faculty members of IIT Bhilai associated with TIH (on rotation basis)
    - Two faculty members from the collaborators (on rotation basis)
    - Two industry experts from the collaborating industries (on rotation basis)
    - Representatives from GoI agencies like DST, MeitY etc.
    - Chairman of PRSG (invited, on need basics)

    a) *Project Selection Group (PSG):* The PGC will form a project selection group with the main responsibility of outreach activities namely, advertising the call for proposals under various schemes of the TIH, organizing hackathon etc. and finally recommending projects for funding based on merit, deliverables, matching of market demands etc. The recommendations will be finally approved by the PGC. The PSG will comprise the following members.
        - Five faculty members of IIT Bhilai associated with TIH (on rotation basis)
        - Five faculty members from the collaborators (on rotation basis)
        - Five industry experts from the collaborating industries (on rotation basis)

    Sub-groups will be formed by the PGC against each specific scheme of the TIH and

the section round, based on expertise of the members.

b) *Project Review Steering Group (PRSG):* For each project, the PCG will form a PRSG to monitor the progress of the project. The PRSG will have the following members.
    - Chairman
    - One faculty member from academia
    - One expert from industry
    - One expert from a start-up company (not under the TIH)

    PRSG will ensure that project objectives and deliverables are adhered to and also timelines are maintained.

- *Start-up coordination team:* The start-up coordination team shall be responsible for providing suggestions, expert advice, networking with relevant industries etc. to the potential entrepreneurs. The team shall comprise the following and shall be meeting as and when necessary for meeting the goals.
    - Five faculty members of IIT Bhilai associated with TIH (on rotation basis)
    - Two faculty members from the collaborators (on rotation basis)
    - Four industry experts from the collaborating industries (on rotation basis); experts from UIDAI, GSTN, NPCI (collaborators of the TIH) etc. would be taken on board.
    - Five representatives from startups, including people for the startups incubated out of the TIH at IIT Bhilai.
- *TIH office administration*: Apart from all the technical activities, the TIH shall be assisted by a set of administrational (project) staff, comprising legal expert, accountants, project manager, project associates, project assistants, attendant, housekeeping etc.

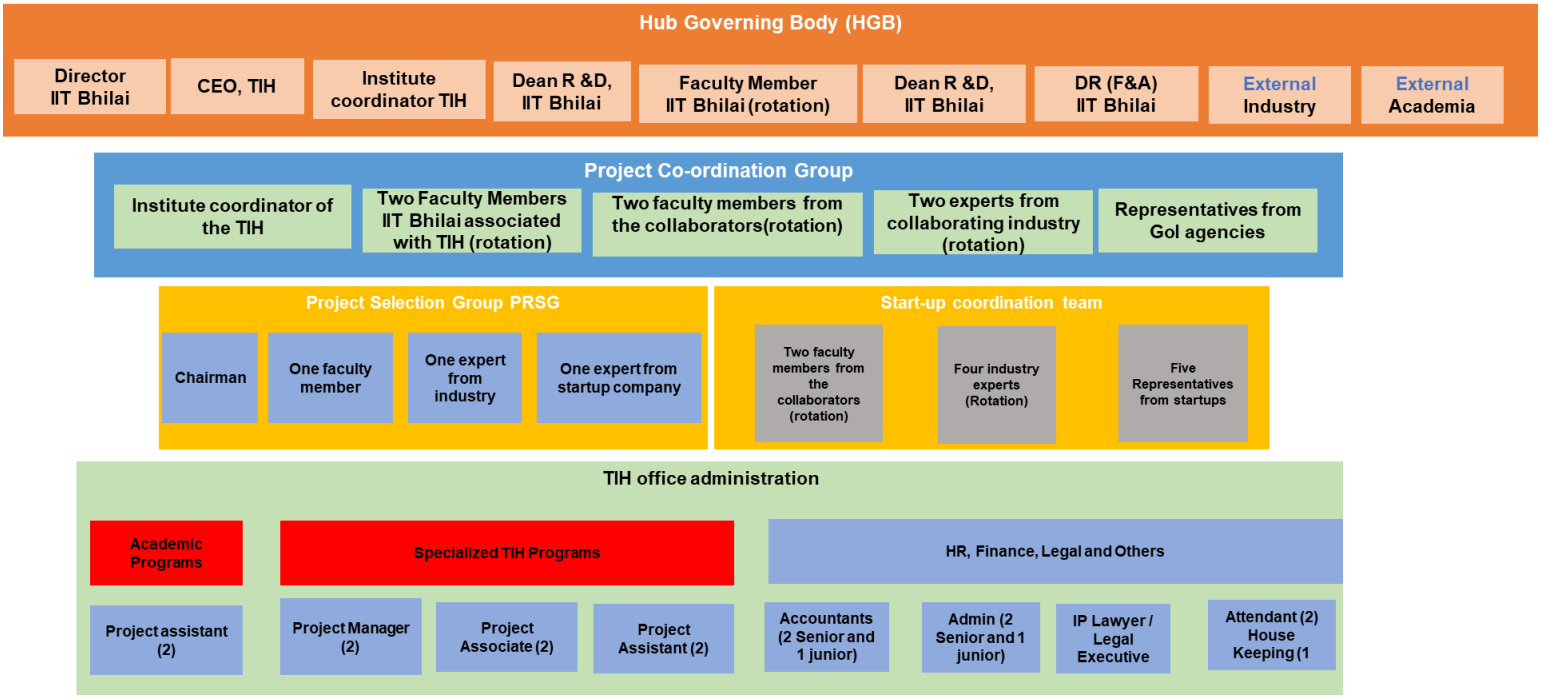
  The table given below presents a tentative resource loading plan of the administrational staff for the different activities of the TIH. It may be noted that depending upon the requirements arising during execution of the project, changes may be brought in terms of

positions and staff working there-in.

Sl No.	Activity of the TIH	Position and Number of Resources	Roles and responsibility
1	Academic Programs: PG, PhD and visiting faculty	Project assistant (2)	Dealing with academic activities like admission, registration, documentation etc. of the students registered with IIT Bhilai under any of the academic programs and funded under TIH program. Interact with the academic section of IIT Bhilai for coordination with the TIH regarding academic activities. Faculty related matters of the visiting faculty members and chair professors
2	Specialized TIH Programs • CPS-Start-ups • CPS-TBI • CPS-PRAYAS • CPS-EIR • CPS-DIAL • CPS- SSS	Project Manager (2) Project Associate (2) Project Assistant (2)	1 Project manager for CPS start-ups and CPS-TBI and 1 project manager for PRAYAS, EIR, DIAL and SSS. The task will be overall management of the funded projects in collaboration with the involved stakeholders. Assistance in project management

3	HR, Finance, Legal and Others	Accountants (2 Senior and 1 junior) Admin (2 Senior and 1 junior) IP Lawyer / Legal Executive Attendant (2) House Keeping (1)	Managing all financial related activities of the TIH Routine Admin Activities, Purchases, stock maintenance etc. Legal activates of the TIH Managing day-to-day activities House keeping

The figure below illustrates the governance structure of the TIH at IIT Bhilai.



10. Finance

10.1 Recurring

10.1.1 Project Staff

Designation **: CEO**

Number of Persons : 1

Justification : Making major corporate decisions, managing the overall operations and resources of the TIH.

Year-wise monthly emoluments

Year	Monthly Emolument (in Lac)	Man months	Total Cost (in Lac)
5	3.23+HRA(16%)=3.75	60	225
Year 1	3.75	12	45
Year 2	3.75	12	45
Year 3	3.75	12	45
Year 4	3.75	12	45
Year 5	3.75	12	45
Total			**225**

Designation : **Project Manager**

Number of Persons : 2

Justification : Planning and defining the scope of the project. Managing the activity and resource planning for the execution of the projects and schemes under TIH.

Year	Monthly Emolument (in Lac)	Man months	Total Cost (in Lac)
5	1.724+HRA(16%)=2	120	240
Year 1	2	24	48
Year 2	2	24	48

Year 3	2	24	48
Year 4	2	24	48
Year 5	2	24	48
Total			240

Designation : **Project Consultant (Legal Expert)**

Number of Persons : 1

Justification : Handling legal documentation and legal issues.

Year-wise monthly emoluments

Year	**Monthly Emolument (in Lac)**	**Man months**	**Total Cost (in Lac)**
5	**0.862+HRA(16%)=1**	**60**	**60**
Year 1	1	12	12
Year 2	1	12	12
Year 3	1	12	12
Year 4	1	12	12
Year 5	1	12	12
Total			**60**

Designation : **Project Associate**

Number of Persons : 5

Justification : Senior level administrative activities of the TIH

Year-wise monthly emoluments

Year	Monthly Emolument (in Lac)	Man months	Total Cost (in Lac)
5	**.34+HRA(16%)=0.4**	**300**	**120**
Year 1	0.4	60	24
Year 2	0.4	60	24
Year 3	0.4	60	24
Year 4	0.4	60	24
Year 5	0.4	60	24
Total			120

Designation : **Project Assistant**

Number of Persons : 10

Justification : Junior level administrative activities of the TIH

Year-wise monthly emoluments

Year	Monthly Emolument (in Lac)	Man months	Total Cost (in Lac)
5	**0.215+HRA(16%)=.25**	**420**	**150**
Year 1	0.25	120	30
Year 2	0.25	120	30
Year 3	0.25	120	30
Year 4	0.25	120	30
Year 5	0.25	120	30
Total			150

Designation : **Project Attendant**

Number of Persons : 2

Justification : To perform the assigned administrative duties in the TIH.

Year-wise monthly emoluments

Year	**Monthly Emolument (in Lac)**	**Man months**	**Total Cost (in Lac)**
5	**0.138+HRA(16%)= 0.16**	**120**	**19.2**
Year 1	0.16	24	3.84
Year 2	0.16	24	3.84
Year 3	0.16	24	3.84
Year 4	0.16	24	3.84
Year 5	0.16	24	3.84
Total			19.2

Designation : **House Keeping**

Number of Persons : 1

Justification : Housekeep related duties as assigned.

Year-wise monthly emoluments

Year	Monthly Emolument (in Lac)	Man months	Total Cost (in Lac)
5	**0.103+HRA(16%)=0.12**	**60**	**7.2**
Year 1	0.12	12	1.44
Year 2	0.12	12	1.44
Year 3	0.12	12	1.44
Year 4	0.12	12	1.44
Year 5	0.12	12	1.44
Total			7.2

Manpower Budget Summary

Designation	Number of Persons	Gross Total (in Lac)
CEO	1	270
Project Assistant	7	105
Project Associate	5	120
Project Manager	2	240
Project Consultant	1	60
Project Attendant	2	19.2
House Keeping	1	7.2
Total		**821.4**

10.1.2 Administrative budget

Budget Head	1st Year	2nd Year	3rd Year	4th Year	5th Year	Total
Contingencies	4	6	4	4	2	20
Consumables	6	6	6	6	6	30
Miscellaneous	2	2	2	2	2	10
Domestic Travel	4	6	10	10	20	50
Overhead	2	2	2	2	2	10
Total	18	22	24	24	32	**120**

Domestic Travel: 500 visits at Rs. 10000/visit by project staff, PI, Co-PI, collaborators, and domain experts

10.1.3 Technology Development

Breakup

Technology	Description	Total
IP, Licensing, Patents etc.	Approx. 10 Indian patents (2 Lakhs for each patent) Approx. 10 international patents (5 Lakhs for each patent)	70 L
Products	Approx. 10 products of Software, Apps, Gadgets regarding Fintech services	200 L
Publications	Approx. 30 Conference papers. Approx. 10 journal papers. Funding will be used for conference travel, registration etc. and extra page charges for the journals.	75 L
Increase in CPS Research Base	Approx. 40-50 White papers, Standards, RFC, concept papers, Technical reports	25 L

Year wise distribution

Year	Total Cost (Lac)
Year 1	5
Year 2	15
Year 3	40
Year 4	160
Year 5	150
Total	**370**

10.1.4 HRD and Skill Development

Breakup

Position Name	No. of positions	Total
PG MTech	40 (12,400/- per month): 29.8L/year for 5 years	298 L
Doctoral Fellowship	35 (25,000pm+16% HRA=29,000pm for first 2 years) (28,000pm+16% HRA=32,480pm from third year onwards) 130.4L/year for 5 years	652 L
Faculty Fellowship	1 (At 80,000pm all-inclusive for 3 years) 9.33L/year for Years 1-3	28 L
Chair Professor Fellowship	1 (80,000pm+1,20,000 (Misc)+1,00,000 (OH) for 3 years) 11.8L/year for Years 1-3	35.4 L
Professional Skill Development Workshop	10 workshops (5L/workshop For 10 workshops) 12.5L/year for Years 2-5	50 L

Year wise distribution

Year	Total Cost (Lac)
Year 1	202.45
Year 2	214.95
Year 3	229.55
Year 4	208.42
Year 5	208.42
Total	**1063.4**

10.1.5 Innovation, Entrepreneurship and Startup Ecosystem

Breakup

Scheme Name	Justification	Amount (in Lakhs)
CPS-GCC	15 lakhs for Hackathon and 30 lakhs for Start-up (10L/Startup) selected out of Hackathon. Funding of 15L for the first 3 years for 3 hackathon.	45 L
CPS-PRAYAS	5 PRAYAS projects (45L each). Funding of 45 L each year spanning from 1st to 5th year	225 L
CPS-EIR	Total of 15 EIR with 30,000 per month for a period of 5 years.	52 L
CPS-Startup	25 startups with grant ranging between 8 L to each one of them.	200L
CPS-DIAL	2 DIAL projects with funding of 100L to each one of them, for one year. This will be in Year 1 and Year 2 (one each).	200L
CPS-Seed Support System	1 start-up with a funding 663L spanning from 1st to 5th year	663L
CPS-TBI	1 TBI with a funding of 800L spanning from 1st to 5th year	800L

Year wise distribution

Year	Total Cost (Lac)
Year 1	317 L
Year 2	606 L
Year 3	619 L
Year 4	490 L
Year 5	152 L
Total	**2184 L**

10.1.6 International Collaboration

Justification: Visit of faculty members, researchers from the collaborating foreign universities to TIH (cost of hosting only and domestic travel), visit of team members from TIH to the foreign collaborating universities, usage of research facilities, Joint publication in journals and conferences

Year	Total Cost
Year 1	15
Year 2	15
Year 3	15
Year 4	30
Year 5	-
Total	**75 L**

10.2 Non-recurring

10.2.1 Lab R&D Infrastructure

Item	Quantity	Price	Total	Justification
PC/Laptop	24	0.72	17.2	For the project staffs
Lab with GPU workstations	30	8	240	For training on Fintech
HPC	1	100	100	For AI application for Fintech
Network setup: Wi-Fi, LPWAN Setup (NB-IoT, LTE-Cat M1, LoRa, SigFox)	1	7	7	Communication medium for IoT
Sensors and associated accessories	1	25	25	Test bed (See the detailed write-up)
Smart Phones	100	0.2	20	Execute the Apps for controlling the IoT devices
Network Simulators with support for IoT devices, sensors, actuators etc.	50	0.5	25	Simulation study of the security solutions with respect to the standards
FPGA and Embedded Programming kits	51	1	51	Embedded systems for in-situ computation
Riscure (Fault Injection Setup)	1	100	100	Fault and Electromagnetic attack analysis setup
MSO	10	20	200	For power based attack analysis setup
SASEBO FPGA	20	2.5	50	For power based attack analysis setup

Differential Prober	20	1	20	For power based attack analysis setup
Miscellaneous (Amazon AWS, consumable, etc.)	1	11	11	
Total			**866.2 Lakhs**	

Budget Summary:

Total Recurring Cost (in Lac)	4633.8
Total Non-recurring Cost (in Lac)	866.2
Total Cost (Recurring + Non-recurring)	**5500.0 L**

10.3 Year wise breakup

Head	**Sub-head**	**1st Year**
Recurring	Manpower	1.7 Cr
	Administrative recurring expenses	.20 Cr
	Technology Development	0 Cr
	HRD and Skill Development	2.03 Cr
	Innovation, Entrepreneurship and Start-up Ecosystem	3.17Cr
	International Collaboration	.15 Cr
Non-Recurring		0 Cr
Grand Total		**7.25 Cr**

Head	**Sub-head**	**2nd Year**
Recurring	Manpower	1.7 Cr
	Administrative recurring expenses	0.22 Cr
	Technology Development	0.2 Cr
	HRD and Skill Development	2.15 Cr
	Innovation, Entrepreneurship and Start-up Ecosystem	6.1 Cr
	International Collaboration	0.15 Cr
Non-Recurring		8.7 Cr
Grand Total		**19.2 Cr**

Head	**Sub-head**	**3rd Year**
Recurring	Manpower	1.6 Cr
	Administrative recurring expenses	0.24 Cr
	Technology Development	0.40 Cr
	HRD and Skill Development	2.27 Cr
	Innovation, Entrepreneurship and Start-up Ecosystem	6.19 Cr
	International Collaboration	0.15 Cr
Non-Recurring		0 L
Grand Total		**10.85 Cr**

Head	**Sub-head**	**4th Year**
Recurring	Manpower	1.6 Cr
	Administrative recurring expenses	0.24 Cr
	Technology Development	1.60 Cr
	HRD and Skill Development	2.08 Cr
	Innovation, Entrepreneurship and Start-up Ecosystem	4.9 Cr
	International Collaboration	0.3 Cr
Non-Recurring		0 L
Grand Total		**10.7 Cr**

Head	**Sub-head**	**5th Year**
Recurring	Manpower	1.64 Cr
	Administrative recurring expenses	0.32 Cr
	Technology Development	1.50 Cr
	HRD and Skill Development	2.08 Cr
	Innovation, Entrepreneurship and Start-up Ecosystem	1.52 Cr
	International Collaboration	0 Cr
Non-Recurring		0 Cr
Grand Total		**7.0 Cr**

11 Time Frame

Attached

12 Cost benefit Analysis

In this section we present the cost benefit analysis of the TIH by identifying the outcomes under the various categories of the TIH (e.g., number of startups, number of technologies, number of papers and patents etc.) vis-à-vis the associated costs.

The target activities of the TIH can be clustered into the following categories.

1. *Technology Development* comprising technologies (IP, Licensing, and Patents etc.), products, publications and research base (White papers, Standards, RFP, concept papers, Technical reports etc.)
2. *Entrepreneurship Development* comprising TBI, start-ups, GCC, PRAYAS, EIR, DIAL, SSS etc.
3. *Human Resource Development* involving, UG, PG, PhD, faculty fellowships, chair professor program, short term courses and certification courses etc.
4. *International collaboration with* top tier universities of the world.
5. *Set up a state of the art laboratory to support research and development for Fintech products.*

Cluster	**Heads**	**Total Cost to be Incurred**	**Benefits vis-à-vis cost**
Technology Development	a) IP, Licensing, Patents etc.	70 Lakhs	**a).** Approx. 10 Indian patents Approx. 5 international patents
	b) Products	200 Lakhs	**b)** Approx. 10 products of Software, Apps, Gadgets regarding Fintech services
	c) Publications (Journals, conferences, Book chapters)	75 Lakhs	**c)** Approx. 30 Conference papers Approx. 10 journal papers
	d) Increase in CPS Research	25 Lakhs	**d)** Approx**.** 40-50 White papers, Standards, RFC, concept papers, Technical reports

	Base (White papers, Standards, RFC, concept papers, Technical reports etc.)		The publications out of the R and D at the TIH will enrich the research base in the Fintech area.
Entrepreneurships and Startups	CPS-GCC- Grand Challenge	45 Lakhs	3 Hackathons Churning of new ideas, concepts, technologies and prototypes in the Fintech area. Expected number of startups 10 Expected number of PRAYAS 2 Expected number of EIRs 2
	CPS-PRAYAS	225 Lakhs	Expected number of PRAYAS schemes to be funded is 5 Young Entrepreneurs in Fintech with out of the box ideas Novel products or prototypes in the Fintech sector is Approx. 3 from PRAYAS Employment Generation;
	CPS-EIR	270 Lakhs	Approx. 15 EIR. Blending of applied research regarding Fintech into start-ups, products; Number of start-ups is approx. 5 from EIR; Number of technologies, prototypes and products is approx. 5 from EIRs; Employment generation;
	CPS-Startup	200 Lakhs	Approx. 20 Startups Support for start-up ecosystem in Fintech Productable and commercially viable technologies; approx. 1 product for each startup Employment generation; *Financial Returns expected from the startups*

			The startups incubated at the TIH and successfully running as a MSME (or large scale industry), will be required pay a minimal percentage (approx. 10%) of the profit for a period of x years (where x, is the number of years incubated at TIH) Assuming 5 (out of 20) startups earn an approx. profit of 100 L per annum: return is 50 L per year to the TIH. Assuming average incubation time of two years and continuous incubation and spin-offs of the start-ups there will be a sustainable revenue generation for the TIH.
	CPS-DIAL	200 Lakhs	Approx. 2 projects funded as DIAL Fast track production and marketing of bright ideas; Products of immediate need in the Fintech sector is approx. 2 from DIAL Employment Generation; *Financial Returns expected from the startups under DIAL* The startups incubated at the TIH and successfully running as a MSME or spin-offs will be required pay a minimal percentage (approx. 20%) of the profit for a period of 1 year. Assuming both the startups under DIAL will earn an approx. profit of 100 L per annum: return is 40 L to the TIH.
	CPS-Seed Support System	500 L	One of the start-ups incubated by the TIH, will be selected under the SSS. Funding of 5 crore will be provided by the TIH to rapidly productize the prototype in collaboration with industry.

			Support for start-up ecosystem in Fintech with special emphasis to FastTrack promising ideas Productable and commercially viable high impact technology, approx. 1 from the SSS Employment generation; The resources from the startup funded as SSS will be on boarded as collaborator in the TIH for mentoring of ongoing activities *Financial Returns expected from the SSS* The startup incubated at the TIH and funded udder SSS, will be required to pay a minimal percentage (approx. 10%) of the profit for a period of 10 years. Assuming the average profit of startup under CSS is 200 L per annum, the return is 200 L to the TIH in a period of 10 years
	CPS-TBI	750 Lakhs	Based on outstanding performance by any collaborator organization of the TIH, one of them will be selected as Technology Business Incubator. TIH will fund approx. 7.5 Cr for functioning of the TBI until it becomes self-sustained. TIH will work jointly with the TBI to expand its activities in terms of, • Job creation, business and revenue generation aligning with national priorities. • Promotion of new technology /knowledge/

			innovation based startups. • Fast track commercialization of technologies developed academia, R&D institution or by an individual. • Support to start-ups regarding mentoring, legal, financial, technical, intellectual property related services
HRD and Skill Development	PG (MTech)	298 L	40 MTech Students will be admitted using TH funds Applied research in the area of Fintech as the PG thesis
	Doctoral Fellowship	652 L	35 PhD scholars will be admitted using TH funds Applied research in the area of Fintech as the Doctoral theses Candidates for EIR program of the TIH
	Faculty Fellowship	280 Lakhs	1 Chair professor in the area of Fintech Mentoring of projects from the angle of applied research will enhance the efficiency and outcome of projects. Guidance of PhD and MTech theses Guidance in EIR program
	Chair Professor	354 Lakhs	1 Chair professor in the area of Fintech Mentoring of projects from the angle of applied research will enhance the efficiency and outcome of projects. Guidance of PhD and MTech theses Guidance in EIR program

	Professional Skill Development Workshop	50 Lacs	Training Workshops: 10 workshops with around 30 attendees in each workshop Conferences: 4 conferences 10L / Conferences Certification courses in the area of Fintech
International Collaboration		75 Lacs	5 collaborators @ 1 visit per year @ average 3 L per visit. Collaboration with faculty members of international universities of repute to inculcate state of the art research and product ideas from the global parlance

State of the art laboratory facility for Fintech related R and D activities, training etc.

Item	**Quantity**	**Price**	**Total**	**Justification**
PC/Laptop	24	0.72	17.2	For the project staffs
Lab with GPU workstations	30	8	240	For training on Fintech
HPC	1	100	100	For AI application for Fintech
Network setup: Wi-Fi, LPWAN Setup (NB-IoT, LTE-Cat M1, LoRa, SigFox)	1	7	7	Communication medium for IoT
Sensors and associated accessories	1	20	20	Test bed (See the detailed write-up)
Smart Phones	100	0.2	20	Execute the Apps for controlling the IoT devices
Network Simulators with support for IoT devices, sensors,	50	0.5	25	Simulation study of the security solutions with respect to the standards

actuators etc.				
FPGA and Embedded Programming kits	51	1	51	Embedded systems for in-situ computation
Riscure (Fault Injection Setup)	1	100	100	Fault and Electromagnetic attack analysis setup
MSO	10	20	200	For power based attack analysis setup
SASEBO FPGA	20	2.5	50	For power based attack analysis setup
Differential Prober	20	1	20	For power based attack analysis setup
Miscellaneous (Amazon AWS, consumable, etc.)	1	10	10	
Total			**860.2 Lakhs**	

From the inception of the TIH, the funding from DST shall be for 5 years. Staring from 3rd year, revenue generation and sustainability would be ensured based on the main four verticals.

- *Training and certification programs:* Comprehensive training and certification programs will be designed aiming at industry professionals working in the area of designing Fintech solutions. As a part of the curriculum, the programs will involve applied theory and elaborate hands-on training in collaboration with leading Fintech organizations/companies like Infineon tech., NPCI, GSTN, UAIDI etc. Since, these programs will be mainly targeted for industry professions, substantial revenue will be generated,
- *Fintech related product prototypes*: The TIH aims to develop product prototypes for e-

payment systems and IoT platforms for Fintech solutions. With help of the collaborating industries, effort will be given to commercialize these porotypes, leading to revenue generation through IP rights (shared with the commercializing industry as per IP laws).

- *Business model of revenue from successful startups*: 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 of x years (where x, is the number of years incubated at TIH)

- *Consultancy to Fintech organizations*: The core team members and the associated collaborators will be able to provide consistency under the umbrella of the TIH thereby fetching a percentage of the consultancy fees to the TIH.

13 Risk Analysis

Risk analysis and mitigation will be an integrated part of the TIH to ensure that the least number of surprises occur while the project is underway. While the future can never be predicted with certainty, a simple and streamlined risk management process to predict the uncertainties in the projects and minimize the occurrence or impact of these uncertainties will be applied.

The risk analysis will be performed in terms of the following parameters.

Risk Category	**Impact of the risk**	**Probability of Occurrence**
Technical	High – Catastrophic	High probability
Financial	Medium –High Critical	Medium-High probability
Legal	Medium – Low Critical	Medium-Low probability
Human resources	Low – Marginal	Low probability

The major anticipated risks in each of the categories and the planned mitigations are as follows.

- ***Technical***
    - **R1:** Selection of overambitious projects involving difficulty to realize due to complexity arising out of the factors like unknown technologies for implementation, complexity of the project etc.
        - *Impact*: High
        - *Probability:* Low
        - *Avoidance and Mitigation*

            The project selection group will consist of experts having in-depth knowledge in the Fintech domain, experience in evaluation of projects, predictive analysis of success of projects via-a-vis the objectives, resources available, state of the art technology available, budget etc. Selection of the projects for funding will be made after group reviews and consultative approach, including major stakeholders. All the projects need to be backed with

detailed proposals that must include, well defined scope, objectives, outcomes, techniques for implementation, architecture, the resource loading plan, previous experience of the team members etc.

Bi-yearly review by PRSG and regular feedback by industry/academic mentors will be provided for corrective and preventive actions namely, modify unachievable objectives, reduction of complexity by suitably lowering the targets, guidance to select viable techniques that may result in lowering the efficacy (quantity, timelines, efficiency etc.) but realizable with a reasonable timeline etc.

- **R2:** Deviation of project deliverables from the aims and objectives during project execution.
    - **R2.1** Correctness of the design
        - *Impact: High*
        - *Probability: Low*
        - *Avoidance and Mitigation*

          The project selection group will ensure to the best of their knowledge and understanding, that none of the goals are extremely tough to achieve within practical timelines, availability of resources, techniques required etc. Based on the toughness of the goals, if required, the experts from the academic and industry will help prepare explicit guidelines, procedure and strategies to ensure proper alignment to the objectives.

          The mentors (from the collaborators) from the academia and industry will regularly review the problems undertaken, the techniques being applied, the implementation details etc. and provide guidance and suggestions in case of deviations perceived by them.

Bi-yearly formal review by PRSG, where detailed project progress reports will be presented and practical demonstrations will be given. If required, the PRSG can invite additional experts for evaluation and advice.

- **R2.2** Lowering of the efficiency in terms of resources required, response time, accuracy etc.
    - *Impact: Medium-High*
    - *Probability: Medium-High*
    - *Avoidance and Mitigation*

      Similar to the strategy of R2.1

- **R2.3** Deviation from the transformability to products or technologies due to Industry /start-up collaboration gaps
    - *Impact: Medium-High*
    - *Probability: Medium-Low*
    - *Avoidance and Mitigation*

      Similar to the strategy of R2.1

- **R3** Delay in procurement of equipment and software etc.
    - *Impact: Major*
    - *Probability: Medium-Low*
    - *Avoidance and Mitigation*

      The project selection group will ensure to the best of their knowledge and understanding, that equipment and software planned to be procured are readily available. In case if some of them require explicit clearance (mainly, in case of import), such procedures will be ensured well ahead of the timelines.

      Fool-proof procurement processes will be established in the TIH according to the well laid policy, already in place at IIT Bhilai, to ensure speedy purchase. The purchase committees to handle procurements for the TIH will involve

experienced members and will take help from the procurement division of IIT Bhilai, as and when required.

In case of urgent requirements, attempts will be made so that the stakeholders can use equipment and software available in other organizations (mainly, with the collaborators).

- ***Financial***
  - **R4:** Delay in release of funds or budget cuts
    - *Impact: High*
    - *Probability: Medium-Low*
    - *Avoidance and Mitigation*

      The project selection group will ensure to the best of their knowledge and understanding that sufficient budget has been allotted for the sanctioned projects, with some amount of buffer to handle inflation, change of forex rates etc.

      During the execution of the project, the stakeholders need to submit their utilization certificates much ahead of time of release of next grants, with clear projection of financial requirements. As the fund requests for the next release are specified well ahead of time, in case of lack of funds due to budget cuts, inflation, etc. the PRSG with the stakeholders can mutually reduce the scope of the project, so as to align to the reduced budget, with minimal possible impact on the outcomes. In case of a project, if budget cuts would lead to severe impact on the outcomes, attempts will be made to grant the required funds (or a part of it) from other sources like venture capitalist funding, corpus etc. Attempts will be made to set up a corpus fund at TIH by accepting grants and donations from industry and government agencies. Finally, fund generation by liquidating equity in the collaborative company will be taken up.

      In case of delay of release in funds, attempts will be made to provide loans from

the collaborative industry or the corpus fund.

- ***Legal***

  - **R5:** Legal issues arising due to inadequate and inconsistency of legal documentation namely, MoU, NDA, contracts, etc., IP related controversies, breach of privacy etc.

    i. *Impact: Low*
    ii. *Probability: Low*
    iii. *Avoidance and Mitigation*

It may be noted that due to the large number of activities and projects to be undertaken by the TIH, and the legal documents will be quite exhaustive and of varying nature. Further, they need to be prepared within a short period of time after sanction of projects and onboarding of the stakeholders to the start of project activities. To make the documents correct and complete, experienced consultants to create the required documentation will be hired. The legal team will ensure that all contracts, MOUs, NDAs etc. are in place before starting of the projects under various schemes of the TIH. The legal team will ensure that MOUs among the stakeholders are signed before the start of the projects, where IP terms are spelled out clearly. In addition, NDAs will be clearly prepared with security and privacy requirements and duly signed, before initiation of the projects.

Regular workshops on IP handling protocols, design by security and privacy etc. will be held.

Legal audits will be done along with the project reviews (bi-yearly). Further, a full time (project) staff with legal/CA/CS background will be hired in the team. The TIH will also empanel with CA and legal firms to handle legal issues.

If a dispute arises in between the stakeholders or stakeholders with the TIH, the parties shall make all efforts to resolve the dispute as per the following procedures.

- The parties shall avoid going to the courts as much as possible.
- The dispute shall be resolved in an amicable manner between the parties involved, mediated by the HGB.

- ***Human Resources***

  - **R6:** Inadequate number of resources due to non-availability of skilled manpower

    - *Impact: Medium-High*
    - *Probability: Low*
    - *Avoidance and Mitigation*

      Wide circulation of the advertisements for recruitment will be made in print media, social media, job portals etc. Recruitment drives will be conducted regularly.

      To attract skilled manpower, the pay structure and incentives will be in line with projects sponsored by GoI agencies. As extra perks, the staffs if found suitable, will be given opportunities to undertake academic programs in IIT Bhilai (subject to clearance of admission norms).

      In case of non-availability of skilled manpower through direct recruitment, empanelment with manpower outsourcing agencies will be made.

  - **R7:** Low performance and incompetence of recruited staff members

    - *Impact: Medium-High*
    - *Probability: Low*
    - *Avoidance and Mitigation*

      The selection team will consist of experts from academia and industry, and recruitment will be through a rigorous process that will ensure onboarding of skilled manpower.

      In case of low performance and incompetence of recruited staff members,

specific training regarding new skill sets, psychological motivation, team work etc. will be given at regular intervals.

HR related necessary corrective actions will be taken namely, team building activities, reallocation of jobs based on interest etc.

- **R8:** Long leaves and attrition of resources
    - *Impact: High*
    - *Probability: Medium-Low*
    - *Avoidance and Mitigation*

In case of long leaves, the duties will be appropriately re-assigned among the other staff members of TIH. In case of overloading of the TIH resources, staff members of IIT Bhilai will be involved on a part time basis to undertake some activities of the TIH during the leave periods (of the TIH staff members). In addition, staff members can also be hired through outsourcing agencies on a temporary basis.

In case of attrition of resources, extra recruitment drives will be made. Further, it will be ensured that proper overlapping time between the outgoing and newly recruited staff members is there for proper transfer of knowledge.

In case of high rates of attrition, necessary corrective actions will be taken namely, team building activities, reallocation of jobs based on interest etc.

14. Outcomes

This section covers the basic criteria in terms of deliverables and outcomes that will be used to assess the success and completion of the objectives of the TIH. 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 masters theses etc. 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.

More specifically, the key outputs indicators are tabulated as follows.

Sl no.	**Objectives**	**Major Parameters**	**Expected Output in numbers**
1	**Technology Development:** Fundamental and applied research in terms of literature review, development of algorithms, architectures, system designs, analysis etc. in the area of financial technology	IP, Licensing, Patents etc.	15-20
		Technology Products	8-10
		Publications (Journals, conferences, Book chapters), IPR	30-40
		CPS Research Bas: White papers, Standards, RFP, concept papers, Technical reports etc.	40-50

2	**Entrepreneurship Development** To establish a start-up ecosystem facilitating a smooth platform for budding entrepreneurs in terms of selection of ideas through hackathons, mentoring through experts from academia and industry, funding under a spectrum of funding schemes based on the nature of the targeted product, provisioning platform to productize and market. Finally, jobs created in the start-ups of the TIH is the most important milestone.	CPS-Technology Business Incubator (TBI)	1
		CPS-Start-ups & Spin-off companies	20-25
		CPS-GCC - Grand Challenges and Competitions	2-3
		CPS-Promotion and Acceleration of Young and Aspiring technology entrepreneurs (CPS-PRAYAS)	3-5
		CPS-Entrepreneur In Residence (CPS-EIR)	11-15
		CPS-Dedicated Innovation Accelerator (CPS-DIAL)	1-2
		CPS-Seed Support System (CPS- SSS)	1
		Job Creation	5000-7000
3	**HRD and Skill Development** Facilitate Human Resource Development (HRD) in Fintech at multiple levels, from basic and applied research (PhD, PG, faculty fellowships, Chair professors), to product	Under Graduate Fellowships	160-200
		Post Graduate Fellowships	30-40
		Doctoral Fellowships	25-35
		Faculty Fellowships	1
		Chair Professors	1
		Skill Development (in terms	250-300

	prototypes (PhD, PG, UC, faculty fellowships), basic training (workshops, certification courses) . Getting market ready, next-generation, scientists, engineers, skilled and semi-skilled resources in the Fintech arena.	of workshops and STPs)	manpower to be trained in 10 workshops
4	**International Collaboration** International collaborative research for cross-fertilization of ideas in global parlance.	Faculty visit from foreign universities, join guidance and mentorship.	1-3 Universities

15. Evaluation

To ensure that all the objectives of the TIH are met, regular evaluations will be undertaken for all the projects and schemes. The key benchmarks for evaluating the projects will be based on quantity (as in the DPR in Section 14) as well as qualitative matrix discussed in this section.

15.1 Qualitative evaluation criterion

- **Technology Development**
    - Impact of the research papers published
    - Patent monetization
    - Revenue and royalty from the IPs and products
- **Entrepreneurship Development**
    - Quality of projects in terms of progression inside the TIH e.g., EIR to Startup-up, PRAYAS to start-up etc.
    - External funding brought in by the startups and TBI based on products, prototypes, technologies, ideas etc. from government, private companies, venture capitalists etc.
    - Turnover and profit of the start-ups incubated out of the TIH
    - Value of start-ups if acquired by large companies or mergers
    - Average salary of resources churned out of different programs of the TIH and working as professionals i.e., job creation vertical
- **HRD and Skill Development and International Collaboration**
    - Impact of the research papers published, patent monetization etc. by the students and faculty members associated
    - Quality of research output in terms of best papers in conferences and journals, best thesis awards, research awards, fellowships to reputed research bodies etc. by the students and faculty members associated.

15.2 Methodology

Review of projects

- To perform the review of each funded project under the schemes like start-ups, PRAYAS, DIAL etc. a dedicated Review Steering Group (PRSG) will be formed by the project coordinating group of the TIH.
- The PRSG will hold its evaluation at least twice in a year and more frequently, if needed
- PRSG will ensure that project objectives and deliverables are adhered to and also timelines are maintained.
- Every project will be asked to submit a progress report specifically reporting the achieved targets, pending targets and reasons there-in.
- The project will be evaluated in terms of quantitative and qualitative parameters (disused above)

Review of the students (UG/PG/PhD)

The review of progress of the students will be as per the academic guidelines of IT Bhilai. The progress of students will be reported to the project coordinating group.

Review of the Faculty fellow and chair professors

Performance evaluation of Chair Professors and Faculty Fellows will be held as per the guidelines of visiting faculty members of IIT Bhilai. The progress of these faculty members will be reported to the project coordinating group.

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