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Ozugur

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(54) **SYSTEM AND METHOD FOR ENHANCING MULTI-FACTOR AUTHENTICATION**

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CPC ***H04L 63/083*** (2013.01); *H04L 2463/082* (2013.01)

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CPC H04L 63/083; H04L 2463/082
See application file for complete search history.

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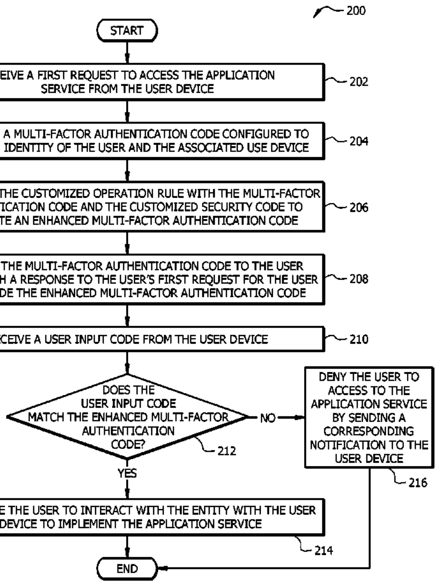
(57) **ABSTRACT**

A system for enhancing multi-factor authentication comprises a processor associated with a server. The processor receives a first request with user identity data to access an application service from a user device. The processor generates a multi-factor authentication code to verify a user identity and a user device. The processor implements a customized operation rule with the multi-factor authentication code and a customized security code to generate an enhanced multi-factor authentication code. The processor presents the multi-factor authentication code to the user device with a response for the user to provide the enhanced multi-factor authentication code. The processor determines whether a user input code matches the enhanced multi-factor authentication code. In response to determining that the user input code matches the enhanced multi-factor authentication code, the processor authorizes the user device associated with the user to interact with the entity, such as, for example, to implement the application service.

20 Claims, 3 Drawing Sheets


200
START
RECEIVE A FIRST REQUEST TO ACCESS THE APPLICATION SERVICE FROM THE USER DEVICE
202
GENERATE A MULTI-FACTOR AUTHENTICATION CODE CONFIGURED TO VERIFY AN IDENTITY OF THE USER AND THE ASSOCIATED USE DEVICE
204
IMPLEMENT THE CUSTOMIZED OPERATION RULE WITH THE MULTI-FACTOR AUTHENTICATION CODE AND THE CUSTOMIZED SECURITY CODE TO GENERATE AN ENHANCED MULTI-FACTOR AUTHENTICATION CODE
206
PRESENT THE MULTI-FACTOR AUTHENTICATION CODE TO THE USER DEVICE WITH A RESPONSE TO THE USER'S FIRST REQUEST FOR THE USER TO PROVIDE THE ENHANCED MULTI-FACTOR AUTHENTICATION CODE
208
RECEIVE A USER INPUT CODE FROM THE USER DEVICE
210
DOES THE USER INPUT CODE MATCH THE ENHANCED MULTI-FACTOR AUTHENTICATION CODE?
212
NO
DENY THE USER TO ACCESS TO THE APPLICATION SERVICE BY SENDING A CORRESPONDING NOTIFICATION TO THE USER DEVICE
216
YES
AUTHORIZE THE USER TO INTERACT WITH THE ENTITY WITH THE USER DEVICE TO IMPLEMENT THE APPLICATION SERVICE
214
END

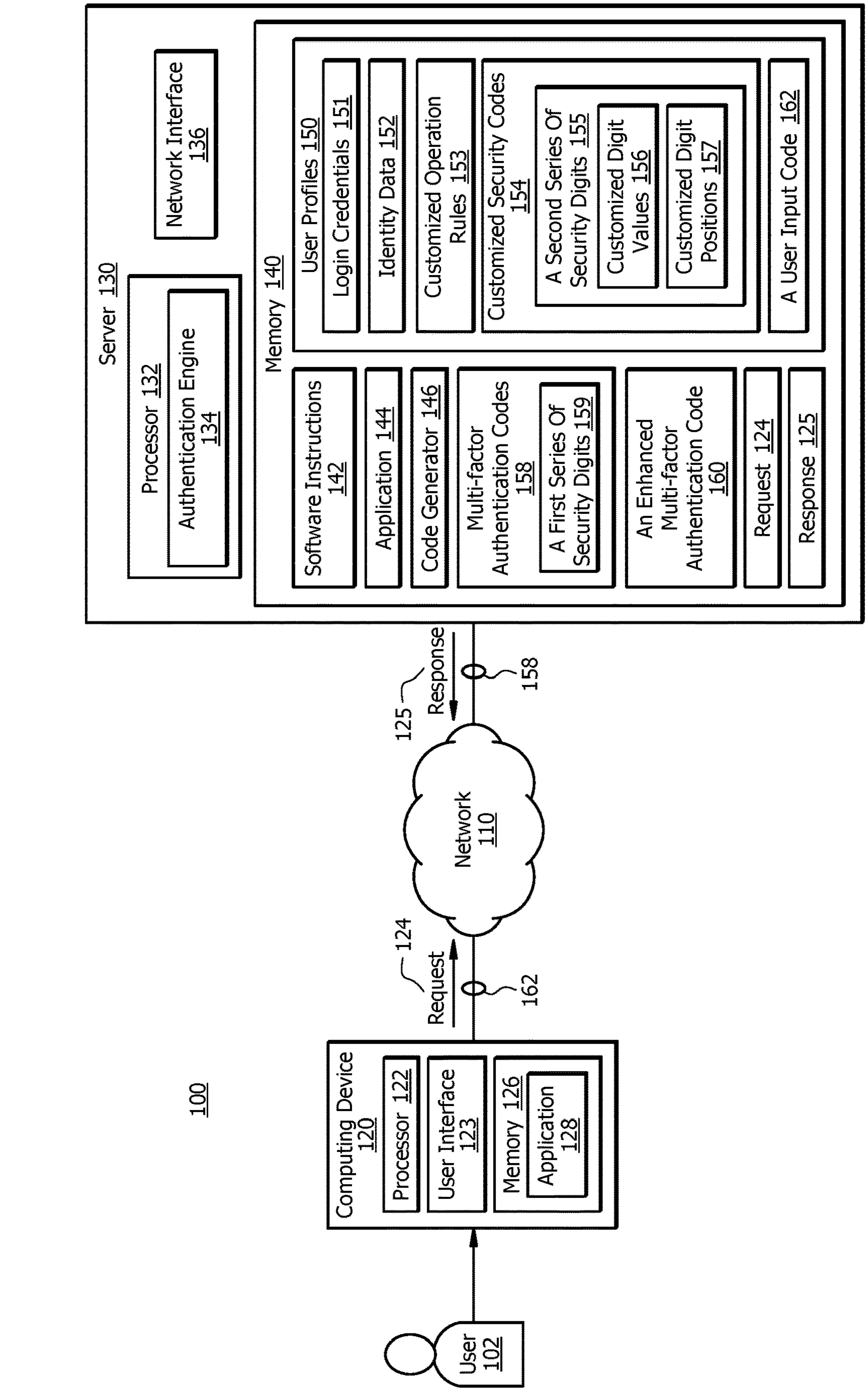

100
User 102
Computing Device 120
Processor 122
User Interface 123
Memory 126
Application 128
Request
124
162
Network 110
125
Response
158
Server 130
Processor 132
Authentication Engine 134
Network Interface 136
Memory 140
Software Instructions 142
Application 144
Code Generator 146
Multi-factor Authentication Codes 158
A First Series Of Security Digits 159
An Enhanced Multi-factor Authentication Code 160
Request 124
Response 125
User Profiles 150
Login Credentials 151
Identity Data 152
Customized Operation Rules 153
Customized Security Codes 154
A Second Series Of Security Digits 155
Customized Digit Values 156
Customized Digit Positions 157
A User Input Code 162

FIG. 1

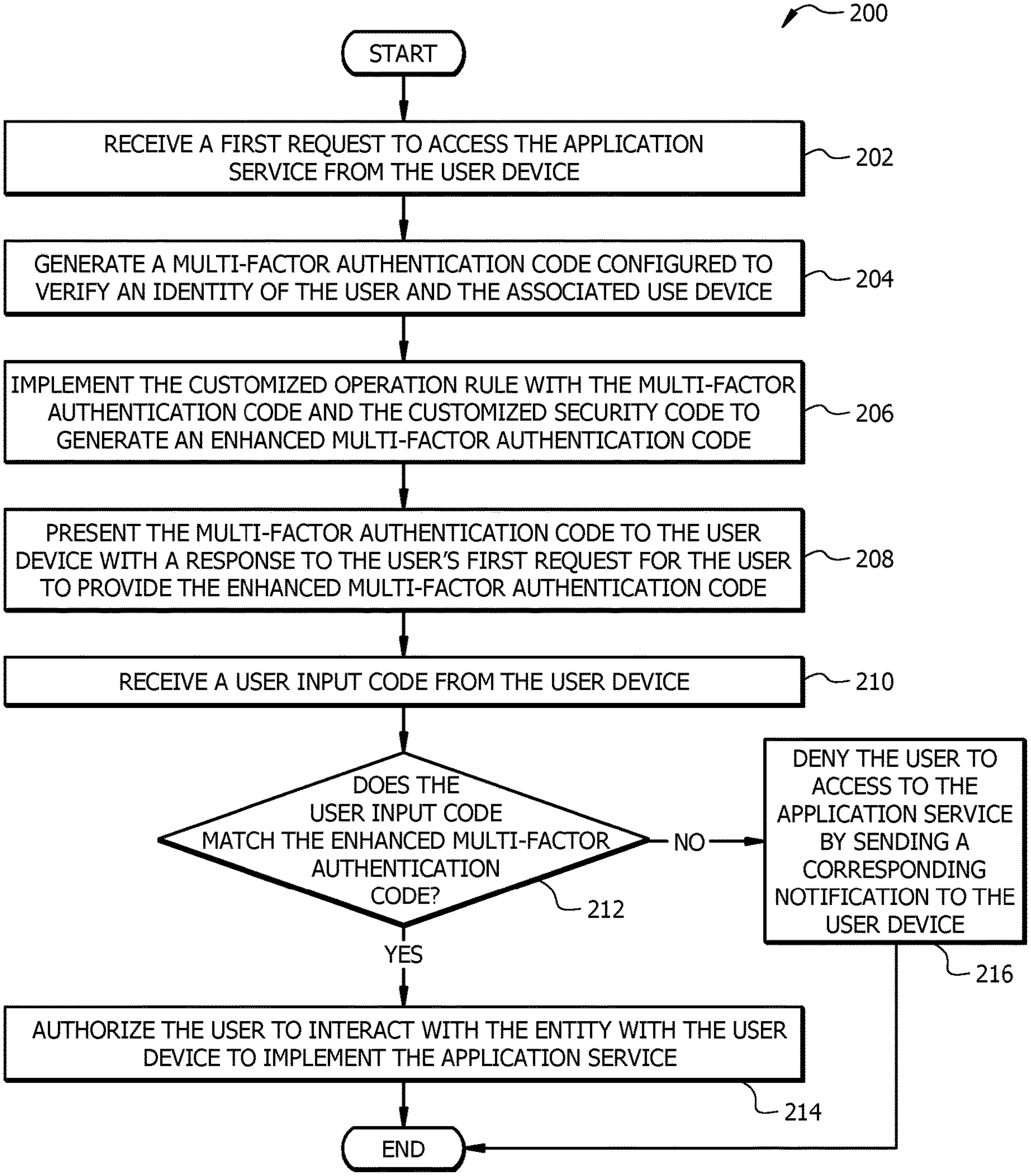

200
START
RECEIVE A FIRST REQUEST TO ACCESS THE APPLICATION SERVICE FROM THE USER DEVICE
202
GENERATE A MULTI-FACTOR AUTHENTICATION CODE CONFIGURED TO VERIFY AN IDENTITY OF THE USER AND THE ASSOCIATED USE DEVICE
204
IMPLEMENT THE CUSTOMIZED OPERATION RULE WITH THE MULTI-FACTOR AUTHENTICATION CODE AND THE CUSTOMIZED SECURITY CODE TO GENERATE AN ENHANCED MULTI-FACTOR AUTHENTICATION CODE
206
PRESENT THE MULTI-FACTOR AUTHENTICATION CODE TO THE USER DEVICE WITH A RESPONSE TO THE USER'S FIRST REQUEST FOR THE USER TO PROVIDE THE ENHANCED MULTI-FACTOR AUTHENTICATION CODE
208
RECEIVE A USER INPUT CODE FROM THE USER DEVICE
210
DOES THE USER INPUT CODE MATCH THE ENHANCED MULTI-FACTOR AUTHENTICATION CODE?
212
NO
DENY THE USER TO ACCESS TO THE APPLICATION SERVICE BY SENDING A CORRESPONDING NOTIFICATION TO THE USER DEVICE
216
YES
AUTHORIZE THE USER TO INTERACT WITH THE ENTITY WITH THE USER DEVICE TO IMPLEMENT THE APPLICATION SERVICE
214
END

FIG. 2

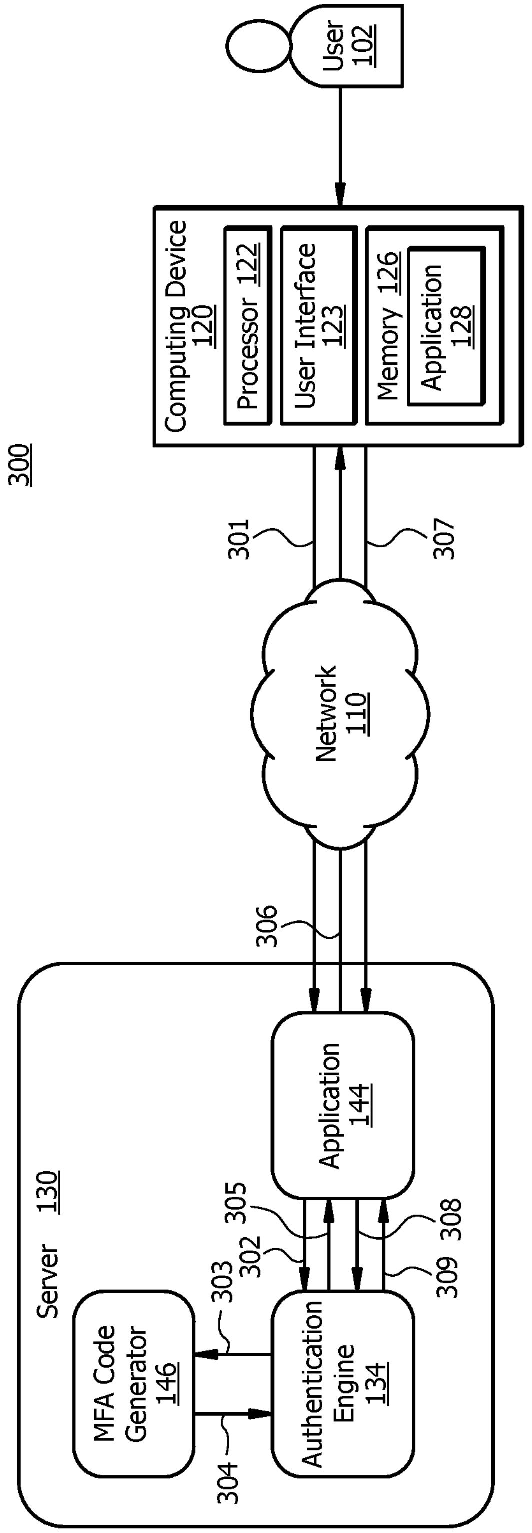

300
User
102
Computing Device
120
Processor 122
User Interface
123
Memory 126
Application
128
301
307
Network
110
306
Server 130
Application
144
305
302
308
309
303
304
MFA Code
Generator
146
Authentication
Engine
134

FIG. 3

SYSTEM AND METHOD FOR ENHANCING MULTI-FACTOR AUTHENTICATION

TECHNICAL FIELD

The present disclosure relates generally to network communications and network security, and more specifically to a system and method for enhancing multi-factor authentication.

BACKGROUND

There are different approaches to security authentication in mobile applications. A user may use a user device to log in to applications by enabling a "Remember Me" feature for automatic login. Even when the automatic login feature is enabled, some applications may send an access code (e.g., multi-factor authentication code) to the user device for an additional user identity authentication. However, such a conventional security authentication approach may not prevent user data leakage or loss caused by fraudulent activities using the user device to log in to the applications to access user data.

SUMMARY

Conventional technology is not configured to provide reliable and effective protection and network security solutions to prevent fraudulent access to user profiles using multi-factor authentication. The system described in the present disclosure is particularly integrated into a practical application of enhancing multi-factor authentication by generating an enhanced multi-factor authentication code with customized codes and operation rules to prevent fraudulent access to user data.

The disclosed system is configured to generate an enhanced multi-factor authentication code for improving user data security. The disclosed system may generate a multi-factor authentication code and send it to a user device to verify a user identity for determining whether to grant a user access to an application for an application service. The disclosed system may be configured to generate an enhanced multi-factor authentication code by applying a customized operation rule to the multi-factor authentication code and a customized security code. The customized security code and operation rule may be preset by the user through the user device. The enhanced multi-factor authentication code is different from the multi-factor authentication code and is stored in a memory of a server. The disclosed system is configured to send the multi-factor authentication code to the user device and require the user to provide a user input code which matches the enhanced multi-factor authentication code. The disclosed system may authorize the user device associated with the user to access the application if the user input code matches the enhanced multi-factor authentication code.

In one embodiment, the system for enhancing multi-factor authentication comprises a processor and a memory. The memory is operable to store a user profile configured to authorize a user device associated with a user to access an application service operated by an entity. The user profile comprises user identity data, a customized security code, and a customized operation rule. The processor receives a first request to access the application service from the user device. The first request comprises the user identity data. The processor generates a multi-factor authentication code configured to verify an identity of the user and the associated user device. The processor implements the customized operation rule with the multi-factor authentication code and the customized security code to generate an enhanced multi-factor authentication code. The processor presents the multi-factor authentication code to the user device with a response to the user's first request for the user to provide the enhanced multi-factor authentication code. The processor receives a user input code from the user device. The processor determines whether the user input code matches the enhanced multi-factor authentication code. In response to determining that the user input code matches the enhanced generated multi-factor authentication code, the processor authorizes the user to interact with the entity with the user device to implement the application service.

The present disclosure presents a practical application that may be implemented by the processor of the server to provide a customized layer of protection by enhancing multi-factor authentication to prevent fraudulent access to user data. The server may generate a multi-factor authentication code in response to each user request to access the application from the user device. The server may generate an enhanced multi-factor authentication code by applying the preset operation rule to the multi-factor authentication code and the customized security code. Accordingly, the server may dynamically generate a corresponding enhanced multi-factor authentication code based on a user request in real-time. Further, the customized security code and the corresponding operation rule may be dynamically updated by the user or by the system. Thus, the enhanced multi-factor authentication code may be dynamically changed based on the customized operation rule, the customized security code and the multi-factor authentication code. The enhanced multi-factor authentication code is different from the multi-factor authentication code and is not presented to the user device. The server may send the multi-factor authentication code to the user device and require the user to provide the same enhanced multi-factor authentication code to verify the user identity. The user needs to have the information of the customized operation rule and the customized security code to determine and provide the correct multi-factor authentication code to match the enhanced multi-factor authentication code. In this way, the unique enhanced multi-factor authentication code may be used to effectively prevent unauthorized or fraudulent activities of using the user device to log in to the applications to access user data.

These practical applications lead to the technical advantage of improving information security by providing an efficient and effective code encryption method. For example, the customized security code and operation rule in the user profile may be preset and updated by the user or dynamically updated by the server. The corresponding enhanced multi-factor authentication code may be dynamically changed in response to a user request in real-time. To access the application, the user requires to provide the correct enhanced multi-factor authentication code which is different from the multi-factor authentication code displayed on a use interface of the user device. This process may effectively and efficiently verify the user identity and protect user data from unauthorized access to the application and related information system through the user device. Therefore, the disclosed system minimizes or prevents unauthorized and fraudulent access to the user device. Thus, the disclosed system improves computer system security and interaction operation efficiency of the overall computer system.

Certain embodiments of this disclosure may include some, all, or none of these advantages. These advantages and other features will be more clearly understood from the following detailed description taken in conjunction with the accompanying drawings and claims.

BRIEF DESCRIPTION OF THE DRAWINGS

For a more complete understanding of this disclosure, reference is now made to the following brief description, taken in connection with the accompanying drawings and detailed description, wherein like reference numerals represent like parts.

FIG. **1** illustrates an embodiment of a system configured to enhance multi-factor authentication;

FIG. **2** illustrates an example operational flow of a method for enhancing multi-factor authentication; and

FIG. **3** illustrates an operational flow of an example practical application in conjunction with the system of FIG. **1** and the method of FIG. **2**.

DETAILED DESCRIPTION

Previous technologies fail to provide reliable network security solutions to using multi-factor authentication for preventing fraudulent access to user data. This disclosure presents a system for enhancing multi-factor authentication for network security by referring to FIGS. **1**-**3**.

System Overview

FIG. **1** illustrates one embodiment of a system **100** that is configured to enhance multi-factor authentication for a computing device **120**. In some embodiments, system **100** comprises a server **130**, a computing device **120**, and a network **110**. Network **110** enables the communication between components of the system **100**. Server **130** comprises a processor **132** in signal communication with a memory **140**. Memory **140** stores software instructions **142** that when executed by the server **130**, cause the server **130** to execute one or more functions described herein. For example, when the software instructions **142** are executed, the server **130** executes an authentication engine **134** to perform operations illustrated in FIGS. **2**-**3**. In other embodiments, system **100** may not have all the components listed and/or may have other elements instead of, or in addition to, those listed above.

In some embodiments, the system **100** may be implemented by the server **130** to enhance multi-factor authentication by generating an enhanced multi-factor authentication code **160** to verify a user identity to access an application **144**. For example, the server **130** may generate and send a multi-factor authentication code **158** to a user device **120** to verify the user identity. The server may determine the enhanced multi-factor authentication code **160** based on the multi-factor authentication code **158**, a preset operation rule **153**, and a customized security code **154**. The user **102** provides a new multi-factor authentication code as a user input code **162** for the server **130** to determine whether it matches the enhanced multi-factor authentication code **160**. If server **130** determines that the user input code **162** matches the enhanced multi-factor authentication code **160**, it authorizes the user device **120** to access the application **144**.

System Components

Network

Network **110** may be any suitable type of wireless and/or wired network, including, but not limited to, all or a portion of the Internet, an Intranet, a private network, a public network, a peer-to-peer network, the public switched telephone network, a cellular network, a local area network (LAN), a metropolitan area network (MAN), a wide area network (WAN), and a satellite network. The network **110** may be configured to support any suitable type of communication protocol as would be appreciated by one of ordinary skill in the art.

Computing Device

Computing device **120** is generally any device that is configured to process data and interact with a user **102**. Examples of the computing device **120** (e.g., a user device) include, but are not limited to, a personal computer, a desktop computer, a workstation, a server, a laptop, a tablet computer, a mobile phone (such as a smartphone), etc. The computing device **120** may include a user interface **123**, such as a display, a microphone, keypad, or other appropriate terminal equipment usable by a user **102**. The computing device **120** may include a hardware processor **122**, memory **126**, and/or circuitry configured to perform any of the functions or actions of the computing device **120** described herein. The hardware processor **122** may include one or more processors operably coupled to the memory **126**. The one or more processors **122** may be any electronic circuitry, including, but not limited to, state machines, one or more central processing unit (CPU) chips, logic units, cores (e.g., a multi-core processor), field-programmable gate array (FPGAs), application-specific integrated circuits (ASICs), or digital signal processors (DSPs). The one or more processors **122** may be a programmable logic device, a microcontroller, a microprocessor, or any suitable combination of the preceding. The one or more processors **122** are configured to process data and may be implemented in hardware or software. For example, the processor may be 8-bit, 16-bit, 32-bit, 64-bit, or of any other suitable architecture. The processor **122** may include an arithmetic logic unit (ALU) for performing arithmetic and logic operations. For example, one or more software applications designed using software code may be stored in the memory **126** and executed by the processor **122** to perform the functions of the computing device **120**.

In some embodiments, the computing device **120** may store and/or include an application **128**. The application **128** may be a software, mobile, or web application. Application **128** may be used by the computing device **120** to access an application **144** for an application service provided by an entity through a server **130**.

Server

Server **130** is generally a server, or any other device configured to process data and communicate with computing devices (e.g., computing device **120**), etc., via the network **110**. The server **130** is generally configured to execute the operations of the authentication engine **134**, as described further below in conjunction with the operational flows of the method **200** described in FIG. **2**. The server **130** may be a central server implemented in the cloud or, alternatively, it may be organized in a distributed manner.

Server **130** comprises one or more processors **132** operably coupled to the memory **140**. The server **130** is any electronic circuitry, including, but not limited to, state machines, one or more central processing unit (CPU) chips, logic units, cores (e.g., a multi-core processor), field-programmable gate array (FPGAs), application-specific integrated circuits (ASICs), or digital signal processors (DSPs). The processor **132** may be a programmable logic device, a microcontroller, a microprocessor, or any suitable combination of the preceding. The one or more processors are configured to process data and may be implemented in hardware or software. For example, the processor **132** may be 8-bit, 16-bit, 32-bit, 64-bit, or of any other suitable architecture. The processor **132** may include an arithmetic logic unit (ALU) for performing arithmetic and logic operations. The processor **132** registers the supply operands to the ALU and store the results of ALU operations, and a control unit that fetches instructions from memory and executes them by directing the coordinated operations of the ALU, registers and other components. The one or more processors are configured to implement various instructions. For example, the one or more processors are configured to execute instructions (e.g., software instructions **142**) to implement the authentication engine **134** and/or to execute one or more operations described herein with respect to server **130**. In this way, the processor **132** may be a special-purpose computer designed to implement the functions disclosed herein. In one embodiment, the processor **132** is implemented using logic units, FPGAs, ASICs, DSPs, or any other suitable hardware. The processor **132** is configured to operate to perform one or more operations as described in FIGS. **2**-**3**.

In an embodiment, the authentication engine **134** may be implemented using logic units, FPGAs, ASICs, DSPs, or any other suitable hardware. The authentication engine **134** may be configured to perform the operations as described in FIGS. **2**-**3**. For example, the authentication engine **134** provides enhanced multifactor authentication by generating an enhanced multi-factor authentication code **160** to verify a user identity.

Memory **140** may be volatile or non-volatile and may comprise a read-only memory (ROM), random-access memory (RAM), ternary content-addressable memory (TCAM), dynamic random-access memory (DRAM), and static random-access memory (SRAM). Memory **140** may be implemented using one or more disks, tape drives, solid-state drives, and/or the like.

The memory **140** is operable to store the software instructions **142** and/or any other data or instructions. The software instructions **142** may store any suitable set of instructions, logic, rules, or code operable to be executed by the processor **132** to implement the processes and embodiments described below. In an example operation, the memory **140** may store an application **144**, a code generator **146**, and other program modules which are implemented in computer-executable software instructions, such as software instructions **142**. The memory **140** is operable to store user profiles **150**, multi-factor authentication codes **158**, an enhanced multi-factor authentication code **160**, requests **124**, responses **125**, and user input codes **162**, and/or any other data or instructions.

A user profile **150** may include user identity data **152** with login credentials **151**, customized operation rules **153**, and customized security codes **154**. Each customized security code **154** may be preset by a user **102** and include a second series of security digits **155**. The second series of security digits **155** may include one or more customized digit values **156** and one or more customized digit positions **157**.

The application **144** may be associated with an organization entity that provides application services to users **102**. The application **144** may be configured to create a user profile **150** with login credentials **151** for a user **102** and an associated computing device **120** to interact with the entity, such as, for example, to access application services (e.g., application **144**). A server **130** associated with the application **144** may be configured to evaluate whether the user login credentials are valid based on comparing the provided login credentials with login credentials **151** previously set by the user **102** and stored in a memory **140**. The user **102** may operate the user device **120** by enabling a "Remember Me" feature of the application **144** for automatic login. In conjunction with validating the login credentials, the code generator **146** may be implemented by the authentication engine **134** executed by the processor **132** to generate a multi-factor authentication code **158** to verify the user identity and the associated user device **120** as described in operations illustrated in FIGS. **2**-**3**. Once the user identity is verified, the user **102** may access the application **144** for an application service.

Network interface **136** is configured to enable wired and/or wireless communications (e.g., via network **110**). The network interface **136** is configured to communicate data between the server **130** and other devices (e.g., computing device **120**), databases, systems, or domains. For example, the network interface **136** may comprise a WIFI interface, a local area network (LAN) interface, a wide area network (WAN) interface, a modem, a switch, or a router. The processor **132** is configured to send and receive data using the network interface **136**. The network interface **136** may be configured to use any suitable type of communication protocol as would be appreciated by one of ordinary skill in the art.

Authentication Engine

The authentication engine **134** may be implemented by the processor **132** by executing the software instructions **142** to determine whether to verify or authorize a user **102** and an associated user device **120** to access an application **144** for an application service. The authentication engine **134** may operate a code generator **146** to generate a multi-factor authentication code **158** in response to a user request **124** to access the application **144**. In some embodiments, the authentication engine **134** may operate an enhanced multi-factor authentication code **160** by applying a customized operation rule **153** to the multi-factor authentication code **158** and a customized security code **154**. The authentication engine **134** may authorize the user device **120** to access the application **144** if a user input code **162** received by the server **130** matches the enhanced multi-factor authentication code **160**. The operation of the disclosed system **100** is described below.

Generate an Enhanced Multi-Factor Authentication Code

This process may be implemented by the server **130** to generate an enhanced multi-factor authentication code **160** based on a multi-factor authentication code **158**, a customized operation rule **153**, and a customized security code **154**. Code generator **146** may be implemented by the processor **132** executing the software instructions **142** to generate a multi-factor authentication codes **158**. The server **130** may generate different multi-factor authentication codes **158** in response to each request **124** from the user device **120** to access the application **144**. A multi-factor authentication code **158** may be a n-digit-token which includes a first series of security digits **159** (A_{11}, A_{12}, . . . A_{1n}).

An example multi-factor authentication code 158 (A first series of security digits 159)	A_{11} (6)	A_{12} (2)	A_{13} (5)	A_{14} (7)	A_{15} (1)	A_{16} (3)
An example customized Security Codes 154 (A second series of security digits 155)	B_{21} –	B_{22} (1)	B_{23} –	B_{24} (6)	B_{25} –	B_{26} –
An example operation rule (R)		+	+	+		
An enhanced multi-factor authentication code 160	C_{11} (6)	C_{12} (3)	C_{13} (6)	C_{14} (3)	C_{15} (1)	C_{16} (3)

Table 1

As illustrated table 1, an example multi-factor authentication code **158** may be a 6-digit-token which includes a first series of security digits **159** (A_{11}, A_{12}, . . . A_{16}). Each security digit is associated with a unique digit position. An example customized security code **154** may be a second series of security digits **155**. The second series of security digits **155** includes one or more customized digit values **156** and one or more customized digit positions **157**. An example customized security code **154** may include two security digits B_{22} and B_{24} in the second series of security digits **155** (-, B_{22}, -, B_{24}, -, -). Each digit value **156** in the second series of the security digits **155** has a corresponding customized digit position **157**. The customized digit position **157** matches a corresponding digit position in the first series of security digits **159** of the multi-factor authentication code **158**. The example customized digit positions **157** associated with the security digits B_{22} and B_{24} correspond to the digit positions which are associated with the first series of security digits **159** (e.g., A_{12} and A_{14}) of the multi-factor authentication code **158**.

In some embodiments, the customized operation rule **153** may be an operation rule (R) which is configured to determine one or more new security digits of an enhanced multi-factor authentication code **160** based on the first series of security digits **159** and the second series of security digits **155**. In one embodiment, an example customized operation rule **153** may be an addition operation which is applied to the first series of security digits **159** and the second series of security digits **155** at each corresponding position to generate an enhanced multi-factor authentication code **160** (C_{11}, C_{12}, C_{16}).

As illustrated in table 1, the enhanced security digit values (C_{12} and C_{14}) may be determined by adding the digit values (A_{12} and A_{14}) of the multi-factor authentication codes **158** and the customized digits values (B_{22} and B_{24}) of the customized security codes **154**. For example, in response to receiving a request **124** from the user device **120**, the code generator **146** may generate a multi-factor authentication code **158** as a 6-digit-token "625713". The user **102** may preset a customized security code **154** as a second series of security digits **155** (-, 1, -, 6, -, -). Each customized digit position **157** at B_{22} or B_{24} matches a corresponding digit position in the first series of security digits **159** of the multi-factor authentication code **158**.

The server **130** may generate an enhanced multi-factor authentication code **160** as "636313" which is different from the 6-digit-token "625713" of the multi-factor authentication code **158**. Each of the digit values of C_{12} and C_{14} in the enhanced multi-factor authentication code **160** may be one's digits based on the corresponding operation result. If the operation result C_{14} (e.g., "13") is larger than 10, the operation result C_{14} in ten's place has a value of "1". As illustrated in the table 1, the value of "1" determined at the digit position C_{14} may be added to the digit value of "5" of A_{13} on the left side of the digit position of A_{14} to generate a new digit value of "6" of C_{13}.

In response to receiving the 6-digit-token "625713" of the multi-factor authentication code **158** via a response **125**, the user **102** may determine and provide a user input code **162** by applying a customized operation rule **153** to the multi-factor authentication code **158** and the customized security code **154**. The server **130** may receive a user input code **162** and compare it with the enhanced multi-factor authentication code **160**. As illustrated in table 1, if the user input code is "636313," the server **130** determines that the user input code **162** matches the enhanced multi-factor authentication code **160**. In response, the server **130** authorizes the user device **120** to interact with the entity, such as, for example, to access application services (e.g., application **144**).

In some embodiments, the system allows the user **102** to preset the customized digit values **156** and customized digit positions **157**. In one embodiment, the system allows the user device **120** to access the user profile **150** to update the customized security code **154**. The user **102** may change or switch one or more of corresponding digit positions **157** of the customized digit values **156** in the user profile **150**. The user **102** may change or switch the positions or the values of security digits B_{22} and B_{24} of the customized security code **154** to the digit positions at B_{25} and B_{26}. For example, the customized security code **154** may be modified to be a different, second series of security digits **155** (-, -, -, -, 1, 6). For the same 6-digit-token "625713" of the multi-factor authentication code **158**, the server **130** may generate a new enhanced multi-factor authentication code **160** which is "625729" based on the example operation rule (R). When the user device **120** receives the 6-digit-token "625713", the user **102** is required to provide the new multi-factor authentication code of "625729" as a user input code **162** through the user device **120** in order to be verified.

In some embodiments, the user **102** may add at least one new security digit to or remove at least one security digit from the second series of the security digits **155**. In some embodiments, the system may dynamically adjust the customized digit values **156** and the corresponding customized digit positions **157**. For example, the system may provide different operation rules for the user **102** to select. The operation rules may involve a number of different operations, including but not limited to addition, subtraction, and multiplication. The system may dynamically provide options for the user to update the customized security code **154** by changing one or more customized digit values **156** and the corresponding customized digit positions **157**. For example, the user **102** may access the server **130** via the user device **120** to update a present customized security code **154** (-, 1, -, 6, -, -) to a new customized security code **154** (-, 2, -, 6, -, -) with a digit value **156** changed at the second digit position **157** at B_{22}. In another example, the user **102** may access the server **130** via the user device **120** to update the customized security code **154** (-, 1, -, 6, -, -) to a new customized security code **154** (-, -, -, -, 2, 5) by changing the digit values **156** and digit positions **157** to the fifth and sixth digit positions at B_{25} and B_{26}. The operation of the disclosed system **100** is described below.

Example Operational Flow for Enhancing Multi-Factor Authentication

FIG. **2** illustrates an example flow of a method **200** for enhancing multi-factor authentication in the system **100**. Modifications, additions, or omissions may be made to method **200**. Method **200** may include more, fewer, or other operations. For example, operations may be performed by the server **130** in parallel or in any suitable order. While at times discussed as the system **100**, processor **132**, authentication engine **134**, code generator **146** or components of any of thereof performing operations, any suitable system or components of the system may perform one or more operations of the method **200**. For example, one or more operations of method **200** may be implemented, at least in part, in the form of software instructions **142** of FIG. **1**, stored on non-transitory, tangible, machine-readable media (e.g., memory **140** of FIG. **1**) that when run by one or more processors (e.g., processor **132** of FIG. **1**) may cause the one or more processors to perform operations **202-216**.

The method **200** begins at operation **202** where the server **130** receives a first request **124** to access an application **144** from the user device **120**. The first request **124** comprises the user identity data **152** from a user profile **150**. The user identity data **152** may include one or more user login credentials which are used for the server **130** to verify the user identity.

At operation **204**, the server **130** generates a multi-factor authentication code **158** configured to verify the identity of the user **102** and the associated user device **120**. The multi-factor authentication code **158** is generated to be a n-digit-token which comprises a first series of security digits **159**. Each security digit is associated with a unique digit position.

At operation **206**, the server **130** implements the customized operation rule **153** with the multi-factor authentication code **158** and the customized security code **154** to generate an enhanced multi-factor authentication code **160**. The server **130** may store the enhanced multi-factor authentication code **160** in the memory **140**. For example, the server **130** may implement a customized operation rule **153** by adding the first series of the security digits **159** and the second series of the security digits **155** at corresponding digit positions of customized digit positions **157** to generate the enhanced multi-factor authentication code **160**. The server **130** stores the enhanced multi-factor authentication code **160** in the memory **140**. The enhanced multi-factor authentication code **160** is different from the multi-factor authentication code **158** and is not presented to the user device **120**.

At operation **208**, the server **130** presents the multi-factor authentication code **158** to the user device **120** with a response **125** to the user's first request **124** for the user **102** to provide the enhanced multi-factor authentication code **160** though a user interface **123** of the user device **120**.

At operation **210**, the server **130** receives a user input code **162** from the user device **120** for providing the enhanced multi-factor authentication code **160**.

At operation **212**, the server **130** determines whether the user input code **162** matches the enhanced multi-factor authentication code **160** stored in the memory **140**.

At operation **214**, in response to determining that the user input code **162** matches the enhanced multi-factor authentication code **160** stored in the memory **140**, the server **130** authorizes the user **102** and the user device **120** to interact with the entity to implement the application service.

At operation **216**, in response to determining that the user input code **162** does not match the enhanced multi-factor authentication code **160**, the server **130** may deny a user access to the application service. For example, the server **130** may generate and send a corresponding notification to the user device **120** to notify the user.

FIG. **3** illustrates an operational flow **300** of an example practical application in conjunction with the system **100** of FIG. **1** and the method **200** of FIG. **2**. For example, the server **130** may verify a user identity for a user **102** and the associated user device **120**. In one embodiment, this permits user **102** to access an application **144** and to transfer a digital item to another entity.

At **301**, the user **102** may operate the user device **120** to send a request **124** to log in to an application **144** with identity data **152** through a browser application **128**. The application **144** is configured to verify the user identity using the identity data **152** of the user profile **150**. The application **144** is further configured to verify the user's identity via an authentication code even though the user enables "Remember Me" feature for the application **144** to remember the user identity data **152** for automatic login.

At **302**, the application **144** may request the authentication engine **134** of the server **130** to generate a multi-factor authentication code **160** to verify the user identity.

At **303**, the server **130** may execute a code generator **146** to receive the request for generating the multi-factor authentication code **160**.

At **304**, the server **130** may execute the code generator **146** to generate the multi-factor authentication code **158** and send the code to the authentication engine **134**. The server **130** may generate an enhanced multi-factor authentication code **160** based on the multi-factor authentication code **158** and store it in the memory **140**. As described above, the server **130** may determine the enhanced multi-factor authentication code **160** by applying the customized operation rule **153** to the multi-factor authentication code **158**, and the customized security code **154**. The customized security code **154** includes one or more customized digit values **156** and customized digit positions **157**. The server **130** stored the enhanced multi-factor authentication code **160** in the memory **140**. The server **130** does not present the enhanced multi-factor authentication code **160** to the user **102** on the user interface **123** of the user device **120**.

At **305**, the authentication engine **134** may be implemented by the processor **132** by executing the software instructions **142** to send the multi-factor authentication code **158** to the application **144**.

At **306**, the server **130** may execute the application **144** to send the multi-factor authentication code **158** to the user device **120** via a text message to verify the user identity. For example, the text message may be an instant message or an email. The server **130** may request the user **102** to enter a user input code **162** for verifying the user identity.

At **307**, in response to receiving the multi-factor authentication code **158** from the server **130**, the user **102** is required to provide a user input code **162** to match the enhanced multi-factor authentication code **160** determined by the server **130**. For example, the user input code **162** may be a new calculated multi-factor authentication code which is different from the multi-factor authentication code **158**. The new calculated multi-factor authentication code may be determined by the user **102** by applying the customized operation rules **153** to the multi-factor authentication code **158**, customized digit values **156**, and customized digit position **157**. The customized digit values **156** and customized digit position **157** are previously set by the user **102**. The user device **120** receives the user input code **162** from the user **102** and sends the user input code **162** to the server **130** through the application **144**.

At **308**, the server **130** may execute the application **144** to send the received user input code **162** to the authentication engine **134** to verify the user identity.

At **309**, the authentication engine **134** may be implemented by the processor **132** by executing the software instructions **142** to compare the enhanced multi-factor authentication code **160** stored in the memory **140** to the user input code **162** to verify the user identity. If the user input code **162** matches the enhanced multi-factor authentication code **160**, the serve **130** may authorize the user device **120** to access the application **144** for the application service. Otherwise, the serve **130** may deny the request to access the application **144** by sending a corresponding notification to the user device **120**.

While several embodiments have been provided in the present disclosure, it should be understood that the disclosed systems and methods might be embodied in many other specific forms without departing from the spirit or scope of the present disclosure. The present examples are to be considered as illustrative and not restrictive, and the intention is not to be limited to the details given herein. For example, the various elements or components may be combined or integrated with another system or certain features may be omitted, or not implemented.

In addition, techniques, systems, subsystems, and methods described and illustrated in the various embodiments as discrete or separate may be combined or integrated with other systems, modules, techniques, or methods without departing from the scope of the present disclosure. Other items shown or discussed as coupled or directly coupled or communicating with each other may be indirectly coupled or communicating through some interface, device, or intermediate component whether electrically, mechanically, or otherwise. Other examples of changes, substitutions, and alterations are ascertainable by one skilled in the art and could be made without departing from the spirit and scope disclosed herein.

To aid the Patent Office, and any readers of any patent issued on this application in interpreting the claims appended hereto, applicants note that they do not intend any of the appended claims to invoke 35 U.S.C. § 112(f) as it exists on the date of filing hereof unless the words "means for" or "step for" are explicitly used in the particular claim.

The invention claimed is:

1. A system comprising:

a memory operable to store:

a user profile configured to authorize a user device associated with a user to access an application service operated by an entity, wherein the user profile comprises user identity data, a customized security code, and a customized operation rule; and

a processor operably coupled to the memory, the processor configured to:

receive a first request to access the application service from the user device, wherein the first request comprises the user identity data;

generate a multi-factor authentication code configured to verify an identity of the user and the associated user device;

generate an enhanced multi-factor authentication code from the multi-factor authentication and the customized security code in conjunction with a customized operation rule, wherein the enhanced multi-factor authentication code is different from the multi-factor authentication code;

present the multi-factor authentication code to the user device with a response to the user's first request for the user to provide the enhanced multi-factor authentication code;

receive a user input code from the user device;

determine whether the user input code matches the enhanced multi-factor authentication code; and

in response to determining that the user input code matches the enhanced multi-factor authentication code, authorize the user to interact with the entity with the user device to implement the application service.

2. The system of claim **1**, wherein the multi-factor authentication code is generated to be a n-digit-token which comprises a first series of security digits, each security digit being associated with a unique digit position.

3. The system of claim **2**, wherein:

the customized security code comprises a second series of security digits;

each digit in the second series of the security digits has a customized digit position; and

the customized digit position matches a corresponding digit position in the first series of the security digits of the multi-factor authentication code.

4. The system of claim **3**, wherein the processor is further configured to:

allow the user device to access the user profile to update the customized operation rule;

implement the customized operation rule by adding the first series of the security digits and the second series of the security digits at each corresponding position to generate the enhanced multi-factor authentication code; and

store the enhanced multi-factor authentication code in the memory.

5. The system of claim **3**, wherein the processor is further configured to allow the user device to access the user profile to update the customized security code by changing or switching one or more of corresponding digit positions of the security digits in the second series of the security digits.

6. The system of claim **3**, wherein the processor is further configured to allow the user device to access the user profile to update the customized security code by changing one or more corresponding values of the security digits in the second series of the security digits.

7. The system of claim **1**, wherein the processor is further configured to, in response to determining that the user input code does not match the enhanced multi-factor authentication code:

deny a user access to the application service by sending a corresponding notification to the user device.

8. A method comprising:

receiving a first request to access an application service from a user device, wherein the application service is operated by an entity and the first request comprises user identity data;

generating a multi-factor authentication code configured to verify an identity of a user and the user device;

generating an enhanced multi-factor authentication code from the multi-factor authentication and the customized security code in conjunction with a customized operation rule, wherein the enhanced multi-factor authentication code is different from the multi-factor authentication code;

presenting the multi-factor authentication code to the user device with a response to the user's first request for the user to provide the enhanced multi-factor authentication code;

receiving a user input code from the user device;

determining whether the user input code matches the enhanced multi-factor authentication code; and

in response to determining that the user input code matches the enhanced generated multi-factor authentication code, authorizing the user to interact with the entity with the user device to implement the application service.

9. The method of claim **8**, wherein the multi-factor authentication code is generated to be a n-digit-token which comprises a first series of security digits, each security digit being associated with a unique digit position.

10. The method of claim **9**, wherein:

the customized security code comprises a second series of security digits;

each digit in the second series of the security digits has a customized digit position; and

the customized digit position matches a corresponding digit position in the first series of the security digits of the multi-factor authentication code.

11. The method of claim **10**, further comprising:

allowing the user device to access a user profile to update the customized operation rule;

implementing the customized operation rule by adding the first series of the security digits and the second series of the security digits at each corresponding position to generate the enhanced multi-factor authentication code; and

storing the enhanced multi-factor authentication code.

12. Method of claim **10**, further comprising allowing the user device to access the user profile to update the customized security code by changing or switching one or more of corresponding digit positions of the security digits in the second series of the security digits.

13. The method of claim **10**, further comprising allowing the user device to access the user profile to update the customized security code by changing one or more corresponding values of the security digits in the second series of the security digits.

14. The method of claim **8**, further comprising, in response to determining that the user input code does not match the enhanced multi-factor authentication code, denying a user access to the application service by sending a corresponding notification to the user device.

15. A non-transitory computer-readable medium that stores instructions, wherein when the instructions are executed by one or more processors, cause the one or more processors to:

receive a first request to access an application service from a user device, wherein the application service is operated by an entity and the first request comprises a user identity data;

generate a multi-factor authentication code configured to verify an identity of a user and the user device;

generate an enhanced multi-factor authentication code from the multi-factor authentication and the customized security code in conjunction with a customized operation rule, wherein the enhanced multi-factor authentication code is different from the multi-factor authentication code;

present the multi-factor authentication code to the user device with a response to the user's first request for the user to provide the enhanced multi-factor authentication code;

receive a user input code from the user device;

determine whether the user input code matches the enhanced multi-factor authentication code; and

in response to determining that the user input code matches the enhanced generated multi-factor authentication code, authorize the user to interact with the entity with the user device to implement the application service.

16. The non-transitory computer-readable medium of claim **15**, wherein the instructions further cause the one or more processors to:

in response to determining that the user input code does not match the enhanced multi-factor authentication code, deny a user access to the application service by sending a corresponding notification to the user device; and

wherein the multi-factor authentication code is generated to be a n-digit-token which comprises a first series of security digits, each security digit being associated with a unique digit position.

17. The non-transitory computer-readable medium of claim **16**, wherein:

the customized security code comprises a second series of security digits;

each digit in the second series of the security digits has a customized digit position; and

the customized digit position matches a corresponding digit position in the first series of the security digits of the multi-factor authentication code.

18. The non-transitory computer-readable medium of claim **17**, wherein the instructions when executed by the processor further cause the one or more processors to:

allow the user device to access a user profile to update the customized operation rule;

implement the customized operation rule by adding the first series of the security digits and the second series of the security digits at each corresponding position to generate the enhanced multi-factor authentication code; and

store the enhanced multi-factor authentication code.

19. The non-transitory computer-readable medium of claim **17**, wherein the instructions further cause the one or more processors to allow the user device to access the user profile to update the customized security code by changing or switching one or more of corresponding digit positions of the security digits in the second series of the security digits.

20. The non-transitory computer-readable medium of claim **17**, wherein the instructions further cause the one or more processors to allow the user device to access the user profile to update the customized security code by changing one or more corresponding values of the security digits in the second series of the security digits.

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