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Method and system for a changing code learning transmitter

Abstract

In one aspect, a method is provided of effecting secure communications for a movable barrier operator and a trainable transmitter. The method includes, at the movable barrier operator, transmitting to a remote control a first radio frequency communication via a first communication protocol wherein the first radio frequency communication includes an access code. The method further includes receiving from the trainable transmitter a second radio frequency communication via a second communication protocol. The second radio frequency communication includes a derived access code based at least in part upon the access code. The method further includes learning the trainable transmitter in response to the derived access code corresponding to the access code.

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Background/Summary

CROSS-REFERENCE TO RELATED APPLICATION (1) This application is a continuation of PCT Application No. PCT/US2022/032947, filed Jun. 10, 2022, which claims the benefit of U.S. Provisional Application No. 63/209,625, filed Jun. 11, 2021. The disclosures of which are hereby incorporated by reference in their entirety.

FIELD

(1) This disclosure relates to movable barrier operators and, more particularly, to learning new security codes to movable barrier operators.

BACKGROUND

(2) A movable barrier operator system usually includes a movable barrier operator, such as a garage

door operator, and a remote control, such as a transmitter. The transmitter transmits a radio frequency (RF) signal including an access code that is received by the movable barrier operator. If the movable barrier operator authenticates the access code, the movable barrier operator performs the requested action such as changing the state (e.g., open/closed) of a movable barrier.
(3) Access codes may include changing codes, such as rolling codes, that change with each operation of the transmitter. The transmitter and the movable barrier operator both use a similar algorithm to predict the next access code to be sent and received.
(4) One type of access code includes four codes, such as a fixed transmitter number identification or code, a rolling code, a fixed transmitter type identification code, and a fixed switch identification code. The fixed transmitter identification code is a substantially unique transmitter identification number for the transmitter such as a universally unique identification (UUID) or globally unique identifier (GUID). The rolling code is a code that changes every transmission in order to confirm that the transmission is not a recorded and replayed transmission. The type identification code of the access code is used to notify the movable barrier operator of the type and features of the transmitter. The switch identification code is used to identify which switch on the transmitter (e.g. if the transmitter is configured with more than one switch/button) is being pressed.
(5) In the garage door operator context, a user typically receives at least one trained transmitter when the garage door opener is purchased and/or installed. The trained transmitter was previously learned by the garage door opener, so that the user may press a button of the transmitter to cause the transmitter to transmit RF signal including an access code to the garage door opener and open the garage door.
(6) “Learning” transmitters, also known as “universal” transmitters, are known that are configured to be learned by a garage door opener as a replacement for, or in addition to, the trained transmitters. Learning transmitters include in-vehicle learning transmitters such as those integrated in the dashboard, visor, or rearview mirror of the vehicle. One such learning transmitter is a HomeLink® device or system.
(7) Various approaches are currently used to train a garage door operator to respond to a RF signal from a learning transmitter of a vehicle. In one approach, the user places the vehicle learning transmitter into a mode to listen for a RF signal from a trained transmitter. The user presses a button of the trained transmitter within range of both the vehicle learning transmitter and the garage door operator. The garage door operator receives the radio frequency signal from the trained transmitter, decrypts and parses the access code of the RF signal, and opens the barrier. Upon receiving the RF signal from the trained transmitter, the garage door opener starts a time window to initiate a learning process.
(8) The vehicle learning transmitter also decrypts and parses the RF signal from the trained transmitter. The vehicle learning transmitter adapts or derives a unique transmitter identifier, a rolling code, and a payload from the transmitter identifier, rolling code, and payload of the RF signal from the trained transmitter. For example, the vehicle learning transmitter may prepend or append a value to the transmitter identifier of the trained transmitter.
(9) Next, the user presses a button of the vehicle learning transmitter within the time window set by the operator and the vehicle learning transmitter transmits a RF signal including the derived transmitter identifier, a derived rolling code (e.g. a next or subsequent rolling code to the rolling code that was transmitted by the trained transmitter), and a derived payload.
(10) Upon the garage door operator receiving the RF signal from the vehicle learning transmitter within the time window, the garage door operator determines whether the derived transmitter identifier, rolling code, and payload correspond to the trained transmitter that last caused the garage door opener to move the garage door.
(11) Some prior security systems for movable barrier operators utilize a unidirectional communication of the access code from the trained or learned transmitter to the movable barrier operator. The movable barrier operator authenticates the access code received from the transmitter

and changes the state of the movable barrier if the access code has been learned by the movable barrier operator.
(12) Some newer security systems utilize a bidirectional communication security protocol such as disclosed in U.S. Pat. No. 10,652,743. In one approach, the bidirectional communication security protocol generally involves a transmitter communicating a first signal to the movable barrier operator, the movable barrier operator sending a second signal to the transmitter in response to the first signal, and the transmitter sending a third signal to the movable barrier operator in response to the second signal. The back-and-forth of communication signals between the transmitter and the movable barrier and changing codes of the signals provides an additional layer of security against "man-in-the middle" attacks.
(13) A customer may purchase a newer garage door opener that includes a bidirectional communication security protocol but already owns a vehicle with a learning transmitter. The vehicle learning transmitter of the customer may not be compatible with bidirectional communication security protocols. In this situation, the user may be unable to operate the newer garage door opener using the learning transmitter in the customer's vehicle.

Description

BRIEF DESCRIPTION OF THE DRAWINGS
(1) FIG. **1** is a perspective view of an example movable barrier operator system including a trained transmitter and a learning transmitter;
(2) FIG. **2** is a schematic view of an example system including the movable barrier operator system of FIG. **1** wherein the learning transmitter is a component of a vehicle;
(3) FIG. **3** is a flow diagram of an example method of facilitating learning of a learning transmitter by a movable barrier operator;
(4) FIGS. **4**A and **4**B illustrate a flow diagram of a second example method of facilitating learning of a learning transmitter by a movable barrier operator;
(5) FIGS. **5**A and **5**B illustrate a flow diagram of a third example method of facilitating learning of a learning transmitter by a movable barrier operator;
(6) FIGS. **6**A and **6**B illustrate a flow diagram of a fourth example method of facilitating learning of a learning transmitter by a movable barrier operator;
(7) FIGS. **7**A and **7**B illustrate a flow diagram of a fifth example method of facilitating learning of a learning transmitter by a movable barrier operator;
(8) FIG. **8** is a flow diagram of a sixth example method of facilitating learning of a learning transmitter by a movable barrier operator;
(9) FIGS. **9**A, **9**B, **9**C, and **9**D illustrate a flow diagram showing an example communication flow between a learning transmitter and a movable barrier operator.
(10) FIG. **10**A is a schematic representation of example memory locations of a movable barrier operator showing memory locations occupied by data of learning transmitters C**1**-C**5** that were trained using trained transmitter C;
(11) FIG. **10**B is a schematic view similar to FIG. **10**A except that the data of learning transmitter C**1** has been erased from a memory location in response to the movable barrier operator learning transmitter C**3** and the data of learning transmitter C**2** and C**3** have been erased from memory locations in response to the movable barrier operator learning transmitters C**4** and C**5**.
DETAILED DESCRIPTION
(12) Regarding FIG. **1**, a movable barrier operator system **10** is provided that is operable to move a movable barrier **12** between open and closed positions to control access to a secured area such as a garage **14**. The movable barrier operator system **10** includes a movable barrier operator **20** and one or more remote controls **22** such as a wall control **24**, a trained transmitter **26**, and a trainable

transmitter such as a learning transmitter **28**. The trained transmitter **26** may be provided with the movable barrier operator **20** so that the access code transmitted by the trained transmitter **26** has been learned by the movable barrier operator **20**. The movable barrier operator **20** and the trained transmitter **26** communicate using a second communication protocol. A user provides a user input to a user interface **27** of the trained transmitter **26**, which causes the trained transmitter **26** to transmit a signal **30** including the access code to the movable barrier operator **20**. The movable barrier operator **20** includes a user interface, such as a learning mode button **29**, to receive a user input such as a button press and cause the movable barrier operator **20** to enter a learning mode wherein the movable barrier operator **20** will learn an access code sent from a remote control.

(13) The learning transmitter **28** is operable to receive the signal **30** from the trained transmitter **26**, decrypt and parse the relevant portions of the access code, and transmit its own signal **32** to the movable barrier operator **20** to cause the movable barrier operator **20** to learn the learning transmitter **28** without a user having to press the learning mode button **29** to initiate the learning mode of the movable barrier operator **20**. The learning transmitter **28** includes a user interface **34**, such as one or more buttons **36**. The learning transmitter **28** may be programmed so that the different buttons **36** of the learning transmitter **28** cause the learning transmitter **28** to transmit signals with different access codes to operate different devices, such as movable barrier operators, lights, locks, and/or a security system.

(14) Regarding FIG. **2**, a system **50** is provided that includes the movable barrier operator system **10**. In FIG. **2**, the learning transmitter **28** is an in-vehicle learning transmitter. The learning transmitter **28** may be integrated in a dashboard, rear view mirror, or infotainment system of a vehicle **52** as some examples. As a further example, the vehicle **52** has a display that operates as a user interface of the learning transmitter **28** and other components of the learning transmitter **28** are installed near the front of the vehicle **52**.

(15) The learning transmitter **28** includes communication circuitry, such as a transceiver **54**, that is configured to communicate with the movable barrier operator **20** and the trained transmitter **26** using a first communication protocol. The first communication protocol includes, for example, radio frequency transmissions **31** at 315 MHz, 390 MHz, or 418 MHz. The first communication protocol may utilize communications having a frequency of less than 1 GHz. The first communication protocol may be a unidirectional communication protocol, e.g., a first device transmits an access code to a second device, but the second device does not send a signal to the first device to complete authentication of the first device. In some embodiments, the learning transmitter **28** is operable to communicating using a plurality of communication protocols other than the second communication protocol. The plurality of communication protocols of the learning transmitter **28** may include RF signals having different frequencies, formats, and/or encryption techniques as some examples to permit the learning transmitter **28** to communicate with a plurality of movable barrier operator types (e.g., different manufacturers and/or models of garage door openers).

(16) The trained transmitter **26** has a controller **55** operatively connected to communication circuitry **56** and a user interface such as one or more buttons **316** (see FIG. **3**). The communication circuitry **56** includes a transmitter **58** that is configured to transmit a RF signal to the learning transmitter **28** via the first communication protocol. In one embodiment, the transmitter **58** is a transceiver with both transmitting and receiving capabilities. In another embodiment, the transmitter **58** comprises a distinct receiver and a transmitter.

(17) The communication circuitry **56** of the trained transmitter **26** also includes a transceiver **60** operable to communicate with the movable barrier operator **20** using a second communication protocol that is different than the first communication protocol. The second communication protocol may be a bidirectional communication protocol, e.g., a first device transmits an access code to the second device and the second device sends a response signal to the first device to facilitate authentication of the first device. Additional communications between the first and second

devices may be utilized in the bidirectional communication protocol, such as the first device transmitting a reply signal to the second device in response to the first device receiving the response signal from the second device. The second communication protocol may include various long-range and short-range wireless communication approaches such as Bluetooth®, Zigbee, Z-Wave, and/or 6LoWPAN. The second communication protocol may utilize radio frequency communications at a frequency of at least 2 GHz. In one embodiment, the transceiver communicates with the movable barrier operator **20** using a Bluetooth low energy (BLE) protocol such as BLE 5. In this manner, the trained transmitter **26** may communicate in a unidirectional, legacy manner with the learning transmitter **28** using the first communication protocol as well as communicate in a bidirectional manner with the movable barrier operator **20** using the second communication protocol.

(18) The movable barrier operator **20** has a controller **70** including communication circuitry **62**, a processor **72**, and a memory **74**. The controller **70** operates a motor **76** of the movable barrier operator **20** and responds to commands from learned remote controls **22**. The wall control **24** has a user interface such as one or more buttons **78** and communicates via wired or wireless approaches with the movable barrier operator **20**. The movable barrier operator **20** and the wall control **24** may be connected via one or more networks **80**, such as a local Wi-Fi network and the internet to one or more remote devices. The one or more remote devices may include, for example, a server computer **82**, a personal computer **84**, a portable electronic device such as a portable electronic device **86**, and an in-vehicle device **88** of the vehicle **52**. The in-vehicle device **88** includes, or is operably coupled to, the learning transmitter **28**. The in-vehicle device **88** has a wireless network interface operable to communicate via one or more wireless networks such as wide-area or cellular approaches (3G, 4G, 4G-LTE, and/or 5G), Wi-Fi, and/or Bluetooth®.

(19) The movable barrier operator **20** communicates the state of the garage door **12** to the server computer **82** as well as receives status/state inquiries and/or control commands via the network **80** from the portable electronic device **86** and/or personal computer **84**. The memory **74** of the movable barrier operator **20** stores a data structure, such as a whitelist **90**, including data regarding the access codes of learned remote controls. The processor **72** facilitates the communication circuitry **62** communicating updates to the server computer **82** regarding the remote controls **22** that have been learned by the movable barrier operator **20**. The movable barrier operator **20** may also broadcast to and receive communications from one or more auxiliary devices **96** such as a camera, an optical sensor, a presence detector, a smart lock, a light, and/or a security system, as some examples.

(20) The trained transmitter **26** and the movable barrier operator **20** are each capable of communicating using at least two different communication protocols including the first communication protocol and the second communication protocol. The second communication protocol is the default communication protocol of the trained transmitter **26** and the movable barrier operator **20**. The learning transmitter **28** is capable of communicating using the first communication protocol but not the second communication protocol. The inability of the learning transmitter **28** to communicate using the second communication protocol inhibits the learning transmitter **28** from communicating with the movable barrier operator **20** using the default communication protocol of the movable barrier operator **20**.

(21) To facilitate the movable barrier operator **20** learning the learning transmitter **28** despite the learning transmitter **28** being unable to communicate using the second communication protocol, the movable barrier operator **20** and the trained transmitter **26** are operable in a legacy learning process wherein the movable barrier operator **20** and trained transmitter **26** interact with the learning transmitter **28** using the first communication protocol as discussed below. Once the movable barrier operator **20** has learned the learning transmitter **28**, the movable barrier operator **20** enters an operating mode wherein movable barrier operator **20** listens for transmissions from the learning transmitter **28** using the first communication protocol and listens for transmissions from other

transmitters using the default second communication protocol. The movable barrier operator **20** will respond to transmissions from the learning transmitter **28** using the first communication protocol, but ignores transmissions from unlearned transmitters using the first communication protocol. In this manner, the movable barrier operator **20** defaults to communicating using the second communication protocol unless trained to use the first communication protocol for a given transmitter (e.g., learning transmitter **28**).

(22) Regarding FIG. **3**, an example method **300** is provided that facilitates the movable barrier operator **20** learning the learning transmitter **28** despite the learning transmitter **28** being unable to communicate using the second communication protocol. The method **300** includes a user **302** utilizing a user device **304** to sign up for an account. The user **302** provides one or more user credentials, such as a username, password, and a mobile phone number for a two-factor authentication procedure. The user **302** provides identifying information for one or more devices the user **302** wants to associate with the user account, such as the movable barrier operator **20**, the trained transmitter **26**, a lock, a light, a vehicle, and/or a security system. The user **302** may provide identifying information in a number of approaches, such as by using a camera of the user device **304** to capture an indicium indicative of an identifier of the device, such as barcode, QR code, vehicle identification number, and/or serial number. The identifier of the device may be a universally unique identifier (UUID) in one approach. The user **302** sets up one or more user profiles for users that are to be associated with the user account. Details of the account are stored in the server computer **82** which may be, for example, one or more computers of a cloud computing system or middleware layer.

(23) In the method **300**, the user **302** accesses the user account via the user device **304**, selects the garage door opener **20**, and requests **308** that the garage door opener **20** participate in a legacy learning process for the learning transmitter **28**. The server computer **82** sends a communication **310** to the movable barrier operator **20** that places the movable barrier operator **20** in the legacy learning mode. The movable barrier operator **20** communicates an acknowledgement **312** of entering the legacy learning mode to the server computer **82** and stands by for a communication from the trained transmitter **26**.

(24) The server computer **82** receives the acknowledgement **312** and prompts **313** the user **302** to provide a user input (e.g., a button press) to the trained transmitter **26** to start the legacy learning process. The prompt **312** may include, for example, a visual and/or auditory notification provided via a user interface of the user device **304**. The user **302** actuates **314** (e.g. via a button press) the trained transmitter **26** in response to the prompt **312** such that the trained transmitter **26** transmits a communication **318** to the movable barrier operator **20** using the second communication protocol. The communication **318** includes an access code having, for example, a fixed code, a rolling code, and a payload.

(25) The movable barrier operator **20** recognizes the access code of the communication **318** as being sent from the trained transmitter **26**. Upon receiving the access code from the trained transmitter **26**, the movable barrier operator **20** determines the trained transmitter **26** is ready to participate in the legacy learning process. The movable barrier operator **20** calculates one or more legacy codes to provide to the learning transmitter **28** via the trained transmitter **26**. In one embodiment, the one or more legacy codes include a fixed code and a rolling code. The one or more legacy codes may be calculated based at least in part on one or more portions of the access code of the trained transmitter **26**. In another embodiment, the one or more legacy codes are randomly generated by the movable barrier operator **20**. For example, the one or more legacy codes may be generated from code values seeded in the memory **74** at manufacture of the movable barrier operator **20**.

(26) The movable barrier operator **20** communicates **320** the one or more legacy codes (e.g., a fixed code and a changing code) calculated by the movable barrier operator **20** to the trained transmitter **26** using the second communication protocol. The trained transmitter **26** acknowledges **322** receipt

of the fixed code and the changing code.
(27) Upon receiving the one or more legacy codes from the movable barrier operator **20**, the trained transmitter **26** enters the legacy training mode. The communication **320** includes a code, value, or other data that causes the trained transmitter **26** to exit an operating mode and enter the legacy programming mode. In one embodiment, the communication **320** may include one or more parameters relating to the first security communication protocol. The trained transmitter **26** utilizes the one or more parameters to configure itself to communicate using the first communication protocol.
(28) The movable barrier operator **20** sends **324** a message to the remote server **82** indicating that the trained transmitter **26** is ready to train the learning transmitter **28**. The remote server **82** prompts **330** the user **302** via the user device **304** to start training the learning transmitter **28**.
(29) In response to the prompt **330**, the user **302** provides **331** a user input to the learning transmitter **28**, such as by pressing an unlearned button of the learning transmitter **28**, to place the learning transmitter in the learn mode. As another example, the user **302** presses a predetermined pattern of buttons of the learning transmitter **28**. The learning transmitter **28** may set a time window, such as five seconds, for receiving a RF signal from another transmitter before the learning transmitter **28** exits the learning mode and enters an operating mode.
(30) The user actuates the trained transmitter **26** to cause the trained transmitter **26** to send a transmission **333** using the first communication protocol. The transmission **333** includes an access code having the one or more legacy codes the trained transmitter **26** received from the movable barrier operator **20** at operation **320**. Actuation of the trained transmitter **26** may be performed by the user **302** providing a user input **332** to the trained transmitter **26**. The user input **332** may include the user **302** pressing a button of the trained transmitter **26** that would cause the trained transmitter **26** to transmit an access code using the second communication protocol if the trained transmitter **26** were in the operating mode. However, because the trained transmitter **26** is in the legacy programming mode after receiving communication **320**, the trained transmitter **26** transmits **333** the access code including the one or more legacy codes (e.g., the fixed code and the changing code) received at communication **320** using the first communication protocol. The trained transmitter **26** may transmit **333** the access code including the one or more legacy codes a plurality of times to give the training transmitter **28** an opportunity to receive the one or more legacy codes. The learning transmitter **28** receives the transmission **333**. In some embodiments, the movable barrier operator **20** also receives the transmission **333** and uses receipt of the transmission **333** as a requirement to continue with the learning process.
(31) With the learning transmitter **28** in the learning mode, the learning transmitter decrypts and parses the transmission **333** from the trained transmitter **26**. The learning transmitter **28** stores a representation of the access code of transmission **333** from the trained transmitter **26** in a memory of the learning transmitter **28**. The learning transmitter **28** adapts or derives one or more codes from the representation of the transmission **333**, such as deriving a fixed code and a changing code from the fixed code and the changing code of the transmission **333**. The fixed code and the changing code derived by the learning transmitter **28** may be unique to the learning transmitter **28**.
(32) In one embodiment, deriving the fixed code includes prepending or appending a value to the fixed code of the transmission **333**. By utilizing a derived fixed code that includes the original fixed code, the movable barrier operator **20** and server computer **82** may track the learning transmitters trained by a particular trained transmitter **26**. As a further example, deriving the changing code includes incrementing the changing code of the transmission **333**. The incrementing of the changing code may include incrementing the changing code while keeping the changing code within a window expected by the movable barrier operator **20**.
(33) The user device **304** continues to guide the user **302** through the process to train the movable barrier operator **20** to recognize communications from the learning transmitter **28**. The user device **304** prompts the user **302** to provide a user input **334** to the learning transmitter **28**.

(34) In response to receiving the user input **334**, the learning transmitter **28** sends a transmission **336** using the first communication protocol. The transmission **336** includes the one or more codes derived from the one or more legacy codes. For example, the transmission **336** includes a unique fixed code, a unique rolling code, and a payload derived from the access code the learning transmitter **28** received from the trained transmitter **26**.
(35) The movable barrier operator **20** receives the transmission **336** including the derived fixed code and the rolling code from the learning transmitter **28**. If the derived code(s) of transmission **336** correspond to the access code of the transmission **333**, the movable barrier operator **20** learns the fixed code and the rolling code of the learning transmitter **28**. For example, the movable barrier operator **20** stores the fixed code and the rolling code of the learning transmitter **28** on the whitelist **90** in the memory of the movable barrier operator **20**. The derived code(s) of the transmission **336** correspond to the access code of the transmission **333** if the derived code(s) have a predetermined relationship to the access code of the transmission **333**. In one example, the access code of the transmission **333** may include a first fixed code and a first changing code. The derived code(s) of the transmission **336** may include a second fixed code and a second changing code. The second fixed code includes the first fixed code with a value added thereto. The second changing code includes a changing code that is within a predetermined number of increments from the first changing code.
(36) If the transmission **336** contains a derived code that does not correspond to the access code of the transmission **333**, the movable barrier operator **20** does not learn the fixed code and the rolling code of the learning transmitter **28**. For example, the learning transmitter **28** may utilize an incorrect algorithm which results in a rolling code not expected by the movable barrier operator **20**.
(37) The movable barrier operator **20** provides a response **340** to the server computer **82** indicating that the learning transmitter **28** has been learned. The response **340** is communicated to the server computer **82** to indicate/confirm learning of the learning transmitter **28** and cause updating of a user account to indicate the now-learned learning transmitter **28** in a list of devices associated with the user account.
(38) The learning transmitter **28** exits the learning mode after sending the transmission **336**. In one embodiment, the transmitter **28** exits the learning mode after a predetermined period of time after sending the transmission **336**.
(39) The movable barrier operator **20** sends **342** a command to the trained transmitter **26** to cause the transmitter **26** to exit the legacy programming mode and return to the operating mode. In some embodiments, the trained transmitter **26** is capable of receiving a command (e.g. command **342**) via the second communication protocol while the trained transmitter **26** is in the legacy training mode. Additionally or alternatively, the trained transmitter **26** may exit the legacy training mode after a predetermined time period, such as a predetermined time period after transmission **333**. The transmitter **26** exiting the legacy programming mode disables communications from the trained transmitter **26** using the first communication protocol. The transmitter **26** returns to the communicating using the second communication protocol once the transmitter **26** has entered the operating mode.
(40) The movable barrier operator **20** may provide a notification to the user the training process was successful, such as the movable barrier operator **20** flashing a light of the user interface **21**, outputting a sound from an integrated speaker/sounder, or illuminating a worklight of the operator **20**. The server computer **82** communicates **346** with the user device **304** to notify the user that the programing of the learning transmitter **28** has been completed.
(41) In one embodiment, upon a successful learning procedure, the movable barrier operator **20** scans in an alternating fashion between a first interval for transmissions utilizing the second communication protocol and a second interval for transmissions utilizing the first communication protocol that contain the fixed code and the changing code of the learning transmitter **28**. The movable barrier operator **20** ignores transmissions utilizing the first communication protocol that

do not include the fixed code and the changing code of the learning transmitter **28**.
(42) Regarding FIG. **4**, an example method **400** is provided that is similar in many respects to the method **300** discussed above such that differences will be highlighted. One difference is that the method **400** utilizes the portable electronic device **86** to guide a user **402** during the method **400**. The method **400** includes the user providing **404** credentials associated with an account of the user **402** to the portable electronic device **86** so that the portable electronic device **86** may provide **406** the credentials to the server computer **82**. The user **402** provides an input **408** requesting the association of a vehicle with the user account. The vehicle has the learning transmitter **28** integrated therein, such as a HomeLink® system.
(43) The user **402** selects **410** vehicle data such as the make, model, and year of the vehicle and the portable electronic device **86** provides **412** the vehicle data to the server computer **82**. The server computer **82** determines **414** whether the movable barrier operator **20** will proceed to utilize the first communication protocol to communicate with the learning transmitter **28** of the vehicle based on the vehicle data provided by the portable electronic device **86**.
(44) If the server computer **82** determines that the first communication protocol is to be used with the learning transmitter **28**, the server computer **82** determines **416** one or more remote controls **22** that may be used to train the learning transmitter **28**. For example, the server computer **82** may generate a list of remote controls **22** that are capable of communicating using both the first communication protocol and the second communication protocol. The list of remote controls **22** is communicated **418** to the portable electronic device **86**.
(45) The portable electronic device **86** provides **420** the list of remote controls **22** to the user **402**. The list of remote controls **22** includes the trained transmitter **26**. The user selects **422** the trained transmitter **26** to use to train the learning transmitter **28**. The portable electronic device **86** provides **424** the selected trained transmitter **26** and the server computer **82** communicates **430** a message to the movable barrier operator **20** that the trained transmitted **26** will be used to participate in training the learning transmitter **28**.
(46) The server computer **82** prompts **432** the user **402** to provide a user input to the trained transmitter **26**, such as pressing a button of the trained transmitter **26** that has previously been learned by the movable barrier operator **20**. The user **402** provides **434** the user input to the trained transmitter **26**. The trained transmitter **26** advertises **436** using the default second communication protocol. The movable barrier operator **20** initiates **438** a connection with the trained transmitter **26** using the second communication protocol. The movable barrier operator **20** communicates **440** a command to the trained transmitter **26** to enter the legacy programming mode. Upon the trained transmitter **26** receiving the communication **440**, the trained transmitter **26** recognizes that the trained transmitter will be used to train a transmitter using a legacy communication protocol (e.g., the first communication protocol).
(47) The movable barrier operator **20** communicates **442** a fixed code and a rolling code to the trained transmitter **26**. In one embodiment, the communication **442** is performed using the second communication protocol. The movable barrier operator **20** sends **444** a message to the server computer **82** indicating the trained transmitter **26** is ready to participate in the training of the learning transmitter **28**. The server **82** sends **446** a message to the portable electronic device **86** indicating the trained transmitter **26** is ready.
(48) The portable electronic device **86** provides **448** one or more outputs to the user **402** such as prompts or step-by-step information to guide the user **402** through the training process. In one example, the portable electronic device **86** provides images and/or text on a display of the portable electronic device **86**.
(49) The user **402** provides **452** a user input to the learning transmitter **28** to cause the learning transmitter **28** to enter a learning mode and identify which portion of the user interface (e.g., a button) the user **402** wants to be learned by the movable barrier operator **20**. For example, the user may press an unlearned button of the learning transmitter **28** or a particular combination of buttons

of the learning transmitter **28**. In the learning mode, the learning transmitter **28** listens for transmissions using the first security protocol.

(50) The user **402** also provides **450** a user input to the trained transmitter **26**, such as a button press, which causes the trained transmitter **26** to send a transmission **454** that utilizes the first communication protocol. The transmission **454** includes an access code having the fixed code and the changing code provided to the trained transmitter **26** via communication **442** from the movable barrier operator **20**. The transmission **454** (which is broadcast to an area proximate the trained transmitter **26**, the learning transmitter **28** and the operator **20**) is received at the learning transmitter **28** and the movable barrier operator **20** substantially contemporaneously.

(51) The learning transmitter **28** upon reception of the transmission **454** from the trained transmitter **26**, stores a representation of the access code of the transmission **454**, and determines **458** one or more codes of the access code of the transmission **454**. The determining **458** may include, for example, the learning transmitter **28** decrypting and parsing the access code to identify the fixed code and the rolling code. The learning transmitter **28** adapts or derives a rolling code and a fixed code from the representation of the access code.

(52) Next, the user **402** provides **459** a user input to the learning transmitter **28** to cause the learning transmitter **28** to send a transmission **460** to the movable barrier operator **20** including the derived fixed code and changing code that was incremented from the derived changing code according to the changing code algorithm shared by the learning transmitter **28** and the movable barrier operator **20**. The movable barrier operator **20** learns the fixed code and the changing code of the transmission **460**.

(53) In one embodiment, the movable barrier operator **20** sets a time window after the movable barrier operator **20** sends the fixed code and the rolling code to the trained transmitter **26** at operation **442**. If the movable barrier operator **20** receives the transmission **460** from the learning transmitter **28** within the time window, the movable barrier operator **20** stores the derived fixed code and the derived rolling code of the learning transmitter **28** in the whitelist **90** of the movable barrier operator **20**. The movable barrier operator **20** also authenticates the derived fixed code and the derived rolling code to confirm the derived fixed code and the derived rolling code correspond to the fixed code and the rolling code the movable barrier operator **20** generated and communicated to the trained transmitter **26** at operation **442**.

(54) In one embodiment, the movable barrier operator **20** and/or the server computer **86** suggests the learning transmitter **28** to operate the movable barrier operator **20** to complete the learning process. To this end, the user **402** is prompted to test the operation of the learning transmitter **28** such as via a request from the portable electronic device **86**.

(55) The user provides **462** a user input to the learning transmitter **28**, such as pressing the button of the learning transmitter **28** the user **402** is learning to the movable barrier operator **20**, which causes the learning transmitter **28** to transmit **464** a second communication via the first communication protocol. Because the movable barrier operator **20** has authenticated the derived fixed code and the derived rolling code of the learning transmitter **28**, the movable barrier operator **20** causes a state change of the garage door **12** upon receiving the transmission **464**. In this manner, the user visually observes that the learning transmitter **28** has been learned by the movable barrier operator **20**.

(56) The movable barrier operator **20** sends **466** a message to the server computer **82** indicating the learning process is complete. The movable barrier operator **20** sends **468** a command to the trained transmitter **26** to exit the legacy programming mode and return to the default mode wherein the trained transmitter **26** communicates with the movable barrier operator **20** via the second communication protocol. The server computer **82** sends **470** a message to the portable electronic device **86** indicating that the learning transmitter **28** has been learned successfully. The mobile device provides **472** a notification to the user **404** indicating the successful completion of the legacy learning process.

(57) Regarding FIG. **5**, another example method **500** is provided that is similar in many respects to the method **400** such that differences will be highlighted. One difference is that the method **500** permits a user to train the movable barrier operator **20** to recognize access codes from the learning transmitter **28** without the involvement, assistance, or use of a server computer **82**, although it will be appreciated that the server computer **82** may be utilized in some embodiments. Further, the method **500** may utilize direct wireless communications between the devices participating in the method **500**.
(58) The method **500** includes a user **502** requesting **504** to add a vehicle to be associated with the user account at the portable electronic device **86**. The user provides **506** vehicle data such as a make, model, and year of the vehicle. Based on the vehicle data, the portable electronic device **86** determines **508** (e.g. using a vehicle/transmitter lookup table or database stored in the portable electronic device **86**) if the trained transmitter **26** and movable barrier operator **20** are to be placed into legacy learning mode in order to train the learning transmitter **28**. If the portable electronic device **86** determines **510** legacy mode should be utilized, the portable electronic device **86** connects **512** with the movable barrier operator **20** using a wireless communication protocol, such as Bluetooth, BLE, and/or a local Wi-Fi network.
(59) The portable electronic device **86** communicates **514** a command for the movable barrier operator **20** to enter the legacy learning mode. The portable electronic device **86** prompts **516** a user to provide **518** a user input to the trained transmitter **26** such as pressing a button of the trained transmitter **26** that has been learned by the movable barrier operator **20**. In response to the user input, the trained transmitter **26** advertises **520** using the default second communication protocol and the movable barrier operator **20** initiates **522** a connection with the trained transmitter **26** using the second communication protocol.
(60) The movable barrier operator **20** communicates **524** a command to the trained transmitter **26** to enter the legacy training mode and communicates **526** a fixed code and a rolling code to the trained transmitter **26** using the first communication protocol.
(61) The movable barrier operator **20** sends **528** a message to the portable electronic device **86** indicating the trained transmitter **26** is ready. The portable electronic device **86** provides **530** one or more outputs to guide the user **502** through the training of the learning transmitter **28**. The user **502** provides **534** a user input to the learning transmitter **28**, such as pressing an unlearned button or a predetermined combination of buttons, which causes the learning transmitter **28** to enter a learning mode and identifies which button the user **502** wants the movable barrier operator **20** to learn. The user **502** also provides **532** a user input such as pressing a button or pressing and holding the button, of the trained transmitter **26**.
(62) In response to receiving the user input at operation **532**, the trained transmitter **26** sends a broadcast transmission **536** via the first communication protocol. The transmission **536** includes an access code with the fixed code and the rolling code received from the movable barrier operator **20** at operation **526**.
(63) The transmission **536** is received substantially contemporaneously at the learning transmitter **28** and the learning transmitter **28**. Upon receipt of transmission **536** from the trained transmitter, the learning transmitter **28** determines **540** one or more codes of the access code of the transmission **536**. The learning transmitter **28** decrypts and parses the transmission **536** for the fixed code and the rolling code. The learning transmitter **28** derives a fixed code and a rolling code from the received transmission **536**.
(64) Next, the user provides **541** a user input to the learning transmitter **28** to cause the learning transmitter **28** to communicate a transmission **542** including the derived fixed code and the rolling code to the movable barrier operator **20** using the first communication protocol. The movable barrier operator **20** learns the fixed code and the changing code of the transmission **460**.
(65) The transmission **536** is also received at the movable barrier operator **20**. The movable barrier operator **20** authenticates and stores the fixed code and the rolling code of the transmission **542**.

(66) The user **502** may optionally provide **544** a second user input to the learning transmitter **28**, which causes the learning transmitter **28** to send a transmission **546** to the movable barrier operator **20**. The transmission **546** includes an access code having the derived fixed code and a changing code that was incremented from the derived changing code. The movable barrier operator **20** recognizes the fixed code and the rolling code of the learning transmitter **28** and moves the garage door **12**. The movable barrier operator **20** then communicates **548** a message to the portable electronic device **86** indicating that training is complete. The movable barrier operator **20** sends **550** a command to the trained transmitter **26** to change from the legacy training mode to the default mode and resume communication using the second communication protocol. The trained transmitter **26** alternatively or additionally has a timer and will exit **552** the legacy training mode if the trained transmitter **26** is still in the legacy training mode after a predetermined duration of time (e.g., five minutes) if the command **550** was not received. The trained transmitter **26** may also monitor button presses of the trained transmitter **26** and exit **554** the legacy training mode after a predetermined number (e.g. five) of button presses if the trained transmitter **26** is still in the legacy training mode.

(67) Regarding FIG. **6**, another example method **600** is provided that is similar in many respects to the method **400** discussed above such that differences will be highlighted. One difference is that the method **600** includes a user **602** interacting with the wall control **24** rather than the user device **304**. The wall control **24** includes a user interface **604** that may include, for example, the one or more buttons **78**, a display to present one or more of icons, images, human-readable text, etc., a microphone, and/or speaker.

(68) The user provides **606** a user input requesting to add a new vehicle to be associated with the account of the user **602**. The wall control **24** communicates **608** a message to the movable barrier operator **20** requesting that the movable barrier operator **20** enter the legacy mode. The wall control **24** prompts **610** that the user **602** provide a user input **612** to the trained transmitter **26**, such as by pressing a button on the trained transmitter **26** that has been previously learned by the movable barrier operator **20**. The trained transmitter **26** advertises **614** using the second communication protocol and the movable barrier operator **20** initiates **616** a connection between the movable barrier operator **20** and the trained transmitter **26** via the second communication protocol.

(69) Once connected, the movable barrier operator **20** sends **618** a command to the trained transmitter **26** to enter the legacy training mode. The movable barrier operator **20** communicates **620** a fixed code and a rolling code. The moveable barrier operator **20** then sends **622** a message to the wall control **24** indicating the trained transmitter **26** is ready to participate in the training of the learning transmitter **28**.

(70) The wall control **24** provides an output **624** via the user interface **604** to guide the user **602** through the process of training the learning transmitter **28**.

(71) The user **602** provides **628** a user input to the learning transmitter **28** that cause the learning transmitter **28** to enter a learning mode and indicate which button of the trained transmitter **28** the user **602** wants the movable barrier operator **20** to learn. For example, the user **602** presses a predetermined combination of buttons to place the learning transmitter **28** in the learning mode and presses a button of the trained transmitter **28** that the user **602** wants to be learned by the movable barrier operator **20**.

(72) The user **602** also provides **626** a user input to the trained transmitter **26**. The trained transmitter **26** sends a transmission **630** via the first communication protocol. The transmission **630** includes an access code having the fixed code and the rolling code received from the movable barrier operator **20** at operation **620**.

(73) The transmission **630** is received at the learning transmitter **28** and the learning transmitter determines **632** the fixed code and the rolling code of the transmission **630**. The learning transmitter **28** adapts or derives a fixed code and a rolling code from the access code of the transmission **630**.

(74) Next, the user **602** provides **633** a user input to the learning transmitter **28** to cause the learning transmitter **28** to send a transmission **634** to the movable barrier operator **20** via the first communication protocol. The transmission **634** includes an access code having the derived fixed code and the derived rolling code.
(75) The movable barrier operator **20** decrypts and parses the access code of the transmission **634** to obtain the derived fixed code and the derived changing code, which the movable barrier operator **20** stores in the memory **74** to learn the learning transmitter **28**.
(76) The user is prompted, such as via the user interface **604** of the wall control **24**, to provide another user input **636** to the learning transmitter **28**. For example, the user **602** may be prompted to press the same button the user pressed at operation **628** wherein the user **602** identified the button of the learning transmitter **28** to be learned by the movable barrier operator **20**.
(77) In response to the user input **636**, the learning transmitter **28** sends another transmission **630** via the first communication protocol. The transmission **630** includes the derived fixed code and an incremented changing code based on the derived changing code. Because the derived fixed code and the derived changing code were previously authenticated by the movable barrier operator **20**, the movable barrier operator **20** moves the garage door **12** upon receiving the transmission **630**.
(78) The movable barrier operator **20** sends **640** a message to the wall control **24** that the movable barrier operator **20** has learned the learning transmitter **28**. The wall control **24** provides **642** an output to the user **602** indicating that the learning transmitter **28** has been learned successfully. The movable barrier operator **20** sends **644** a command to the trained transmitter **26** to exit the legacy training mode. The trained transmitter **26** returns to the operating mode and resumes communicating with the movable barrier operator **20** using the second communication protocol.
(79) The trained transmitter **26** may also be configured to monitor the time lapsed from the beginning of the legacy training mode and exits **646** the legacy training mode if the trained transmitter **26** has been in the legacy training mode for more than a predetermined duration such as five minutes. Similarly, the trained transmitter **26** may exit **648** the legacy training mode after a predetermined number of operations of the learning transmitter **28**.
(80) Regarding FIG. **7**, another example method **700** is presented that is similar in many respects to the method **600** discussed above such that differences will be highlighted. One difference is that the method **700** involves a user **702** interfacing directly with the movable barrier operator **20** to coordinate the learning of the learning transmitter **28** by the movable barrier operator **20**.
(81) The method includes the user **702** providing **704** a user input to the user interface **21** of movable barrier operator **20**. For example, the user **702** presses a button or a specific sequence of buttons of the user interface **21**. The movable barrier operator **20** enters **706** the legacy learning mode in response to receiving the user input.
(82) The movable barrier operator **20** provides **708** an output to the user **702** via the user interface **21**, such as a flashing of one or more lights, that prompts the user **702** to activate the trained transmitter **26**. The user **702** provides **710** a user input such as by pressing a button of the trained transmitter **26** that has been previously learned by the movable barrier operator **20**. In response receiving the user input, the trained transmitter **26** advertises **712** using the second communication protocol.
(83) The movable barrier operator **20** initiates **714** a connection between the movable barrier operator **20** and the trained transmitter **26**. Once the connection between the movable barrier operator **20** and the trained transmitter **26** has been established, the movable barrier operator **20** communicates **716** a command to the trained transmitter **26** to enter the legacy training mode. The movable barrier operator **20** communicates **718** a fixed code and a rolling code to the trained transmitter **26** via the second communication protocol. The movable barrier operator **20** provides **720** a notification to the user **702** that the trained transmitter **26** is ready, such as by flashing one or more lights of the movable barrier operator **20**.
(84) In one embodiment, the method **700** includes the user **702** receiving **722** instructions to train

the learning transmitter **26**. For example, the user **702** may retrieve an instruction sheet from a container associated with the movable barrier operator **20**. As another example, the user **702** may receive **722** the instructions (e.g., a portable document format file) by using a user device to retrieve the instructions from a website of the manufacturer of the movable barrier operator **20**. As another example, the movable barrier operator **20** outputs a pre-recorded audio message from a speaker of the user interface **21** after or concurrent with the notification provided at operation **720**.
(85) The user **702** provides **726** a user input to the learning transmitter **28** that causes the learning transmitter to enter a learning mode. The user **702** also provides **724** a user input to the trained transmitter **26**, such as by pressing the button of the trained transmitter **26** that the user **702** previously pressed at operation **710**. The user input to the trained transmitter **26** causes the trained transmitter **26** to send a transmission **728** using the first communication protocol. The transmission **728** includes an access code having the fixed code and the rolling code received from the movable barrier operator **20** at operation **718**.
(86) The learning transmitter **28** receives the transmission **728** and determines **730** one or more codes of the access code of the transmission **728**. For example, the determining **730** may include the learning transmitter **28** decrypting and parsing the access code of the transmission **728** for the fixed code and the rolling code of the access code. The learning transmitter **28** derives a fixed code and derives a rolling code from the access code of the transmission **728**.
(87) Next, the user **702** provides **731** a user input to the learning transmitter **28** to cause the learning transmitter **28** to send, using the first communication protocol, a transmission **732** to the movable barrier operator **20** that includes the derived fixed code and the derived rolling code. The movable barrier operator **20** receives the transmission **732** and stores the derived fixed code and the derived rolling code in the memory **74** of the movable barrier operator **20** to learn the learning transmitter **28**.
(88) The user **702** is prompted to provide **734** another user input to the learning transmitter **28**, such as pressing the same button the user previously requested be learned by the movable barrier operator **20** at operation **726**. In response to the user input, the learning transmitter **28** sends a transmission **736** to the movable barrier operator **20** using the first communication protocol. The transmission **736** includes the derived fixed code and a changing code incremented from the derived changing code. The incremented changing code may be, for example, the next roll value according to a rolling code algorithm employed by the movable barrier operator **20** and the learning transmitter **28**.
(89) The movable barrier operator **20** authenticates the rolling code and the incremented changing code of the transmission **736** and provides **738** an indication to the user **702** that the learning transmitter **28** has been learned by the movable barrier operator **20**. The movable barrier operator **20** sends **740** a command to the trained transmitter **26** to exit the legacy training mode. The trained transmitter **26** reverts back to the operating mode wherein the trained transmitter **26** communicates with the movable barrier operator **20** using the second communication protocol. The trained transmitter **26** may exit **742** the legacy training mode after a predetermined period or duration of time, such as after five minutes if the trained transmitter **26** is still in the legacy training mode. Further, the trained transmitter **26** may exit **744** the legacy training mode after a predetermined number of button presses, such as five button presses, if the trained transmitter **26** is still in the legacy training mode.
(90) Regarding FIG. **8**, an example method **800** is provided that facilitates the operator **20** learning a learning transmitter **800** without the user having to press a learn button of the movable barrier operator **20**. The method **800** utilizes the trained transmitter **26** and a learning transmitter **802**. The learning transmitter **802** may be, for example, a learning transmitter integrated in a dashboard, visor, rearview mirror, or other location of a vehicle. As further examples, the learning transmitter **802** may be a transmitter associated with a set of keys or a transmitter that clips to a visor of a vehicle. Unlike in the previously-described examples, the present learning transmitter **802** is

capable of communicating via the second communication protocol utilized by the operator **20** and the remote **26**.
(91) Initially, the user provides **804** a user input that causes the learning transmitter **800** to enter a learning mode and identifies a button of the learning transmitter **802** the user wants to be learned by the movable barrier operator **20**. In the learning mode, the learning transmitter **802** scans for advertising packets from the trained transmitter **26**.
(92) The user provides **808** a user input to the trained transmitter **26**, such as by pressing a previously learned button of the trained transmitter **26**. The user provides **808** the user input within a predetermined time, such as within five seconds, of the user providing **804** the user input to the learning transmitter **802**. In response to receiving the user input **808**, the trained transmitter **26** transmits an advertisement **810** that is received **814** by the learning transmitter **802** and also substantially contemporaneously by the operator **20** (as will be discussed hereinafter).
(93) The learning transmitter **28** determines one or more codes of the advertisement **810**. For example, the learning transmitter **28** sniffs a packet of the advertisement, decrypts the packet, and parses the decrypted packet for a fixed code and a rolling code of the advertisement. Based on the fixed code and the rolling code of the transmission **810**, the learning transmitter **802** derives or calculates **816** a new fixed code and an initial rolling code. The initial rolling code may be a next or subsequent rolling code that is expected by the operator **20**. For example, the initial rolling code may be a newly determined rolling code based on the rolling code that partially constituted the transmission that was output by trained transmitter **26** relative to received user input **808**.
(94) The movable barrier operator **20** also receives the advertisement **810** as previously mentioned. The movable barrier operator **20** initiates a time window, such as 45 seconds, for the learning transmitter **802** to be learned. Next, the movable barrier operator **20** calculates **812** a fixed code and a rolling code that the movable barrier operator **20** expects to receive if a learning transmitter is to be learned during the time window. The calculation **812** is based at least in part on the fixed code and the rolling code of the transmission **810** from the trained transmitter **26**.
(95) The user provides **818** a user input to the learning transmitter **802**, such as pressing the button to be learned, which causes the learning transmitter **802** to transmit **820** an advertisement including the new fixed code and initial rolling code calculated at operation **816**.
(96) The movable barrier operator **20** receives the transmission **820** and performs an operation **822** in which the operator **20** enters a learning mode when the transmission **820** is received within the predetermined time window or duration that was previously initiated (e.g. upon receipt by the operator **20** of the broadcast communication **810** from trained transmitter **26**). The movable barrier operator **20** during performance of operation **822** also sets a “learnmode bit” (e.g. a specific, predetermined bit value) in the Device ID of the movable barrier operator **20** to indicate that the movable barrier operator **20** is in the learning mode. The movable barrier operator **20** communicates **824** a connection request to the learning transmitter **802**. The communication **824** initiates a learning method **1400** discussed hereinafter with reference to FIGS. **9**A, **9**B.
(97) With reference to FIGS. **9**A, **9**B, example communications between a learning transmitter **28**, such as a transmitter, and a movable barrier operator **20**, such as a movable barrier operator, during a learning method **1400** are provided. The method **1400** utilizes asymmetric key cryptography to encrypt the learning process between the learning transmitter **28** and movable barrier operator **20**. The asymmetric key cryptography includes the learning transmitter **28** and movable barrier operator **20** each generating a random public/private key pair and calculating a temporary shared secret session key. The session key is used during an authentication procedure of the method **1400** wherein the movable barrier operator **20** authenticates the learning transmitter **28**. The session key is also used during a learning procedure of the method **1400** wherein the movable barrier operator **20** learns the fixed code and changing code of the learning transmitter **28** via a bidirectional communication protocol. Once the movable barrier operator **20** has learned the learning transmitter **28**, the movable barrier operator **20** calculates and communicates a long-term key **1484** to the

learning transmitter **28**. The long-term key **1484** is used for subsequent communications between the learning transmitter **28** and movable barrier operator **20**, such as when the learning transmitter **28** communicates a state change request to the movable barrier operator **20**.
(98) The method **1400** includes the learning transmitter **28** communicating **1408** a response to the connection request **824** (see FIG. **8**) from the movable barrier operator **20**. The learning transmitter **28** and movable barrier operator **20** establish **1408** a wireless connection between the learning transmitter **28** and the movable barrier operator **20** using the second communication protocol. In one embodiment, the second communication protocol includes utilizing a Bluetooth Low Energy (BLE) protocol.
(99) The learning transmitter **28** communicates **1409** a Device ID of the learning transmitter **28** to the movable barrier operator **20**. The movable barrier operator **20** communicates **1410** a message including the Device ID of the movable barrier operator **20** and the device status **1412** of the movable barrier operator **20** to the learning transmitter **28**. The learning transmitter **28** reads the device status **1412** to determine if the movable barrier operator **20** is in a learn mode. If the movable barrier operator **20** is in the learn mode, the learning transmitter **28** communicates **1414** a message including a client hello message **1416** and an indication **1418** of the public/private key algorithm the learning transmitter **28** supports, such as an indication of the elliptic curves the learning transmitter **28** supports for an elliptical curve Diffie-Hellman (ECDH) algorithm.
(100) The movable barrier operator **20** utilizes the indication **1418** to select the elliptic curve Diffie-Hellman algorithm to be used in the learning process and generates **1420** a random public/private key pair. The movable barrier operator **20** communicates **1422** a message including a server hello message **1424** and an indication **1426** of the elliptic curve that the movable barrier operator **20** selected.
(101) The learning transmitter **28** generates **1430** a public/private key pair using the elliptic curve selected by the movable barrier operator **20**. The learning transmitter **28** communicates **1432** the public key **1434** and a list **1436** of ciphers the learning transmitter **28** will support.
(102) The ECDH algorithm is used by both the learning transmitter **28** and the movable barrier operator **20** to securely generate a temporary shared secret session key. The movable barrier operator **20** calculates the session key using the generated public key of the movable barrier operator **20**, the generated secret key of the movable barrier operator **20**, the public key of the learning transmitter **28**, and the list **1436** of ciphers supported by the learning transmitter **28**. The movable barrier operator **20** selects one of the ciphers from the list **1436**.
(103) With reference to FIG. **9**B, the movable barrier operator **20** sends a communication **1441** including the public key **1447** of the movable barrier operator **20** and an indication **1445** of the symmetric cipher the movable barrier operator **20** has selected from the list **1436** of ciphers from the learning transmitter **28**.
(104) The communication **1441** includes a certificate request message **1441**A to initiate a certificate verification process. In some situations, the movable barrier operator **20** may not authenticate the certificate of the learning transmitter **28** and instead sends a learn start message **1441**B. The learn start message **1441**B causes the learning transmitter **28** to initiate a learning mode sequence **1480**.
(105) The learning transmitter **28** calculates **1442** the session key using the generated public key of the learning transmitter **28**, the generated secret key of the learning transmitter **28**, the public key **1447** of the movable barrier operator **20**, and the indication **1445** of the selected symmetric cipher.
(106) Using a random public/private pair allows for a session key **1443** to be calculated at operations **1440**, **1442** that is unique even if the movable barrier operator **20** is learning a learning transmitter **28** from which the movable barrier operator **20** has previously received communications. In one embodiment, the session key **1443** is calculated at operations **1440**, **1442** via a SHA-256 function.
(107) The method **1400** includes an authentication operation **1444** wherein the learning transmitter **28** communicates a certificate **1446** to the movable barrier operator **20** and the movable barrier

operator **20** validates the certificate **1446** including comparing **1451** the certificate **1446** to a list of revoked certificates. In some embodiments, if the movable barrier operator **20** is able to communicate with the server computer **82**, the movable barrier operator **20** queries **1453** the server computer **82** for an updated list of revoked certificates. The server computer **82** responds **1455** with the updated list of revoked certificates and the movable barrier operator **20** saves the updated list of revoked certificates in the local memory **74**. The movable barrier operator checks **1457** whether the certificate **1446** of the learning transmitter **28** is in the list of revoked certificates.

(108) If the certificate **1446** of the learning transmitter **28** is not in the list of revoked certificates, the movable barrier operator **20** generates **1460** a challenge **1462**, such as random data, and communicates **1464** the challenge **1462** to the learning transmitter **28**.

(109) The learning transmitter has a certificate private key and a certificate public key that are generated by middleware (e.g., server computer **82**) when the middleware generates the certificate **1446** for the learning transmitter **28**. The certificate **1446**, which includes the certificate public key, and the certificate private key are seeded in the learning transmitter **28** such as during manufacture of the learning transmitter **28**.

(110) To respond to the challenge from the movable barrier operator **20**, the learning transmitter **28** concatenates the session key with the random data and signs the output of the concatenation with a certificate private key of the learning transmitter. The learning transmitter **28** communicates **1472** the challenge response to the movable barrier operator **20**.

(111) The movable barrier operator **20** validates **1474** the challenge response. In one approach, the validation **1474** includes the movable barrier operator **20** utilizing an elliptic curve digital signature algorithm (ECDSA) verification operation in conjunction with the public key in the certificate **1446** of the learning transmitter **20**, the challenge data the movable barrier operator **20** sent to the learning transmitter **28**, and the session key.

(112) The challenge-response procedure permits the movable barrier operator **20** to prove to itself that there is not a malicious actor intercepting communications between the learning transmitter **28** and movable barrier operator **20**. Specifically, the movable barrier operator **20** determines the learning transmitter **28** is the owner of the certificate **1446** the movable barrier operator **20** received. Proving ownership of the certificate **1446** is accomplished by performing an operation that proves the learning transmitter **28** has the private key associated with the certificate **1446** the movable barrier operator **20** received. The operation includes having the learning transmitter **28** sign the session key concatenated with the random data of the challenge from the movable barrier operator **20** and the learning transmitter **28** sending the output of the signing operation back to the movable barrier operator **20**. If there was a malicious actor intercepting communications between the learning transmitter **28** and movable barrier operator **20**, there would be two session keys. The first session key would be between the learning transmitter **28** and the malicious actor and the second session key would be between the movable barrier operator **20** and the malicious actor. The two session keys would be different since the session keys are calculated based on the public/private key pairs randomly generated by the devices. Because the session key is calculated by each side and not sent over the air, the learning transmitter **28** will not know the second session key and the movable barrier operator **20** will not know the first session key. Therefore, even if the malicious actor forwarded the challenge request from the movable barrier operator **20** to the learning transmitter **28**, the learning transmitter **28** would send a challenge response different than the challenge response expected by the movable barrier operator **20** and the validation **1474** would be unsuccessful. More specifically, the learning transmitter **28** would send a challenge response signed using the first session key while the movable barrier operator **20** is expecting a challenge key signed using the second session key.

(113) If the validation **1474** is successful, the movable barrier operator **20** communicates **1476** a learn start message **1478** to cause the learning transmitter **28** to initiate the learning message sequence **1480**. The learning transmitter **28** sends a communication **1479** including a fixed code

and a rolling code.
(114) The movable barrier operator **20** sends a communication **1481** including a fixed code and a rolling code with a value that indicates the movable barrier operator is learning the learning transmitter **28**. For example, the rolling code in the communication **1481** may have a value of zero to indicate that the movable barrier operator **20** is in the learning mode.
(115) The learning transmitter **28** sends a communication **1483** including the fixed code and a rolling code that has been incremented from the rolling code sent in communication **1479**.
(116) At operation **1482**, the movable barrier operator **20** confirms that the incremented rolling code received in communication **1483** are the expected values based on the rolling code algorithm utilized by both the movable barrier operator **20** and the learning transmitter **28**. If the learning message sequence **1480** is successful, the movable barrier operator **20** generates a long-term key **1484** at operation **1482**.
(117) The movable barrier operator **20** communicates **1486** the long-term key **1484** to the learning transmitter **28**. The learning transmitter **28** and movable barrier operator **20** thereafter utilize the long-term key **1484** to encrypt and decrypt communications between the learning transmitter **28** and movable barrier operator **20**.
(118) Once the movable barrier operator **20** has learned the learning transmitter **28**, any command from one of the learning transmitter **28** and movable barrier operator **20** to the other of the learning transmitter **28** and movable barrier operator **20** involves communication session constituted by a sequence of bidirectional communication messages. Further, the bidirectional communication message sequence is encrypted using the long-term key **1484** calculated by the movable barrier operator **20** and provided to the learning transmitter **28** in communication **1486**.
(119) One issue with existing learning transmitters is that a user may use a trained transmitter to cause a movable barrier operator to learn multiple transmitters such as trainable transceivers/transmitters or universal transceivers/transmitters. The multiple transmitters each derive a fixed code and a rolling code from the trained transmitter. The user is only limited by the total number of transmitters supported by the movable barrier operator. This is particularly problematic in some gated communities, where facility managers provide a resident with a transmitter having a credential associated with the resident. If the resident uses the supplied transmitter to train learning transmitters that are not associated with the resident, e.g., in-vehicle transmitters of relatives or friends, the movable barrier operator will incorrectly associate a request for access by one of the trained learning transmitters as being sent by the resident user. Further, it may also be difficult to identify and revoke access credentials of a resident's transmitters when the resident moves out of the gated community.
(120) A method **1549** of managing identifying data for transmitters associated with a movable barrier is provided below that facilitates autonomous management of the transmitter access credentials. With reference to FIG. **10**A, an example data array **1500** is provided having memory locations **1502** that receive identifying data of transmitters. The identifying data may include, for example, a fixed code, a changing code, transmitter type data, and/or switch ID data for a transmitter. The memory locations **1502** of the data array **1500** include unoccupied or available memory locations **1503**A, memory locations **1503**B containing identifying data of trained transmitters that have been learned by the movable barrier operator, and memory locations **1503**C storing identifying data of learning transmitters that have been learned by the movable barrier operator.
(121) As shown in FIG. **10**A, the “A” trained transmitter **1506** may be used to train the movable barrier operator to recognize the A**1**, A**2** learning transmitters **1508**, **1510**. Similarly, another user may use the “C” trained transmitter **1512** to train the movable barrier operator to recognize the C**1**-C**5** learning transmitters **1514**, **1515**, **1516**, **1518**, **1520**. Still further, another user may use the “G” trained transmitter **1522** to train the movable barrier operator to recognize the G**1** learning transmitter **1524**.

(122) To limit the number of memory locations learning transmitters may occupy in a data array of a memory (e.g. the previously mentioned whitelist **90** shown in FIG. **2**) of a movable barrier operator, the processor of the movable barrier operator may be configured to utilize the method **1549** to limit the number of learning transmitters that have been trained using the trained transmitter to a predetermined number. With reference to FIG. **10**B, the data array **1550** stores identifying information for the "A" trained transmitter **1552** and A**1**, A**2** learning transmitters **1554**, **1556**. If a user were to attempt to use the "A" trained transmitter **1552** to train the movable barrier operator to recognize another learning transmitter (e.g., A**3**), the movable barrier operator may provide to the server computer a message that the user is attempting to train more than two learning transmitters. The movable barrier operator may decline the attempt (e.g. based on learning rules implemented at the server and/or movable barrier operator wherein such rules restrict or limit a number/quantity of learning or universal transmitters/transceivers to be derived from a known transmitter) and inhibit the user from training the movable barrier operator to recognize the third learning transmitter.
(123) In another embodiment, the processor utilizes a first-in, first-out approach to limit the number of learning transmitters learned by the movable barrier operator. For example, the "C" trained transmitter **1560** was previously used to train the movable barrier operator to recognize C**1** and C**2** learning transmitters. The user associated with the "C" trained transmitter **1560** used the "C" trained transmitter **1560** to train the movable barrier operator recognize a new C**3** learning transmitter. The movable barrier operator, in response to learning the C**3** learning transmitter, acts to maintain a predefined number of C-related transmitters by removing the C**1** learning transmitter from the data array **1550**.
(124) Next, the user associated with the "C" trained transmitter **1560** used the "C" trained transmitter to train the movable barrier operator to recognize C**4** and C**5** learning transmitters. The movable barrier operator, in response to learning C**4** and C**5**, proceeds to remove the C**2** and C**3** learning transmitters from the data array **1550** such that the movable barrier operator stores the identifying data of the predefined quantity/number (e.g. three) for the C and the C**4** and C**5** transmitters **1562**, **1564** in the data array **1550**.
(125) With continued reference to FIG. **10**B, the user associated with the "G" trained transmitter used the "G" trained transmitter to train the movable barrier operator to recognize G**1** and G**2** learning transmitters. The user associated with the "G" trained transmitter subsequently used the "G" trained transmitter to train the movable barrier operator to recognize control signals from G**3**, G**4**, and G**5** learning transmitters. The movable barrier operator removed the identifying data for the G**3** learning transmitter as part of learning the G**4** learning transmitter, and likewise removed the identifying data for the G**4** learning transmitter as part of learning the G**5** learning transmitter. The first-in, first-out approach is provided for each trained transmitter to limit the number of memory locations that may be occupied by learning transmitters associated with each of the transmitters trained by the facility.
(126) Uses of singular terms such as "a," "an," are intended to cover both the singular and the plural, unless otherwise indicated herein or clearly contradicted by context. The terms "comprising," "having," "including," and "containing" are to be construed as open-ended terms. It is intended that the phrase "at least one of" as used herein be interpreted in the disjunctive sense. For example, the phrase "at least one of A and B" is intended to encompass A, B, or both A and B.
(127) While there have been illustrated and described particular embodiments of the present invention, it will be appreciated that numerous changes and modifications will occur to those skilled in the art, and it is intended for the present invention to cover all those changes and modifications which fall within the scope of the appended claims.

Claims

1. A method of training a trainable transmitter, the method comprising: transmitting, from a controllable device to a remote control previously learned by the controllable device, a first radio frequency communication via a first communication protocol, the first radio frequency communication including an access code; transmitting, from the remote control to a trainable transmitter, a second radio frequency communication via a second communication protocol different than the first communication protocol, the second radio frequency communication including the access code; determining, by the trainable transmitter, a derived access code based at least in part upon the access code of the second radio frequency communication; transmitting, from the trainable transmitter to the controllable device, a third radio frequency communication via the second communication protocol, the third radio frequency communication including the derived access code; and learning, by the controllable device, the trainable transmitter in response to correspondence between the derived access code and the access code.
2. The method of claim 1 wherein transmitting, from the controllable device to the remote control, the first radio frequency communication comprises: transmitting, from the controllable device to the remote control, a command radio frequency communication configured to cause the remote control to change from an operating mode to a training mode; and transmitting, from the controllable device to the remote control, an access code radio frequency communication including the access code.
3. The method of claim 2 further comprising communicating a message to a user device upon the controllable device transmitting the access code radio frequency communication to the remote control, the message configured to cause the user device to prompt a user to provide a user input to user interfaces of the remote control and the trainable transmitter.
4. The method of claim 1 wherein the first radio frequency communication is configured to cause the remote control to change from an operating mode to a training mode, wherein the remote control in the operating mode is configured to communicate using the first communication protocol, and wherein the remote control in the training mode is configured to communicate using the second communication protocol.
5. The method of claim 1 further comprising at least one of: transmitting, from the controllable device to the remote control, an exit command in response to the controllable device learning the trainable transmitter, the exit command configured to cause the remote control to change from a training mode to an operating mode; and changing the remote control from the training mode to the operating mode in response to a predetermined amount of time elapsing.
6. The method of claim 1 wherein the access code includes a first fixed code and a first changing code, the first fixed code identifying the remote control; wherein determining the derived access code includes deriving a second fixed code from the first fixed code and deriving a second changing code from the first changing code, the second fixed code identifying the trainable transmitter; and wherein learning the trainable transmitter includes learning the trainable transmitter in response to: the second fixed code corresponding to the first fixed code; and the second changing code corresponding to the first changing code.
7. The method of claim 1 further comprising transmitting, from the remote control to the controllable device, an authentication radio frequency communication via the first communication protocol; and wherein transmitting, from the controllable device to the remote control, the first radio frequency communication comprises transmitting the first radio frequency communication in response to the controllable device receiving the authentication radio frequency communication.
8. The method of claim 1 wherein the controllable device comprises a movable barrier operator, the method further comprising: transmitting, from a wall control to the movable barrier operator, a command to enter a learn mode; prompting, by the wall control, a user to provide a user input to the remote control; and transmitting, from the remote control to the movable barrier operator, an authentication radio frequency communication via the first communication protocol.

9. The method of claim 1 wherein the controllable device comprises a movable barrier operator, the method further comprising: entering, by the movable barrier operator, a learn mode in response to receiving a first user input at a user interface of the movable barrier operator; and flashing a light of the movable barrier operator to prompt a user to provide another user input to the remote control.
10. The method of claim 1 wherein the access code comprises a first fixed code and a first changing code, wherein the first fixed code identifies the remote control; and wherein the derived access code comprises a second fixed code and a second changing code, wherein the second fixed code identifies the trainable transmitter.
11. The method of claim 1 further comprising receiving, by the controllable device, a learn mode command from a server computer; and wherein transmitting the first radio frequency communication comprises transmitting the first radio frequency communication in response to the controllable device receiving the learn mode command.
12. The method of claim 1 further comprising receiving, by a user device, a user input requesting learning of the trainable transmitter by the controllable device; communicating, from the user device to a server computer, a request for the controllable device to learn the trainable transmitter; and communicating, from the server computer to the controllable device, a message configured to cause the controllable device to enter a learn mode.
13. The method of claim 1 wherein the controllable device includes a movable barrier operator, the method further comprising: in response to the movable barrier operator learning the trainable transmitter, the movable barrier operator performing operations including at least one of: flashing a light; and moving a movable barrier.
14. The method of claim 13 wherein the derived access code includes a fixed code and a changing code, the method further comprising: transmitting, from the trainable transmitter to the movable barrier operator, a fourth radio frequency communication via the second communication protocol, the fourth radio frequency communication including the fixed code and a changed version of the changing code; and moving, by the movable barrier operator, the movable barrier in response to the movable barrier operator receiving the fourth radio frequency communication.
15. A system comprising: a remote control comprising a remote control communication circuitry and a remote control controller, the remote control controller configured to: receive through the remote control communication circuitry a first radio frequency communication via a first communication protocol, the first radio frequency communication including an access code; control the remote control communication circuitry to transmit a second radio frequency communication via a second communication protocol, the second radio frequency communication including the access code; a trainable transmitter having a trainable transmitter communication circuitry and a trainable transmitter controller, the trainable transmitter controller configured to: receive through the trainable transmitter communication circuitry the second radio frequency communication; determine a derived access code based at least in part upon the access code of the second radio frequency communication; control the trainable transmitter communication circuitry to transmit a third radio frequency communication via the second communication protocol, the third radio frequency communication including the derived access code; a controllable device comprising a controllable device communication circuitry and a controllable device controller, the controllable device controller configured to: control the controllable device communication circuitry to transmit the first radio frequency communication including the access code; receive through the controllable device communication circuitry the third radio frequency communication including the derived access code; and learn the trainable transmitter in response to correspondence between the derived access code of the third radio frequency communication and the access code of the first radio frequency communication.
16. The system of claim 15 wherein the controllable device controller is configured to control the controllable device communication circuitry to transmit the first radio frequency communication comprising: transmitting a command radio frequency communication configured to cause the

remote control to change from an operating mode to a training mode; and transmitting an access code radio frequency communication including the access code.

17. The system of claim 15 further comprising a server computer configured to: receive, from a user device, a request for the controllable device to enter a learn mode; communicate, to the controllable device, a command configured to cause the controllable device to enter the learn mode; wherein the controllable device controller in the learn mode is configured to receive through the controllable device communication circuitry an authentication from the remote control; and wherein the controllable device controller is configured to control the controllable device communication circuitry to transmit the first radio frequency communication in response to the controllable device communication circuitry receiving the authentication from the remote control.

18. The system of claim 15 wherein the controllable device controller is configured to enter a learn mode in response to at least one of: a user input at a user interface of the controllable device; the controllable device communication circuitry receiving a learn mode command from a remote device; and wherein the controllable device controller in the learn mode is configured to receive through the controllable device communication circuitry an authentication from the remote control; and wherein the controllable device controller is configured to control the controllable device communication circuitry to transmit the first radio frequency communication in response to the controllable device communication circuitry receiving the authentication from the remote control.

19. The system of claim 15 wherein the trainable transmitter is unable to communicate via the first communication protocol.

20. The system of claim 15 wherein the access code comprises a first fixed code and a first changing code, the first fixed code identifying the remote control; wherein the derived access code includes a second fixed code and a second changing code, the second fixed code identifying the trainable transmitter; and wherein the controllable device controller is configured to learn the trainable transmitter in response to the second fixed code corresponding to the first fixed code and the second changing code corresponding to the first changing code.