

# The Architecture of Trust: An In-Depth Analysis of India's Unified Payments Interface (UPI)

## Section 1: Introduction to the UPI Revolution

### 1.1 Defining UPI: More Than Just a Payment System

The Unified Payments Interface (UPI) is an Indian instant, real-time payment system developed by the National Payments Corporation of India (NPCI).<sup>1</sup> Launched in 2016, it represents a paradigm shift in digital finance, functioning not as a monolithic application or a digital wallet, but as a foundational protocol that facilitates seamless inter-bank transactions. At its core, UPI is a system that powers multiple bank accounts into a single mobile application, regardless of the participating bank, merging a variety of banking features, fund routing, and merchant payment capabilities into one cohesive framework.<sup>2</sup> It enables both peer-to-peer (P2P) and person-to-merchant (P2M) transactions, operating 24/7 on mobile devices to instantly transfer funds between any two bank accounts.<sup>1</sup>

To understand UPI is to understand its architecture as a public good. It runs as an open-source Application Programming Interface (API) on top of the pre-existing Immediate Payment Service (IMPS) and is regulated by India's central bank, the Reserve Bank of India (RBI).<sup>3</sup> This design as an open, technology-agnostic set of "rails" is a deliberate choice that fostered a competitive and innovative ecosystem.<sup>5</sup> Unlike closed-loop systems, UPI allows any licensed entity—be it a traditional bank, a global technology giant, or a nimble fintech startup—to build applications that can communicate with each other seamlessly. This fundamental design philosophy is what distinguishes UPI from most other digital payment systems globally and is the primary catalyst for its unprecedented success.<sup>6</sup>

## 1.2 The Genesis: NPCI, RBI, and the Vision for a Cashless India

The creation of UPI was not an isolated technological development but the capstone of a deliberate, multi-year national strategy aimed at modernizing India's financial infrastructure. The pilot launch was conducted on April 11, 2016, with an initial cohort of 21 member banks, inaugurated by the then-Governor of the RBI, Dr. Raghuram G. Rajan.<sup>2</sup> This launch was the culmination of a vision held by the RBI and executed by the NPCI, a non-profit entity established by the RBI and the Indian Banks' Association to operate retail payment and settlement systems in India.

UPI's success was made possible by the foundational pillars of India's Digital Public Infrastructure (DPI) that were already in place. The first pillar was Aadhaar, a biometric identity system that provided a unique, verifiable digital identity to over a billion Indians. The second was the Pradhan Mantri Jan Dhan Yojana (PMJDY), a massive financial inclusion program that ensured hundreds of millions of citizens had access to a basic bank account. The third was the proliferation of low-cost mobile data and smartphones, which provided the necessary connectivity and hardware.<sup>7</sup> UPI was strategically designed to be the transactional layer built upon this trinity of identity, bank accounts, and connectivity. The role of NPCI as a non-profit operator was critical, as it allowed the system to be developed with a focus on public benefit and national economic goals—such as financial inclusion and the formalization of the economy—rather than on generating profit, a key factor that enabled its revolutionary zero-fee model for users.<sup>6</sup>

## 1.3 Key Characteristics: Instant, Interoperable, and Inclusive

The transformative power of UPI can be attributed to three core characteristics that are embedded in its design: it is instant, interoperable, and inclusive.

First, all UPI transactions are **instantaneous**. Funds are transferred in real-time, 24 hours a day, 7 days a week, including all public and bank holidays.<sup>5</sup> This real-time nature of settlement, which leverages the underlying IMPS rails, builds immense trust and confidence among users, as both the sender and receiver get immediate confirmation of the fund transfer. This stands in stark contrast to older digital payment systems that often involved delays.

Second, the system is fundamentally **interoperable**. This is perhaps its most revolutionary feature. A user of any UPI-enabled application can transact with a user of any other

UPI-enabled application, regardless of which bank either party uses.<sup>5</sup> This open network approach dismantled the "walled gardens" of the pre-UPI era, where users of one digital wallet could not easily transact with users of another. This forced competition among service providers based on user experience, features, and security, rather than on network lock-in, giving users ultimate freedom of choice.<sup>7</sup>

Third, UPI was designed to be profoundly **inclusive**. By simplifying the payment process, reducing costs to zero for users, and building on the widespread availability of bank accounts, it has become a powerful instrument of financial inclusion.<sup>6</sup> It has empowered individuals and small businesses, from street vendors in Delhi to farmers in rural Madhya Pradesh, to participate in the digital economy, reducing their dependence on cash and middlemen.<sup>7</sup> This focus on bringing millions into the formal financial system has been a demonstrable success and a key objective of the platform since its inception.<sup>6</sup>

## Section 2: Onboarding the Digital Economy: A User's Guide to UPI

The onboarding process for UPI is a masterclass in balancing a simplified user experience with robust, multi-layered security. It intelligently leverages existing, trusted elements of the banking and telecom ecosystems to bootstrap a new, secure digital identity for the user. This section provides a practical, step-by-step walkthrough of the entire user registration journey.

### 2.1 Prerequisites: The Foundational Requirements

Before a user can begin their UPI journey, four foundational prerequisites must be met. These are non-negotiable and form the bedrock of the system's identity verification and security model.

1. **An Active Bank Account:** The user must have an operative savings or current account with a bank that is part of the UPI network. UPI is a system for inter-bank transfers, so a bank account is the fundamental source and destination of funds.<sup>9</sup>
2. **A Linked Mobile Number:** The user's mobile number must be officially registered with their bank account. This linkage is the cornerstone of identity verification in the UPI ecosystem, as the system uses this number to identify and authenticate the user.<sup>14</sup>
3. **A Smartphone with Internet Access:** To use UPI, one must download and install a UPI-enabled application on a smartphone. The device requires an active internet

connection (mobile data or Wi-Fi) to perform transactions and communicate with the banking network.<sup>9</sup>

4. **A Debit Card:** For the initial registration and setup of the secure UPI PIN, the user will need the physical debit card associated with their bank account. The card's details are used for a one-time authentication with the bank's systems.<sup>14</sup>

## 2.2 Step-by-Step Registration: From App Download to First Use

The entire registration process is designed to be completed in a matter of minutes, guiding the user through a secure and intuitive flow.<sup>16</sup>

1. **Download a UPI-Enabled Application:** The user begins by downloading a UPI app of their choice from the Google Play Store or Apple App Store. The ecosystem offers a wide variety of options, including NPCI's own BHIM app, apps from third-party providers like Google Pay, PhonePe, and Paytm, or the mobile banking apps of most major banks.<sup>14</sup>
2. **Mobile Number Verification and Device Binding:** Upon opening the app for the first time, the user is prompted to grant permission to manage phone calls and SMS messages. The app then asks the user to select the SIM card corresponding to the mobile number registered with their bank. It initiates a silent, automated SMS from the device to a verification number. The telecom network and the bank's servers validate this SMS, confirming that the user is in possession of the correct SIM card. This critical step securely binds the UPI profile to that specific device.<sup>14</sup>
3. **Linking the Bank Account:** Once the mobile number is verified, the user is presented with a list of UPI-enabled banks. After selecting their bank, the application securely communicates with the bank's servers using the verified mobile number to automatically fetch and display the associated bank account(s).<sup>14</sup> The user simply has to select the account they wish to link.
4. **Setting the UPI PIN:** This is the final and most crucial step in the setup process. The user is prompted to create a unique 4 or 6-digit UPI PIN. To do this, they must enter the last six digits and the expiry date of their debit card. The bank then sends a One-Time Password (OTP) to the user's registered mobile number. The user enters this OTP into the app, and is then prompted to set and confirm their new UPI PIN. This process leverages the bank's existing, trusted debit card authentication infrastructure to authorize the creation of the new UPI credential.<sup>14</sup>

With the UPI PIN set, the registration is complete. The user's bank account is now linked, their UPI ID is created, and they are ready to make their first transaction.

## 2.3 Creating Your Digital Address: The UPI ID (VPA)

A core innovation of UPI is the creation of a unique identifier known as the UPI ID or Virtual Payment Address (VPA). This VPA is a user-friendly, memorable address, typically in the format of `yourname@bankhandle` or `mobilenumber@bankhandle`.<sup>5</sup>

The VPA serves as a powerful abstraction layer. Instead of needing to share sensitive and cumbersome details like a bank account number and IFSC code for every transaction, a user can simply share their VPA.<sup>4</sup> This makes sending and receiving money as simple as sending an email, significantly lowering the cognitive barrier for users who may not be familiar with traditional banking details. More importantly, it is a fundamental security feature. By masking the underlying account details, the VPA ensures that a user's core banking credentials are never exposed to a merchant or another individual during a transaction, drastically reducing the risk of financial data compromise.<sup>2</sup> Users can also create multiple UPI IDs for a single bank account, providing further flexibility and control.<sup>22</sup> Additionally, the system supports a "UPI Number," which is a simple numeric identifier (often the user's 8-9 digit phone number) that can be mapped to a UPI ID, further simplifying the process of receiving payments.<sup>23</sup>

## 2.4 The Key to Your Vault: Setting and Using the UPI PIN

The UPI PIN (Personal Identification Number) is a 4 or 6-digit secret code that the user creates during the registration process.<sup>5</sup> This PIN is the key that authorizes every transaction that involves debiting money from the user's linked bank account. It serves as the second factor of authentication, confirming the user's intent to make a payment.<sup>24</sup>

It is critical to understand that the UPI PIN is distinct from an ATM PIN, a debit card PIN, or a mobile banking password. Its sole purpose is to authorize UPI debit transactions. The PIN must be entered within the secure environment of the UPI app each time a payment is made.<sup>5</sup> This PIN is confidential and should never be shared with anyone, including bank employees or customer service representatives.<sup>16</sup> A crucial point of user education, which is often a vector for fraud, is that a UPI PIN is **never** required to *receive* money. It is only ever used to *send* money or approve a payment request.<sup>26</sup>

## Section 3: The Anatomy of a Transaction

The UPI framework is designed with remarkable versatility, supporting a wide range of transaction types that cater to virtually every payment scenario in a modern economy. From simple transfers between friends to complex merchant payments at online checkouts, the system's mechanics are tailored for efficiency and user convenience. This section dissects the different modes of UPI transactions.

### 3.1 Person-to-Person (P2P) Transfers: The "Push" and "Pull" Mechanisms

The foundation of UPI's utility lies in its ability to facilitate seamless transfers between individuals. This is accomplished through two primary mechanisms: push and pull payments.

- **Push Payment (Sending Money):** This is the most common and straightforward type of UPI transaction. The payer initiates the transaction by opening their UPI app and choosing to send money. They can identify the recipient using various identifiers: their UPI ID (VPA), their mobile number (if it's linked to a UPI profile), or their traditional bank account number and IFSC code. After entering the amount and an optional remark, the user is shown a confirmation screen displaying the recipient's verified name. To authorize the transfer, the user enters their confidential UPI PIN. The funds are then instantly debited from the payer's account and credited to the payee's account.<sup>4</sup>
- **Pull Payment (Requesting Money / Collect Request):** This mechanism allows a user (the payee) to request money from another individual (the payer). The payee initiates a "collect request" by entering the payer's UPI ID and the specific amount they wish to receive. The payer then receives a notification in their UPI app detailing the request. They have the option to either approve or decline it. To approve the payment, the payer must enter their UPI PIN, which authorizes the debit from their account. If approved, the funds are transferred instantly.<sup>4</sup> While this feature is useful, its potential for misuse in fraudulent schemes (e.g., sending fake requests disguised as refunds) has led NPCI to discontinue it for P2P use cases in some contexts to enhance user security.<sup>26</sup> This adaptive response demonstrates the ecosystem's commitment to mitigating emerging threats.

### 3.2 Person-to-Merchant (P2M) Payments: QR Codes, In-App Payments, and Online Checkouts

UPI's impact on the retail landscape has been driven by its simple and cost-effective methods for accepting payments at merchant locations, both physical and digital.

- **QR Code Payments:** The Quick Response (QR) code has become the ubiquitous symbol of digital payments in India, enabling millions of merchants, from large retail chains to street-side vendors, to accept UPI payments.<sup>7</sup> The process is simple: a customer opens any UPI-enabled app, scans the merchant's QR code, enters the amount (if required), and authorizes the payment with their PIN. There are two types of QR codes:
  - **Static QR Code:** This is a simple, printed QR code that contains only the merchant's UPI ID. When a customer scans it, they must manually enter the transaction amount before proceeding to pay. This is the most common type used by small merchants due to its zero cost.<sup>5</sup>
  - **Dynamic QR Code:** This is a unique QR code generated for each individual transaction, often displayed on a screen at the point of sale. It contains both the merchant's UPI ID and the specific bill amount. This eliminates the need for manual entry by the customer, speeding up the checkout process and reducing the chance of errors.<sup>5</sup>
- **Intent / App-to-App Payments:** This method provides a seamless payment experience for e-commerce and m-commerce transactions conducted on a smartphone. When a customer is ready to check out on a merchant's website or app, they can select "Pay with UPI." This action triggers an "intent call" that automatically opens the user's preferred UPI app on their phone, with all transaction details (merchant name, amount) pre-populated. The user simply needs to verify the details and enter their UPI PIN to authorize the payment. Once completed, they are seamlessly redirected back to the merchant's app or website with a confirmation of the successful transaction. This mobile-native flow is significantly faster and less prone to drop-offs than traditional methods that require manually entering card details.<sup>5</sup>

The strategic design of these P2M methods, particularly the zero-cost static QR code, was a deliberate choice to undercut the high-cost infrastructure of traditional card payments. By removing the barriers of expensive Point of Sale (POS) terminals and transaction fees (Merchant Discount Rate or MDR), UPI democratized digital payment acceptance for millions of micro-merchants, catalyzing a bottom-up adoption wave that was instrumental to its national scale.<sup>5</sup>

## Section 4: The Technical Backbone: A Five-Party Transaction Flow

Behind the simple, user-facing interface of a UPI transaction lies a complex, high-speed

orchestration of communication between multiple entities. This entire process, from the moment a user taps "Pay" to the confirmation message, occurs in near real-time, typically within a few seconds. The architecture masterfully separates the user-facing application layer, where innovation and competition thrive, from the core infrastructure layer, which is centrally managed for stability and security. This section details the technical journey of a standard UPI transaction.

## 4.1 Mapping the Journey: Payer App -> Payer Bank -> NPCI -> Payee Bank -> Payee App

A typical UPI "push" transaction involves a five-party model, with the National Payments Corporation of India (NPCI) acting as the central switch. The sequence of events is as follows:

1. **Initiation (Payer's App / Payment Service Provider - PSP):** The transaction begins when the payer enters the payee's details (e.g., UPI ID) and the amount into their UPI app and authenticates the transaction with their UPI PIN. The Payer's PSP (e.g., Google Pay, PhonePe) securely encrypts this payment instruction and sends it as a PayRequest to the NPCI's central UPI switch.<sup>24</sup>
2. **Routing and Debit Request (NPCI to Payer's Bank):** The NPCI switch receives the encrypted request. It validates the request and uses the payer's UPI ID to identify the associated bank (the Remitter Bank). NPCI then forwards a debit request to the Payer's Bank's systems, asking it to authorize the transaction and debit the specified amount from the payer's account.<sup>24</sup>
3. **Authentication and Debit (Payer's Bank):** The Payer's Bank receives the debit request from NPCI. Its core banking system performs several crucial checks: it validates the credentials, verifies that the UPI PIN is correct for the account, and checks if the account has sufficient funds to cover the transaction. If all checks pass, the bank debits the amount from the payer's account and sends a success response back to NPCI. If any check fails (e.g., incorrect PIN, insufficient funds), it sends a failure response with the appropriate reason code.<sup>24</sup>
4. **Credit Request (NPCI to Payee's Bank):** Upon receiving a successful debit confirmation from the Payer's Bank, NPCI's switch immediately initiates the second leg of the transaction. It uses the payee's UPI ID to identify the destination bank (the Beneficiary Bank) and sends a credit request, instructing it to credit the specified amount to the payee's account.<sup>24</sup>
5. **Credit and Confirmation (Payee's Bank and Payee's App):** The Payee's Bank receives the credit request from NPCI. It credits the amount to the payee's bank account and sends a success confirmation back to NPCI. NPCI then relays the final transaction status (success or failure) to both the Payer's PSP and the Payee's PSP. The respective PSPs then display a confirmation message on the user's screen and often trigger an SMS



notification from the banks to both the payer and the payee, completing the transaction loop.<sup>24</sup>

## 4.2 The Role of the Payment Service Provider (PSP)

PSPs are the user-facing entities in the UPI ecosystem. They can be categorized into two types: banks that offer UPI services through their own mobile banking applications (e.g., HDFC Bank's app) and Third-Party Application Providers (TPAPs) like Google Pay, PhonePe, and Paytm.<sup>3</sup> TPAPs partner with sponsor banks to gain access to the UPI network. The primary responsibilities of a PSP include user onboarding, creation and management of UPI IDs, providing the user interface for initiating and receiving payments, and ensuring the secure capture and encryption of payment instructions before they are sent to NPCI. The PSP layer is where the majority of competition and innovation occurs. While the underlying payment rails are standardized, PSPs differentiate themselves by offering a superior user experience, value-added services like bill payments and ticket booking, and customer rewards.<sup>32</sup>

## 4.3 NPCI: The Central Switch and Clearing House

The National Payments Corporation of India (NPCI) is the heart of the UPI system. It operates the central switch that connects over 550 member banks, ensuring seamless interoperability across the entire network.<sup>5</sup> NPCI's role is multifaceted:

- **Orchestration:** It manages the entire transaction flow, receiving requests from the payer's side and routing them to the correct destination banks.
- **Routing and Address Resolution:** It maintains the central directory that maps every UPI ID to the corresponding bank account, enabling it to resolve payment addresses in real-time.
- **Security and Standardization:** It defines the technical and security standards, API specifications, and operating guidelines that all participating members must adhere to, ensuring a consistent and secure experience across the ecosystem.<sup>3</sup>
- **Clearing and Settlement:** It facilitates the clearing of transactions between banks and provides the final settlement figures.

By acting as a centralized, trusted intermediary, NPCI eliminates the need for each bank to establish direct technical integrations with every other bank, a task that would be logistically prohibitive and would stifle the system's ability to scale.

## 4.4 Real-Time Settlement via the IMPS Rails

The "instant" nature of UPI transactions is enabled by its foundation on the Immediate Payment Service (IMPS) infrastructure.<sup>3</sup> IMPS is another real-time, 24/7 inter-bank electronic fund transfer system operated by NPCI. When a UPI transaction is processed, the actual debit and credit of funds between the remitter and beneficiary banks occur over the IMPS rails. This was a strategic architectural decision that allowed UPI to leverage an existing, proven, and highly scalable settlement layer from its inception, significantly accelerating its development and deployment. It ensured that from day one, UPI could offer the robust, real-time settlement that users now expect.

## Section 5: A Fortress of Security: Understanding UPI's Defense Layers

The widespread adoption of UPI is built on a foundation of user trust, which is maintained through a multi-layered security architecture. This framework is designed to be proactive, anticipating threats and integrating defenses at every stage of the transaction lifecycle. It moves beyond simple password protection to a more sophisticated model where the user's device itself becomes a core part of the authentication process. This section provides a deep dive into the security features that make UPI a trusted platform.

### 5.1 The Principle of Two-Factor Authentication (2FA)

At its core, every UPI transaction is secured by Two-Factor Authentication (2FA), a principle mandated by the RBI to ensure the legitimacy of digital payments.<sup>2</sup> In the context of UPI, this is often referred to as "Single Click 2FA" because of its seamless integration into the user experience.<sup>2</sup> The two factors are:

1. **Possession Factor (What you have):** This is the user's mobile device, which has been securely registered and bound to their UPI profile. The system verifies possession of this specific device for every transaction.
2. **Knowledge Factor (What you know):** This is the user's confidential 4 or 6-digit UPI PIN,

which must be entered to authorize any debit transaction.<sup>24</sup>

Unlike some systems that may require a separate OTP for every transaction, UPI's model integrates the device itself as the first factor, making the process faster and more user-friendly while still adhering to stringent security standards.

## **5.2 Device Binding: The Unseen Guardian Linking SIM, Device, and Account**

Device binding is arguably the most critical and foundational security feature of the UPI system. It is a mandatory process that creates a unique and cryptographically secure link between the user's UPI profile, their mobile device, and the SIM card corresponding to their bank-registered mobile number.<sup>33</sup>

During the initial registration, the UPI app initiates a silent outbound SMS from the user's SIM card to a verification server. This process confirms that the SIM card linked to the bank account is physically present in the device on which the app is being installed.<sup>34</sup> This creates a "device fingerprint" and generates a cryptographic key pair. The private key is stored in a secure, hardware-backed environment on the device (such as the Android Keystore or iOS Secure Enclave), making it extremely difficult to extract or tamper with. The public key is registered with the UPI network.<sup>34</sup>

The role of device binding in securing transactions is paramount. It ensures that even if a fraudster manages to steal a user's UPI PIN, they cannot use it to transact from their own device. The UPI system expects every transaction request to be cryptographically signed by the private key stored on the legitimate, bound device. A request originating from any other device would lack this valid signature and would be rejected instantly by the servers.<sup>34</sup> This effectively turns the user's phone into a hardware security token, making remote account takeovers and the use of stolen credentials exceptionally difficult. This is the technical reason why a user cannot simply log into their UPI account on a friend's phone to make payments.<sup>34</sup>

## **5.3 The UPI PIN: Your Authorization Signature**

The UPI PIN serves as the user's explicit consent and final authorization for any payment. This secret code, known only to the user, must be entered on the app's secure PIN entry screen to approve any transaction that debits their account.<sup>5</sup> The system is designed such that the PIN

is encrypted at the point of entry and is never stored in plain text on the device or transmitted in an insecure manner.<sup>16</sup> The user interface is also designed to make it clear that the PIN is only ever required for *sending* money, not for receiving it—a key piece of information in preventing common scams.<sup>26</sup>

## **5.4 Data Encryption and Secure Communication Protocols**

Beyond the user-facing security features, the entire UPI backbone is protected by robust data security measures. All communication between the user's app, the PSP's servers, NPCI, and the banks occurs over secure, encrypted channels, typically using HTTPS with additional protections like SSL/TLS pinning.<sup>33</sup> SSL pinning is a technique that prevents man-in-the-middle attacks by ensuring the app communicates only with the authentic, whitelisted server. As mentioned, sensitive cryptographic keys are stored within the device's hardware-backed secure element, which is designed to protect them from malware or other software-based attacks on the phone.<sup>34</sup> This comprehensive approach to encryption ensures the confidentiality and integrity of user data both when it is in transit across the network and when it is at rest on the device.

## **Section 6: Rules of the Road: Transaction Limits, Charges, and Balances**

The operational framework of the Unified Payments Interface is governed by a clear set of rules established by the National Payments Corporation of India (NPCI) and the Reserve Bank of India (RBI). These rules, particularly concerning transaction limits and charges, are not merely static regulations but are dynamic policy levers used to manage risk, encourage specific economic activities, and drive mass adoption. This section clarifies the financial parameters and operational guidelines of the UPI system.

### **6.1 Understanding Transaction Limits: Daily, Per-Transaction, and Category-Specific Caps**

To manage risk and ensure system stability, UPI transactions are subject to certain limits.

These limits are standardized across the ecosystem and cannot be altered by individual users.<sup>37</sup>

- **General Transaction Limit:** For the vast majority of everyday P2P and P2M transactions, the limit is capped at ₹1 lakh (₹100,000) per day, per bank account. This daily cap applies to the cumulative value of all transactions made within a 24-hour period.<sup>17</sup>
- **Transaction Count Limit:** In addition to the value limit, there is typically a limit on the number of transactions a user can perform in a day, which is generally set at 20 transactions per 24-hour period.<sup>38</sup>
- **Category-Specific Higher Limits:** Recognizing the need for larger transaction values in certain sectors, the NPCI and RBI have established higher limits for specific, verifiable use cases. This tiered approach is a form of calibrated risk management. For instance, the limit was increased to ₹5 lakh for payments to hospitals and educational institutions to facilitate essential, high-value payments digitally.<sup>3</sup> Similarly, to streamline retail investor participation in capital markets, the limit for Initial Public Offering (IPO) applications and investments in the RBI's Retail Direct Scheme is ₹5 lakh per transaction.<sup>10</sup> For other specific categories like capital markets, credit card bill payments, loan repayments, and insurance premium payments, the per-transaction limit is ₹2 lakh.<sup>37</sup>

These dynamically adjusted limits demonstrate how the UPI framework can be fine-tuned to support specific national economic objectives, from deepening capital markets to reducing friction in healthcare payments.

## 6.2 The "Zero-Fee" Model for Users and the Merchant Discount Rate (MDR) Debate

A cornerstone of UPI's explosive growth has been its pricing model. For individual users, conducting P2P or standard P2M transactions via UPI is completely free of charge.<sup>5</sup> This was a deliberate policy decision, supported by a government mandate for a zero Merchant Discount Rate (MDR) on UPI transactions.<sup>5</sup> The MDR is a fee that merchants typically pay to banks and payment providers for accepting digital payments via credit or debit cards. By eliminating this cost for UPI, the government drastically lowered the barrier for small and micro-merchants to adopt digital payments, catalyzing adoption at an unprecedented scale.

However, this zero-fee model presents a long-term challenge for the financial sustainability of the ecosystem. While it has been a powerful tool for adoption, the payment service providers (PSPs) and banks that build and maintain the UPI infrastructure incur significant operational costs without a direct revenue stream from the transactions themselves. This has sparked an ongoing policy debate. There have been calls from within the industry to introduce a regulated MDR, at least for large-volume merchants, to create a sustainable business model

for the ecosystem's participants.<sup>5</sup> For now, the model remains free for users. It is worth noting that for transactions made to merchants from a Prepaid Payment Instrument (PPI) like a digital wallet, an interchange fee of 0.5% to 1.1% may be levied on transactions above ₹2,000, but this fee is payable by the merchant, not the customer.<sup>38</sup>

### 6.3 Clarifying the "Minimum Balance" Requirement

There is a common misconception among users that a UPI account itself has a minimum balance requirement. This is incorrect. UPI, as a payment service, does not impose any minimum balance rules.<sup>39</sup> UPI is simply a payment layer that operates on top of a user's existing bank account. Therefore, any minimum balance requirements are those dictated by the user's bank for their specific type of account (e.g., a savings account may have a Minimum Average Balance or MAB requirement). UPI does not alter or add to the terms and conditions of the underlying bank account. The only exception is UPI Lite, an on-device wallet feature, which has a maximum balance limit but no mandatory minimum balance.<sup>39</sup>

Table 1: UPI Transaction Limits by Category

Transaction Category	Per-Transaction Limit	Daily Transaction Limit (Cumulative)	Daily Transaction Count Limit
General (P2P and P2M)	₹1,00,000	₹1,00,000	20
Capital Markets, Insurance, Collections, Credit Card Payments, Loan Repayments	₹2,00,000	₹1,00,000 (overall daily limit applies)	20
IPO Applications, RBI Retail Direct Scheme	₹5,00,000	₹5,00,000	20
Hospitals and Educational	₹5,00,000	₹5,00,000	20

Institutions			
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## Section 7: The Evolving Ecosystem: Advanced UPI Services

The Unified Payments Interface is not a static platform; it is a dynamic and evolving ecosystem. Guided by the data-driven approach of NPCI and RBI, a suite of advanced and specialized services has been built upon the core UPI rails. These are not arbitrary features but targeted solutions designed to address specific challenges and opportunities that have emerged as the platform has scaled, such as system load from micropayments, the need for recurring mandates, and the imperative to bridge the digital divide.

### 7.1 UPI Lite: The On-Device Wallet for Small, Fast Payments

The overwhelming success of UPI, particularly for a high volume of small-ticket transactions, began to place a significant load on the core banking systems of banks, occasionally leading to transaction failures during peak hours. In response, NPCI introduced UPI Lite in 2022.<sup>41</sup>

UPI Lite is an "on-device wallet" integrated within a user's main UPI app.<sup>40</sup> Users can add funds from their linked bank account into their UPI Lite balance. The key features are:

- **PIN-less Transactions:** Payments up to ₹1,000 can be made instantly without entering a UPI PIN, making small transactions faster and more convenient.<sup>40</sup>
- **Balance and Spending Limits:** The maximum balance that can be held in the UPI Lite wallet at any point is ₹5,000. The cumulative daily spending limit is ₹10,000.<sup>40</sup>
- **Reduced Bank Server Load:** Since the transaction is debited from the on-device wallet, it does not hit the bank's core banking system in real-time for every small payment. This significantly reduces the traffic on bank servers, leading to higher success rates and a more stable system overall.<sup>45</sup>
- **Decluttered Bank Statements:** A major user benefit is a cleaner bank passbook. Only the transactions to "top-up" the UPI Lite wallet are recorded in the bank statement, while the individual small-value payments are tracked only within the app's transaction history.<sup>40</sup>
- **Offline Capability with UPI Lite X:** An enhanced version, UPI Lite X, leverages Near Field Communication (NFC) technology to enable completely offline payments between

devices, which is useful in areas with poor or no internet connectivity.<sup>41</sup>

## 7.2 UPI AutoPay: Automating Recurring Mandates

As users grew accustomed to UPI for one-off payments, the next area of friction was recurring payments, such as monthly subscriptions, insurance premiums, loan EMIs, and mutual fund SIPs. To address this, UPI AutoPay was introduced as part of the UPI 2.0 upgrade.<sup>3</sup> This feature allows users to set up electronic mandates through their UPI app for recurring transactions. The user pre-authorizes a merchant to debit their account for a fixed or variable amount at a specified frequency. This brings the convenience, transparency, and control of UPI to the world of automated payments, providing a modern alternative to older systems like credit card standing instructions and NACH mandates. To further enhance convenience, the limit for e-mandates that can be processed without an additional factor of authentication has been raised from ₹15,000 to ₹1 lakh (₹100,000) for certain categories like credit card repayments and insurance premiums.<sup>3</sup>

## 7.3 UPI 123Pay: Bridging the Digital Divide for Feature Phone Users

While UPI was primarily designed for smartphones, a significant portion of India's population, especially in rural areas, still relies on feature phones. To ensure that the benefits of digital payments are accessible to this demographic, the RBI and NPCI launched UPI 123Pay.<sup>3</sup> This innovative service enables UPI transactions on basic feature phones without requiring an internet connection. It operates through four distinct technology alternatives:

1. **IVR (Interactive Voice Response):** Users can call a pre-defined number and follow voice prompts to initiate a fund transfer.
2. **App Functionality:** An app-like functionality is embedded on certain feature phones.
3. **Missed Call:** Users can give a missed call to a specific number, after which they receive a callback to authenticate and complete the transaction.
4. **Proximity Sound-based Payments:** This uses sound waves to enable contactless payments.<sup>10</sup>

UPI 123Pay is a critical initiative for deepening financial inclusion, extending the reach of the digital payment revolution to the last mile. In recognition of its growing adoption, the per-transaction limit for this service has been enhanced from ₹5,000 to ₹10,000.<sup>3</sup>



## 7.4 e-RUPI: Purpose-Specific Digital Vouchers

e-RUPI represents a significant evolution of UPI into a platform for programmable payments. It is a person- and purpose-specific, prepaid digital voucher that is delivered to a beneficiary's mobile phone in the form of a QR code or an SMS string.<sup>3</sup> Unlike a general fund transfer, an e-RUPI voucher is non-transferable and can only be redeemed for a specific purpose at a designated merchant or center.

This makes it an ideal instrument for the leak-proof delivery of government welfare services and subsidies, such as scholarships for students or benefits for healthcare schemes. It ensures that the funds are used precisely for their intended purpose, eliminating intermediaries and reducing the potential for corruption. The private sector can also leverage e-RUPI for corporate social responsibility (CSR) initiatives or for employee benefits programs.<sup>3</sup> e-RUPI is a precursor to the concept of a Central Bank Digital Currency (CBDC), as it helps build out the infrastructure and user familiarity with purpose-bound digital currency.<sup>3</sup>

Table 2: Comparison of Key UPI Services

Feature	Standard UPI	UPI Lite	UPI 123Pay
Target Device	Smartphone	Smartphone	Feature Phone
Internet Required	Yes	No (for UPI Lite X using NFC)	No
PIN Requirement	Yes (for every transaction)	No (for transactions up to ₹1,000)	Yes
Per-Transaction Limit	Up to ₹1,00,000 (General)	Up to ₹1,000	Up to ₹10,000
Daily Spending Limit	Up to ₹1,00,000 (General)	Up to ₹10,000	Up to ₹1,00,000
Key Use Case	All-purpose digital	Quick, low-value	Financial inclusion

	payments	retail payments	for non-smartphone users
<b>Bank Statement Entry</b>	Every transaction is listed	Only top-up transactions are listed	Every transaction is listed

## Section 8: User Vigilance: Navigating Common Frauds and Best Practices

While the technical architecture of UPI is exceptionally secure, no payment system is immune to fraud. The primary threat vectors in the UPI ecosystem are not technical breaches of the system itself, but rather social engineering attacks that manipulate users into unwittingly authorizing fraudulent transactions. The robustness of the technology has forced criminals to target the human element. Therefore, user awareness and education are as critical to security as the underlying technology. This section serves as a practical guide to identifying common scams and adopting safe usage practices.

### 8.1 Identifying Common Threats: Phishing, Malicious QR Codes, and SIM Swap Attacks

Fraudsters employ a variety of tactics to trick users. Understanding their methods is the first step toward effective prevention.

- **Phishing Scams:** This is a classic fraud technique where scammers send fake SMS messages, emails, or social media messages that appear to be from a legitimate source like a bank or a UPI app. These messages contain malicious links that lead to fake websites designed to look like the real thing. Unsuspecting users are tricked into entering their sensitive information, such as their UPI ID, UPI PIN, OTP, or card details, which are then captured by the fraudster.<sup>26</sup>
- **Collect Request Scams (Request-to-Pay Fraud):** This is one of the most common UPI frauds. A scammer sends a "collect request" to the victim's UPI ID with a deceptive message, often claiming it is for a "refund," "cashback," or a "prize." If the user is not vigilant, they might approve the request by entering their UPI PIN, believing they are

about to receive money. In reality, entering the PIN authorizes a debit, and money is instantly transferred from the victim's account to the scammer's.<sup>26</sup>

- **QR Code Fraud:** Scammers exploit the common use of QR codes for payments. They may send a QR code to a victim, falsely claiming that scanning it will credit money to their account. However, a UPI QR code can only be used to *make* a payment. When the victim scans the code and enters their PIN, they are actually sending money to the fraudster.<sup>26</sup>
- **Remote Access and Screen-Sharing Fraud:** In this scenario, a fraudster, often posing as a customer support executive from a bank or tech company, convinces the victim to download a remote access or screen-sharing application (e.g., AnyDesk, TeamViewer). Once installed, the app gives the fraudster complete visibility and control over the victim's mobile screen, allowing them to view sensitive information and operate financial apps to transfer money.<sup>26</sup>
- **SIM Swap (SIM Cloning) Fraud:** This is a more sophisticated attack where a scammer gathers a victim's personal information and uses it to convince the mobile service provider to issue a duplicate SIM card for the victim's number. Once the duplicate SIM is activated, the original SIM stops working. The fraudster now controls the victim's mobile number and can receive OTPs, allowing them to take over bank accounts and authorize UPI transactions.<sup>26</sup>

## 8.2 A Practical Guide to Safe and Secure UPI Usage

Security is a shared responsibility. While the UPI platform provides robust technical safeguards, users must adopt vigilant practices to protect themselves from social engineering attacks.

- **Guard Your UPI PIN:** The UPI PIN is the most critical piece of information. Treat it like your ATM PIN. Never share it with anyone, under any circumstances. Remember that no bank, UPI app, or legitimate company will ever ask for your UPI PIN.<sup>16</sup>
- **The Golden Rule of Receiving Money:** A UPI PIN is **only** required to *send* money or to approve a payment request. You **never** need to enter your PIN to *receive* money. Be extremely suspicious of anyone who asks you to enter your PIN to get a payment or refund.<sup>26</sup>
- **Verify Before You Pay:** Before you enter your PIN to complete a transaction, the UPI app will display the legal name of the recipient. Always take a moment to verify that this is the correct person or merchant you intend to pay. If the name is unexpected, cancel the transaction.<sup>16</sup>
- **Scrutinize Requests and Links:** Decline all unexpected "collect requests." If you are not expecting to pay someone, do not approve their request. Similarly, never click on unsolicited links received via SMS, email, or messaging apps, especially those that ask for

financial information.<sup>26</sup>

- **Practice Good App Hygiene:** Only download UPI-enabled apps from official sources like the Google Play Store or Apple App Store. Keep your apps updated to ensure you have the latest security patches. Be cautious about the permissions you grant to applications; never give screen-sharing or accessibility permissions to unknown or untrusted apps.<sup>16</sup>
- **Report Fraud Immediately:** If you suspect a fraudulent transaction, time is of the essence. Immediately report the transaction through the UPI app's dispute resolution mechanism. Contact your bank to report the fraud and request a payment stop. Finally, call the National Cyber Crime Reporting Helpline at number 1930 to file a formal complaint.<sup>26</sup>

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**Table 3: UPI Fraud Prevention Matrix**

Fraud Type	How it Works	Red Flag	Prevention Action
<b>Collect Request Scam</b>	Scammer sends a payment request disguised as a refund, prize, or payment for an item you are selling.	You receive a "Collect Request" or "Payment Request" when you are expecting to receive money.	<b>Decline all unexpected payment requests.</b> Remember: You never need to enter your PIN to receive money.
<b>Phishing Scam</b>	You receive an SMS or email with a link to a fake website that mimics a real bank or UPI app, asking for your details.	An unsolicited message with a sense of urgency, asking you to click a link to "verify your account" or "claim a reward."	<b>Do not click on suspicious links.</b> Always access your bank or UPI app directly. Check website URLs carefully for misspellings.
<b>QR Code Fraud</b>	Scammer sends you a QR code and tells you to scan it to receive money.	You are asked to scan a QR code and then enter your PIN to receive a payment.	<b>Only scan QR codes to make a payment.</b> Scanning a QR code is always a debit action. Never scan to receive

			funds.
<b>Remote Access Fraud</b>	A person claiming to be from "customer support" asks you to install a screen-sharing app to "fix a problem."	Anyone asking you to download an app like AnyDesk, TeamViewer, or ScreenShare.	<b>Never install remote access software at the behest of a stranger.</b> No legitimate customer service will ask for remote control of your device.
<b>SIM Swap Fraud</b>	Your mobile network suddenly stops working for no reason ("No Service" or "Emergency Calls Only").	Your phone's SIM card unexpectedly deactivates. You stop receiving calls and messages.	<b>Contact your mobile operator immediately</b> through an alternate channel to check if a duplicate SIM has been issued.

## Section 9: UPI Goes Global: India's Digital Export

The phenomenal success of the Unified Payments Interface within India has positioned it as a model for digital payment systems worldwide. This has led to a strategic and rapidly accelerating international expansion, driven by NPCI's dedicated global arm, NPCI International Payments Limited (NIPL). This expansion is more than just a commercial venture; it is a form of techno-diplomatic soft power. By exporting UPI, India is not merely offering a payment technology but is also promoting its philosophy of open, interoperable, and low-cost Digital Public Infrastructure. This presents an attractive alternative for other nations, particularly in the Global South, seeking to build their own digital economies without relying on proprietary systems from the West or China.<sup>7</sup>

### 9.1 Mapping UPI's International Footprint

The global acceptance of UPI is growing at a remarkable pace. What began as a domestic payment system is now operational in several countries across Asia, Europe, and Africa, with numerous other partnerships in various stages of development. As of late 2025, UPI is accepted in countries including Bhutan, which was the first to adopt the system, as well as Nepal, Singapore, the United Arab Emirates (UAE), Mauritius, Sri Lanka, and France.<sup>7</sup> The expansion continues with recent agreements to enable UPI acceptance in Japan through a partnership with NTT DATA, and in Qatar at select retail outlets.<sup>48</sup> Discussions and Memoranda of Understanding (MoUs) are also in place with a host of other nations, including Australia, the United States, the United Kingdom, and several countries in Southeast Asia and Europe, signaling a clear ambition for a widespread global presence.<sup>48</sup>

## 9.2 Strategic Partnerships and Cross-Border Linkages

UPI's international expansion is not a one-size-fits-all approach. NIPL employs a flexible strategy, tailoring the integration model to the specific needs and financial infrastructure of each partner country. Two primary models have emerged:

1. **Merchant Payments for Indian Travelers:** This is the most common model, focused on enhancing convenience for Indian tourists and the diaspora. NIPL partners with local payment networks or acquirers in the host country to enable UPI acceptance at merchant locations. For example, in France, the partnership with Lyra Network allows Indian tourists to pay by scanning QR codes at locations like the Eiffel Tower.<sup>47</sup> Similarly, in the UAE, a partnership with Network International has enabled UPI at over 200,000 retail points.<sup>47</sup> This model allows Indians to use their familiar UPI apps for payments abroad, avoiding the complexities of currency conversion and high forex card charges.
2. **Interlinking of Domestic Payment Systems:** This is a deeper form of integration aimed at facilitating seamless cross-border remittances and peer-to-peer (P2P) transfers. The prime example is the linkage between India's UPI and Singapore's domestic real-time payment system, PayNow. Launched in February 2023, this linkage allows users in either country to send money to each other instantly and at a low cost, using just the UPI ID or PayNow-registered mobile number. This is a powerful tool for the large Indian diaspora in Singapore, particularly migrant workers and students sending money home.<sup>47</sup> Similar integrations are being explored with other countries to create efficient remittance corridors.

This dual-pronged strategy—facilitating tourism-related payments while simultaneously building deeper infrastructure for remittances—allows UPI to establish a global footprint that serves multiple economic and diplomatic objectives. Each partnership not only represents a commercial agreement but also strengthens bilateral ties and showcases Indian innovation on

the world stage.<sup>7</sup>

Table 4: UPI's Global Presence (as of late 2025)

Country	Year of Launch/Agreement	Key Local Partner(s)	Primary Use Case	Status
Bhutan	2021	Royal Monetary Authority (RMA)	P2M for Tourists (QR Payments)	Fully Live
Nepal	2024	Fonepay Payment Service	P2M for Tourists (QR Payments)	Fully Live
Singapore	2023	PayNow (MAS)	P2P Remittances & P2M for Tourists	Fully Live
UAE	2024	Network International, Mashreq Bank	P2M for Tourists & NRIs	Fully Live
Mauritius	2024	Bank of Mauritius	P2M for Tourists & NRIs	Fully Live
Sri Lanka	2024	LankaPay	P2M for Tourists	Fully Live
France	2024	Lyra Network	P2M for Tourists	Fully Live
Qatar	2025	Qatar National Bank (QNB)	P2M for Tourists (at select merchants)	Partial Rollout

<b>Japan</b>	2025	NTT DATA	P2M for Tourists	MoU Signed
<b>Oman</b>	2023	Central Bank of Oman	P2M for Tourists & NRIs	MoU Signed
<b>Malaysia</b>	2025	Merchantrade Asia	Remittances, P2M for Tourists	Partial Rollout
<b>Europe (Benelux, CH)</b>	2022	Worldline SA	P2M for Tourists	MoU Signed

## Section 10: Conclusion: The Transformative Impact of UPI

The Unified Payments Interface has evolved far beyond its initial conception as a mere payment system. It has become a core pillar of India's Digital Public Infrastructure, a powerful engine for economic transformation, and a global symbol of financial technology innovation. Its impact on India's economy and society has been profound, catalyzing a behavioral shift at a national scale and laying the groundwork for the next generation of digital finance.

### 10.1 Driving Financial Inclusion and Formalizing the Economy

UPI's most significant achievement has been its role as a key enabler of financial inclusion. By offering a simple, secure, and zero-cost platform for digital transactions, it has successfully brought millions of previously unbanked and under-banked individuals into the formal financial system.<sup>6</sup> Its reach has democratized digital payments, extending far beyond metropolitan centers into the tier-2, tier-3 cities and rural areas that form the backbone of the Indian economy.<sup>3</sup>

The scale of this transformation is evident in the transaction data. The system now processes over 20 billion transactions per month, with a staggering value exceeding ₹24.85 lakh crore (approximately US\$281 billion) as of August 2025.<sup>7</sup> UPI now accounts for the overwhelming



majority—around 85% to 90%—of all digital retail transaction volumes in India, fundamentally altering the country's payment landscape.<sup>6</sup> This mass adoption has had a powerful effect on economic formalization. When a small street vendor accepts a payment via a UPI QR code, it creates a digital transaction record. This digital footprint, in turn, can be used to establish a credit history, making it possible for that vendor to access formal credit, insurance, and other financial services for the first time, thereby fostering a virtuous cycle of economic growth and empowerment.<sup>8</sup>

## **10.2 UPI as a Core Pillar of India's Digital Public Infrastructure**

The success of UPI cannot be viewed in isolation. It is the transactional layer of a much larger, integrated national strategy for building Digital Public Infrastructure (DPI). It works in perfect synergy with the other pillars: Aadhaar, which provides a verifiable digital identity, and the Jan Dhan Yojana, which ensured widespread access to bank accounts.<sup>7</sup> This layered "India Stack" approach—identity, accounts, and finally, payments—is what has enabled UPI to achieve a scale and impact that is unparalleled globally. This model is now being studied by international organizations like the International Monetary Fund (IMF) as a potential blueprint for other developing nations seeking to leapfrog into the digital age.<sup>7</sup> UPI's design as an open, interoperable public good, rather than a proprietary product, is the core tenet of this philosophy and the primary reason for its success.

## **10.3 Future Outlook: Credit Lines, AI Integration, and Beyond**

The journey of UPI is far from over. The platform continues to evolve, with its future trajectory pointing towards an expansion from simple payments into more complex financial services. The next frontier is the deeper integration of credit. Initiatives are already underway to link RuPay credit cards to UPI and to enable pre-sanctioned credit lines directly through the UPI interface, which would allow users to "scan and pay" using credit instead of just their bank balance.<sup>3</sup>

Furthermore, the ecosystem is embracing next-generation technologies. Biometric authentication, using fingerprints or facial recognition, is being rolled out as an alternative to the UPI PIN for smaller transactions, enhancing both speed and security.<sup>3</sup> There is also significant potential for the integration of conversational Artificial Intelligence. Pilot programs are exploring how users could interact with AI assistants like ChatGPT to find products or services and complete the purchase seamlessly within the same conversational flow, using

features like "UPI Reserve" for secure, AI-handled payments.<sup>32</sup> These developments indicate that UPI is poised to become the foundational infrastructure for a new era of digital commerce and finance in India, moving beyond being just a way to pay to becoming a comprehensive platform for managing one's entire financial life.

Ultimately, UPI has fundamentally altered the economic behavior of a nation. While cash remains resilient, particularly for certain demographics and high-value transactions, UPI has decisively won the battle for transaction *volume*, especially in the high-frequency, low-value payments that constitute the bulk of daily economic activity.<sup>6</sup> This shift from cash to digital as the default option for everyday life is a profound and likely irreversible change, one that has made India's economy more transparent, efficient, and inclusive.