A Technical Look At The Indian Personal Data Protection Bill

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Abstract

The Indian Personal Data Protection Bill 2019 provides a legal framework for protecting personal data. It is modeled after the European Union’s General Data Protection Regulation (GDPR). We present a detailed description of the Bill, the differences with GDPR, the challenges and limitations in implementing it. We look at the technical aspects of the bill and suggest ways to address the different clauses of the bill. We mostly explore cryptographic solutions for implementing the bill. There are two broad outcomes of this study. Firstly, we show that better technical understanding of privacy is important to clearly define the clauses of the bill. Secondly, we also show how technical and legal solutions can be used together to enforce the bill.

Keywords: Data Protection, Personal Data Protection Bill-India (PDPB), GDPR-EU, Proof of Consent.

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1 Introduction

Privacy (also called as data privacy or information privacy) is defined as the ability of an individual or an organization to decide when, whom, and how much data in a computer system may be disclosed to a third party. It is a fundamental right in the Indian constitution [1]. The fundamental rights are a set of rights which require a higher degree of protection from the government irrespective of a person’s caste, race, religion, gender or place of birth. “Any individual, group, or organization can exclude themselves or information about themselves, thereby, representing themselves selectively”.

Data privacy is expected to be preserved by any individual or organization while disseminating the data and technology. Typically, an organization collect data from a small amount to a large extent with/without user’s consent. This data may be used for purposeful processing as well as for other purposes like data analysis, marketing, automated decision making and profiling. An organization may share this data with third parties also without prior knowledge of data owners. Further, the data which are not protected properly by a system may lead to various risks like location disclosure, profile disclosure, data traffic analysis, behaviour monitoring or identity disclosure.

The goal of data protection is to identify the possibilities of these risks and to develop proper technologies and services in such a way which can eliminate such risks [2]. In particular, data protection concern about the protection of data from breaches, disclosure, modification and privacy leakage throughout the life cycle of data. Although the organizations are using various technologies to protect data like encryption, authentication, authorization, access control etc, however, there are still so many data breaches happening around the world [2, 3, 4]. Even if the data breach is protected, it does not ensure the privacy of data. For instance, consider an online shopping website where a user, after login, did shopping and paid online. If the merchant is not trusted, the personal data may be disclosed to third parties without the user’s awareness. Such data can be sold, distributed or shared with other parties for monetary purpose [3, 5, 6]. Therefore, the assurance of data protection in the current system does not ensure data is indeed protected, and privacy is preserved. So, we require two components: first, the law and obligation under which processing will be carried out; second, a set of technical method that can translate legal tenets into the technical framework. Here, the law and regulation will ensure legal binding and penalties for data processing while the technical standard will ensure security, safety and privacy of data.

Data Protection = Legal Framework + Technical Standards

Many countries have introduced a data protection framework, or some other kind of legislation to protect user’s data [7]. European Union(EU) is the first one who has proposed General Data Protection Regulation(GDPR) [8] that will work as a legal tenet to protect users data within EU territory. As per GDPR, it is the data processor’s responsibility to protect the user’s data. GDPR provides several rights to data owner over their data, impose regulation on processing, and restriction over organizations how they can use personal data. Similarly, Government of India has recently proposed the Personal Data Protection Bill-2019 (PDPB-2019) [9] to provide legal framework for protecting personal data from organizations who are operating their business within India. It is a draft to protect the data and privacy of all individuals residing within the territory of India, and describes how data processing shall be outside India. As per the framework, now companies have to modify their data processing activity, privacy policy, and cookies policy in such a way that is compliant with the framework. In order to be compliant various technical and engineering tools need to be in place. It is important to take preventive measures to protect the privacy of individuals, as much as it is important to take legal actions after violations of privacy. In other words technical implementation and challenges should be considered while formulating the requirements of such a policy and formulate the legal guidelines.

Our aim is two fold: First, to understand the problem and definitions of privacy and analyse the bill in light of these definitions. Second, to provide technical guidelines to organizations to make data processing and storage compliant with the legal framework.

1.1 Motivation

To the best of our knowledge, no work is done in the context of technical implementation of PDPB. In the area of GDPR, the work has been done mostly in the five major categories: (i) on the challenges and limitations of GDPR [10, 11, 12, 13]; (ii) on the properties of GDPR like right to forget, and how it can be achieved [14, 15]; (iii) how changes should be done in the current system that can fulfil the
requirement of obligations of GDPR [16, 17, 10]; (iv) the possible architecture of the system as per GDPR standard and (v) design and implementation of consent. Since there are few differences between GDPR and PDPB, some of the above work cannot be trivially applied for PDPB. Also, there are still various categories where technological aspects needs to be explored in GDPR. We therefore ask the following questions:

1. What issues do the current bill address?
2. What are the properties of obligations of various entities that will need technical implementation?
3. What are the various technologies that might be required to satisfy the conditions given in the bill?
4. How can organizations implement the data management framework given in the bill?
5. How to make it easier for individuals to verify that the terms and conditions are honoured.
6. How to make it easier for law enforcement agencies to validate claims, in the face of a dispute regarding the enforcement of the policies.
7. In trying to address the above issues, we analyse the existing bill and suggestion modifications that we feel are important to protect data privacy.

In this paper, we have solved the above problem. We believe that a better understanding of the technical challenges, makes it easier to formulate the bill and guidelines to be followed to protect data privacy.

1.2 Our Contribution

Our major contributions are as follows:

- A detailed description of Indian personal data protection bill (PDPB), its major components, and outline of various obligations is provided.
- We have shown the differences of PDPB and GDPR with respect to regulation point of view.
- For each major obligation of PDPB framework, we have mentioned all the properties, challenges, and security concern that need to be implemented in order to fulfil the requirement of obligations. A detailed analysis is given for various obligations such as data principal consent, data collection, data processing, security by design, transparency and data audit.
- For the above properties and challenges, we have described how cryptographic (such as encryption, signature schemes, zero-knowledge proof etc) and other solutions (such as anonymisation, de-
identification, access control, etc) can be used for technical implementation.
- We have mentioned the set of challenges in obligations where existing solutions can not solve the problem. For such challenges, we advanced methods have to be explored.
- Using the example of the permanent account number (PAN), we show that achieving the goal of data protection is a collective responsibility of multiple organization. If a single organization is modifying their business model as per the data protection framework, it will require other communicating parties too, to change their business model.
- Lastly, we have provided the existing limitations of Indian data protection framework that needs to be modified.

1.3 Organization

The rest of the paper is organized as follows. Section 2 describes related work and section 3 contains background and description of PDPB. Section 4 discuss the comparison of PDPB and GDPR. Next, section 5 is about the major obligations of PDPB and their implementation. Further, we have provided the limitation of PDPB in section 6. At last, conclusion of the paper is provided.
2 Related work

Privacy of user’s personal data is very old concept. It was first proposed by Cavoukian in [18]. Earlier development of privacy oriented application was, user’s centric. The goal was application should be privacy oriented so that user’s can control their privacy and personal data. The earliest privacy laws were formulated by France (1978) [19] and Canada(1983) [20]. Similarly Australia (1988) [21], New Zealand (1993) [22] and USA (HIPAA,1996) [23] have also formulated privacy acts that set guidelines to collect, use, disclose and share the personal information. Many countries and economies have also come together to establish regulatory frameworks for cross border transfer of personal information. Such frameworks include APEC Cross-Border Privacy Rules (CBPR) System [24], OECD Guidelines on the Protection of Privacy and Transborder Flows of Personal Data [25] and EU-US shield framework [26].

PDPB [9] is also one step towards data protection. Currently very little has been discussed about PDPB. Since PDPB has been inspired by GDPR and has a good deal of similarity, we have described some of the earlier work done for GDPR.

The biggest challenge in the design of the data protection framework is to translate legal obligations into a technical platform. The effort involves many stakeholders like legal experts, law enforcement agencies, software architects, developers, requirement analysts and security and privacy experts. They have to collaborate with a coherent goal to achieve data protection privacy by design [18]. Work done by various stakeholders in different areas have been categorized in Table 1. There is excessive antagonism between the development style of product in software industry and legal tenets of data protection framework. Several limitations and challenges exist in the legal framework that make implementation difficult. A set of dichotomy between GDPR standards and system design perspective has been discussed in [27]. GDPR obligations like data storage, data deletion, data reuse are challenges in the real world. Gruschka et al. [10] have discussed about data protection challenges while processing big data. They have suggested to use of anonymity and de-identification techniques while processing big data. Esteve [12] has discussed the use of personal data by Google and Facebook for advertisement and business purposes and how this will affect protection of personal data under GDPR. Fuller [13] argues why privacy is a failure till now. The debate is whether a company should collect data freely to provide a service, or they should impose a fee for the service, in turn to protect the privacy. Similarly, [11] has analyzed GDPR challenges and limitations with respect to whether it is for a purpose or it was a necessity.

| Area                                      | References       |
|-------------------------------------------|------------------|
| Challenges and limitation in achieving goal of Data Protection | [27], [10], [11], [12], [13], [28] |
| Architecture                              | [29], [30]       |
| Data Protection Properties                | [14], [15], [31], [32] |
| Review of implementation of GDPR Policy in the system | [16], [17], [10], [33] |

Table 1: Related work in the area of personal data protection

After the implementation of data protection framework, each data fiduciary has to change their system according to legal requirements of the framework. Hjerppe et. al [30] and [29] have analyzed and proposed software development models and threat models that can be implemented as per the obligations of GDPR. The other kind of works are based on procedure to accomplish the tenets of the framework. For instance [15] has examined the importance of “right to forgotten” covenant of GDPR. Similarly, [14] has discussed about deletion of data stored in the blockchain from the perspective to “right to forget” of GDPR. Many authors have analyzed efficacy of present system: Such as, [16] has examined the privacy policy of cookies by various websites after the implementation of GDPR. They have shown that, processing of personal data in cyber trust project for security of smart home environment. Similarly, [17] has described the use case of cyber trust project for security of smart home environment. They have shown that, processing of personal data in cyber trust project follows the policy of GDPR. Likewise, [16] has analyzed use case of two project “SWAN” and “OSLO”. In this it is investigated that, policy of GDPR is implemented effectively for the processing of big data and proper anonymization and de-identification has been followed as per the policy of GDPR.

Our work is completely different from all the previous work. To the best of our knowledge it is the
first paper assessing the effectiveness of PDPB. We have described the technical challenges for each major obligation of PDPB framework and provided a set of properties and technical methods to help translate the legal covenant into technical standards. We have described set of cryptographic methods that may help to implement PDPB’s obligation. We have argued how proper implementation of cryptographic methods can provide better privacy, data protection and effective control on personal data.

3 Background

In this section we first discuss the Personal Data Protection Bill and then give some definitions of the cryptographic primitives that we will propose to use.

3.1 Personal Data Protection Bill (PDPB): What it is and how it will impact data processing?

In 2017, right to privacy was declared as fundamental right under the constitution of India [34]. The judgment by the Supreme Court of India, declares: “the right to privacy is protected as an intrinsic part of the right to life and personal liberty under Article 21 and as a part of the freedoms guaranteed by part III of the constitution”.

In this digital era, no one is trustworthy over the Internet. The principal concern is to determine when an individual or organisation can share its personal data with others for processing and how the privacy of the personal data will be protected. These concerns demand an urgent requirement to develop a legal framework to protect privacy of individuals, to protect the data of individuals and to prevent against data breaches. In order to ensure this, Central Government of India established a committee lead by justice B. N. Srikrishna to study the existing challenges and to establish a legal data protection framework to address the data privacy of individuals. The objective was “to ensure the growth of the digital economy while keeping personal data of citizens secure and protected”. The committee has proposed a data protection framework known as the Personal Data Protection Bill-2019 (PDPB) [9] which is the first step towards India’s data privacy journey.

3.1.1 Basic constituents of PDPB

Figure 1 shows the primary entities of PDPB framework.

Data is any information, opinion, facts, concepts and it can be categorized as health data, biometric data, genetic data, financial data etc. Personal data is the “data about or relating to a natural person who is directly or indirectly identifiable, having regard to any characteristic, trait, attribute or any other feature of the identity of such natural person, or any combination of such features, or any combination of such features with any other information”. This bill also emphasises on some special types of data called as sensitive personal data that requires more security and safeguard. It includes health data, financial data, sex life, sexual orientation, biometric data, genetic status, caste or tribe, political or religious belief or affiliation. Another category of data is critical personal data which requires higher degree of protection and would be processed within India only. The data belonging to this category is not yet defined but in future the complete list will be notified by the Central government of India.

The entities involved are as follows: The owner of the data is known as Data principal. Data Fiduciary is defined as “any person, including the state, a company, any juristic entity or any individual who alone or in conjunction with others determines the purpose and means of the processing of personal data”. Data processor, who either can be a data fiduciary or a third party who processes the data on the behalf of data fiduciary. This bill explicitly mentions that the responsibility of data fiduciary is to protect the data of an individual.

Other entities involved could be independent auditors who perform data audits, the Data Protection Authority of India (DPAI) that sets guidelines and makes legal decisions based on the inputs of the data principal, data fiduciary and independent auditors.

3.1.2 Brief description of obligations of PDPB

In Table 2, we have shown organization of PDPB framework.
Data fiduciary has to collect, disclosed, shared and processed personal data for purposes that should be clear, specific, reasonable and lawful (as per Article 4). Clear means, data principal knows the exact reason for which data has been collected. Further, data shall be processed only for reasonable and specified purposes (as per Article 5). Such purpose will be identified and defined by the data fiduciary before the data collection and shall be disclosed to the data principal at the time of collection. Data fiduciary has to perform fair and reasonable processing of data. In particular, any individual or organization who is processing personal data owes a duty to the users to process such personal data fairly and reasonably that respects the privacy of the data principal (as per Article 5(a)). Fair data processing will impact the technical design of a system and the way data is collected and processed. Therefore data fiduciary has to collect least and minimum data as possible according to the “collection limitation” requirements (as per Article 6).

Before collection and processing, data fiduciary has to provide the necessary notice (as per Article 7) to the data principal. The notice will contain few basic prerequisite such as purpose of collection, consent form, nature of data being collected, information about any cross border transfer etc. Data fiduciary also needs to maintain quality of personal data during processing. This means that data must be accurate, complete and not misleading (as per Article 8).

Consent is required before the commencement of data processing (as per Article 11). Consent would be free, informed, specific and clear. Data fiduciary will have responsibility to keep a proof that consent has obtained from data principal before the processing. The protection framework puts more restriction on the processing of sensitive personal data. The processing of such kind of data will require explicit consent (as per Article 11(3)) from the data principal. Explicit consent means data fiduciary has to draw attention to the data principal about the sensitivity of personal data, the reason why such collection is necessary and possible consequences. Data principal will also have to acknowledge explicitly. A consent
manager will also established by data fiduciary which will record and manage all the consent obtained from data principal. The Data Protection Authority of India (DPAI) shall publish list of personal attributes which would be considered as sensitive personal data periodically (as per Article 15).

| Articles       | Details                                                                 |
|----------------|-------------------------------------------------------------------------|
| Article 1-8    | Objective and establishment of grounds for processing of personal data  |
| Article 9-10   | Data retention policy and Accountability                                  |
| Article 11     | Definition of consent and explicit consent                                |
| Article 12-14  | Norms for processing of personal data without consent                     |
| Article 15     | Criteria for consideration of personal data as sensitive personal data    |
| Article 16     | Grounds for processing of personal and sensitive personal data of children |
| Article 17-21  | Establish the rights of data principal                                    |
| Article 22-24  | Privacy, transparency, consent manager and security safeguards            |
| Article 25-32  | Significant data fiduciary, data breach, data audit, data impact assessment and data protection officer |
| Article 33,34  | Grounds for transfer of personal data outside of India, critical personal data, |
| Article 35-40  | Mandate about processing of personal data for other purposes like security of state, for law or legal processing, journalistic purpose, research or statistical purpose etc. |
| Article 41-56  | Establishment, responsibilities and power of data protection authority of India |
| Article 57-85  | Covers penalties, liability, establishment of appellate tribunal and execution of other offences |
| Article 86-98  | Miscellaneous power of central government, grounds for framing digital India policy and norms for processing biometric data |

Table 2: Organization of articles of PDPB-2019

The processing of children’s data will be in such a manner which protects the rights of children (as per Article 16). Data fiduciary has to verify the age of children and has to obtain consent from parent or guardian before processing the data. DPAI will specify the procedure and the appropriate mechanism to conduct age verification under this regulation. These procedure may vary depends on the type, volume and sensitivity of personal data corresponds to the children. Consequently, data fiduciary has to implement it technically. Further, based on the nature of commercial website, online services offered and the volume of children personal data being processed, DPAI will categorize few data fiduciary as guardian data fiduciary. They are not allowed for profiling, target based advertising or any other activities which may lead harm to the children.

The data protection framework provides various rights to the data principal such as the right to confirmation and access (as per Article 17), the right to correction and erasure (as per Article 18), the right to data portability (as per Article 19), and the right to be forgotten (as per Article 20). Data principal may ask what data is being processed from data fiduciary. He has right to obtain the summary of processed personal data. Data principal may request to update - alter, correct or erase his personal data. He may also request data fiduciary to prevent or restrict continuing disclosure of personal data.

The design of a system should provide privacy, transparency and security to the individual automatically. Therefore data fiduciary has to take necessary steps to implement privacy by design (as per Article 22), transparency (as per Article 23) and security safeguard (as per Article 24). Here transparency means disclosure of steps which has used to protect personal data and security safeguards are like the use of suitable de-identification, encryption mechanism, integrity protection and access control mechanism.

Data fiduciary may conduct data protection impact assessment before commencement of processing of personal data (as per Article 27). Impact assessment depends on nature, scope, context and volume of personal data. Each data fiduciary will maintain up-to-date records. Records may contain activities such is important operation, impact assessment, periodic review etc (as per Article 28). Also, an audit may be conducted periodically by an independent auditor approved by data protection authority to review data processing policy, to analyze risk and to verify data protection impact assessment (as per Article 29). Each data fiduciary shall assign a data protection officer (as per Article 30) who will advice the
data fiduciary for matters related to data processing. The data protection officer also works as a point of contact for the data principal as well as for the data protection authority. The fiduciary who has not established their office in India and performing processing activities of personal data has to assign a data protection officer within India itself. All data breaches (as per Article 27) which may harm the data principal, shall be reported to DPAI by the data fiduciary.

PDPB puts multiple restrictions on cross-border transfer of personal data (as per Article 33). Sensitive personal data can be transferred outside India but data fiduciary has to store at least one copy within India. The DPAI will determine which kind of sensitive personal data can be transferred. It will based on nature of data, international relation of India with the countries and international agreement. Explicit consent of data principal is required before such transfer. Critical personal data shall be processed within India itself.

Based on nature, volume and severity of data being processed by a data fiduciary or class of data fiduciary can be called as significant data fiduciary (as per Article 26). Each social media data fiduciary which is intimated as significant data fiduciary will verify the account of all user who uses their services in India or use their service from India (as per Article 28).

### 3.2 Basic cryptographic primitives

Cryptography is a practice of making secure communication between sender and receiver in the presence of adversaries. Cryptographic algorithms design can provide security, integrity and privacy of data. Here we discuss recent techniques of cryptography that can be used in data protection.

**Encryption** [35] is a process of converting message (plaintext) to ciphertext, in such a way that the ciphertext does not reveal any meaningful information about the message. A cryptographic key (a random string) and message is supplied into a well defined encryption algorithm to obtain ciphertext. The receiver who obtains ciphertext and has knowledge of key can recover the plain text using a decryption algorithm. Mainly there are two kind of encryption symmetric and asymmetric. Ciphertext provides confidentiality or privacy and security while data is moving or at the rest. An adversary observing message and ciphertext pairs cannot distinguish between ciphertexts of two different messages. The limitation of encryption is, privacy and security can not be guaranteed when sensitive data is disclosed improperly.

**Digital signature** [35] is a cryptographic scheme which verifies the authenticity of sender and integrity of a digital document (message). Sender creates a signature on the message and sends to the receiver. Upon receiving both message and signature receiver can verify that message has not been altered and is signed and send by the claimed sender itself. Signatures should be unforgeable, such that an adversary who observes message signature pairs cannot construct a valid message, signature pair. Data fiduciary can use signatures to prove authenticity, integrity and non-repudiation.

**Message authentication** [35] message authentication is scheme which proves that message is not altered (data integrity) while in transit and receiver can verify the source of the message. Message authentication can be implemented through message authentication code (MAC) or Authenticated Encryption (AE) schemes. Along with message a tag value is send to the receiver which can be used to verify authenticity and integrity of the message. While signatures can be verified by any party with public information, MAC and AE need secret keys (information) for verification.

**Zero knowledge proofs** [36] Zero knowledge proofs (ZKP) are useful when a party wants to prove that it possesses some information, without revealing the information. For example, proving that a person is above 18 years without revealing the age (or showing the identity document). Generally, ZKP has two parties prover and verifier. Prover(such as data principal, owner of secret information) can prove to the data fiduciary that he knows a personal data \( x \) without disclosing any information apart from fact the he knows a value \( x \).

**Secure multiparty computation** [37] Secure multiparty computation (SMPC) allow multiple parties to perform computation on encrypted or private data without revealing the data to the other parties. SMPC gives more privacy over user’s private data. Two parties(such as two hospitals) can compute a joint function (say total number of cancer patients) jointly while keeping their inputs private.

**Homomorphic encryption** [38] Homomorphic encryption allows computing on encrypted data. Data principal shares personal information to data fiduciary possibly over encrypted channel. These information are decrypted and used by data fiduciary and sometimes can be misused. To prevent
improper disclosure, homomorphic encryption (HE) allows user to share their personal data without losing confidentiality and privacy.

Searchable Encryption [39] Searchable encryption is a cryptographic technique that can query on encrypted data stored in outsourced servers. The search neither leaks the response (search results) to the server, nor does it make the server aware of the query itself. Popular queries include single/conjunctive keyword search, range queries etc.

Blockchain Blockchain [40] is a distributed, tamper proof, immutable and decentralized ledger. The data recorded in the blockchain are publicly verifiable. All transactions originating from users are propagated to the network and validated by multiple validators. This improves the trust of the system. Immutability guarantees non-repudiation, meaning that users cannot deny making the transactions. Blockchains guarantee that all transactions are recorded, verified and cannot be retracted. In the literature framework has been proposed to integrate blockchain for the data protection [41].

Differential Privacy [42] It allows organization to share aggregate information of their users while protecting private information. Differential privacy mathematically ensure that any one obtaining the analysis result would make the same conclusion about individual’s private information whether or not his data is included in the input for the analysis.

4 Comparison of GDPR-EU and PDPB

After the implementation of GDPR in May 2018 [8], many organizations that are providing their service in the European Union have changed their data processing policy as per GDPR standards [16]. PDPB framework is proposed with respect to the Indian context and has been inspired by GDPR. Both protect individual’s in the processing and free movement of personal data. There is a good deal of similarity between GDPR and PDPB with few differences. We have analyzed the major differences that exist between GDPR and PDPB, why such differences exist, what are the effects and whether these differences makes PDPB stronger or weaker. Table 3 compares GDPR and PDPB.

The primary difference is that both frameworks have different approach for sensitive personal data and critical personal data processing and its storage. In GDPR, European Union allows cross border transfer of data to non-EU countries/organisations if commission decides that such transfer has an adequate level of protection. The adequate level of protection includes criteria such as nature of the data, law and enforcement in non-EU country/territory, international relations and the commitment of data fiduciary for the security and safeguard of data. Such transfer will not require any specific authorisation. PDPB enforces more restrictions on cross boundary transfer of data. First of all, the data protection authority of India will specify the definition of sensitive personal data and critical personal data. For the case of sensitive personal data, DPAI will authorize a party to be transferred to outside of the border. DPAI will also authorize whether such transfer has an adequate level of protection. Additionally, data fiduciary has to notify data principal explicitly regarding cross-border of transfer. Another constraint of PDPB is, data fiduciary has to maintain a local copy because Indian government is more concern about availability of data. Critical personal data has to be be stored and processed only within India. Definition of critical personal data is yet to be disclosed but it could be Aadhar data (unique identification number), PAN data (permanent account number, issued by income tax department), digi-locker data. Presence of such control might be because the government is concerned about the security of critical personal data after data breaches were reported [43].

Another major difference is, GDPR and PDPB have different approach to report personal data breaches to the data principal. In PDPB, data fiduciary will report data breaches directly to the data protection authority. Later, taking into account the severity of harm and the necessary action will be taken. The authority may decide whether it should be reported to the data principal. In GDPR, data subject has more power in the case of data breach. According to this, data controller has to report data breach directly to the data principal. Subsequently if data fiduciary finds that data breach may result in high risk to the rights and freedom of natural person such breach shall be reported with undue delay. This reporting will also disclose the necessary steps and remedial action which have been performed by the data controller to mitigate the risk. Thus, PDPB regulation provides more power to the DPAI instead of data principal in the case of breach reporting.

Further, PDPB introduce the definition of significant data fiduciary which is not present in the GDPR. Based on the volume of personal data processed, sensitivity of personal data, risk of harm in
| Detail                                      | GDPR-EU                                                                 | PDPB                                                                 |
|--------------------------------------------|-------------------------------------------------------------------------|----------------------------------------------------------------------|
| Status                                     | Implemented                                                             | Draft                                                                |
| The entity whose data is being processed   | Data subject                                                            | Data principal                                                       |
| The entity who is processing data          | Data controller                                                         | Data fiduciary                                                       |
| Cross border transfer of sensitive personal data | May be transferred without any restriction, if commission/authority assure appropriate safeguard and protection | May be transferred if data fiduciary follows the guidelines of authority. Also, data fiduciary has to store one local copy within India. |
| Critical personal data                     | May be transferred without any restriction, if commission/authority assure appropriate safeguard and protection | Processed and stored within India                                    |
| Data breaches                              | Data controller may inform to data subject, in case of high risk         | Data protection authority will decide whether it should be reported to data principal or not |
| Right to object                            | Data subject may object further processing of data                       | Not specified                                                        |
| Right to restriction                       | Data subject may restrict processing                                      | Not specified                                                        |
| Children consent                           | Approval of parental authority is required to process children personal data for children below 16 years | Children data shall be processed with appropriate safeguard which protects the rights of children; Age verification and parent’s/guardian’s consent is required |
| Children data processing                   | Not specified                                                           | Guardian data fiduciary shall be barred from profiling, tracking, behavioural analysis and target based advertisement that can cause significant harm to the child. |
| Right to object automated decision making  | Data subject may have right not to participate in automated decision making like profiling which can harm him/her significantly | Not specified                                                        |
| Right to access                            | Data subject may obtain copy of personal data being processed           | Data principal May obtain summary of personal data being processed   |
| Social media significant data fiduciary     | Not specified                                                           | Specified, have to maintain user verification records also           |
| Data audit                                 | ✔️                                                                       | ✔️                                                                   |
| Consent Manager                            | Not specified                                                           | Record and manage consent of data principal                          |
| Trust score                                | ✗                                                                        | ✔️                                                                   |
| Certificate                                | ✔️                                                                       | ✗                                                                   |

Table 3: Comparison of GDPR-EU and PDPB
processing or any other criteria DPAI will categorize some data fiduciary as significant data fiduciary. They have to register themselves with the DPAI. Authority will direct and monitor him directly regarding the implementation and important operations such as data audit, data protection impact assessment, maintenance of record, establishment of data protection officer or direction for security and safeguard of the data. Similarly, authority will further classify and publish a list of social media significant data fiduciary. These will be from the area who provides online social media services. Such data fiduciary would have an additional responsibility of identification and verification of every users who are getting service from or within India. PDPB also introduced the concept of consent manager. Consent manager is an entity who will manage and update all the records of consent provided by data principal.

Both frameworks are concerned about an adequate protection during the processing of children personal data. As per the PDPB, a person below 18 year will considered child in India. PDPB mandates age verification prior to data processing, in addition to consent from the authorized guardian. In GDPR, children (below 16 years) data can be processed only if the holder of parental responsibility gives consent. PDPB will specify appropriate mechanism that can be used for age verification. PDPB has introduced the concept of guardian data fiduciary. They are not allowed to do profiling, targetted advertising or any action which can harm the children. Such restriction is not specified in GDPR. Overall, for children data processing, PDPB is stricter than GDPR.

Taking into account of rights of data principal, both framework has different definitions and approach. GDPR gives more rights to data subject.

Data subject has right to get information in both framework when data is not collected directly from data subject. In PDPB, if data fiduciary has not collected personal data directly from data principal then it has to disclose source of such data before the commencement of processing or as early as reasonably practical. On the other side in GDPR, if personal data has not obtained from data subject then data controller has to provide the source the collection, purpose for which data will be used, categories of personal data obtained, further recipient of this data and any other relevant information. Further, if data controller does profiling, automated decision making or any behavioral analysis then data subject may request information regarding this under GDPR. If it is not possible to give all such details then the detail of the idea behind the logic involved, significance of processing and possible consequences may be provided. Such clause is not present in PDPB.

Under GDPR, if any data controller wishes to use personal data for further processing other than the purpose for which it is collected, the controller has to inform to the data subject about the purpose of processing along with any other relevant information. PDPB does not have any clause regarding such further processing. Similarly, In GDPR data subject solely have right not to participate in profiling and automated decision making which might harm him significantly. In PDPB, data principal does not have such rights.

GDPR has right of restrictions and right of object for data principal. Data principal may restrict his processing instead of deletion. Restriction can be imposed on the presence of conditions such as the accuracy of personal data processed by controller is disputed or data principal believes that processing is unlawful. Restriction can also be requested if controller can not delete data. It can be the situation where the storage of personal data is necessary for the establishment, exercise or defence of legal claim. Similarly, at any time data subject may object the processing under GDPR. Instead of right to restriction, PDPB has right to forgotten. Using this data principal can restrict or prevent continuing disclosure of his personal data. But it is applicable only by the order of an adjudicating officer.

Some minor similarity and differences also exist which are mentioned in Table 3. For instance, in right to access data subject may obtain a copy of personal data undergoing in processing under GDPR. While in PDPB, only a brief summary of personal data may obtained. Similarly, PDPB has concept of trust score (a kind of rating on a scale) while GDPR has concept of certificate to the data fiduciary.

5 Major PDPB Regulations From System Design Perspective

To comply with the privacy regulations, data fiduciaries need to modify their systems and data processing procedures.

To achieve the goal of obligations, the first and foremost requirement is to understand and interpret the legal requirements precisely. Data fiduciary needs to investigate what are the necessary data protection, security and privacy by design requirements. Data protection goal can not be accomplished until
and unless the data fiduciary understands the explicit meaning of obligations.

Next step is to understand how the requirements can be achieved using privacy tools. There are many tools and techniques in the literature. We strongly argue that if such tools are used appropriately then it will help to implement the law effectively. This will help in achieving the goals of data protection bill.

For instance, the bill gives excessive power to the Government (as per Article 91). Central Government can ask for any personal data to design policy framework for the country or to promote digital economy. Data fiduciary has to reveal data to the Government. In such cases, we assert that there are cryptographic tools and techniques which would not only help to implement data sharing but also preserve the privacy of data principal. For example, zero-knowledge proofs and secure multi party computations can be used for data processing without revealing the data [44, 45]. Another scenario where implementation of cryptographic techniques will be useful is that in sharing data about Aadhar number (unique identification number for Indian citizens) [46]. Individuals need to share biometric information to get government beneficiaries services. Zero knowledge proofs and fuzzy attribute based encryption [47] can be used to verify individuals identity without revealing biometric information to the data fiduciary.

We have considered only the major obligations (that we call verticals) from the framework. These are shown in Figure 2. Analysis of each vertical is done primarily in two parts. First, clauses in the vertical are well identified and the security and privacy requirements are derived. Second, a description of appropriate tools and techniques has been provided against properties derived from the previous step. Wherever possible, an explanation has also been provided regarding why such properties are necessary.

The essence of implementation is the translation of explored properties into technical implementation. To achieve this, a summary of the list of vertical’s and their corresponding set of tools has been shown in Table 4. Many cryptographic methods can be used to solve security, privacy and data protection requirements of obligations. In many cases we have shown that appropriate use of cryptographic solutions such as authentication, encryption, integrity, proof of storage, proof of possession, proof of location, zero knowledge proof, secure multiparty computation and other techniques can provide a solid support for implementation of the data protection bill. A detailed discussion of each verticals is done next section.
| S.No. | Required Properties            | Technological methods                                                                 | References         |
|-------|--------------------------------|--------------------------------------------------------------------------------------|--------------------|
| 1.    | Data consent                   | Digital signature, encryption and blockchain                                          | Section 5.1.1      |
| 2.    | Limited data collection        | Data minimization techniques                                                          | Section 5.2        |
| 3.    | Data storage limitation        | Required expiry of data                                                               | Section 5.2.5      |
| 4.    | Privacy by design(PbD)         | Storage of encrypted data, searchable encryption, zero knowledge, secure multiparty computation, homomorphic encryption, anonymous and confidential storage | Section 5.4        |
| 5.    | Integrity protection and authentication | Authenticated encryption, continuous data authentication scheme, 2 way authentication, 2-factor authentication, multiparty authentication and time based authentication | Section 5.3        |
| 6.    | Security and safeguard         | Encryption, authentication and authorization of data, client side encryption of cloud data, searchable encryption, secure multiparty computation, secret sharing | Section 5.3        |
| 7.    | Anonymization and de-identification of data | K-anonymity, l-diversity, t-closeness, differential privacy, tokenization, federation, hashing, binning format preserving encryption | Section 5.3        |
| 8.    | Access control                 | Role based access control, access control list, policy based access control, geolocation based access control, attribute based access control, lattice based access control | Section 5.3        |
| 9.    | Right to access, Right to correction | Blockchain base method                                                                | Section 5.7        |
| 10.   | Right to forget                | Erasure based proof                                                                  | Section 5.7        |
| 11.   | Data audit                     | Proof of storage, proof of consent, proof of possession, proof of retrievability, proof of sharing of data | Section 5.6 and Section 5.6.3 |
| 12.   | Data breach                    | Data audit                                                                            | Section 5.8        |
| 13.   | Children data processing       | Anonymous user credential, Parental control, zero-knowledge based proof                | Section 5.10       |
| 14.   | Location of sensitive personal data | Proof of location, geo fencing, proof of geo-location of data                           | Section 5.9        |

Table 4: Tenets of PDPB and various methods to implement it technologically
5.1 Data Principal Consent

As per the right to privacy, the user has the right to set their choices, preferences, permissions, to decide access control on their personal information, to select with whom, where and how much personal information shall be shared [48]. To enforce this data protection framework, specify the definition of user's consent. It states that consent is necessary and should be obtained before collecting and processing of personal data. Many organizations are collecting user's personal information for their monetary purpose, social and personal benefit, business analysis, target-based advertising or for behavioural analysis [49, 13, 12], which may affect users privacy. Therefore, consent as a legal evidence will help to develop trust and prevent data fiduciary and third parties from data misuse.

PDPB states the nature and scope of the consent for data processing. According to Article 11(1) of PDPB, “data may be processed based on consent...”. Data fiduciary must notify the data principal regarding the data collection and should obtain the consent. This is known as informed consent. Further, Article 11.2(a) - 11.2(d)) states: “consent shall be free, informed, specific, clear...”. Data principal also has the right to withdraw their consent (as per Article 11.2(e)). Subsequently, for sensitive personal data, explicit consent is required (as per Article 11(3)). Explicit consent means the consent is informed, fair, specific and unambiguous. In other words, data principal has to acknowledge before such data collection. This acknowledgement can be done by a statement, an affirmation, an action, selection, choices or any other kind of agreement. Next, data fiduciary as per Article 11 (5), “shall bear the burden of proof to establish that consent is given by data principal” so that he can prove transparency to anyone in the processing. Finally, data fiduciary has to implement an entity consent manager through which he can record, manage and process all of the consent (as per Article 23(3)).

We will now discuss set of properties that need to be solved to implement the consent technically. Further, we have discussed whether or not current model of consent exhibits such properties. Later we have discussed the high-level idea of how it can be implemented.

5.1.1 Proof of Consent

The Data Protection Bill presents consent from legal perspective. This essentially means that parties are questionable in the court of law, if they deviate from the terms and conditions in the consent form. Legal action is taken after an event and requires evidences. These evidences can be (possibly) encoded within the software to ensure that the consent properties are implemented accurately and transparently. We call such encoded evidence or proofs as proof of consent (PoC). These proofs will prevent data fiduciary from deviating from the legal contract (as in the consent form). It will help to resolve disputes if they arise, or it can be presented to the jurisdiction of DPAI for any legal investigation. Such PoC should be verifiable during data audit in order to detect malicious activities. At a very high level, the following properties are required to be implemented to construct proof of consent:

1. Data fiduciary should establish a free, informed, specific, and clear method to implement consent. Consent can be established through opt-in methods so that user will have an option to click check boxes and select his choices. Data fiduciary should maintain purpose explicitly for which consent is being made. A separate consent can be established for different purposes.
2. Data fiduciary should implement a proof that a consent is established with the data principal. If data principal claims that data fiduciary is processing data without their consent, then data fiduciary can prove legally that consent was indeed established.
3. As per the bill, data fiduciary should mention the list of third parties with whom data will be shared in consent form. List of third parties will help data principal to keep track of personal data. But as of now, data fiduciary does not keeps transparency in disclosure of third party. Such transparency is required to implement technologically.
4. Data fiduciary should implement a proof that personal data has been shared with those third parties only, for which data principal has given consent.
5. Data principal has right to withdraw consent. Data fiduciary has to provide a method using which consent can be withdrawn. Data fiduciary should keep a proof of withdrawal of consent. Also, data fiduciary should maintain a proof that all the third parties have been intimated about such
withdrawal and both have stopped processing and sharing this data. Such proofs are required because as per the law, no data processing should be done after consent has been withdrawn. Violation of this may lead to punishment/penalty. On the contrary, this violation will work only if it came under the observation. Otherwise behind the wall data fiduciary may use this data for monetary purpose even after consent has been withdrawn. To the best of our knowledge, this problem is rather difficult to solve without legal interventions.

6. Data fiduciary should maintain a record of whom, when, how and why consent has been established with data principal.

7. Data fiduciary should allow data principal to change his choices or preferences. If such changes have been approved by data principal then further data processing will be done as per the new consent. Data fiduciary should maintain a proof that modified consent is recorded and processing is being done on modified consent.

8. In the case of explicit consent, data fiduciary shall make a clear and concise statement. Data fiduciary will write statement about sensitivity of data, why it is required and will ask for agreement of data principal explicitly before processing it. He/she should keep a proof that explicit consent has been obtained before processing of sensitive personal data.

9. Data fiduciary may review the consent policy time to time and should inform the data principal accordingly. He can update the list of changes in the consent established previously. Data fiduciary has to provide an option to the users either they may change their preferences as per the new consent policy or they may withdraw their consent from further processing. In both cases, data fiduciary should keep a proof of such modifications.

10. Data fiduciary has to follow the guidelines of PDPB. If any change in the bill occurs regarding consent then data fiduciary has to review it and have to modify their policy as per the new standards. He will notify the same to the users and ask for necessary modification of consent before further processing. Data fiduciary should keep a proof of such modifications.

11. Data fiduciary should maintain a method of proof that he is not collecting any personal data automatically without user’s consent.

Existing methods of retrieval of consent and its limitations: The current status is, organizations are trying to modify their business so that they can provide more choices, preferences and control of data to the users in the form of consent. Figure 3 shows the current model of establishment of consent. Data fiduciary provides a form \( F \) to the data principal. Generally, data principal gets either of the two options. In the first one, he has to accept or reject the consent. In such cases, all terms and conditions are enclosed in the consent form itself. In the second case, data fiduciary provides opt-in methods which allow users to select few choices and preferences. After selecting appropriate preferences data principal can return the document \( X \). Few organizations allow to modify the consent. To do this data principal can request to modify his choices. He can re-submit it as document \( X' \) after doing necessary changes.

The current model of taking consent does not fulfill the properties of consent discussed above. It has several limitation and drawbacks. For example, both accept/reject method and opt-in method of collection of preferences does not guarantee correctness of proof of consent (PoC) establishment. There are three reasons: (1) Since consent is managed solely by data fiduciary itself it may allow data fiduciary to perform maliciously by altering the consent form. It can also prove to the individuals(?) that consent has been taken even without obtaining it. (2) Even if it takes consent, there is no way of verifying that processing was done according to the terms in the consent form. (3) Processing is done on the basis of recent (modified) consent or old consent. The current model also does not provide an option to delete the consent. So, there is a need to implement proofs of consent properties which can resolve dispute and breaches.

To achieve the goal of consent, the data fiduciary needs to implement all the items listed in Subsection 5.1.1. We have provided a high level overview how technical methods can used to implement this. We have skipped the detailed construction as future work. If we assume that data fiduciary uses opt-in method of consent then items 1, 3 and 8 of subsection 5.1.1 can be implemented directly by writing all the conditions explicitly. For this, data fiduciary can create a simple form with opt-in methods. All
Figure 3: Current model of consent establishment between data principal and data fiduciary

purposes, list of third parties and explicit consent for data processing can be mentioned in the form thoroughly.

**Undeniable consent proofs:** We need to address how can we encode the consent into the data collection and storage software to satisfy Item 2. One way is using digital signature schemes which will work as non-repudiation technique for the consent. Data principal should digitally sign the consent form. Signature on the document will ensure two things. 1) Data fiduciary can prove that he has obtained consent before data processing and data principal can not deny it. 2) No party other than data fiduciary can have such proof of consent (if implemented correctly with combination of other cryptographic techniques). To modify the consent (points 7) or withdrawal (point 6) of the consent, data fiduciary can ask user to resubmit another form with different signatures. Therefore, signature can help to resolve the dispute of consent establishment between both parties.

**Inclusion of time information:** In order to prove “since when” parts of point 6, digital signature is not sufficient. Signature can not guarantee correctness of time since when consent is established, modified or withdrawn. To prove when the document was signed, any secure time stamping algorithm can be used.

**The dilemma of old and new consent proof:** Items (5, 7,9,10) describe the cases of modification or withdrawal of the consent. Modification in the consent can be started from either of the party. It is possible in the case if any change happens either due to the privacy policy of the organization or change in policy of PDPB standards. As discussed above, data principal can submit modified consent form along with the new signature. Now, the data fiduciary has both old and recent copy of the consent. Both consent are valid and processing can be done upon either of them. This may allow data fiduciary to be malicious. For instance, he can delete either copy of the consent and can do processing on the basis of his choice of consent. In such cases, data principal can not prove malicious behavior of data fiduciary. Therefore keeping both old and new consent does not enforce data fiduciary to process the personal data based on recent consent.

To distinguish between old and new consent blockchain based protocols can be used. Blockchain is a tamper proof, immutable verifiable ledger used to record transactions. Transactions recorded on the blockchain are transparent. Proof of consent can be recorded in any public blockchain for example. Since all the consent will be available on public chain, both party can agree on the latest consent. This will also ensure parties to resolve the dispute (if any) through the legal authority. We will provide a formal construction of consent properties in a follow up work.

**Other desirable properties of proof of consent**

There are few consent properties where proof of correctness would be difficult to achieve, but these are desirable. For instance, data fiduciary collecting data without consent (Item 11), or data fiduciary is sharing data with unauthorized parties (not mentioned in the consent form) (Item 4), or data fiduciary is processing data even after consent has been withdrawn (Item 5). We summarize more such desirable proofs below:

1. Data fiduciary should implement transparency in disclosure of the list of third parties with whom data is being shared. On the other side, as per the bill, third party has to disclose the source of
data, if it is not collected directly from data principal. For this, he should implement a proof to show the origin of personal data. Such proofs are necessary because no one actually knows how data is processed behind the wall [27].

2. Third parties should implement proofs that processing is being done as per the contract with data fiduciary.

3. If consent is being withdrawn by data principal, same will also be communicated to third parties. Now third party should implement proofs that no processing is being done after consent has been withdrawn.

4. Data fiduciary should implement proofs that he is not using data for other purposes. If he wants to do so, he can inform to the data principal and can ask separate proof of consent. As of now, such proofs are difficult to implement and would required more advanced methods.

Currently, technical solutions to complying with consent have not been discussed thoroughly in the literature. Though many authors claim [41, 54, 55] that Blockchain is a panacea for this, the authors are skeptic. The primary reason is the difficulty to prove what operations are performed on data. Maintaining an audit log is not sufficient, as it cannot keep track of activities performed by unauthorized users. Even data fiduciary might choose not to log some of the events, in particular when it shares data with unauthorized third parties or performs illegal operations.

The more advanced technical method could be explored to solve the existing challenges of proof of consent. For instance, to verify the consent a more advanced cryptography based method such as third party audit [56] could be developed. The audit scheme will increase transparency and minimize manual interference. The algorithm may check and verify multiple parameters to confirm that consent is as per the PDPB standards. From legal perspective, a penalty can be imposed if it is found that either data fiduciary or third party is processing data for additional purposes without prior consent.

5.2 Data collection

Data can be collected after retrieving the consent from data principal. In the bill, many sections cover the properties of data collection such as Articles 5, 6 and 9 corresponds to the “purpose limitation, collection limitation, and storage limitation” respectively. From implementation perspective the following properties should be considered to prove that data collection is as per the regulation.

1. Purpose limitation

2. Collection limitation(by following minimum data collection, and putting restrictions on category of personal data being collected)

3. Storage limitation (duration of personal data storage)

4. Information about third parties with whom personal data is being shared.

5. Security and safeguard of data (while collection, transfer, share and storage of data)

Data fiduciary should identify and inform the purpose for which data is being collected (purpose and collection limitation), and disclose estimated data retention period (storage limitation). If such period could not be determined then disclose a tentative duration. To compute this, a review can be conducted on regular interval, and can be informed to the data principal accordingly. Similarly, each data fiduciary has to maintain the list of “third parties with whom data is being shared” (as per Article 7). This list could be made available at their website or can be informed directly. Further, during collection, cat fiduciary should disclose other information such as “any cross border transfer of data”, “type, nature and category of personal data being collected” or “source of collection if data is not obtained directly from data principal”. All such notification should be done before the commencement of processing.
5.2.1 Goal of data fiduciary: collect minimum data

The primary accountability from data fiduciary is, he should prove that collected data is minimum. It is necessary because data fiduciary can have strong monetary incentive by collecting enormous personal information. Sometimes sensitive data like health information, credit card number or medical record are collected even without user’s knowledge. But, it is still a big question, how it will be justified whether collected data is necessary and minimum? We discuss two approach here that can provide a direction how technically data fiduciary can minimize the collection. The first approach is, analysis of what to collect using flow chart.

Figure 4: Data collection minimisation using flow chart

Minimisation using flow chart: If data fiduciary can decide what NOT to collect, then he can achieve a significant level of the goal of data collection. One model that can help here is flow-chart. Using this, data fiduciary can decide whether or not any information he should ask from users. For example, at very high level data fiduciary can create a flow chart of four kind of choices (as demonstrated in Figure 4). First, if data fiduciary finds that, “service can be provided without collecting any personal information then he must not collect anything”. We call it zero-collection. In such case, organization must disclose their privacy policy of zero collection. He can do this either by disclosing the policy directly to data principal or by prompting the message at their website. At practical level zero collection can be implemented by organizations who provides informational services, user awareness services or knowledge sharing services [59, 60].

Data fiduciary should obtain further information such as IP, cookies, session or browser information. These information are set for pseudonymous users (known through nick name over the internet). Any physical identifiable information should not collected at this stage. We call it pseudonym associated personal data (PA-PD). Consent and choice of preferences will still required before such collection. At next level, data fiduciary can go for the collection of personal identifiable personal data(PI-PD) and sensitive personal identifiable personal data(SPI-PD). PI-PD are like name, date of birth or mobile number. SPI-PD are like financial information, health data or biometric data. Data fiduciary should analyze thoroughly which one should collect from both.

Enrichment in data processing methodology: The second approach of minimum collection is, data fiduciary should change their existing data processing methodology. A few technical changes in the processing will not only full-fill the goal of data collection but also serve the same business purpose. We have justified our argument using two use cases. Both use cases conclude different observation. First use case argues, the requirement of technology change in the processing, while second use case argues, the necessity of collaboration among data processing parties. Since data fiduciary is collecting multiple sensitive personal information in both use cases. We have argued that neither it is minimum data collection nor it is providing data protection. Later, we have shown that the same objective (the goal of minimum data collection, and necessary data protection) can be achieved by just a few modification in their processing activities.

5.2.2 Use Case 1: storage of debit card/credit card information

Debit or credit card data is sensitive personal information and requires extra protection during processing. Commercial platform provides ease of doing facility wherein quick payment could be done by storing
user’s card details [61] at data fiduciary portal. The purpose is stated as: “It’s quicker. You can save the hassle of typing the complete card information every time you shop at Flipkart by saving your card details. Your card information is 100 percent safe with us. We use world class encryption technology while saving your card information on our highly secure systems” [61]. Fig. 5(X) shows the current model in which data fiduciary stores card’s information to facilitate quick transactions. The data is generally encrypted by data fiduciary’s key hence always available to him. Whenever user’s place an order, merchant sends a payment request. Payment request contains partial auto filled form having card information already filled. Thus, user’s does not need to submit card details manually. In the next step, user enters one time password(OTP) and submit it to the to the payment system. The advantage of such processing is user would get ease of doing and quick processing by not entering card information manually.

After introduction of bill, it is questionable whether such collection and storage is required? If yes, then in which form data fiduciary should store. Because, data fiduciary is non trustworthy, and weak protection of data may reveal card detailed publicly or card information can be used for malicious purposes. Data breaches over here may lead to severe harm which sometimes appears in the news when user’s card information becomes available over the the dark net. Hence such storage increases doubts on security and privacy of user’s data. Whether the same purpose quick transaction and ease of doing could be achieved by preserving privacy, protecting card details, ensuring limited data collection and the data minimization? To achieve this, each party involved in the processing should get necessary information only. Data fiduciary does not need to know the details of card. It should be visible to the bank only. As the specification of secure electronic transaction(SET) also [62] states, “order information(OI) information shall be processed by merchant and payment information(PI) by the bank”. Both section should be processed separately.

**Use of more advanced methods:** Cryptographic technique can help to achieve the above goal. For instance, figure 5(Y) ensures the privacy preserving minimum data collection, and also provides *ease of doing*. Data fiduciary collects card details as a cipher text $C = Encryption(card\_info)$ encrypted using customer’s key. The key may be anything such as user’s password. Since data fiduciary does not know key user’s key so it is useless at the merchant’s end and would be available at the bank’s end instantly. Whenever user places an order data fiduciary can send the request of payment along with order details and the cipher value $C$. User can decrypt card information and can forward payment request to the payment system. Since decryption is being done at user’s side data fiduciary would not able to know the card details. It will ensure the goal of data minimization, purpose limitation, collection limitation, storage limitation and sharing of information.

![Diagram](attachment:figure5.png)

**Figure 5:** An example of data collection: original vs modified method
1. **Purpose limitation**: In the first case, merchant stores debit/credit card information directly which is not safe. While in the second, storing encrypted card information, does not reveal any information, serve the propose of ease of doing and such details can not be used for other purposes. Hence, it achieves the purpose limitation.

2. **Collection limitation (data minimization)** Storage of multiple card details can reveal multiple information. In the second case, card information is not available to the data fiduciary which limits the amount of collected data.

3. **Storage limitation** By using encrypted storage, user does not need to worry about data retention period of sensitive personal information.

4. **Sharing of data** No meaningful information will revealed by sharing card details to the third party.

5. **Security and safeguard** Encrypted storage ensures security and safeguard of the data at fiduciary’s end.

Data protection bill encourage that data fiduciary should implement such kind of technology. It would enforce visibility of data at the right place only and, with appropriate security and safeguard. Uses of more cryptographic methods will enhance the confidence of data principal that he has control upon their data and it is safe. Such techniques would also provide transparency during processing, storage and sharing of data.

5.2.3 **Use case 2: Prevention of disclosure of sensitive personal information - a PAN card example**

What if one data fiduciary is enhancing their processing methodology while others are not? Sometimes it requires the participation and collaboration of all parties involved in processing to upgrade their techniques. Through the use case of PAN card we have shown that until and unless all the parties with whom data is being shared does not enhance their data processing methods the goal of data protection can not accomplished.

PAN card is a unique number assigned to all tax payer within India. Income tax department keeps track of individual’s tax declaration and their income. Is can also be used for identity proof. If any one does purchasing or availing a service of of more than specified amount he has to disclose the details of PAN card to the merchant. The authority can use these details to inspect individual’s tax declaration. It has been observed that details of PAN card collected by merchants can be used for malicious purposes such as to purchase benami properties, for identity theft [63], to perform fraud payment [64] or to hide income taxes. Consider one example of such PAN detail submission at the commercial websites as shown in figure 6. Merchant collects PAN details when user’s does purchase of more than specified limit. Merchant forward information of purchased details to the IT department. The IT authority may verify whether or not purchase details violets the regulation of tax disclosure. In the case of fraud/theft, an investigation may be started against suspicious user’s.

The existing model does not solve the intended goal (transparency in expenditure and declaration of taxes) of data collection. In this case multiple breaches are possible such as tracking of user’s behavior by merchant, or the use of card details for impersonation and identity theft. From authority point of view details shared by merchant are not trustful. Merchant can share inaccurate data or he can share false information submitted by the users. The authority expects more monitoring and transparency in the purchase activity. But, current model of PAN details submission neither solve the purpose of any party nor full fill the goals of collection. Further, even one party such as merchant enhance their methodology to full fill the goal of data collection still the purpose will not be solved until and unless other parties does not collaborate.

**Collective change in processing methodology** Figure 7 shows that if all parties collaborate and modify their data processing approach they will solve the above issues. In this case, instead of collecting PAN detail directly data fiduciary (merchant) ask user’s to logged their transaction (purchasing activities) $T$ at the IT portal if it is higher than specified amount. As shown in the figure both User and merchant can confirm logging of purchase details using appropriate authentication and verification. A comparison is shown in the Table 5. In the new model every party is getting only relevant details. Merchant is
not collecting any PAN details hence achieves the goal of limited data collection, storage. Merchant does need to share anything (limited data sharing). All the required purchase are being logged by the authority using suitable authentication hence IT department can achieve transparency and monitoring in the purchase. Moreover such transaction will also eliminate the possibility of impersonation and identity theft and tax fraud.

Thus, using cryptology, enhancement in processing techniques, modification in existing data processing methods, and participation of every organization can accomplish the goal of data collection.
| Property                          | Present method of PAN details processing | Modified method of PAN details processing |
|----------------------------------|-----------------------------------------|------------------------------------------|
| Limited data collection          | ✗                                       | ✓                                        |
| Limited data storage             | ✗                                       | ✓                                        |
| Limited data sharing             | ✗                                       | ✓                                        |
| Authentication of user’s          | ✗                                       | ✓                                        |
| Transparency in processing       | ✗                                       | ✓                                        |
| Privacy of personal data         | ✗                                       | ✓                                        |

Table 5: Comparison of existing vs modified model of PAN details processing

5.2.4 Technological limitations of data collection

But the challenging task is how will be decided that collected data by data fiduciary is minimum, justifiable, and having limited purpose. Regarding this a technical proof would be required for data collection. We summarize all such properties as follows:

1. How one will prove that data fiduciary is collecting limited data.
2. How one will prove that data fiduciary is not using data for other purpose.
3. How one can prove that data is used only for specified purpose (limited purpose).
4. If data is processed for additional purpose, how will be proved that consent is received from users.
5. If data is collected indirectly, how will be proved that he has informed to data principal.
6. Proof that he has conveyed to data principal regarding intimation of any cross border transfer of data.
7. How can be proved that data is being used for specified period.

As of now the exact solution of above problem is unknown. One solution could be, data fiduciary can make data collection process more transparent. For instance, he can publish necessary reasoning and explanation for such data collection on their website and can inform to data principal as well. These publishing can be audited by DPAI. Data fiduciary can also publish a certificate issued by DPAI. Certificate will work as a proof that data collection by data fiduciary is appropriate. On the other side, if any one finds maliciousness in data collection means, data collection is not as per the standard then he can do complain to data protection authority (DPAI). Authority may setup an independent analysis or audit for against such incident. The Auditor can analyze over all collection activity and the intention behind such collection. The authority can impose punishment if data fiduciary found culprit. But these methods are just like safeguard, not a full proof methods. A further research and more advanced methods are required to solve the above problems.

5.2.5 Data retention policy: storage limitation

Data fiduciary would require to store the data for the period as long as it is necessary (as per Article 9). If such period can not be determined at the time of collection then a periodic review could be conducted to estimate the retention period and a tentative duration can be provided to the data principal. The prime concern is, in the real world it is quite debatable and difficult to determine the period for which data will be stored. Presently organizations like Facebook, Google’s are storing data for longer period than it is necessary for analysis and monetizing purpose. The essential concern is what should be the criteria for the organization to determine a duration to retain the old data. For instance, Facebook has stored the data since the user is active [65] while Whatsapp [66] deletes the data from their server once it gets delivered.

Inherent constraints: ease data hiding how it would be proved that data is not being used after retention period over or data fiduciary has not kept another copy of data after the deletion [67].
Proof of storage [68] is one such cryptographic technique which can used to proof whether data fiduciary has retained personal data. With proof of storage integrity of remote file can be verified. Similarly, data fiduciary can implement erasure based proofs. Through it, one can verify that data is erased and re-written in the volatile memory. Data principal can request for proof of secure erasure (PoSE) [69] from data fiduciary to verify and validate data has been erased (re-written). However, these methods are not well formed and have their own inherited technical limitations. For instance, if data is copied at make hidden at another location then such proofs will not work. Even, it can not guarantee that data is not being used for further processing once retention period is over. From implementation perspective, a more practical methods need to develop to accomplish the goal of storage limitation.

5.3 Data Processing

Data processing consist of operations such as addition/deletion/alternation, analysis, sharing and storage performed over the data, to obtain, transform or classify the information. As per the framework, data processing shall be done after the consent and data must be protected throughout all the significant steps of the processing. Although, there are many sections in the bill regarding data processing, we have discussed only the three major sections from point of view of software implementation. These are, privacy and security safeguard (as per Article 24), privacy by design (as per Article 22) and transparency (as per Article 23). Security and safeguard is discussed in next Section and the other two, privacy by design and transparency have been discussed in the next subsections.

5.3.1 Cryptographic and other techniques for protected data processing

We describe the list of security and safeguard goals mentioned in the framework. For each goal, we have discussed the set of available techniques to implement it. There are numerous methods present in the literature that can provide a strong security and privacy of data. We have discussed below, some of the cryptographic techniques.

**Incorporation of encryption methods**: Article 24.1(a) of the framework says, *each data fiduciary needs to implement appropriate methods of encryption*. Encryption is a very old method which converts plain text into cipher text. It should be used as a primary tool at every significant step of data processing. There are two kinds of encryption: symmetric and asymmetric. AES, 3DES are examples of standard symmetric encryption schemes [35] and RSA, Diffie-Hellman key exchange are the example of asymmetric encryption schemes [70]. Encryption algorithms are theoretically proved to be secure and correct implementation can provide confidentiality, security and privacy of data.

Improper implementation of encryption mechanism may lead to data breaches. There are instances where breaches have been reported even when the data fiduciary claimed that they follow best encryption schemes and well defined practices for security of data. For example, Aadhaar, the biometric based unique identification system for citizens of India was subjected to data breach [43] due to poor implementation. Unauthorized access of data also resulted in data breach in [71, 72, 2].

To achieve more security and privacy, data fiduciary can use multiple kinds of encryption at different levels such as user data encryption, file-system encryption, database encryption or disk encryption. All these methods provide security when data is at rest. Based on the architecture of the system data fiduciary can decide which encryption technique would be appropriate. End to end encryption mechanisms such as SSL/TLS should be used for all data communication.

Correctness of implementation of encryption schemes can be verified independently by any third party audit team. Audit team can analyze which kind of encryption methods data fiduciary is using and how well it has been implemented. They can also provide necessary guidelines to the data fiduciary if they find that the used procedures are not sufficient to protect the data. The encryption algorithms, with appropriate parameters should be made public to improve the transparency.

**Client side encryption of cloud data**: The growth of cloud will be higher with the recent development of advanced technologies like "software as a service (SAAS) [73] and software defined network (SDN)" [74]. In future many data fiduciary will shift their adequate number of computation, services and storage at the cloud. For such mass storage, encryption of cloud data would be essential. But the main problem is most of the cloud service providers uses server-side encryption. In this, the key is owned and stored by service provider itself. Hence user’s data is completely accessible to the cloud servers. Breaches in such data may be harmful [75], even data can be shared and used for malicious intention [76, 75].
To address the above limitations, data fiduciary should encourage data principal to store encrypted data on the cloud. This can be achieved by using client-side encryption (CSE) schemes. These are cryptographic techniques that encrypts data at user’s end and transmit cipher text to the server. At commercial level such techniques are also known as “bring your own encryption(BYOE) or bring your own key(BYOK)”. BoxCyrypter and Cryptometer [77, 78] are example of two such application that implements client side encryption (BYOK) schemes. Data is believed to be secure because master key is managed by user’s itself.

**Encourage the use of integrity proofs:** With the enforcement of the law, all the data, messages and document used for processing would have legal accountability. Data fiduciary has to disclose a proof of: i) nature and category of data being collected from data principal (as per Article 7(b)) ii) source of personal data if it is not collected directly from data principal (as per Article 7(f)), iii) the list of third parties with whom personal data is shared and disclosed(as per Article 7(g)) and iv)data fiduciary has to take the necessary step to protect the integrity of personal data (as per section 24.1(b)). Many of the above points could be implemented by providing an integrity proof of origin of the data. This may include the proof of source of data, identity of the sender and properties of non-repudiation. Data fiduciary can prove legal accountability for the personal data using such proofs.

Integrity protection is an assurance of consistency and accuracy of data during entire life cycle of data processing. It ensures that data fiduciary is honest with respect to their process and any malicious changes in the data during storage, processing, sharing and disclosure will lead to loss its integrity. Therefore, a verification and validation of data is essential for integrity check. To do this, four kind of integrity validation could be done: i) message integrity (validation during transfer of data), ii) system integrity (validation of data storage), iii) assurance of no information leakage (during sharing and disclosure of data), and iv) data erasure integrity (proof of data deletion).

Integrity of message should be ensured during transfer of personal data. Regarding this, both the sender and receiver can implement cryptographic message integrity validation schemes with authenticated encryption(AE) [79] or standard message authentication code(MAC)[80] algorithms. These algorithms would ensure that the received data is in original form without any modification. To ensure integrity of data in physical storage, data fiduciary could use techniques such as integrity validation of data storage, redundant data storage and data storage at multiple geo-locations. Similarly, data fiduciary could also perform file system level or block level check-sum integrity verification. In such methods, an initial check-up is performed against the file system or blocks to validate the integrity.

Meaning of data deletion integrity is the honesty in the action of deletion. To prove this, data fiduciary can provide erasure based proof [69] which will verify the integrity of data deletion. Data fiduciary also needs to ensure the integrity of personal data when data is shared, disclosed with third parties. However, currently no standard methods exist to prove that data fiduciary maintains integrity while sharing and disclosure because data fiduciary can make redundant copy secretly and use it for malicious intentions.

**Authentication of users and services:** It describes how users identify himself to the system. Improper implementation of authentication method may lead to data and security breaches. Attackers can modify, disclose or destruct personal data or can perform other malicious functions. As per the bill, data fiduciary needs to take necessary actions to implement authentication, “to prevent misuse, unauthorized access to, modification, disclosure and destruction of personal data” (as per Article 24.1(c)). To implement the above, strong user authentication methods like two factor authentication [81], multi-factor authentication [82], continuous data authentication scheme [83] and time based authentication [84] can be used. Each kind of authentication method provides various degrees of certainty that right object is interacting with the system.

**Authorization and access control:** No one can access all: Apart from authentication, data fiduciary should implement correct authorization. Authorisation defines who can access what resources. Not everyone should have access of everything. Unauthorized access may also leads to modification, disclosure and destruction of data. Authorization can be implemented by creating access policy. Based on nature, scope and context of data, type of users, nature of processing data fiduciary can create conditional access or access control for various objects. Examples of possible conditions are OS, software version, browser, IP, geo-location etc. Access control is important because many attacks are launched by unauthorized users [71, 72, 43]. A well configured access control can prevent systems from data breaches and ensures security and safety of system. Based on design of the system, a set of specific access control methods can be used like, role based access control [85], access control list, policy based access control [86], capability based access control [87], attribute based access control [88], geo-location
based access control [89], geo-fencing and lattice based access control [90]. Data fiduciary must be able to that identify and authenticate users accessing the data, are legitimate and have access of personal data within constrained domain.

**De-identification and anonymization:** Access control brings restriction on resources of the system. However, personal data is still identifiable to those who have access. To provide further level of protection, data fiduciary can implement anonymization and de-identification techniques. In this method, when data is collected and processed, personal identifiable information is removed and replaced with some perturbed data so that data cannot be identified. Translation of identifiable data into de-identifiable form prevents user’s personal data from being disclosed. As per the framework, data fiduciary and data processor shall implement necessary methods such as anonymization and de-identification during data processing in order to implement appropriate security and safeguard in the system (as per Article 24.1(a)). Generally, data fiduciary should anonymize the data before processing, transferring or sharing of personal data to third party. Depending on the anonymity requirement, different methods can be used such as k-anonymity [91], l-diversity [92], t-closeness [93], differential privacy [42]. Similarly, other methods also exist like, tokenization, federation, hashing, binning, format preserving encryption [94], and format preserving hashing [95]. There is always a trade-off between amount of data shared and the method of anonymity that has been applied.

De-identification process is purely subjective. It completely depends on nature and context of data to decide which method should be used by data fiduciary in order to implement anonymization [10]. Another assumption is, it is believed that anonymized data are not really personal data and it can be sold, shared with third parties or freely used without any restriction. However, researchers has shown that in many cases anonymized data can be re-identified [96]. So, protection for both anonymous and unanonymized data are needed.

### 5.3.2 Existing limitations of data processing

The framework gives excessive power to the central government. For instance, any personal or sensitive personal data can be processed for the function of state or to compliance with law (as per Article 12-14). Similarly, to promote any policy of digital economy central government can direct data fiduciary to provide any personal data in anonymised form or any other non personal data to create policies or to promote better delivery of services (as per Article 91). Other limitation is, effectiveness of data processing highly depends on transparency in data sharing and disclosure agreement with third parties.

### 5.4 Privacy by Design

Earlier, maintaining privacy was the responsibility of data principal. Software development was focused on technologies behind which data principal could hide and protect their data. Applications had the aim to make data principal anonymous thus enforcing them to share limited data. TOR, Incognito web browsing, SafeWeb are some examples to achieve privacy and anonymity from data principal’s side. The primary assumption was that data fiduciary is malicious and can collect, share and misuse personal information without data owner’s knowledge. The Data protection framework scenario is completely different. Now the responsibility to protect the privacy of personal data is shifted to data fiduciary. According to the framework, each data fiduciary should design his system which provides strong privacy of user’s personal data and preserve rights of the users.

Privacy by design (PbD) means that the design of technologies and systems must protect the privacy of users inherently [18]. According to the data protection framework, each data fiduciary has to implement necessary policies and other activities to accomplish privacy by design (as per Article 22). As stated: “systems are designed in a manner that avoid harm to data principal, technology used in the processing ... in accordance with certified standard, legitimate business interest, and innovation ... achieved without compromising privacy, privacy protection throughout life cycle of personal data, transparent processing and interest of personal data shall be accounted”. From implementation perspective, the following will provide a direction to achieve this privacy goal.

1. Data fiduciary should set a privacy by design objective. He should prepare a privacy by design architecture of the system, so that it describes how privacy will be achieved throughout all the processes in the system. For this, a design documentation can be prepared and made available to
the public. It should be fully documented. Necessary and major points should be covered about how privacy of users is being preserved. Hiding the design always creates disbelief on data fiduciary [37]. Therefore, disclosing the privacy design document, so that the data principal, auditor and third party can verify privacy preservation and data protection techniques in the system.

2. Data fiduciary should implement data consent carefully. (Informed) Consent should include the purpose for collection of data, the entities with whom the data will be shared and how long the data will be stored. If the data is to be shared for other purposes, this should be clearly mentioned. To do this he can ask more choices, preferences and consent from users. Data fiduciary should implement opt-in methods and check boxes so that user can select and opt for more choices [32].

3. Data fiduciary should provide various technical proofs that data is well protected and privacy is being maintained over small to large scale data. Data principles and third party auditors can query the data fiduciary and verify that the privacy features are properly implemented as stated by the data fiduciary.

4. Data fiduciary should not collect, store, use, share, and process the data which are not required.

5. Data fiduciary should share and disclose the right data in the right form to the right entity. If data fiduciary shares data with third parties, it should use privacy enhancing technologies like anonymization or encryption.

6. Data fiduciary should maximize the use of encryption methods thoroughly for all processing of data. If processing can be done on encrypted data data fiduciary must do it using techniques like Searchable encryption, homomorphic encryption and secure multi party computation [39, 38, 37]. The data fiduciary should maximize collection, storage and transfer of data in encrypted form.

7. Data fiduciary should provide users more control on their data and allow data principals to query the present status of data. The data principals should be able to stop further processing of his data or request to delete his data.

8. Data fiduciary should provide an option of right to withdraw and tell users why they need it.

9. As per PDPB, each data fiduciary should assign a data protection officer(DPO) who will monitor over all privacy and data protection activity of the system and will work as point of contact (PoC) for other parties.

10. Data fiduciary should conduct privacy impact assessment (PIA) before design of the system is released. He should also conduct it on regular intervals. Such assessment can be done either by data fiduciary alone or together with data processor. Depending on the nature, scope, size, and kind of data processing, an independent third party may also assigned to perform privacy impact assessment before or during commencement of data processing. Data fiduciary should publish an impact assessment report.

11. Data fiduciary should inform user about process of data retention, data processing activity, data sharing, data transfer, data collection strategies and data deletion methods uses in the organization. He can disclose and prove that how he has implemented privacy of user’s data in significant steps. It will help to build the trust.

12. Data fiduciary can also obtain a certificate of the assessment of privacy by design activity from any third party audit team approved by DPAI. Disclose this certificate on the website for verification by the users.

5.4.1 Cryptographic and other methods to achieve the goals of privacy by design

Use of cryptographic methods can help to achieve a better level of privacy. We discuss below a set of cryptographic based approach that can be used to enforce privacy by design. Note that no method is complete. Each method can assure privacy up to a certain degree and have inherent limitations. Therefore, we have discussed scenario and use cases where such methods would be suitable. Subsequently, the benefit and limitation of each method is also provided. Efficient implementation of all these will not
only minimize data breach but also provide effective privacy by design based system. Though there are other methods to achieve privacy by design like anonymization using k-anonymity, l-diversity, differential privacy, we have not considered these in this paper. For a detailed discussion, one can refer to [98].

Encryption: is example of cryptographic techniques which provide both confidentiality and privacy to the data. Using encryption privacy of data can be preserved in both cases when data is at rest or in motion. Data fiduciary should encourage multiple kinds of encryption to gain higher privacy. However, the limitation of encryption is that the privacy of personal data can not be guaranteed after decryption of the data or data is available in plain text form. Computation on encrypted data impose communication and computation costs.

SMPC and Homomorphic Encryption: To achieve privacy further, advanced cryptographic methods could be implemented such as secure multiparty computation (SMPC) [37] and homomorphic encryption (HE) [38]. Both techniques provide computation over encrypted data. Consider the case of a hospital which regularly share their patient’s information with a research institute. Direct sharing of sensitive health data can be risky. Other parties may be able to find out various sensitive information which may result privacy breach. Privacy preserving aggregation and computation (of summary statistics) of patient’s data could be implemented using homomorphic encryption [99]. To enable data sharing without affecting the privacy, both hospital and research institute can implement secure multi-party computation. In SMPC, a set of parties can compute the result function without revealing their data. Therefore, both hospital and research institute can compute a joint function through SMPC service upon the health data rather than sharing data directly. Using such methods, data fiduciary/data users can perform computation on the encrypted data without access of individual’s data or secret keys. The resulting computation is also encrypted. The benefit of this can be applied in the area of sensitive personal data, cloud environment, health data, biometric data or remote computation.

Privacy of Cloud data: Client-side encryption provides stronger privacy to the users data because key is managed by the user itself. Sending encrypted data allow users to have “full control on their data”. However, client-side encryption has limitation that it is useful exclusively when the data is stored on the cloud and synchronized with the local storage.

Privacy preserving search and query processing: Suppose, if a data owner wants to reduce the burden of local storage and keep all data to the cloud. Privacy achieved through client side encryption techniques is not sufficient here because such storage does not allow any meaningful operation like search and query on the data until and unless the completed data is downloaded and decrypted. This operation is computationally expensive and highly inefficient. Cryptographic techniques such as searchable encryption [39] and private information retrieval [100] can be implemented which enable users to perform query on the stored encrypted data.

Provide both confidentiality and anonymity: There are cryptographic methods which can achieve further level of privacy such as assurance of both the anonymity of the user as well as the confidentiality of stored data at cloud. It is useful in the scenario where data principal wants to hide his identity too. For instance, in medical data exchange program detail of patients(for e. g. HIV patients) needs to preserve the privacy as well as patients would not like to get inferred anything from their identity. Therefore anonymity is required along with privacy of user’s data. One such method is anonymous and confidential encrypted cloud storage which has proposed in [101]. This method protects the identity of user by making data principal anonymous while maintaining the confidentiality of the data.

Zero knowledge proofs: More advanced cryptographic method such as zero knowledge proof (ZKP) can be used to achieve further level of privacy. Consider the scenario where user wants to get a service without revealing its secret and proving that he posses the secret information. Zero knowledge proofs are useful in such cases. Using this, any user can prove their honest and ethical behavior while maintaining the privacy of his secret information. In data protection framework one example is children age verification (as per Article 16) where it can be used. Any child can prove his right age in order to get a service without revealing the exact age or date of birth. On the other side, data fiduciary can use it to verify the fact that child has valid age the knowledge real data of birth is not necessary.

Blockchain technology: Another way to achieve privacy of personal data is through integration of blockchain technologies. It is a good alternative for privacy preserving data sharing, data exchange and data market place. Since the inherent property of blockchain is decentralization, privacy and transparency both data principal and data fiduciary can implement it to achieve privacy by design. For instance, consider a user who wants to find a match on an online dating service without revealing the criteria of finding partner to anyone (not even to third party who stores the data set). The third party will return the
output to the user after obliviously searching in its data set. This can be achieved using the combination of searchable encryption technique and blockchain technology that allows a party to perform oblivious match on the data without revealing the input [102]. Another example is zero knowledge contingent payment (ZKCP) protocol that allow fair exchange of goods and payment without any third party [103].

Privacy of data is completely subjective. It depends on nature and context of the user’s at which extent he wants to achieve the privacy. Data fiduciary can analyze the nature and the scope of processing, severity of harm and can implement different technologies to facilitate suitable privacy to the user’s personal data. Such implementation also depends upon where and how much data has been disclosed.

5.5 Transparency

Transparency can be achieved through openness and accountability. Article 23 of data protection framework states: “the data fiduciary shall take reasonable step to maintain transparency...”. To achieve it, data fiduciary may avail various kind of information easily accessible like “category of personal data collected, purpose of collection, the existence of procedure.. for data principal rights.., platform to lodge complaints, information regarding cross border transfer.., or any other information”.

A transparent system builds more trust among users. To gain more confidence of users, data fiduciary should keep more transparency in their process. To achieve this, he can disclose multiple number of verification, validation and check points to data principal. The check marks could be their processing activity, design of system, the way security of data is being implemented, system security architecture, or the way privacy is being preserved within or outside the system. A trade off always exists between privacy and transparency. It is a fact that more number of disclosed parameter leads to the reduction of security and privacy but on the other side openness is also needed to achieve the transparency at a greater extent. Therefore, it is purely subjective to data fiduciary how he can establish coordination between both and builds trust among users.

We discuss set of properties that could be made available to the users to make processing more transparent. These points provides a direction how data fiduciary can achieve transparency as per the framework.

– Disclose high level security design of system. Almost every organization claims that it uses best practices to secure the system still breaches are happening. To gain trust of people it is required to disclose security design of system so that the users can ensure and verify that the personal data is being secured. For instance consider the usages of electronic voting machine (EVM) [104]. Govt of India demonstrate its security feature periodically and confirm that it is fully secured. Still, people suspect the security of EVM and always challenge that it can be tampered [97]. Disclosure of security design by data fiduciary can provide more transparency. Making design public will build more trust on the system as user can validate its security parameters against various attacks.

– Disclose list of parties with whom data fiduciary is sharing personal data. This list will help users to track their data. It is required because list of third parties are completely black box till now. Currently, policy of most of the server does not disclose the list of parties with whom data is being shared.

– Disclose whether data fiduciary implements any encryption methods. Also, disclose the kind of encryption and different level of encryption methods have used.

– Disclose whether data fiduciary implements any access control techniques. Who has access of what? For instance data fiduciary can announce that system provides geo-location based access control.

– Data fiduciary should make advertisement process more transparent with respect to user.

– Disclose to data principal why data fiduciary is collecting data. List of category of personal data and the procedure using which data is being collected.

– Inform user’s what are their rights and how they can achieve it. Implement web pages easily accessible to lodge complaints for right to access, right to delete etc.

– Data fiduciary can disclosed the contract using which data is shared with third parties. Security and safeguard of such data should be bound by such contract.
- Disclose if there is any cross-border transfer of data. If yes, disclose whether explicit consent is taken or not.
- Disclose whether system implements anonymization and de-identification technique.
- Disclose the security standard data fiduciary follows. Data fiduciary may disclose the architecture of their security within an organization. It may help data personal to understand security while sharing his data. For example, Dropbox provides high level security description [105] of storage of data on the cloud.
- Disclose trust level of your organization. It can be done be getting certificate from protection authority.
- Disclose rating of the organization publicly obtained from the authority.
- Data fiduciary shall notify the data principal of important operation in the processing of personal data. Data fiduciary can announce how frequently audit/checks is performed in order to ensure privacy and security safeguard.
- Disclose how code of conduct is followed with in organisation.
- Disclose the audit procedure. Nature and scope of audit can me made available. Disclose how many kind of audit the system implements.
- Disclose data collection method used by data fiduciary.
- Disclose data retention and deletion period. Disclose data deletion method used and proofs of honest in the deletion.
- Disclose Privacy be design method. What are the operations used by data fiduciary to achieve the privacy.
- If data fiduciary is providing storage services then data fiduciary can disclose about proof of storage, proof of space, proof of location, proof of possession of data, proof of retrievability methods.
- Data fiduciary can disclose Data Breach Mitigation Plan (DBMP). It can also disclose how much transparently breach notification system is established with the authority.
- Disclose whether system has CISO, security handling team, data protection officer, and impact assessment team. It will help to report data breach, to resolve query and other incidents of data protection.
- Disclose whether system implements more advanced method of security and privacy such as data loss prevention (DLP) [106] methods, insider threat detection and prevention (ITDP) [107] or security operation center (SOC) [108].

5.6 Data protection audit, rating and data protection impact assessment

Data processing will be scrutinize by an auditor. The purpose of audit is to verify that system achieves the intended goal of the data protection. Auditor is an independent third party registered with authority who may conduct the audit. As per Article 29, “data fiduciary shall perform, data audit annually,..., the audit will evaluate, effectiveness of consent, privacy, transparency, safeguard and any other kind of audit which may be specified”.

5.6.1 Challenges in data audit and rating

Defining audit procedure in the context of data protection framework is highly important because “it will help to verify the proof and correctness of many features such as data collection, data consents, data storage and data deletion.”. To keep higher transparency, the audit should minimize manual auditing method and should encourage automation. As per the framework, it is the responsibility of data protection authority to specify the parameter and procedure for data protection audit. However, currently no such specification exists. Therefore, we first point out the list of challenges that needs to be considered for the specification and implementation of data audit procedure.
– How audit should be conducted and what will be the procedure, parameter and set of criteria to design audit and empanelment process.
– How the audit conducting authority will implement the procedure of rating?
– How to verify that the rating disclosed by an organization is correct and generated from verified auditor?
– What are the period when audit can be conducted such as six month, yearly etc.
– What are the techniques using that audit can be automated with minimum manual interference?
– In some cases auditor may be malicious and he can submit false report. How transparency in the audit can enforced when the auditor is malicious?
– Should data fiduciary also provide any procedure of audit to data principal?

Currently standards for security audit already exists [109]. These standards primarily assess information security risks [110] and, the auditor generally conducts vulnerability assessment, penetration testing, review of used security standards and verification of access control policy. However, there is no standards for data protection audit. One way to design audit standards is by modifying the standards of security audit. The resultant broader framework would contain all the steps of security audit as well as many additional steps of data protection audit. It can be called as data protection audit framework (DPAF). It should contain parameters, standard operating procedure and techniques for audit. It will be a procedural guideline by which auditor can perform verification and validation. We now describe what kind of proofs authority can includes in DPAF.

5.6.2 Design of Data protection audit framework (DPAF)

DPAF should define the technical specification, form, manner, and standard operating procedure clearly through which the audit will conducted. Many of the audit procedure will require advanced technical implementation. We suggest the following proofs and validation as an example which can be included in the data protection audit framework (DPAF). These are not final, many other properties can be explored, formalized and included in the DPAF.

The auditor can ask consent management proofs: Auditor should check how data fiduciary establishes consent with data principal. How consent are updated and managed? He can also review the list of information data fiduciary disclose for the consent establishment. Next, he can also investigate what are the additional information data fiduciary is adding along with consent. This could be a list of third parties or data processors with whom personal data being shared, disclosure of data retention period, cookies policy or information about any cross border transfer. Further, it could be also checked how the consent manager is being implemented.

The auditor can verify compliance of PDPB law: The Auditor should verify whether the design of the system is compliance with PDPB law?. Means whether data fiduciary follow purpose limitation, collection limitation, quality control, accountability or other conditions of processing. The auditor can verify whether they are doing any cross transfer of data or not. For instance, the auditor can ask geo-locations proof of the data.

An assessment can be done to examine the data retention policy. The auditor can verify how long data is being stored. Does data principal get any notification about the retention period of data? Whether data fiduciary does any periodical review of retention or not? Data auditor can ask whether any cryptographic proof for retention of data such as proof of storage or proof of retrievability is used? Data fiduciary can also give the proof of concept of how right of erasure request is handled when it is raised by data principal. On the other side, data auditor can check whether data fiduciary implements any proof of erasure technique to prove the deletion. Subsequently, it may also verified, what are the data storage location, storage back up plan of personal data. Further level of check can be done to confirm that how data is being erased from multiple geo-locations.

The auditor can ask proof of X: It can be the list of proofs of various techniques that data fiduciary has implemented to protect data processing. It may include proof of concept such as proof of storage [68] whether the remote server has indeed storage as claimed by data fiduciary, proof of space [111] in order to check that stored data has not been modified and changed. Similarly, auditor can check
whether data fiduciary provides proof of location to ensure what is the list of all locations where personal data reside, proof of possession to verify data fiduciary indeed holds user’s personal data. Further, the auditor can also verify proof of retrievability to know whether stored data can be retrieved or not or proof of geo-location to check is there any cross border transfer of data. It may be possible that all proof may or may not be implemented. But the goal of data fiduciary should be to maximize the number of proofs in order to review of transparency of the system.

Data fiduciary who is processing children data, the auditor can verify what are the age verification mechanism being used, how parental consent is established. If the data fiduciary is guardian data fiduciary, auditor can confirm whether data fiduciary does any profiling, behavior analysis, target based advertsing or other acts which can harm to the children.

The auditor can verify security safeguard methods: An evaluation can be done to verify that what are the security and safeguards implemented within the system. What are the encryption techniques data fiduciary is using, how many layers of encryption has done, list of authentication, set of authorization techniques data fiduciary uses to protect the data? Whether the system implements any de-identification and anonymization method. What are the access control policy of the data fiduciary? Similarly, auditor can verify methods used to implement privacy by design and transparency.

The auditor can verify data distribution procedure: Further level of verification can be done regarding the mechanism used for distribution and selling of data. To verify this sell and purchase agreement can be demanded. Auditing team can also request information regarding how data fiduciary handle data breach. What are the mitigation plan available in the system to prevent and minimize data breach and the data loss. Additionally, it can be verified that how data fiduciary communicates data breach and other things to the authority. Subsequently, a list can be obtained regarding last few breaches happened in the system (if any) and the steps that have been followed to remove them.

Data fiduciary should also conduct audit periodically by itself to verify the correctness of processing internally. This kind of audit is called as data protection impact assessment. In such assessment he can follow the role reversing method. For this, data fiduciary can consider himself as data principal and audit the system from his perspective. All data protection requirement from the view of data principal can be listed and examined by applying all the procedure of data audit. Using this, data fiduciary can understand the complete security and privacy design of the system.

All the above use cases will help to build the data protection audit framework. A proper design can be done for each points and a strategy can be developed how it will be implemented technically at the ground level. Against each checkpoints a weighted score can be assigned. Based on overall score a rating can be generated and a certificate can be provided to the data fiduciary. Data fiduciary can publish this certificate on his website for user awareness.

5.6.3 Cryptographic techniques for data protection audit framework (DPAF)

The audit should minimize human intervention. More manual intervention may lead to prejudice in the audit procedure. For instance, the goal of audit can not accomplished if few parties are malicious. We discuss here how cryptography techniques can provide consensus in data audit even if few parties are malicious. We discuss here two such methods.

Audit can reveal sensitive information to the auditor. If the auditor is not honest then such data can be used maliciously. Therefore, audit should performed on personal data without influencing the privacy. Privacy preserving data audit [56, 112] is the example of such techniques which allow an independent third party auditor (TPA) to perform the audit on the stored data at remote server without affecting privacy.

Further, the above model has limitation that it assumes data owner and the third party are honest and data fiduciary could be malicious [56]. There are blockchain based privacy preserving data audit [113, 55] models present in the literature which can implement data auditing even if all the parties (data owner, data fiduciary and auditor) are malicious. In such settings, blockchain helps to provide consensus in the audit.

The ultimate goal of the audit is to evaluate overall system activities and make an assurance that data processing is up to the standard of data protection framework. The auditor can provide a rating or trust score to data fiduciary. This certificate will show how much processing is compliance with data protection framework.
5.7 Assurance of users rights

Data principal has right to access, right to correction, right to erasure and right to forgotten of their personal data as per Article 17, 18 and 20 respectively. Data principal can ask in a plain text form the set of collected data, the list of data generated from processing and methodology used for processing of personal data. Data fiduciary has to provide a method using which correction and update in personal data can be recorded as per the request of data principal. User’s have right to prevent data fiduciary from further processing of personal data as well as disclosure of data to third parties.

In the real world, rights of access as well right of correction can be provided to the users easily. For this data fiduciary can display a web portal where data principal can request necessary update and correction. The bigger challenge may arise at the time of dispute between both parties. For instance, data principal finds that correction has not recorded, or processing is being done as per the old data even after correction has been updated. Data fiduciary has to provide a proof that data has accessed, or a proof that correction has recorded and processing is being done on updated personal data. To prove all these, a record manager such as Blockchain [52] can be used that can record and prove what data has accessed, corrected and updated. The implemented method should also able resolve the dispute.

Proof of deletion and immutability of data: Data principal has right to erase and right to forgotten. In the first case user can do the request to delete their personal data while in second case user can prevent data fiduciary from further processing and disclosure of data to the third parties. In the real world it is difficult to prove honesty of data fiduciary in both right to erasure and right to forgotten. It is hard to prevent data fiduciary from further processing and disclosure as well as it is also challenging to verify that data is really erased due to various technical limitations [27]. Further data processing community has no consensus on deletion of data. As in [15], author has discussed about the efficacy of right to forgotten tenet of GDPR. They mentioned that right to forgotten is effective thing, but business model of many organization like Facebook rely on user’s data only. Request of deletion of personal data may affect the existence of their business model. Similarly, personal data is also processed by blockchain [55, 12]. Due to immutable property of data in blockchain it would not be possible to delete the data stored in the chain. By considering the efficacy of deletion of data in GDPR, [14] has discussed about this immutability problem and mentioned challenges and possible solution to delete the data from blockchain. Overall deletion of data in the real world is still challenging task.

5.8 Data breaches

Data breaches are the incident due to disclosure of personal data intentionally/unintentionally. In the framework it is stated as “any unauthorised, accidental disclosure, acquisition, sharing, use, alteration, destruction,...that compromise confidentiality, integrity or availability of personal data to data principal” is known as data breach. “Any data breach shall be notify to the data protection authority” (as per Article 25 ). It is essential to report the data breach to the authority. Depends on the sensitivity of the data, authority may decide whether breach should be reported to the data principal or not.

Necessity of transparency: Data breach of an organization can be reported either internally or externally. Therefore, the essential technical problem is, how transparency can maintain during the reporting of the breach? If external entity reports the breach it would come under the observation of data protection authority immediately. But if the data breach is identified internally then transparency in the reporting would entirely depend on the honesty of data fiduciary. It may possible that data fiduciary can hide it and does notify to the authority. In such cases, the consequences can not be determined. This can be seen in the recent data breaches also where organization has not accepted any loss of personal data even after reporting of the breach [49]. The other reason why transparency is necessary because sometimes organization accept about the breach but they strongly deny the loss of any personal data [114]. However, no technical solution exist that can ensure transparency in the reporting of the data breach. From legal perspective, a penalty is specified in the framework which can be imposed if the authority finds a data breach incident concealed by data fiduciary.

Unfairness in the reporting: Reporting of the data breach is not fair. PDPB makes reporting very restrictive by isolating data principal from breach notification. Personal data belongs to data principal, therefore, data breach should be also reported to the data principal along with DPAL. Further, if data breach has the impact of high risk authority may direct data fiduciary to inform about breaches to the data principal. During such reporting, he has to provide guidelines about what remedial actions have
been performed to mitigate the risk. Presently, the definition and the criteria of high risk is not specified in the bill. DPAI should publish a definition of the type and nature of the risk which can be considered as high risk.

**Implementation:** From implementation perspective detection and validation of data breach can be done through data protection audit and data protection impact assessment of the system. A third party independent audit team can also be assigned for the quest of data breach. The team can proactively observe the presence of breach (if any). To do this, the audit team can examine and verify the sensitive operations such as modification, disclosure, manipulation or deletion of the personal data. Other verification such as access control or authentication can be also checked. Data fiduciary can also implement more advanced incident handling procedure such as threat hunting[115] which can look continuously for the presence of threats that could create a data breach. Further, data loss prevention[106] can be implemented to prevent data loss from vulnerabilities. Many times data breaches happen due to insider threats[116]. To prevent this, data fiduciary can execute insider threat analysis program in their system periodically or could implement insider threat management plan[107].

5.9 Processing of sensitive personal data and critical personal data

Data fiduciary has to inform to the data principal if there is any cross border transfer of personal data. He can inform him at the time of consent establishment. For sensitive personal data then restriction becomes more stronger. Sensitive personal data can transferred out side India if authority approve such transfer (as per Article 33). Approval is to be determined on the grounds of type and nature of sensitive personal data, international relation with other country or any other condition as specified. Additionally, data fiduciary has to maintain a local copy of sensitive personal data within India.

Further, data protection framework restrict that critical personal data can be stored and processed within India only. Any data fiduciary who is providing service to Indian customer requires to install their gateway and application services located within Indian territory. Storage of a local copy personal data within India will increase hardware and software cost as well as the man power. Ultimately it will increase overall management cost of the system.

**Why localization is necessary:** It is still controversial why PDPB has such restriction? As per our point view the main reason might be that India government wants to hold more control on how data should flow across the border. Here with following reasoning we argue that such restriction have been kept purposefully.

- To achieve accessibility of the data to pursue the law. For instance, to maintain the law state may require data from an organization who provide service to the Indian customer. But, if the storage is located out side the border it can be denied as per the privacy policy of foreign country or the data sharing agreement between both country. Localization of data will help to access these data easily in order to pursue the law.

- Indian government is more concern about the geo-location availability of the data in addition with protection of sensitive personal data and critical personal data.

- To conduct data audit easily for protection of the data. Authority can do the data protection audit freely and to ensure safety of data.

- It will ensure the availability of data to analyse data breach from recent attacks. Ease of access and the availability would also assure that data can be used for other purposes such as statistical analysis, research, innovation and policy making.

- Government’s data are highly critical. A strong security protection is required while processing. Availability of this data to other country might have significant risks. For instance, to implement cloud services for data processing it is a debatable point whether storage of cloud should be with in India and government should follow the policy of localization of data or not? These data are sensitive and cross border transfer could be harmful. [117].

From implementation point of view, if local copy of sensitive personal data is stored within India then a proof will be required to prove the geo location of data. Also, data fiduciary has to prove that local copy of India is complete, accurate and updated.
5.10 Processing of children data

It is a common belief that children are easy target over the internet. Therefore, PDPB restricts that children data will be processed with higher protection and data fiduciary has to preserve the rights of children. To accomplish this, each data fiduciary has to implement an age verification mechanism in order to verify the age of the children. Further, data fiduciary should incorporate parental consent mechanism to acknowledge for parent consent (as per Article 16). Additionally, the authority will publish the list of websites who are engaged in the processing of children data. Data fiduciary has to disclose the nature (such as providing counselling and child protection services) and the volume data being processed. Based on it, DPAI will announce some data fiduciary as guardian data fiduciary. They will be "barred from profiling, tracking, behavior analysis and target based advertisement".

Age verification: From technological implementation perspective the data fiduciary has to implement a system for the verification of children’s age. In literature few work exists regarding it, such as an online anonymous age verification system has been proposed in [118]. Any individual can obtain an universal age identification number(UAID) from a legal authority. This number can be used to verify their age on the website to get controlled access. Similarly, other techniques such as anonymous credential [119], zero knowledge proof based verification [36] can be useful to prove the age.

Parental consent: Internet is a powerful platform for the children to get education, gaming, sports and the entertainment. While on the opposite side they are big opportunity for online market. Children can be easily targeted and can be the victim of privacy breach, harassment, and disclosure of sensitive personal information. To prevent this, monitoring and notification of children activity to the parent can provide an appropriate safeguard to the children. Practically, many parental control methods exist which enable guardians to control children online behavior [120]. Use of such regulation enable children to accomplish the effective use of internet and prevent them being a victim online market [121].

Challenges: The major challenge is to categorize the list of service providers who is processing children data. Next, how such list will be periodically updated? The another challenge is, how will be verified and validate that profiling, tracking, behavior analysis and target based advertising is not being done by the restricted data fiduciary?

6 Major Challenges and Limitations of PDPB

The data protection framework is a major step towards the protection of individual’s data. However, it is still not clear how adequately it will achieve its objective. This uncertainty arises due to both the inherent limitation of data protection bill and the constraints of practical implementation. Here we discuss some limitations and challenges present in the framework which needs to be taken care:

Disclosure to the government: This bill provides excessive power to the government for processing of personal and sensitive personal data. Boundary of privacy is not defined when state processes the data. Government can ask any personal data for the functioning of state, during emergency, for the security of the state, for the purpose of prevention, detection, investigation or prosecution of any offence, or for any other contravention of the law (as per Section 12). Further, to promote any policy of digital economy, the government can direct data fiduciary to provide any personal data in anonymised form or any other non personal data to create policies or to promote better delivery of services (as per Article 91). Request for such kind of data is controversial and gives unlimited power to the government.

Cloudiness in definition: Data protection framework will create a regulatory body known as data protection authority of India (DPAI). It has an independent regulatory power to monitor the data protection activity. It has control to update and approve various definitions, capability to provide notification and direction to the data fiduciary. Further, it has rights of call to information, rights of search and seize, rights to conduct the enquiry and has power to coordinate with other regulatory authorities. PDPB has many undefined terms that will be defined by DPAI in the future. For instance, definition of critical personal data, list of guardian data fiduciary or social media data fiduciary has to be specified. Similarly, the boundary between personal data, critical personal data and sensitive personal data is not yet defined. Further, a certain category of biometric data will be prohibited from processing (as per Article 92). The name of such specific category is not yet defined but later it will be notified by the DPAI. Subsequently, any breach in the personal data shall be reported only to DPAI. In the case of high risk, it can be reported to the data principal. As of now, definition of high risk is not mentioned.
Further, the exact motive behind the localization of at least one copy of sensitive personal data and complete localization of critical personal data is still not clear. It may be either for maintaining control on the data or to ensure availability of data. If it is regarding availability then many other technical standards also exist which can provide stronger availability than maintaining a local copy of data.

Requirement of fairness: Verification of distribution and reselling of data will be very challenging in the era of data market where every one wants to sell data. The other challenge is how transparency will ensured in certificate, rating and trust level generation? It is not clear how framework will coordinate with data protection regulation and law of other countries? For instance, PDPB asks to assign a local representative if company does not have an establishment in India, but providing service in India. However, it is not clear how the incidents will be handled if data policy of one country overrides the others?

7 Conclusion

After the introduction of PDPB, the major challenge will be to translate legal tennets into technological implementation using existing technologies. In this paper, we have discussed the Indian data protection framework (PDPB) in details from technical perspective. The high-level idea for implementation of each major obligation has been presented. The various features like data consent, data collection, data processing, privacy by design and data audit has been explained thoroughly. A set of cryptographic and non-cryptographic solutions along with various examples and use cases have been also been provided. This high-level idea of methods for legal tennets can motivate developers to use it for the development and building the real world system as per the PDPB standard. Along with technical implementation, we have also discussed existing challenges and limitations that will require to solve to make data protection framework more strong. Overall, this work will provide a direction to the software developers, system designers, organisation, and data fiduciary to design their system as per PDPB by developing and implementing PDPB standard based technology at a different levels. This paper will also work as a guideline for other regulatory authorities to change and set set their activities as per the new standards. In future work, more advanced methods can be developed to solve the existing limitations. A new set of techniques will be explored for more effective implementation of major tennets like data consent, privacy by design and data collection.

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