US012387201B2

(12) United States Patent

Kulkarni et al.

(10) Patent No.: US 12,387,201 B2

(45) Date of Patent: Aug. 12, 2025

(54) MULTI-FACTOR USER AUTHENTICATION USING BLOCKCHAIN TOKENS

(71) Applicant: **Bank of America Corporation**, Charlotte, NC (US)

(72) Inventors: **Harish Tammaji Kulkarni**, Singapore (SG); **Kumudini Choyal**, Tung Chung (HK); **Min Cao**, Singapore (SG); **Nhat Minh Nguyen**, Singapore (SG); **Ra Uf Ridzuan Bin Ma Arof**, Singapore (SG); **Surendran Surendran**, Singapore (SG)

(73) Assignee: **Bank of America Corporation**, Charlotte, NC (US)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 184 days.

(21) Appl. No.: **17/856,097**

(22) Filed: **Jul. 1, 2022**

(65) **Prior Publication Data**

US 2024/0005312 A1 Jan. 4, 2024

(51) **Int. Cl.**

G06Q 20/38 (2012.01)

(52) **U.S. Cl.**

CPC ***G06Q 20/3823*** (2013.01); ***G06Q 20/3827*** (2013.01); ***G06Q 20/389*** (2013.01); *G06Q 2220/00* (2013.01)

(58) **Field of Classification Search**

None

See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

9,137,228	B1 *	9/2015	Newstadt	H04L 63/08
9,172,698	B1 *	10/2015	Evans	G06F 21/34
10,043,174	B1 *	8/2018	Chikkanna	G06Q 20/3676
10,148,629	B1 *	12/2018	Roth	H04L 63/0838

(Continued)

FOREIGN PATENT DOCUMENTS

WO	WO-2012005744 A1 *	1/2012		H04L 63/0838
WO	WO-2017080755 A1 *	5/2017		G06Q 20/12
WO	WO-2022154051 A1 *	7/2022		G06F 21/31

OTHER PUBLICATIONS

Schneier, Bruce "Applied Cryptography Second Edition : protocols, algorithms, and source code in C" ISBN 0-471-12845-7, pp. 34-41 (Year: 1996).*

(Continued)

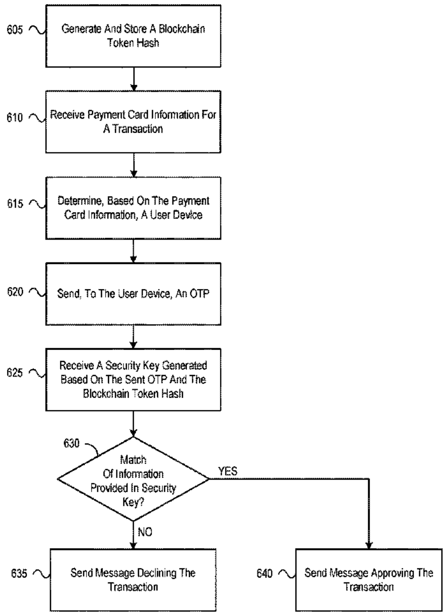
Primary Examiner — Eduardo Castilho

(74) *Attorney, Agent, or Firm* — Banner & Witcoff, Ltd.

(57) ABSTRACT

Aspects of the disclosure relate to multi-factor user authentication for card-based payment transactions using blockchain tokens. An computing platform may receive, from a computing device, transaction details associated with a card-based payment transaction corresponding to a user, wherein the transaction details comprise a card number of a payment card. The computing platform may determine, based on the card number, a user device associated with the user. The computing platform may send, to the user device, a one-time passcode (OTP). After sending the OTP, the computing platform may receive a security key. The security key may be generated based on the sent OTP and a blockchain token hash. The computing platform may, based on the

(Continued)


605
Generate And Store A Blockchain Token Hash
610
Receive Payment Card Information For A Transaction
615
Determine, Based On The Payment Card Information, A User Device
620
Send, To The User Device, An OTP
625
Receive A Security Key Generated Based On The Sent OTP And The Blockchain Token Hash
630
Match Of Information Provided In Security Key?
YES
NO
635
Send Message Declining The Transaction
640
Send Message Approving The Transaction

received security key, send, to the computing device, a message indicating whether the transaction is approved or declined.

20 Claims, 11 Drawing Sheets

(56) **References Cited**

U.S. PATENT DOCUMENTS

11,310,052	B1*	4/2022	Keogh	H04L 9/3239
2015/0324789	A1	11/2015	Dvorak et al.	
2016/0261411	A1*	9/2016	Yau	G06Q 20/38215
2018/0047014	A1	2/2018	Maus et al.	
2018/0176222	A1*	6/2018	Bhaskar	G06Q 20/363
2018/0219861	A1	8/2018	Schultz et al.	
2019/0034612	A1*	1/2019	Smales	G06F 21/34
2019/0044942	A1	2/2019	Gordon et al.	
2019/0140844	A1	5/2019	Brown et al.	
2020/0014528	A1	1/2020	Nandakumar et al.	
2020/0026834	A1	1/2020	Vimadalal et al.	
2020/0052899	A1	2/2020	Finlow-Bates	
2020/0058021	A1*	2/2020	Mittal	G06Q 20/3829
2020/0084018	A1*	3/2020	Pande	H04L 9/0844
2020/0127813	A1	4/2020	Millar et al.	
2020/0195437	A1	6/2020	Gallagher et al.	
2020/0244441	A1*	7/2020	Madineni	H04L 9/3239
2020/0244652	A1	7/2020	Iyer et al.	
2020/0279235	A1	9/2020	Booth et al.	
2020/0364711	A1*	11/2020	Sarin	G06Q 20/3672
2020/0366671	A1	11/2020	Larson et al.	
2021/0014064	A1	1/2021	Channa et al.	
2021/0105271	A1	4/2021	Nitturkar et al.	
2021/0133750	A1	5/2021	Leddy, III	
2021/0241270	A1	8/2021	Raevsky et al.	
2021/0256511	A1	8/2021	Peacemaker et al.	
2021/0314143	A1*	10/2021	Conner	G16Y 40/50
2021/0344502	A1	11/2021	Purves	
2021/0399894	A1	12/2021	Gallagher et al.	
2021/0409195	A1*	12/2021	Kim	G06Q 20/385
2022/0114245	A1	4/2022	Krishan	

OTHER PUBLICATIONS

Buccafurri et al., "Securing MQTT by Blockchain-Based OTP Authentication," Sensors (Basel), Apr. 3, 2020;20(7):2002. doi: 10.3390/s20072002. PMID: 32260049; PMCID: PMC7180730. (Year: 2020).*

M. Zhang, L. Wang and J. Yang, "A Blockchain-Based Authentication Method with One-Time Password," 2019 IEEE 38th International Performance Computing and Communications Conference (IPCCC), London, UK, 2019, pp. 1-9, doi: 10.1109/IPCCC47392.2019.8958754. (Year: 2019).*

W.-S. Park, D.-Y. Hwang and K.-H. Kim, ""A TOTP-Based Two Factor Authentication Scheme for Hyperledger Fabric Blockchain,"" 2018 Tenth International Conference on Ubiquitous and Future Networks (ICUFN), Prague, Czech Republic, 2018, pp. 817-819, doi: 10.1109/ICUFN.2018.8436784 (Year: 2018).*

Machine Translation of Foreign Patent Document WO2022154051A1 (Year: 2022).*

* cited by examiner

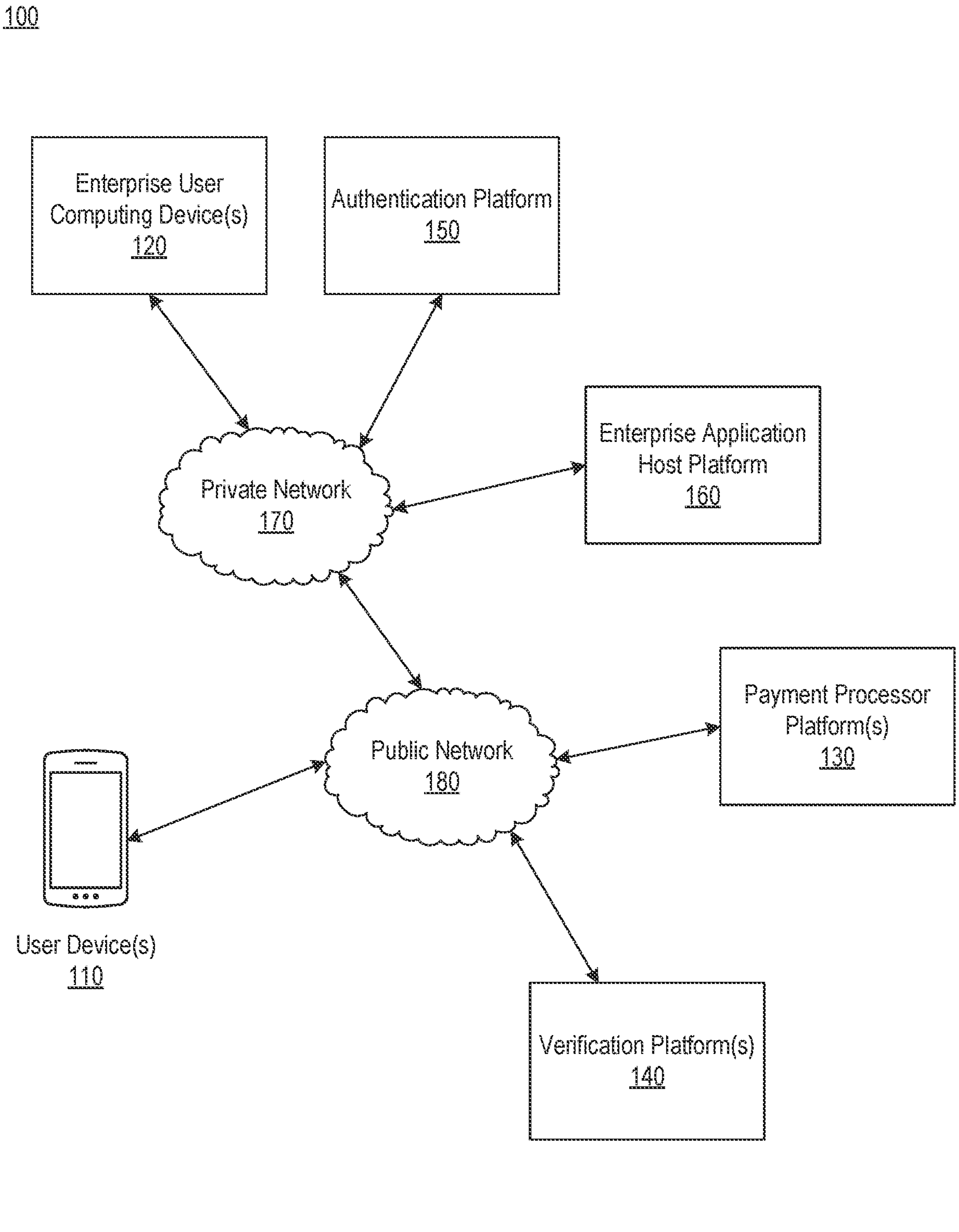

100
Enterprise User Computing Device(s) 120
Authentication Platform 150
Enterprise Application Host Platform 160
Private Network 170
Public Network 180
Payment Processor Platform(s) 130
User Device(s) 110
Verification Platform(s) 140

FIG. 1

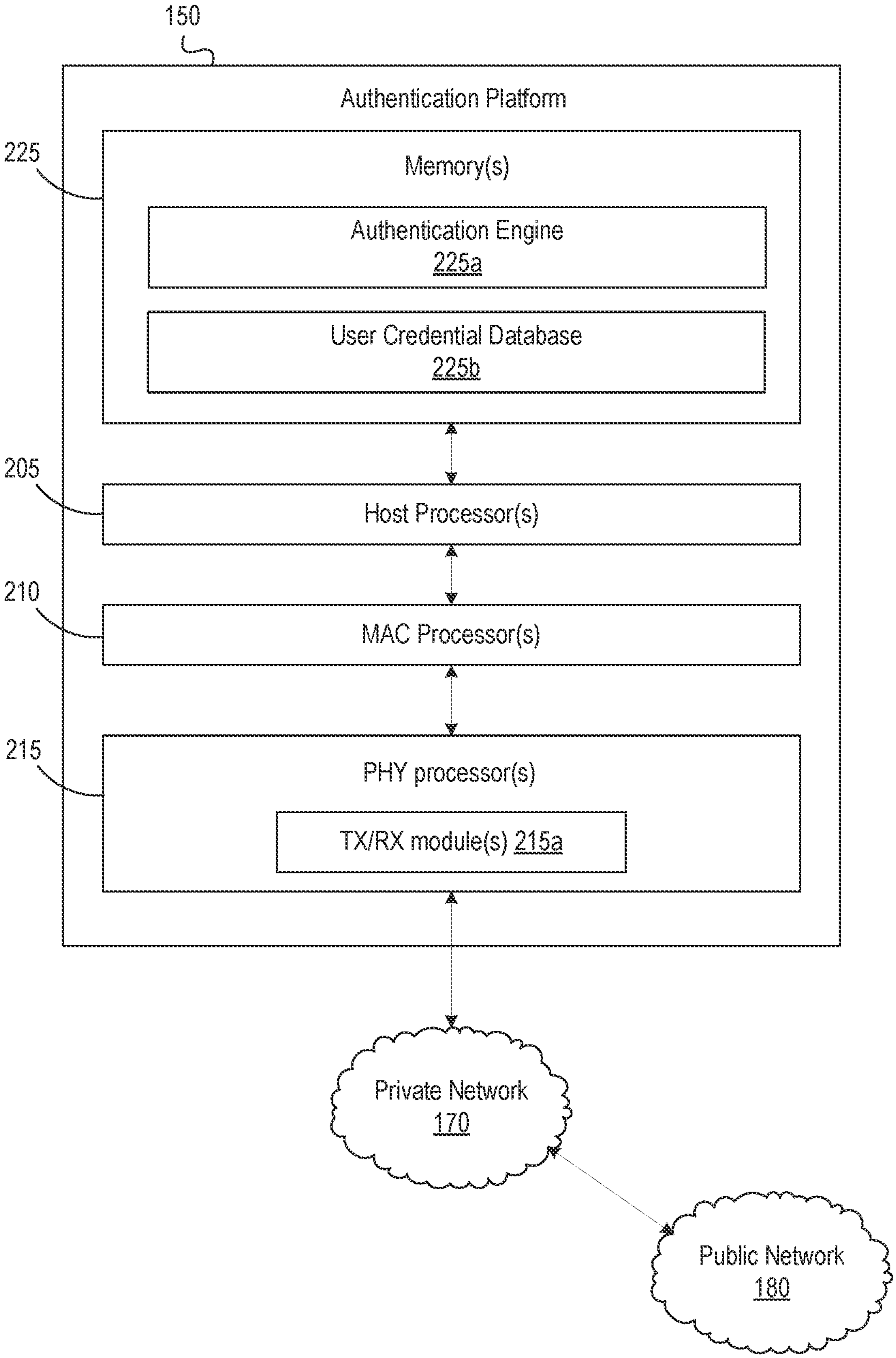

150
Authentication Platform
225
Memory(s)
Authentication Engine
225a
User Credential Database
225b
205
Host Processor(s)
210
MAC Processor(s)
215
PHY processor(s)
TX/RX module(s) 215a
Private Network
170
Public Network
180

FIG. 2

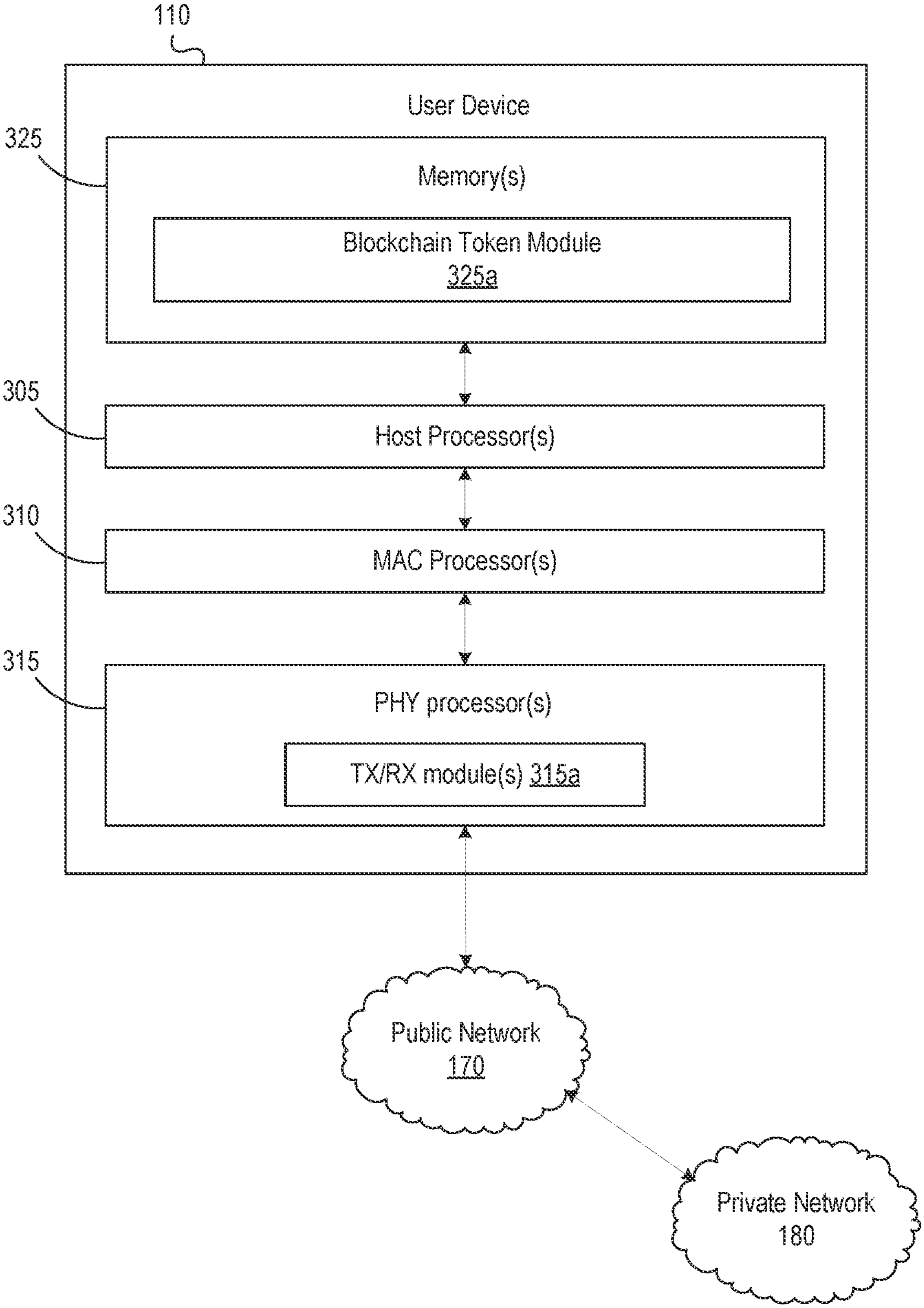

110
User Device
325
Memory(s)
Blockchain Token Module
325a
305
Host Processor(s)
310
MAC Processor(s)
315
PHY processor(s)
TX/RX module(s) 315a
Public Network
170
Private Network
180

FIG. 3

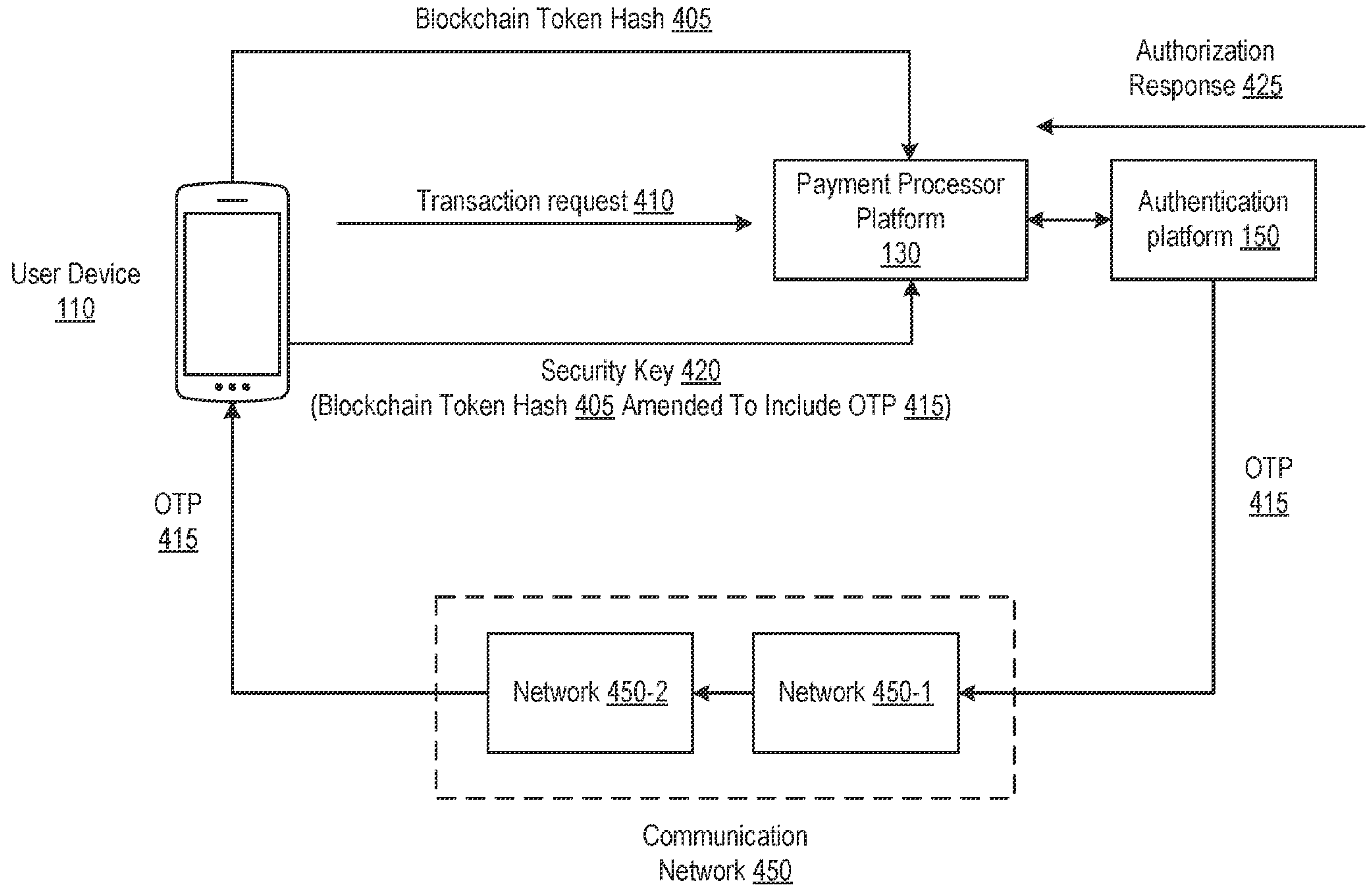

Blockchain Token Hash 405
Authorization
Response 425
User Device
110
Transaction request 410
Payment Processor
Platform
130
Authentication
platform 150
Security Key 420
(Blockchain Token Hash 405 Amended To Include OTP 415)
OTP
415
OTP
415
Network 450-2
Network 450-1
Communication
Network 450

FIG. 4

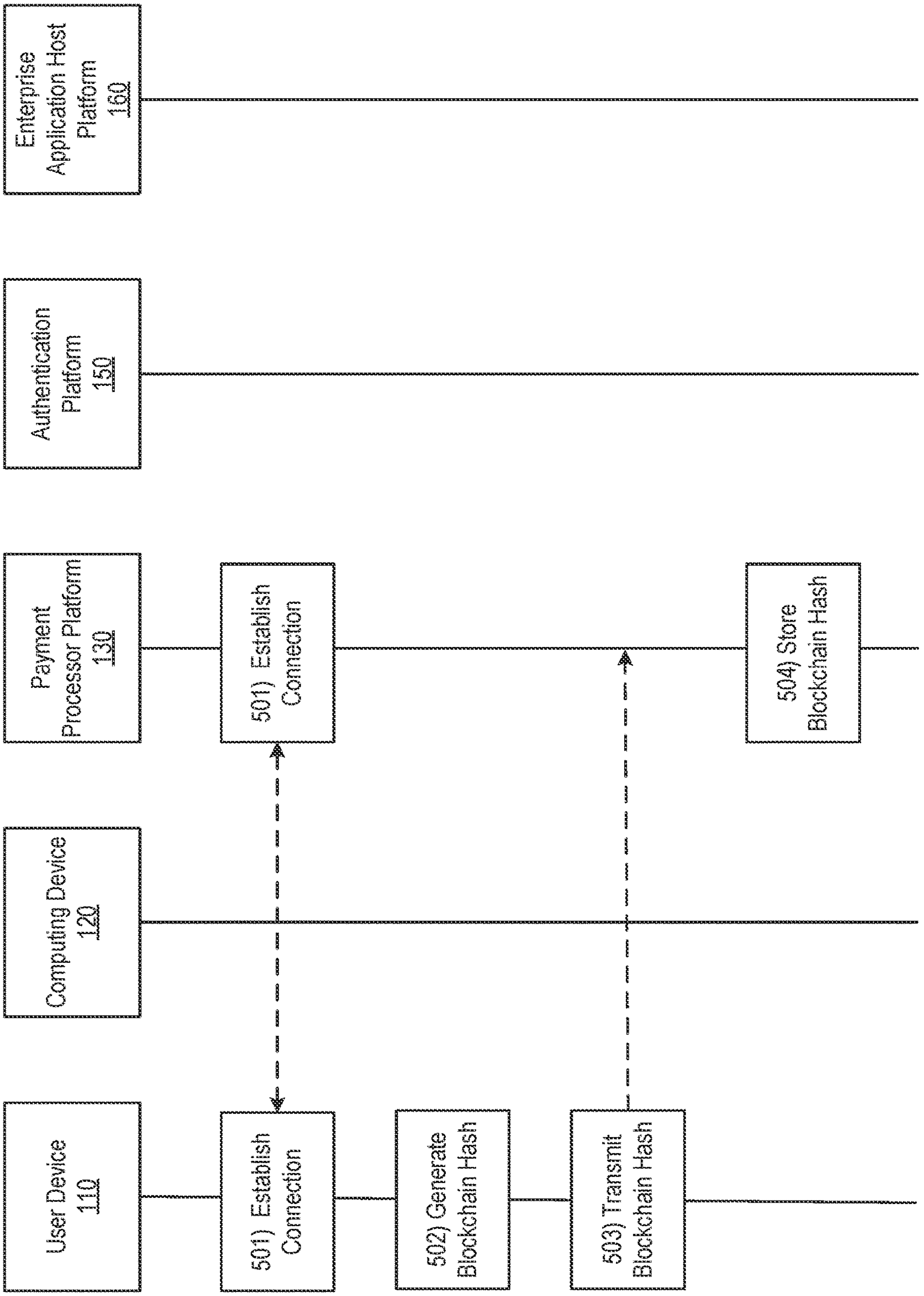

User Device 110
Computing Device 120
Payment Processor Platform 130
Authentication Platform 150
Enterprise Application Host Platform 160
501) Establish Connection
501) Establish Connection
502) Generate Blockchain Hash
503) Transmit Blockchain Hash
504) Store Blockchain Hash

FIG. 5A

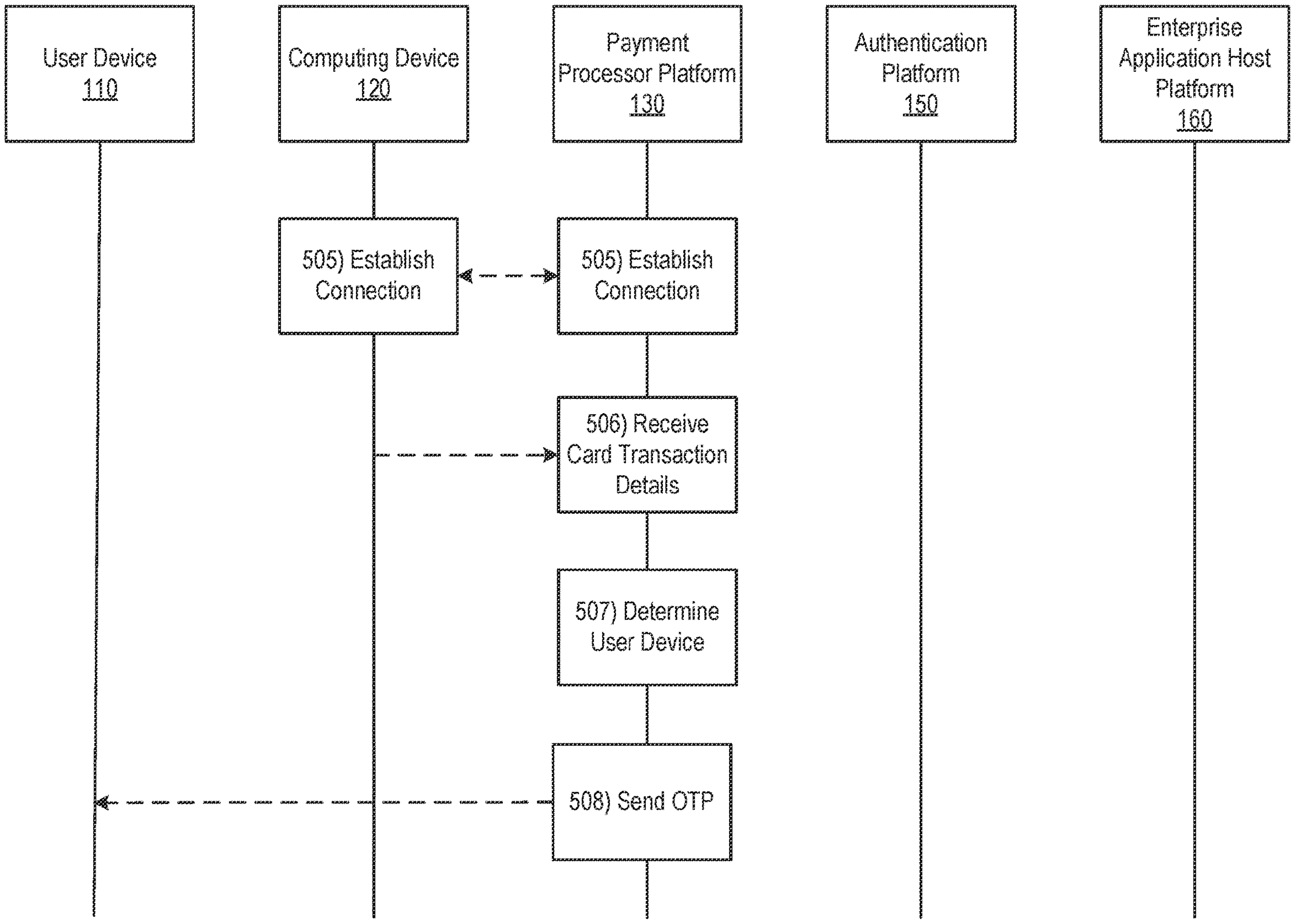

User Device
110
Computing Device
120
Payment
Processor Platform
130
Authentication
Platform
150
Enterprise
Application Host
Platform
160
505) Establish
Connection
505) Establish
Connection
506) Receive
Card Transaction
Details
507) Determine
User Device
508) Send OTP

FIG. 5B

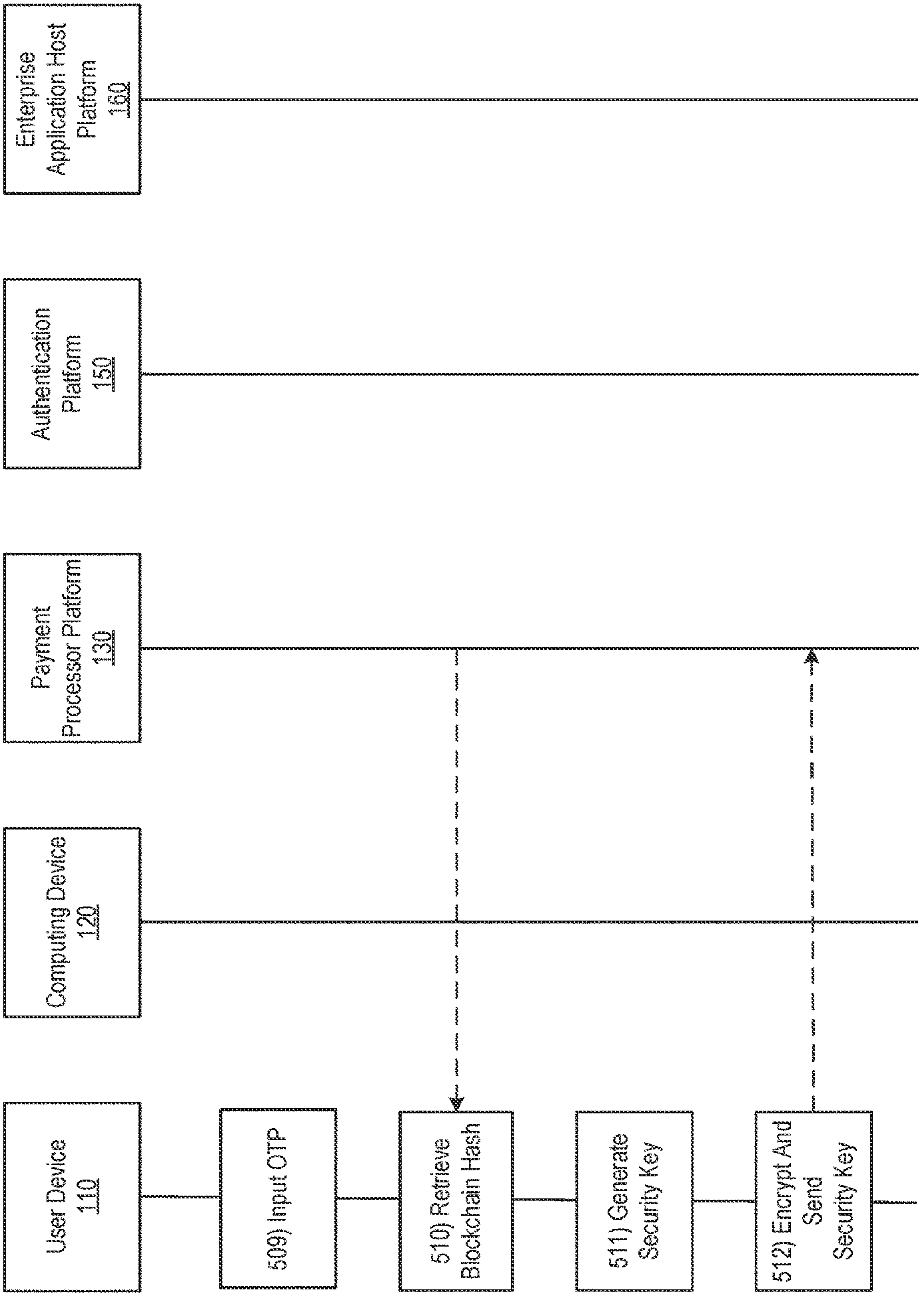

Enterprise Application Host Platform 160
Authentication Platform 150
Payment Processor Platform 130
Computing Device 120
User Device 110
509) Input OTP
510) Retrieve Blockchain Hash
511) Generate Security Key
512) Encrypt And Send Security Key

FIG. 5C

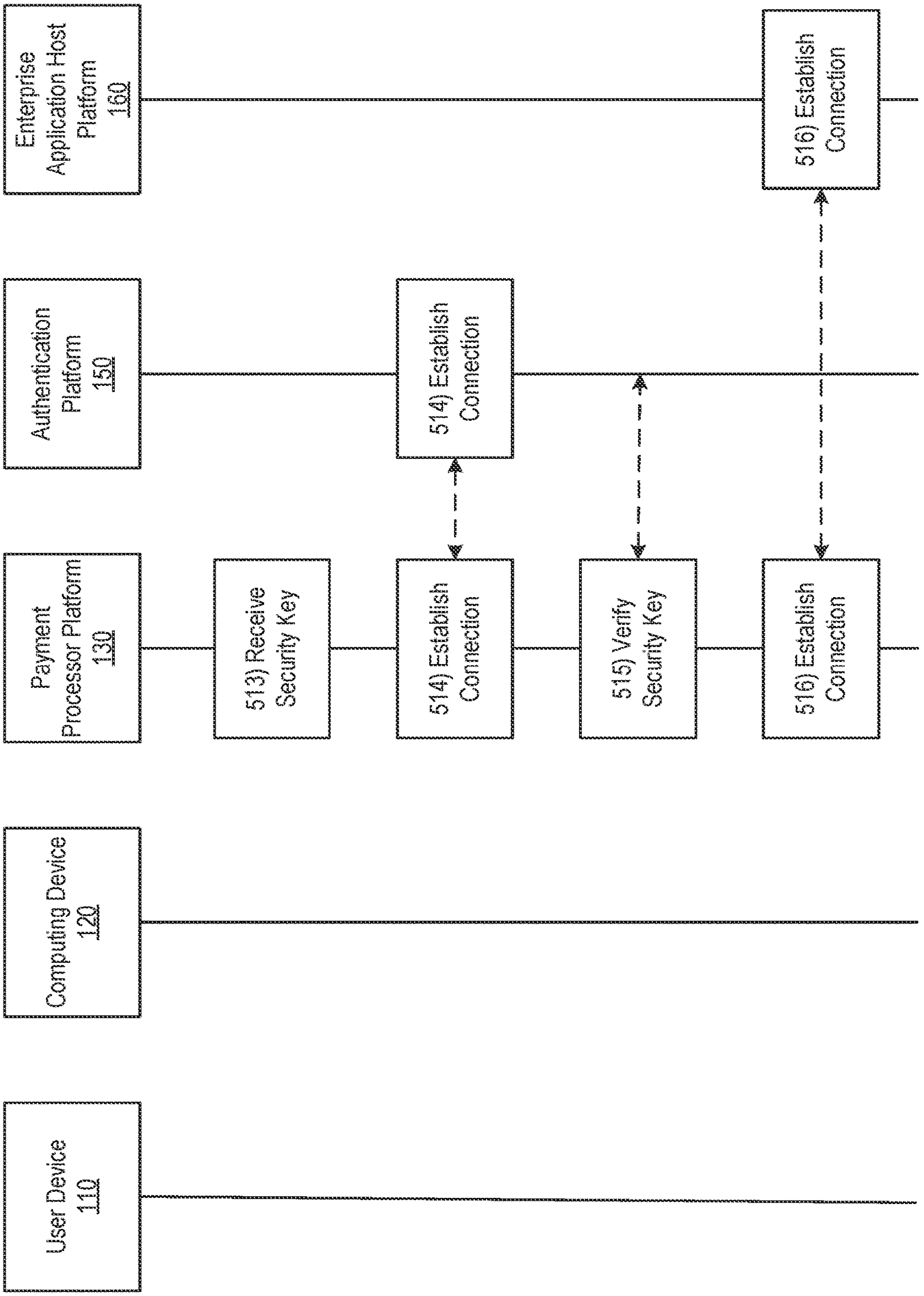

User Device 110
Computing Device 120
Payment Processor Platform 130
Authentication Platform 150
Enterprise Application Host Platform 160
513) Receive Security Key
514) Establish Connection
514) Establish Connection
515) Verify Security Key
516) Establish Connection
516) Establish Connection

FIG. 5D

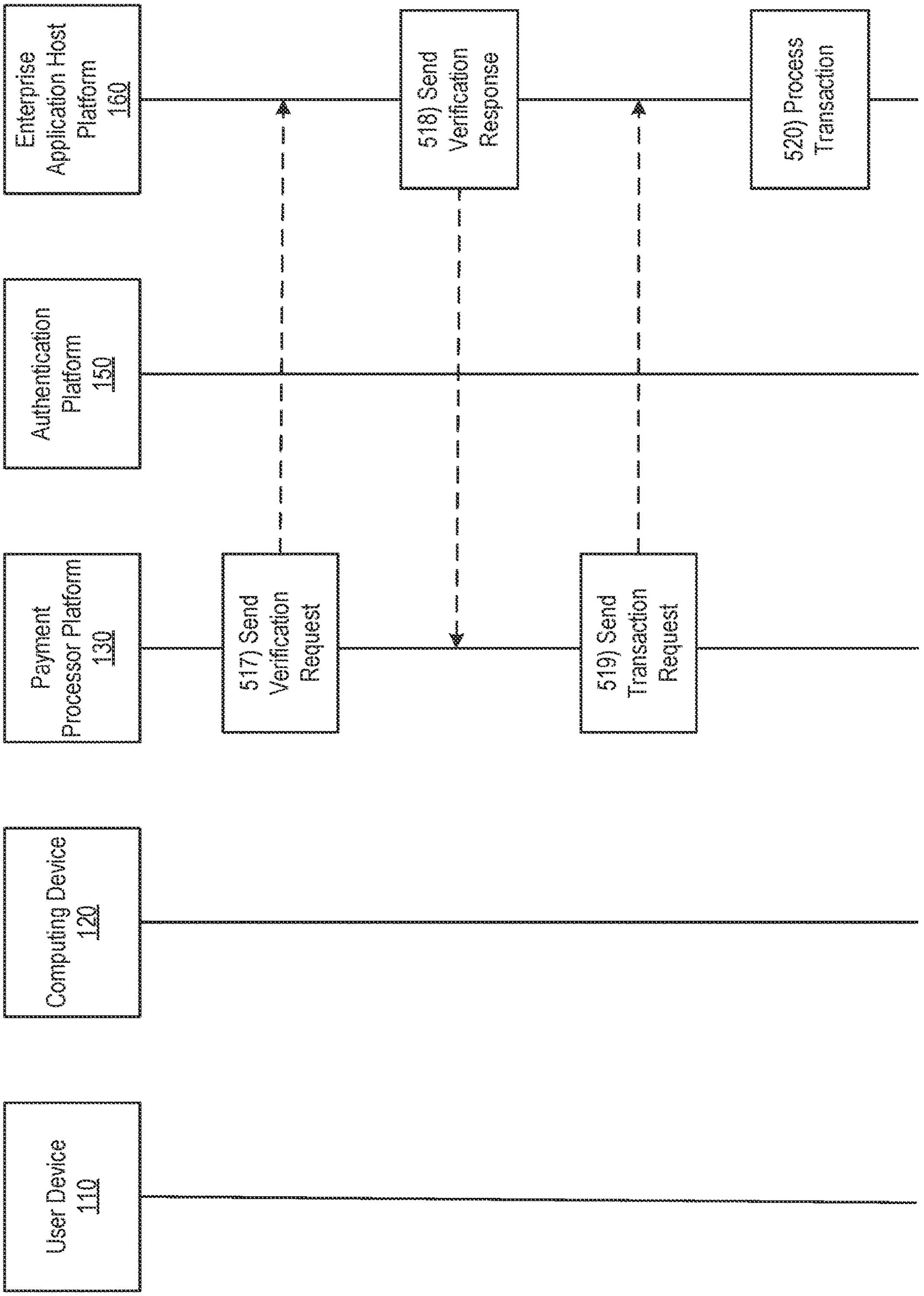

User Device 110
Computing Device 120
Payment Processor Platform 130
Authentication Platform 150
Enterprise Application Host Platform 160
517) Send Verification Request
518) Send Verification Response
519) Send Transaction Request
520) Process Transaction

FIG. 5E

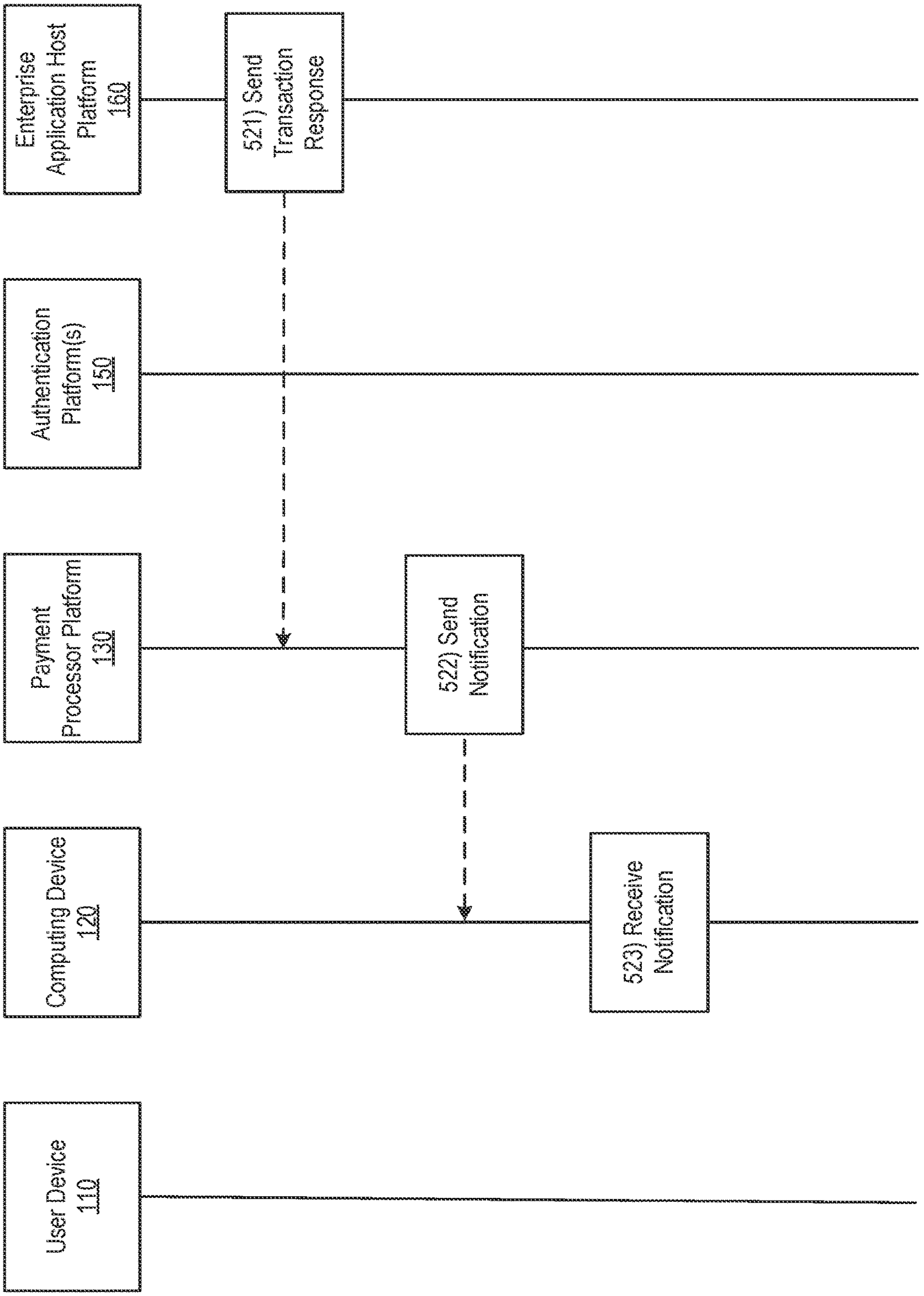

User Device 110
Computing Device 120
Payment Processor Platform 130
Authentication Platform(s) 150
Enterprise Application Host Platform 160
521) Send Transaction Response
522) Send Notification
523) Receive Notification

FIG. 5F

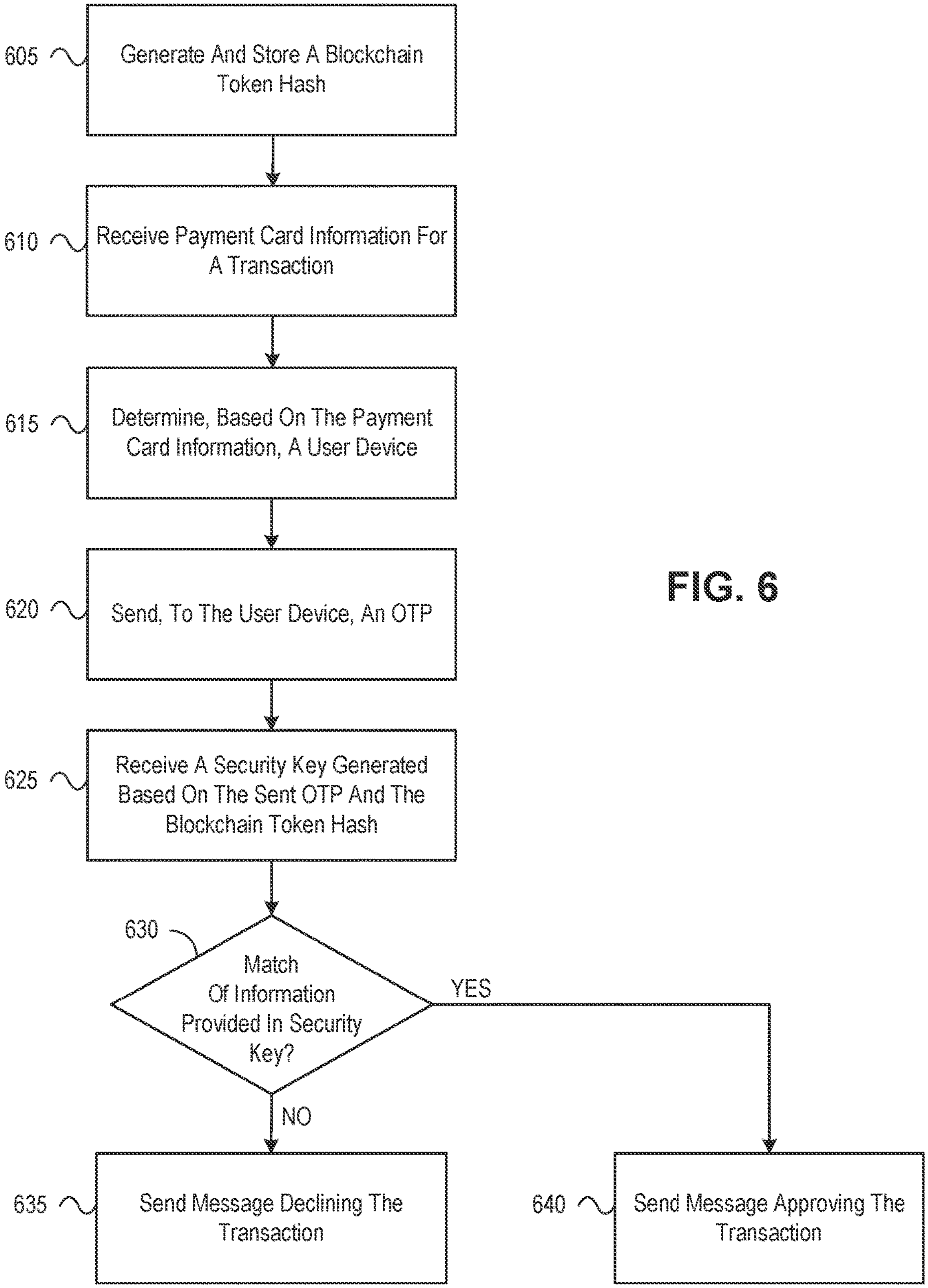

605
Generate And Store A Blockchain Token Hash
610
Receive Payment Card Information For A Transaction
615
Determine, Based On The Payment Card Information, A User Device
620
Send, To The User Device, An OTP
625
Receive A Security Key Generated Based On The Sent OTP And The Blockchain Token Hash
630
Match Of Information Provided In Security Key?
YES
NO
635
Send Message Declining The Transaction
640
Send Message Approving The Transaction

FIG. 6

MULTI-FACTOR USER AUTHENTICATION USING BLOCKCHAIN TOKENS

BACKGROUND

Aspects described herein generally relate to the field of user security, and more specifically to multi-factor user authentication for card-based payment transactions using blockchain tokens.

Payment card-based transactions (e.g., via credit/debit card) have been ubiquitous for both offline and online transactions. To prevent unauthorized use, card issuers (e.g., banks) and payment processors have put in place security protocols that may require additional user authentication. A commonly used protocol is two-factor authentication (or more generally, multi-factor authentication) where, in addition to requiring card details (e.g., card number, card verification value (CVV) number, name, expiration date, etc.), the payment processor or a card issuing bank may require a user to validate themselves using an additional layer of authentication. For example, the payment processor or the issuing bank may send a one-time password/passcode (OTP) via a short messaging service (SMS) or an email message to the user. To complete the transaction, the user would need to input the OTP at an interface/portal to complete the transaction.

SUMMARY

The following presents a simplified summary in order to provide a basic understanding of some aspects of the disclosure. The summary is not an extensive overview of the disclosure. It is neither intended to identify key or critical elements of the disclosure nor to delineate the scope of the disclosure. The following summary merely presents some concepts of the disclosure in a simplified form as a prelude to the description below.

Aspects of the disclosure provide effective, efficient, scalable, and convenient technical solutions that address and overcome the technical problems associated with user authentication and unauthorized activity prevention for card-based transactions. Specifically, methods, devices, and systems as described herein may use multi-factor authentication (e.g., in addition to standard OTP-based authentication, or augmented with OTP-based authentication) to ensure that card-based transactions are authenticated. In accordance with one or more embodiments, a computing platform having one or more processors, a communication interface, and memory may receive, from a computing device, transaction details associated with a card-based payment transaction corresponding to a user. The transaction details may include a card number of a payment card. The computing platform may determine, based on the card number, a user device associated with the user. The computing platform may send, to the user device, a one-time passcode (OTP). The computing platform may, after sending the OTP, receive a security key. In addition, the security key may be generated based on the sent OTP and a blockchain token hash. The computing platform may, based on the received security key, send, to the computing device, a message indicating whether the transaction is approved or declined.

In some embodiments, the blockchain token hash may be generated based on information associated with: the user, the user device, and the payment card.

In some arrangements, the computing platform may cause the user device to generate the security key based on a predefined rule set by a payment gateway device.

In some examples, the computing platform may cause the user device to generate the security key by interleaving the OTP and the blockchain token hash based on the predefined rule set by the payment gateway device.

In some embodiments, the computing platform may cause the user device to generate the security key by appending the blockchain token hash to the OTP.

In some example arrangements, the computing platform may cause the user device to generate the security key by prepending the blockchain token hash to the OTP.

In some examples, the message may indicate that the transaction is approved based on: the OTP provided in the security key matching the sent OTP, and the blockchain token hash provided in the security key matching a blockchain token hash, corresponding to the user, stored at a predetermined number of nodes associated with a plurality of card networks.

In some arrangements, the message may indicate that the transaction is declined based on one or more of: the OTP provided in the security key not matching the sent OTP; or the blockchain token hash provided in the security key not matching a blockchain token hash, corresponding to the user, stored at a predetermined number of nodes associated with a plurality of card networks.

In some embodiments, the payment card may be a credit card or a debit card.

In some examples, the user device may be a mobile communication device.

In some embodiments, receiving the security key may include receiving the security key via the user device.

BRIEF DESCRIPTION OF THE DRAWINGS

The present disclosure is illustrated by way of example and not limited in the accompanying figures in which like reference numerals indicate similar elements and in which:

FIG. **1** shows an illustrative computing environment in which an authentication system for processing card-based transactions may be deployed, in accordance with one or more example arrangements;

FIG. **2** shows an example computing platform, in accordance with one or more examples described herein;

FIG. **3** shows an example user device, in accordance with one or more examples described herein;

FIG. **4** shows an example procedure process for multi-factor authentication, based on an OTP and a blockchain token, of a card-based transaction, in accordance with one or more example arrangements;

FIGS. **5**A-**5**F show an example event sequence for multi-factor authentication of a card-based transaction based on a blockchain token, in accordance with one or more example arrangements; and

FIG. **6** shows an example process for authenticating a transaction based on a blockchain token, in accordance with one or more example arrangements.

DETAILED DESCRIPTION

In the following description of various illustrative embodiments, reference is made to the accompanying drawings, which form a part hereof, and in which is shown, by way of illustration, various embodiments in which aspects of the disclosure may be practiced. It is to be understood that other embodiments may be utilized, and structural and functional modifications may be made, without departing from the scope of the present disclosure.

It is noted that various connections between elements are discussed in the following description. It is noted that these connections are general and, unless specified otherwise, may be direct or indirect, wired or wireless, and that the specification is not intended to be limiting in this respect.

While multi-factor authentication systems (e.g., as described above) may provide security against unauthorized activity in most scenarios, it might not be completely secure. For example, two-factor authentication based on OTP (e.g., as may be sent via an SMS message) may be diverted to a device of an attacker, instead of a device of an authorized user. The attacker may, based on the diverted OTP, initiate an unauthorized card-based transaction.

FIG. **1** shows an illustrative computing environment **100** in which an authentication system for processing card-based transactions may be deployed, in accordance with one or more arrangements. The computing environment **100** may comprise one or more devices (e.g., computer systems, communication devices, and the like). The computing environment **100** may comprise, for example, an authentication platform **150**, an enterprise application host platform **160**, and/or one or more enterprise user computing devices **120**. The one or more of the devices and/or systems, may be linked over a private network **170**. In an arrangement, the private network **170** may be associated with an enterprise organization (e.g., a bank/financial institution). For example, the private network **170** may correspond to a network associated with an issuing bank of a payment card (e.g., credit card, debit card). The payment card may be issued to an authorized user for initiating transactions.

The computing environment **100** may additionally comprise one or more external devices/systems connected, via a public network **180**, to the devices in the private network **170**. For example, the public network **180** may comprise user device(s) **110** that may be used to initiate card-based transactions. The public network **180** may further comprise various platforms associated with a card payment infrastructure that facilitates card-based transactions. For example, the public network **180** may comprise one or more payment processor platform(s) **130** and one or more verification platform(s) **140**.

The devices in the computing environment **100** may transmit/exchange/share information via hardware and/or software interfaces using one or more communication protocols. The communication protocols may be any wired communication protocol(s), wireless communication protocol(s), one or more protocols corresponding to one or more layers in the Open Systems Interconnection (OSI) model (e.g., local area network (LAN) protocol, an Institution of Electrical and Electronics Engineers (IEEE) 802.11 WIFI protocol, a 3rd Generation Partnership Project (3GPP) cellular protocol, a hypertext transfer protocol (HTTP), and the like).

The authentication platform **150** may comprise one or more computing devices and/or other computer components (e.g., processors, memories, communication interfaces) configured to perform one or more functions as described herein (e.g., as described with reference to FIGS. **4-6**). For example, the authentication platform **150** may comprise one or more computers (e.g., laptop computers, desktop computers, servers, server blades, or the like). As described herein, the authentication platform **150** may authenticate a user requesting a card-based payment transaction using multi-factor authentication. The authentication may be based on one or more of an OTP, a blockchain token, a hash of a blockchain token, a security key generated at a user device, etc.

The enterprise application host platform **160** may comprise one or more computing devices and/or other computer components (e.g., processors, memories, communication interfaces). In addition, the enterprise application host platform **160** may be configured to host, execute, and/or otherwise provide one or more enterprise applications. In an arrangement where the private network **170** is associated with a banking/financial organization, the enterprise application host platform **160** may be configured, for example, to host, execute, and/or otherwise provide one or more transaction processing programs, such as online banking applications, fund transfer applications, data transmission applications, and/or other programs associated with the financial institution. The enterprise application host platform **160** may comprise various servers and/or databases that store and/or otherwise maintain account information, such as financial account information including account balances, transaction history, account owner information, and/or other information. In addition, the enterprise application host platform **160** may process and/or otherwise execute transactions on specific accounts based on commands and/or other information received from other computer systems comprising the computing environment **100**.

For example, the enterprise application host platform **160** may determine available funds in a user account associated with a debit card, or an available credit corresponding to a credit card (e.g., as described at step **518**). Based the determining, the enterprise application host platform **160** may initiate a card-based payment transaction (e.g., fund transfer to a recipient account), or send a notification to one or more platforms in the computing environment **100** indicating that the transaction may be approved.

The enterprise user computing device(s) **120** and/or the user device(s) **110** may be personal computing devices (e.g., desktop computers, laptop computers) or mobile computing devices (e.g., smartphones, tablets). The enterprise user computing device(s) **120** may be linked to and/or operated by specific enterprise users (who may, for example, be employees or other affiliates of the enterprise organization).

The user device(s) **110** may be linked to and/or operated by clients associated with the banking/financial organization (e.g., who may have been issued payment cards). The user device(s) **110** may be used to request a credit/debit card transaction via a payment interface (e.g., an online payment portal). A user device **110** may be a cellphone to which an OTP may sent (e.g., by an authentication platform, payment processor platform, etc.). A user device **110** may be a smartphone that may be used to generate and transmit a security key for validation at the authentication platform **150**. A user device **110** may be a smartphone that may comprise a keypad interface that may be used to input a received OTP.

The payment processor platform(s) **130** and the verification platform(s) **140** may comprise one or more computing devices and/or other computer components (e.g., processors, memories, communication interfaces). The payment processor platform(s) **130** may correspond to one or more payment processors. The verification platform(s) **140** may include a card network platform, a financial institution platform, or the like. The payment processor platform(s) **130** and the verification platform(s) **140** may be configured to host, execute, and/or otherwise provide one or more applications for enabling card-based transactions. For example, the payment processor platform(s) **130** and the verification platform(s)

140 may facilitate transmission of transaction data (e.g., transaction details, authorization responses, etc.) between payment interfaces and bank networks. A payment processor may maintain connections with multiple different card networks. The payment processor forward transaction details, associated with a payment transaction that uses a card, to a card network corresponding to the card. Additionally, the payment processor platform(s) **130** or the verification platform(s) **140** may perform one or more of the authentication steps as described herein.

In one or more arrangements, the authentication platform **150**, the enterprise application host platform **160**, the enterprise user computing devices **120**, the user device(s) **110**, the payment processor platform(s) **130**, the verification platform (s) **140**, and/or other devices/systems in the computing environment **100** may be any type of computing device capable of receiving input via a user interface, and communicating the received input to one or more other computing devices in the computing environment **100**. For example, the authentication platform **150**, the enterprise application host platform **160**, the enterprise user computing devices **120**, the user device(s) **110**, the payment processor platform(s) **130**, the verification platform(s) **140**, and/or the other devices/systems in the computing environment **100** may, in some instances, be and/or include server computers, desktop computers, laptop computers, tablet computers, smart phones, wearable devices, or the like that may comprised of one or more processors, memories, communication interfaces, storage devices, and/or other components. Any and/or all of the authentication platform **150**, the enterprise application host platform **160**, the enterprise user computing devices **120**, the user device(s) **110**, the payment processor platform(s) **130**, the verification platform(s) **140**, and/or the other devices/systems in the computing environment **100** may, in some instances, be and/or comprise special-purpose computing devices configured to perform specific functions.

FIG. **2** shows an example computing platform **150**, in accordance with one or more examples described herein. Although functions and aspects are described as associated with authentication platform **150**, payment processor platform **130** may include the same or similar modules, perform the same or similar functions, and/or the like. The authentication platform **150** may comprise one or more of host processor(s) **205**, medium access control (MAC) processor (s) **210**, physical layer (PHY) processor(s) **215**, transmit/receive (TX/RX) module(s) **215***a*, memory **225**, and/or the like. One or more data buses may interconnect host processor(s) **205**, MAC processor(s) **210**, PHY processor(s) **215**, and/or Tx/Rx module(s) **215***a*, and/or memory **225**. The authentication platform **150** may be implemented using one or more integrated circuits (ICs), software, or a combination thereof, configured to operate as discussed below. The host processor(s) **205**, the MAC processor(s) **210**, and the PHY processor(s) **215** may be implemented, at least partially, on a single IC or multiple ICs. Memory **225** may be any memory such as a random-access memory (RAM), a read-only memory (ROM), a flash memory, or any other electronically readable memory, or the like.

Messages transmitted from and received at various devices (e.g., in the computing environment **100**) may be encoded in one or more MAC data units and/or PHY data units. The MAC processor(s) **210** and/or the PHY processor (s) **215** of the authentication platform **150** may be configured to generate data units, and process received data units, that conform to any suitable wired and/or wireless communication protocol. For example, the MAC processor(s) **210** may be configured to implement MAC layer functions, and the PHY processor(s) **215** may be configured to implement PHY layer functions corresponding to the communication protocol. The MAC processor(s) **210** may, for example, generate MAC data units (e.g., MAC protocol data units (MPDUs)), and forward the MAC data units to the PHY processor(s) **215**. The PHY processor(s) **215** may, for example, generate PHY data units (e.g., PHY protocol data units (PPDUs)) based on the MAC data units. The generated PHY data units may be transmitted via the TX/RX module(s) **215***a* over the private network **170**. Similarly, the PHY processor(s) **215** may receive PHY data units from the TX/RX module(s) **215***a*, extract MAC data units encapsulated within the PHY data units, and forward the extracted MAC data units to the MAC processor(s). The MAC processor(s) **210** may then process the MAC data units as forwarded by the PHY processor(s) **215**.

One or more processors (e.g., the host processor(s) **205**, the MAC processor(s) **210**, the PHY processor(s) **215**, and/or the like) of the authentication platform **150** may be configured to execute machine readable instructions stored in memory **225**. The memory **225** may comprise one or more program modules/engines having instructions that when executed by the one or more processors cause the authentication platform **150** to perform one or more functions described herein. The one or more program modules/engines and/or databases may be stored by and/or maintained in different memory units of the authentication platform **150** and/or by different computing devices that may form and/or otherwise make up the authentication platform **150**. For example, the memory **225** may have, store, and/or comprise an authentication engine **225***a* and/or a user credential database **225***b*.

The authentication engine **225***a* may have instructions that direct and/or cause the authentication platform **150** to perform one or more operations relating to transaction authentication (e.g., based one or more of an OTP, a blockchain token, a hash of a blockchain token, a security key, etc., as described with respect to FIGS. **4**-**6**). The user credential database **225***b* may comprise user credentials, associated with a plurality of users corresponding to the issuing bank or a payment processor, that may be used for various steps corresponding to authenticating a transaction. For example, the user credential database **225***b* may store a cell phone number associated with a user (e.g., for sending an OTP), an OTP as sent to a user device, etc. The various credentials corresponding to a user may be associated, in the user credential database **225***b*, with a card number of a payment card of the user. In this manner, when transaction details (e.g., comprising a card number) for a user transaction are received at the authentication platform **150**, the computing platform may send an OTP to a user device based on retrieving a cell phone number, and further validate a received security key.

While FIG. **1** illustrates the authentication platform **150**, the enterprise application host platform **160**, and the enterprise user computing devices **120**, as being separate elements connected in the private network **170**, in one or more other arrangements, functions of one or more of the above may be integrated in a single device/network of devices. For example, elements in the authentication platform **150** (e.g., host processor(s) **205**, memory(s) **225**, MAC processor(s) **210**, PHY processor(s) **215**, TX/RX module(s) **215***a*, and/or one or more program/modules stored in memory(s) **225**) may share hardware and software elements with and corresponding to, for example, the enterprise application host platform **160** and/or the enterprise user computing devices **120**.

FIG. **3** shows an example user device **110**, in accordance with one or more examples described herein. The user device **110** may correspond to a device that may be used for multi-factor authentication as described herein. The user device **110** may comprise one or more of host processor(s) **305**, medium access control (MAC) processor(s) **310**, physical layer (PHY) processor(s) **315**, transmit/receive (TX/RX) module(s) **315***a*, memory **325**, and/or the like. One or more data buses may interconnect host processor(s) **305**, MAC processor(s) **310**, PHY processor(s) **315**, and/or Tx/Rx module(s) **315***a*, and/or memory **325**. The user device **110** may be implemented using one or more integrated circuits (ICs), software, or a combination thereof, configured to operate as discussed below. The host processor(s) **305**, the MAC processor(s) **310**, and the PHY processor(s) **315** may be implemented, at least partially, on a single IC or multiple ICs. Memory **325** may be any memory such as a random-access memory (RAM), a read-only memory (ROM), a flash memory, or any other electronically readable memory, or the like.

Messages transmitted from and received at various devices (e.g., in the computing environment **100**) may be encoded in one or more MAC data units and/or PHY data units. The MAC processor(s) **310** and/or the PHY processor (s) **315** of the user device **110** may be configured to generate data units, and process received data units, that conform to any suitable wired and/or wireless communication protocol. For example, the MAC processor(s) **310** may be configured to implement MAC layer functions, and the PHY processor (s) **315** may be configured to implement PHY layer functions corresponding to the communication protocol. The MAC processor(s) **310** may, for example, generate MAC data units (e.g., MAC protocol data units (MPDUs)), and forward the MAC data units to the PHY processor(s) **315**. The PHY processor(s) **315** may, for example, generate PHY data units (e.g., PHY protocol data units (PPDUs)) based on the MAC data units. The generated PHY data units may be transmitted via the TX/RX module(s) **315***a* over the private network **180**. Similarly, the PHY processor(s) **315** may receive PHY data units from the TX/RX module(s) **315***a*, extract MAC data units encapsulated within the PHY data units, and forward the extracted MAC data units to the MAC processor(s). The MAC processor(s) **310** may then process the MAC data units as forwarded by the PHY processor(s) **315**.

One or more processors (e.g., the host processor(s) **305**, the MAC processor(s) **310**, the PHY processor(s) **315**, and/or the like) of the user device **110** may be configured to execute machine readable instructions stored in memory **325**. The memory **325** may comprise one or more program modules/engines having instructions that when executed by the one or more processors cause the user device **110** to perform one or more functions described herein. The one or more program modules/engines and/or databases may be stored by and/or maintained in different memory units of the user device **110** and/or by different computing devices that may form and/or otherwise make up the user device **110**. For example, the memory **325** may have, store, and/or comprise a blockchain token module **325***a*.

The blockchain token module **325***a* may have instructions that direct and/or cause the user device **110** to generate a blockchain token hash (e.g., based on user information, device information, and/or card information). In addition, the blockchain token module **325***a* may have instructions that direct and/or cause the user device **110** to generate a security key (e.g., based on a received OTP and the blockchain token hash). The blockchain token module **325***a* may further cause the user device to send the security key for validation at an authentication platform.

FIG. **4** shows an example system for implementing a process for an augmented multi-factor authentication, based on an OTP and a blockchain token, of a card-based transaction, beginning with a registration process of generating a blockchain token associated with an authorized user. A user device **110** (e.g., a smartphone), corresponding to the authorized user, may comprise a mobile application executing thereon (e.g., a credit card provider application, a financial institution application, or the like). In an arrangement, the mobile application (or a link to download and install the mobile application) may be provided to the user when the user executes a triggering event (e.g., is issued a payment card (e.g., credit/debit card) by an issuing bank, opens an account, or the like). The mobile application may generate a blockchain token and its hash corresponding to the user. The hash may be generated based on user information (e.g., card number, user name, card account number, bank account number, etc.), device information (e.g., mobile device identifier), and/or card information (e.g., credit card number).

The mobile application installed on user device **110** may encrypt and send the blockchain token hash **405** to a payment processing gateway (e.g., payment processor platform **130** that may be in communication with or include a card network platform, a financial institution platform, or the like). For example, the blockchain token and its hash may be encrypted and sent to payment processing platform **130** for registration on a blockchain network of a credit card provider system. In some examples, the payment processor platform **130** may be in communication with more than one credit card provider systems or platforms (e.g., corresponding to different credit card companies or banks/financial institutions). In some examples, the user device **110** may distribute the blockchain token hash **405** (and the associated user information) for storage in corresponding blockchain networks of the payment processor platform **130** and other platforms. Each of the platforms may correspond to "nodes" that may be used to validate a future received blockchain token hash **405** for validating a transaction, as further described herein.

Following the registration process, a user may initiate/request a card-based transaction (e.g., credit card/debit card payment to a merchant). For example, the user device **110** may be used to request a card-based transaction via a payment interface (e.g., an online payment portal). The payment interface **304** may receive at least some of transaction details for the card-based transaction. The transaction details may include one or more of: a card number, CVV number, user name, expiration date, transaction amount, a recipient account number, recipient bank, merchant identifier (ID), merchant category code (MCC), etc. The payment interface may comprise a payment portal provided via a web page associated with an online merchant, and provided on a computing device requesting the transaction. In another example, the payment interface may comprise a card reader device (e.g., at a brick and mortar store) that may be used to scan/read the card and determine at least some of the transaction details.

The payment interface may encrypt and send the transaction details (e.g., as part of a transaction request **410**) to a network associated with an issuing bank/financial institution of the card. The transaction details may be forwarded by payment processor platform **130** that facilitates communication between the payment interface and the network associated with the issuing bank. The payment processor platform **130** may comprise one or more platforms that function as/correspond to a payment gateway, payment processor, card network infrastructure, etc., that perform various functions associated with processing a card-based transaction.

For example, the payment interface may send the transaction details to an authentication platform **150** associated with the issuing bank. The network associated with the issuing bank may comprise one or more other platforms/servers to review the transaction details to confirm that the transaction details are valid (e.g., valid card number, user name, expiration date, etc.). The authentication platform **150** may determine a user associated with the card based on the transaction details (e.g., the card number). The authentication platform **150** may determine a user device **110** (e.g., cell phone number) associated with the user based on the transaction details. Following this, the authentication platform **150** may send a message (e.g., an SMS message), via a communication network **450** (e.g., a cellular network) to the user device **110**, wherein the message may comprise a randomly-generated, single-use OTP **415**. In an arrangement, the user device **110** may be the same as the computing device processing or requesting processing of the transaction. In an arrangement, the user device **110** may be different from the computing device processing or requesting processing of the transaction.

A security key **420** may be determined and generated based on the sent OTP **415**. For example, the user device **110** may generate the security key **420** by amending the blockchain token hash (e.g., stored during the registration process and retrieved from one or more nodes associated with a plurality of card networks) to include the sent OTP **415**. The blockchain token and its hash may be generated, for example, when the user registers a credit card (e.g., via a credit card application) on their mobile communication device. The blockchain token hash may comprise a string of numeric or alphanumeric characters.

The security key **420** may be determined using the blockchain token hash and the OTP **415**, and further based on based on one or more predefined rules set by a payment gateway device. In some examples, the one or more predefined rules may be set by the payment gateway device at the time of a transaction. Consider an example where the blockchain token hash is $H_1H_2H_3H_4H_5H_6H_7H_8H_9$, and the OTP **415** is $O_1O_2O_3O_4O_5O_6$. The one or more predefined rules may indicate the manner in which the characters/numbers of the blockchain token hash and the OTP **415** are to be placed for generating the security key **420**.

The one or more predefined rules may indicate that the blockchain token hash and the OTP are to be interleaved as per a specific pattern to generate the security key **420**. For example, the one or more predefined rules may indicate that the security key **420** may be generated as $H_1H_2H_3H_4H_5H_6O_1O_2O_3O_4O_5O_6H_7H_8H_9$. As another example, the one or more predefined rules may indicate that the security key **420** may be generated as $H_1H_2O_1O_2H_3H_4H_5H_6O_3O_4O_5H_7H_8H_9O_6$.

The one or more predefined rules may indicate that the security key **420** may be generated by appending the blockchain token hash to (e.g., add on to the end of) the OTP **415**. For example, the one or more predefined rules may indicate that the security key **420** may be generated as $O_1O_2O_3O_4O_5O_6H_1H_2H_3H_4H_5H_6H_7H_8H_9$.

The one or more predefined rules may indicate that the security key **420** may be generated by prepending the blockchain token hash to (e.g., add on to the beginning of) the OTP **415**. For example, the one or more predefined rules may indicate that the security key **420** may be generated as $H_1H_2H_3H_4H_5H_6H_7H_8H_9O_1O_2O_3O_4O_5O_6$.

The above are merely illustrations and any other predefined rule or code patterns may be used for generating the security key **420** based on the blockchain token hash and the sent OTP **415**. The payment gateway device may set the one or more predefined rules, for example, when the user sets up their card account. Additionally or alternatively, in at least some examples, the blockchain token hash may be amended to include the OTP in a random position.

The user device **110** may encrypt and send the security key **420** to the payment processor platform **130** (e.g., payment processing gateway). The payment processor platform **130** may forward the security key **420** to the authentication platform **150** (e.g., via Internet, using hypertext transfer protocol (HTTP), or other communication channel **1**). The OTP **415** may be time-sensitive, and the authentication platform **150** may expect to receive the security key **420** within a predetermined time period following the sending of the OTP **415** to the user device **110**.

The authentication platform **112** may decrypt the received security key **420** and extract the OTP and the blockchain token hash from the security key. In some examples, only when both the OTP and the blockchain token hash provided in the security key are successfully verified, the transaction may be authorized. For example, based on the OTP provided in the security key **420** matching the sent OTP and the blockchain token hash provided in the security key matching a blockchain token hash stored at a predetermined number of nodes associated with a plurality of card networks, the authentication platform **150** may approve the transaction. Based on the OTP provided in the security key **420** not matching the sent OTP or the blockchain token hash provided in the security key not matching a blockchain token hash, corresponding to the user, stored at a predetermined number of nodes associated with a plurality of card networks (or the security key **420** not being received within the predetermined time period), the authentication platform **150** may decline the transaction. Approving or declining the transaction may further be based on determining whether an account associated with the user has sufficient balance or credit for the transaction. For example, the authentication platform **150** may communicate with one or more other servers/platforms within the bank network to determine account details associated with the card and determine whether the account associated with the card has sufficient balance or credit for the transaction. Based on approving the transaction, the authentication platform **150** may send an indication to one or more other servers/platforms within the bank network to initiate processing of the transaction.

The authentication platform **150** may send an authorization response **425** to the payment interface, via payment processor platform **130**. The authorization response **425** may indicate whether the transaction is approved or declined. The payment interface may indicate whether the transaction is approved or declined based on the authorization response **425**.

The procedure described with reference to FIG. **4** may be integrated with existing card-based payment infrastructure. For example, existing protocols and messages associated with standard two-factor authentication (e.g., sending an OTP and receiving a user response) do not need to be modified. The OTP may be sent via an SMS which may ensure that the procedures may function even in scenarios with basic cellular infrastructure (e.g., no internet connectivity).

Accordingly, by relying on the security key including both the blockchain hash and OTP to authorize a transaction, even if a malicious actor is able to divert an OTP, the malicious actor would not be able to gain knowledge of the blockchain token and/or its hash (e.g., via social engineering/phishing) to process the transaction. Since a user's blockchain token hash is stored in, for example a payment processing gateway that may be in communication with or include the backend of a credit card company's mobile application, without having full physical control over a user's device, the malicious actor would not be able to authenticate the transaction. It would be difficult for the malicious actor to authenticate themselves short of compromising the communication network, the payment processing gateway, and the whole blockchain network of the credit card company, in addition to knowing the user's credit card details (e.g., credit card number). The authentication platform may block any transactions associated with the card if a number of failed transactions exceeds a threshold. As such, the blockchain token based authentication mechanism described herein has multiple additional layers of security over standard two-factor OTP traditionally used for payment authentication.

FIGS. **5**A-**5**F show an example event sequence for multi-factor authentication of a card-based transaction in accordance with one or more arrangements described herein. As discussed herein, the multi-factor authentication may use a blockchain token hash associated with authorized user information, device information, and/or card information amended to include a generated OTP to authorize the transaction. A user may input at least some of transaction details for the card-based transaction (e.g., credit card/debit card payment transaction) via a payment interface. The transaction details may comprise/indicate one or more of a card number, CVV number, user name, expiration date, transaction amount, recipient account number, recipient bank ID, etc. The payment interface may correspond to a payment portal provided via a web page associated with an online merchant, and provided on a computing device **120** requesting processing of the transaction. In another example, the computing device **120** may correspond to a card reader device (e.g., at a brick and mortar store) that may be used to scan/read the card and determine at least a portion of the transaction details.

Referring to FIG. **5**A, at step **501**, user device **110** may connect to (e.g., establish a connection with) payment processor platform **130**. For example, user device **110** may establish a first wireless data connection with payment processor platform **130** to link user device **110** with payment processor platform **130**. In some instances, user device **110** may identify whether or not a connection is already established with payment processor platform **130**. If a connection is already established with payment processor platform **130**, user device **110** might not re-establish the connection. If a connection is not yet established with payment processor platform **130**, user device **110** may establish the first wireless data connection as described above.

A registration process may be performed, for example, at steps **502** through **504**. At step **502**, user device **110** may generate a blockchain hash (e.g., based on user information, device information, and/or card information). At step **503**, user device **110** may transmit (e.g., while the first wireless data connection is established) the blockchain hash to a payment processor (e.g., payment processor platform **130**). In turn, at step **504**, payment processor platform **130** may store the blockchain hash. In some examples, the blockchain hash may be stored in a payment processing gateway that may be in communication with or include the backend of a credit card company's mobile application. In some examples, the registration may be performed via an application executing on the user device (e.g., user device **110**).

Referring to FIG. **5**B, at step **505**, computing device **120** may connect to (e.g., establish a connection with) payment processor platform **130**. For example, computing device **120** may establish a second wireless data connection with payment processor platform **130** to link computing device **120** with payment processor platform **130**. In some instances, computing device **120** may identify whether or not a connection is already established with payment processor platform **130**. If a connection is already established with payment processor platform **130**, computing device **120** might not re-establish the connection. If a connection is not yet established with payment processor platform **130**, computing device **120** may establish the second wireless data connection as described above.

At step **506**, a payment processor platform **130** may receive, from the computing device **120** (e.g., while the second wireless data connection is established), the transaction details. In an arrangement, the payment processor platform **130** may receive the transaction details from the computing device via a payment gateway.

At step **507**, the payment processor platform **130** may determine or identify a user device **110** associated with the user based on the transaction details. The user device **110** may be a smartphone and determining or identifying the user device **110** may comprise determining a cell phone number corresponding to the user device **110** (e.g., based on data provided via, for instance, a registration process and stored in association with user identifying data).

Following this, the payment processor platform **130** may send, at step **508** (e.g., while the first wireless data connection is established), a message (e.g., an SMS message), via a communication network (e.g., a cellular network) to the user device **110**, wherein the message may comprise a randomly-generated, single-use OTP. In an arrangement, the user device **110** may be the same as the computing device **120** requesting the transaction. In an arrangement, the user device **110** may be different from the computing device **120** requesting the transaction.

Referring to FIG. **5**C, at step **509**, the user may input the OTP at the user device **110**. At step **510**, user device **110** may retrieve (e.g., while the first wireless data connection is established), the stored blockchain hash (e.g., from payment processor platform **130**). At step **511**, the user device **110** may generate a security key based on the OTP and a blockchain token hash associated with the user and stored by, for instance, the payment processor platform **130** in communication with or including the credit card back end and/or the user device **110**. At step **512**, the user device **110** may encrypt and send (e.g., while the first wireless data connection is established) the security key to the payment processor platform **130** which may, in some examples, be associated with the card network. The OTP may be time-sensitive, and the payment processor platform **130** may expect to receive the security key within a predetermined time period following the sending of the OTP to the user device **110**.

Referring to FIG. **5**D, at step **513**, payment processor platform **130** may receive the encrypted security key sent by the user device **502**. At step **514**, payment processor platform **130** may connect to (e.g., establish a connection with) authentication platform **150**. For example, payment processor platform **130** may establish a third wireless data connection with authentication platform **150** to link payment processor platform **130** with authentication platform **150**. In some instances, payment processor platform **130** may identify whether or not a connection is already established with authentication platform **150**. If a connection is already established with authentication platform **150**, payment processor platform **130** might not re-establish the connection. If a connection is not yet established with authentication platform **150**, payment processor platform **130** may establish the third wireless data connection as described above.

At step **515**, the payment processor platform **130** may verify (e.g., while the third wireless data connection is established) the security key as received from the user device **110**. Verifying the security key may comprise payment processor platform **130** decrypting the security key, extracting the OTP from the security key, comparing the extracted OTP with the OTP sent by the payment processor platform **130** (e.g., at step **508**), and verifying the blockchain token with the blockchain node stored at the payment processor platform **130** in communication with or including the credit card back end. The payment processor platform **130** may determine that the user is authenticated based on the OTP provided in the security key matching the sent OTP and the blockchain token hash provided in the security key matching a blockchain token hash stored at a predetermined number of nodes associated with a plurality of card networks. The payment processor platform **130** may determine that the user is not authenticated based on the OTP provided in the security key not matching the sent OTP, or the blockchain token hash provided in the security key not matching a blockchain token hash, corresponding to the user, stored at a predetermined number of nodes associated with a plurality of card networks. In an example, verifying the received blockchain token hash may comprise comparing the received blockchain token hash with a respective blockchain token hash, corresponding to the user, as stored in one or more nodes and retrieved from one or more nodes. The one or more nodes may correspond to different verification platforms **140** (e.g., corresponding to different card networks/card association infrastructures) and/or authentication platforms (e.g., authentication platform **150**) associated with multiple different banking/financial institutions. The payment processor platform **130** may send the received blockchain token hash to the one or more nodes. The one or more nodes may compare the received blockchain token hash with respective stored blockchain token hash corresponding to the user. The one or more nodes may send notification(s) to the payment processor platform **130** indicating whether the received blockchain token hash matches the respective stored blockchain token hash corresponding to the user. The payment processor platform **130** may determine that the user is authenticated based on a predetermined number of nodes (e.g., one or more nodes, a majority of the nodes, or the like) indicating that the blockchain token hash matches respective stored blockchain token hashes corresponding to the user. The payment processor platform **130** may determine that the user is not authenticated based on determining that the predetermined number of nodes indicate that the received blockchain token hash does not match respective stored blockchain token hashes corresponding to the user. Based on this determination, the payment processor platform **130** may decline the transaction.

At step **516**, payment processor platform **130** may connect to (e.g., establish a connection with) authentication platform **150**. For example, payment processor platform **130** may establish a fourth wireless data connection with authentication platform **150** to link payment processor platform **130** with authentication platform **150**. In some instances,

payment processor platform **130** may identify whether or not a connection is already established with authentication platform **150**. If a connection is already established with authentication platform **150**, payment processor platform **130** might not re-establish the connection. If a connection is not yet established with authentication platform **150**, payment processor platform **130** may establish the fourth wireless data connection as described above.

Referring to FIG. **5**E, at step **517**, if the user is determined to be authenticated, the payment processor platform **130** may send (e.g., while the fourth wireless data connection is established) a verification request, to an enterprise application host platform **160** associated with a network of a bank/financial institution that issued the card. Enterprise application host platform **160** may be in communication with or include a card network platform, a financial institution platform, or the like. The verification request may comprise one or more of the transaction details. The enterprise application host platform **160** may, based on the transaction details, determine a balance associated with the banking account corresponding to the card (e.g., if the card is a debit card), or an available credit associated with the card (e.g., if the card is a credit card). The enterprise application host platform **160** may determine whether a balance associated with a banking account corresponding to the card exceeds the transaction amount (e.g., if the card is a debit card), or if an available credit associated with the card exceeds the transaction amount (e.g., if the card is a credit card).

At step **518**, an enterprise application host platform **160** may send (e.g., while the fourth wireless data connection is established) a verification response to the payment processor platform **130**. The verification response may indicate whether the transaction is approved. The verification response may indicate that the transaction is approved if a balance associated with a banking account corresponding to the card exceeds the transaction amount, or if an available credit associated with the card exceeds the transaction amount. The verification response may indicate that the transaction is declined if a balance associated with a banking account corresponding to the card exceeds the transaction amount, or if an available credit associated with the card exceeds the transaction amount.

At step **519**, and based on the verification response indicating that the transaction is approved, the payment processor platform **130** may send (e.g., while the fourth wireless data connection is established) a transaction request to the enterprise application host platform **160**. The transaction request may comprise the transaction details (e.g., one or more of a card number, CVV number, user name, expiration date, transaction amount, recipient account number, recipient bank). At step **520**, the enterprise application host platform **160** may process the transaction. For example, the enterprise application host platform **160** may initiate a fund transfer from an account associated with the card to the recipient account. Referring to FIG. **5**F, at step **521**, the enterprise application host platform **160** may send, to the payment processor platform **130** (e.g., while the fourth wireless data connection is established), a transaction response indicating that the transaction has been processed.

At step **522**, the payment processor platform **130** may send (e.g., while the second wireless data connection is established) a notification to the computing device **120**. In turn, at step **523**, computing device **120** may receive the notification from payment processor platform **130**. The notification may indicate that the transaction has been processed, for example, if the payment processor platform receives the transaction response indicating that the transaction has been processed. The notification may indicate that the transaction has been declined, for example, based on at least one of (i) the received OTP not matching the sent OTP, (ii) the received blockchain token hash not matching the stored blockchain token hash (e.g., at step **515**), or (iii) the verification response indicating that the transaction has been declined (e.g., at step **516**).

While FIGS. **5**A-**5**F shows various steps being performed at a payment processor platform, in other embodiments, other platforms in the network (e.g., an authentication platform associated with a bank) may be used to perform one or more of the functions described herein.

The event sequence of FIGS. **5**A-**5**F may ensure that even if an OTP is diverted/compromised, card-based transactions may be secure due to the added additional layer of authentication provided by generated security key that includes both the blockchain token hash and the OTP. Further, the blockchain token may be securely stored on the blockchain at the verification platform and/or the user device and just the encrypted security key including, for example, an encrypted blockchain token's hash and amended OTP, is transmitted. In some examples, the use of multiple nodes for authenticating the blockchain token hash may ensure that even if a single node in the network is compromised, the authentication mechanism is not affected (e.g., because a predetermined number of the nodes need to authenticate the blockchain token hash).

FIG. **6** shows an example process for multi-factor authentication for processing a card-based transaction. At step **605**, a computing platform may generate and store a blockchain token hash. At step **610**, the computing platform may receive card information for a transaction associated with a user (e.g., card number of the user, user name, expiration date, CVV number, etc.). The card information may be indicated in transaction details as input (e.g., by a user and/or at a merchant) via a payment interface at a computing device (e.g., as described with respect to FIG. **4**).

At step **615**, the computing platform may determine or identify a user device based on the card information. For example, the computing platform may determine or identify a mobile device phone number, associated with the user device, corresponding to a card number included in the card information. The card number (or any other card information) may be associated with the mobile device phone number and may be stored in a user credential database at the computing platform (e.g., during a registration process). The computing platform may query the user credential database to retrieve the mobile device phone number corresponding to the card information.

At step **620**, the computing platform may send, to the user device, an OTP. The OTP may be randomly generated. The OTP may be sent to the user device via an SMS addressed to the mobile device phone number corresponding to the user device. In turn, the user device may generate a security key based on the sent OTP and a blockchain token hash. In some examples, the blockchain token hash may be generated based on information associated with the user, the user device, and/or the payment card. At step **625**, the computing platform may receive the security key.

At step **630**, the computing platform may determine if there is a match of information provided in the security key. For instance, if the OTP provided in the security key matches the sent OTP and the blockchain token hash provided in the security key matches a blockchain token hash (e.g., corresponding to the user) stored at at least a predetermined number of nodes (e.g., at least one node, at a majority of nodes associated with a plurality of card networks, or the like), the computing platform may send a message (e.g., an authorization response) (step **640**) approving the transaction. If the OTP provided in the security key does not match the sent OTP, or the blockchain token hash provided in the security key does not match a blockchain token hash (e.g., corresponding to the user) stored at at least the predetermined number of nodes, the computing platform may send a message (e.g., an authorization response) (step **635**) declining the transaction. The computing platform may further approve/decline a transaction based on available funds/credit in an account associated with the card. The computing platform, based on approving the transaction may send one or more indications to one or more other platforms in a network associated with the card-issuing bank. The one or more indications may signal that the transaction may be processed from a source account (e.g., associated with the user/card) to the recipient account.

One or more aspects of the disclosure may be embodied in computer-usable data or computer-executable instructions, such as in one or more program modules, executed by one or more computers or other devices to perform the operations described herein. Generally, program modules include routines, programs, objects, components, data structures, and the like that perform particular tasks or implement particular abstract data types when executed by one or more processors in a computer or other data processing device. The computer-executable instructions may be stored as computer-readable instructions on a computer-readable medium such as a hard disk, optical disk, removable storage media, solid-state memory, RAM, and the like. The functionality of the program modules may be combined or distributed as desired in various embodiments. In addition, the functionality may be embodied in whole or in part in firmware or hardware equivalents, such as integrated circuits, application-specific integrated circuits (ASICs), field programmable gate arrays (FPGA), and the like. Particular data structures may be used to more effectively implement one or more aspects of the disclosure, and such data structures are contemplated to be within the scope of computer executable instructions and computer-usable data described herein.

Various aspects described herein may be embodied as a method, an apparatus, or as one or more computer-readable media storing computer-executable instructions. Accordingly, those aspects may take the form of an entirely hardware embodiment, an entirely software embodiment, an entirely firmware embodiment, or an embodiment combining software, hardware, and firmware aspects in any combination. In addition, various signals representing data or events as described herein may be transferred between a source and a destination in the form of light or electromagnetic waves traveling through signal-conducting media such as metal wires, optical fibers, or wireless transmission media (e.g., air or space). In general, the one or more computer-readable media may be and/or include one or more non-transitory computer-readable media.

As described herein, the various methods and acts may be operative across one or more computing servers and one or more networks. The functionality may be distributed in any manner, or may be located in a single computing device (e.g., a server, a client computer, and the like). For example, in alternative embodiments, one or more of the computing platforms discussed above may be combined into a single computing platform, and the various functions of each computing platform may be performed by the single computing platform. In such arrangements, any and/or all of the above-discussed communications between computing platforms may correspond to data being accessed, moved, modified, updated, and/or otherwise used by the single computing platform. Additionally or alternatively, one or more of the computing platforms discussed above may be implemented in one or more virtual machines that are provided by one or more physical computing devices. In such arrangements, the various functions of each computing platform may be performed by the one or more virtual machines, and any and/or all of the above-discussed communications between computing platforms may correspond to data being accessed, moved, modified, updated, and/or otherwise used by the one or more virtual machines.

Aspects of the disclosure have been described in terms of illustrative embodiments thereof. Numerous other embodiments, modifications, and variations within the scope and spirit of the appended claims will occur to persons of ordinary skill in the art from a review of this disclosure. For example, one or more of the steps depicted in the illustrative figures may be performed in other than the recited order, and one or more depicted steps may be optional in accordance with aspects of the disclosure.

What is claimed is:

1. A computing platform, comprising:

one or more processors;

a communication interface communicatively coupled to the one or more processors; and

memory storing computer-readable instructions that, when executed by the one or more processors, cause the computing platform to:

receive, from a user device associated with a user, a blockchain token hash;

receive, from a computing device, transaction details associated with a card-based payment transaction corresponding to the user, wherein the transaction details comprise a card number of a payment card;

determine, based on the card number, the user device associated with the user;

send, to the user device, a one-time passcode (OTP);

after sending the OTP, receive a security key including the OTP and blockchain token hash and having a pattern placing characters of the OTP and the blockchain token hash based on one or more predefined rules identifying the pattern and set at a time of the card-based payment transaction associated with the transaction details, wherein the security key is generated by the user device associated with the user;

extract, from the security key, the OTP and blockchain token hash;

validate the extracted OTP and blockchain token hash; and

based on validating both the extracted OTP and the blockchain token hash, send, to the computing device, a message indicating whether the card-based payment transaction associated with the transaction details is approved or declined.

2. The computing platform of claim **1**, wherein the blockchain token hash is generated based on information associated with: the user, the user device, and the payment card.

3. The computing platform of claim **1**, wherein the one or more rules are set by a payment gateway device.

4. The computing platform of claim **3**, wherein the pattern placing the characters of the OTP and blockchain token hash to generate the security key includes interleaving the OTP and the blockchain token hash.

5. The computing platform of claim **1**, wherein the placing the characters of the OTP and blockchain token hash to generate the security key includes appending the blockchain token hash to the OTP.

6. The computing platform of claim **1**, wherein the pattern placing the characters of the OTP and blockchain token hash to generate the security key includes prepending the blockchain token hash to the OTP.

7. The computing platform of claim **1**, wherein the message indicates that the transaction is approved based on:

the OTP provided in the security key matching the sent OTP, and

the blockchain token hash provided in the security key matching a blockchain token hash, corresponding to the user, stored at a predetermined number of nodes associated with a plurality of card networks.

8. The computing platform of claim **1**, wherein the message indicates that the transaction is declined based on one or more of:

the OTP provided in the security key not matching the sent OTP; or

the blockchain token hash provided in the security key not matching a blockchain token hash, corresponding to the user, stored at a predetermined number of nodes associated with a plurality of card networks.

9. The computing platform of claim **1**, wherein the payment card is a credit card or a debit card.

10. The computing platform of claim **1**, wherein the user device is a mobile communication device.

11. The computing platform of claim **1**, wherein receiving the security key comprises receiving the security key via the user device.

12. A method comprising:

receiving, from a user device associated with a user, a blockchain token hash;

receiving, from a computing device, transaction details associated with a card-based payment transaction corresponding to the user, wherein the transaction details comprise a card number of a payment card;

determining, based on the card number, the user device associated with the user;

sending, to the user device, a one-time passcode (OTP);

after sending the OTP, receiving a security key including the OTP and blockchain token hash and having a pattern placing characters of the OTP and the blockchain token hash based on one or more predefined rules identifying the pattern and set at a time of the card-based payment transaction associated with the transaction details, wherein the security key is generated by the user device associated with the user;

extract, from the security key, the OTP and blockchain token hash;

validate the extracted OTP and blockchain token hash; and

based on validating both the extracted OTP and the blockchain token hash, sending, to the computing device, a message indicating whether the card-based payment transaction associated with the transaction details is approved or declined.

13. The method of claim **12**, wherein the blockchain token hash is generated based on information associated with: the user, the user device, and the payment card.

14. The method of claim **12**, wherein the one or more rules are set by a payment gateway device.

15. The method of claim **14**, wherein the pattern placing the characters of the OTP and blockchain token hash to generate the security key includes interleaving the OTP and the blockchain token hash.

16. The method of claim **12**, wherein the pattern placing the characters of the OTP and blockchain token hash to generate the security key includes appending the blockchain token hash to the OTP.

17. The method of claim **12**, wherein the pattern placing the characters of the OTP and blockchain token hash to generate the security key includes prepending the blockchain token hash to the OTP.

18. The method of claim **12**, wherein the message indicates that the transaction is approved based on:

the OTP provided in the security key matching the sent OTP, and

the blockchain token hash provided in the security key matching a blockchain token hash, corresponding to the user, stored at a predetermined number of nodes associated with a plurality of card networks.

19. The method of claim **12**, wherein the message indicates that the transaction is declined based on one or more of:

the OTP provided in the security key not matching the sent OTP; or

the blockchain token hash provided in the security key not matching a blockchain token hash, corresponding to the user, stored at a predetermined number of nodes associated with a plurality of card networks.

20. One or more non-transitory computer-readable media storing instructions that, when executed by a computing platform comprising at least one processor, a communication interface, and memory, cause the computing platform to:

receive, from a user device associated with a user, a blockchain token hash;

receive, from a computing device, transaction details associated with a card-based payment transaction corresponding to the user, wherein the transaction details comprise a card number of a payment card;

determine, based on the card number, the user device associated with the user;

send, to the user device, a one-time passcode (OTP);

after sending the OTP, receive a security key including the OTP and blockchain token hash and having a pattern placing characters of the OTP and the blockchain token hash based on one or more predefined rules identifying the pattern and set at a time of the card-based payment transaction associated with the transaction details, wherein the security key is generated by the user device associated with the user;

extract, from the security key, the OTP and blockchain token hash;

validate the extracted OTP and blockchain token hash; and

based on validating both the extracted OTP and the blockchain token hash, send, to the computing device, a message indicating whether the card-based payment transaction associated with the transaction details is approved or declined.

* * * * *