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(54) **SYSTEMS AND METHODS FOR AIRCRAFT COMMUNICATION WITH OFF-BOARD SYSTEMS**

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(57) **ABSTRACT**

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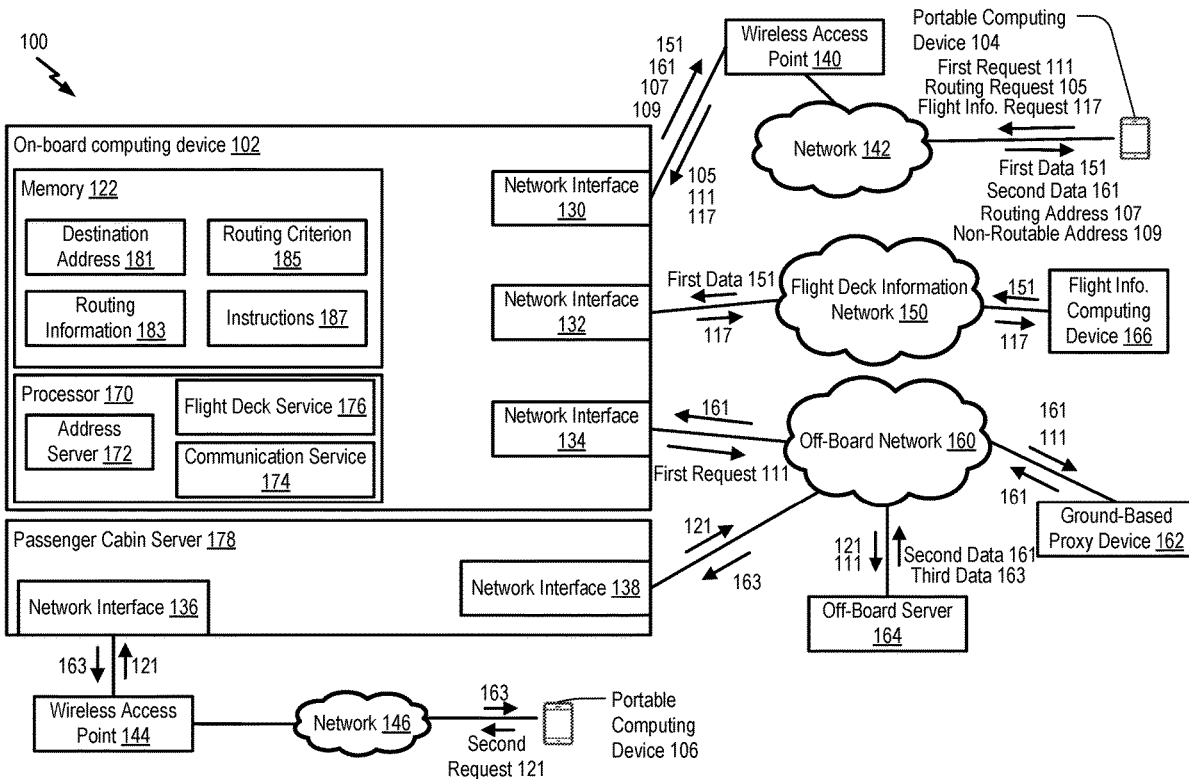
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A system for aircraft communication includes an on-board computing device. The on-board computing device includes a first network interface, a second network interface, a third network interface, and a processor. The first network interface is configured to communicate via a wireless access point with a portable computing device. The second network interface is configured to communicate with a flight deck information network. The third network interface is configured to communicate with an off-board network with an off-board server. The processor is configured to route first data from the second network interface to the portable computing device via the first network interface. The first data includes aircraft flight information. The processor is also configured to, concurrently with routing the first data, route second data from the off-board server via the third network interface to the portable computing device via the first network interface.



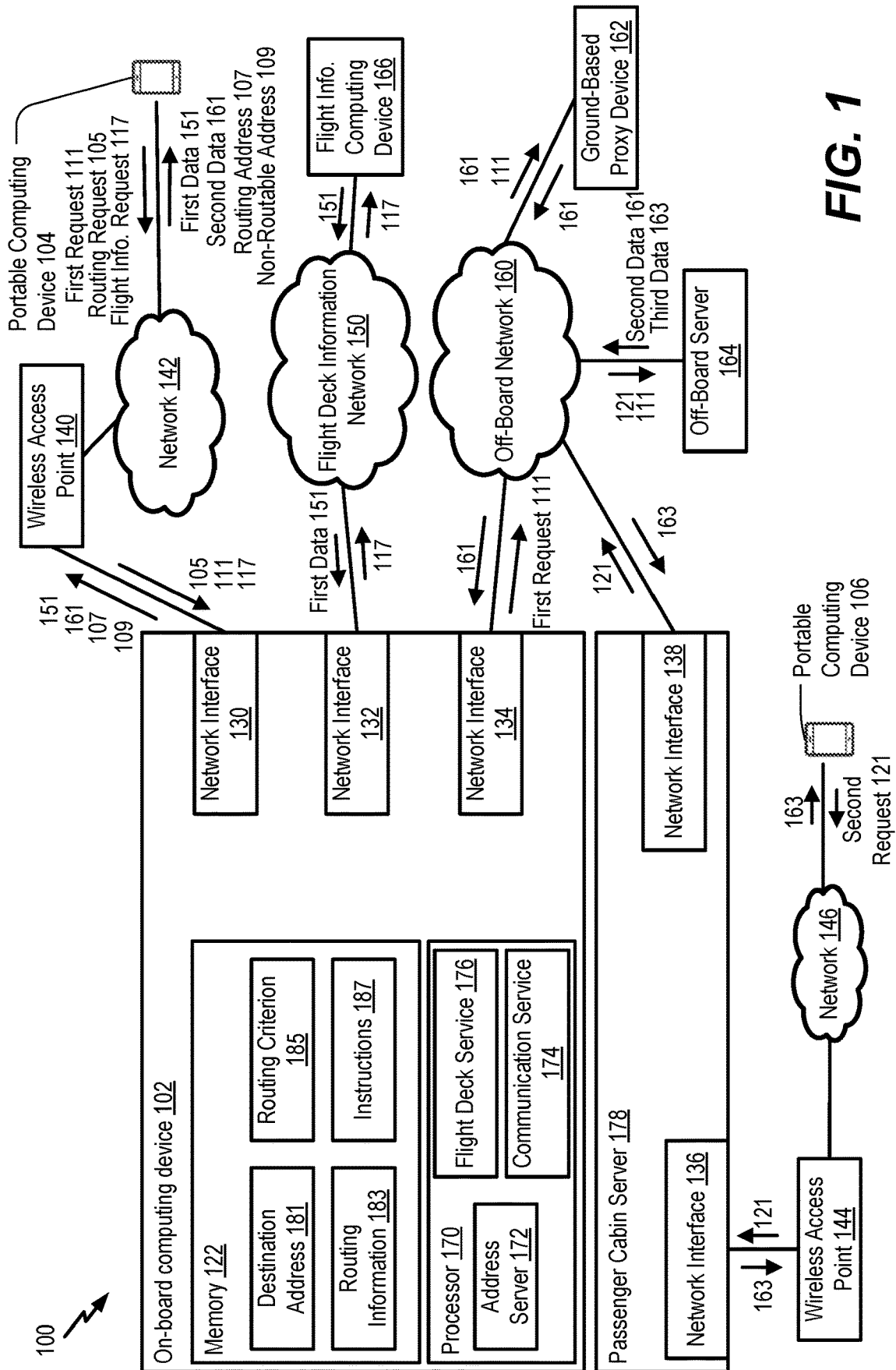


FIG. 1

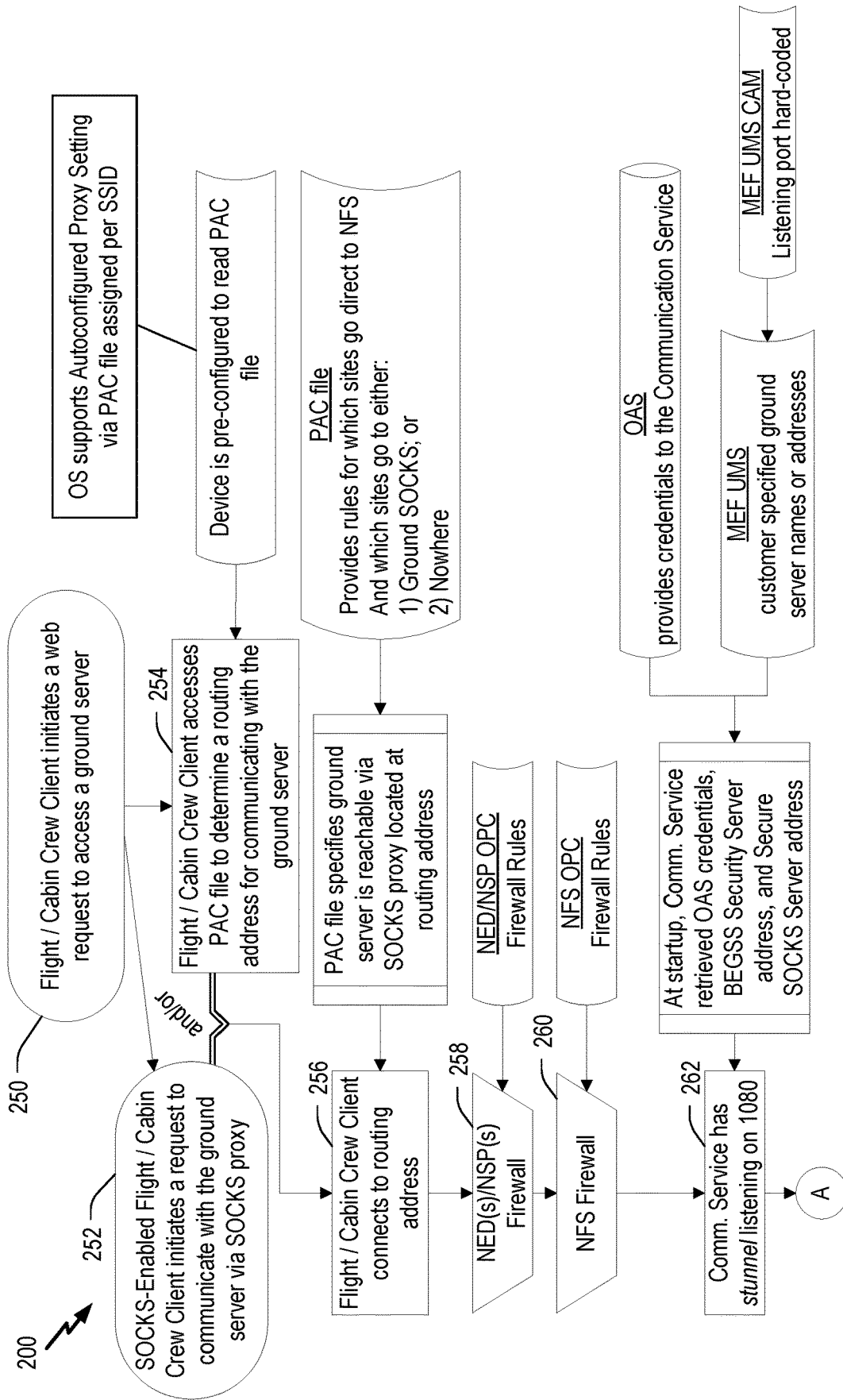


FIG. 2

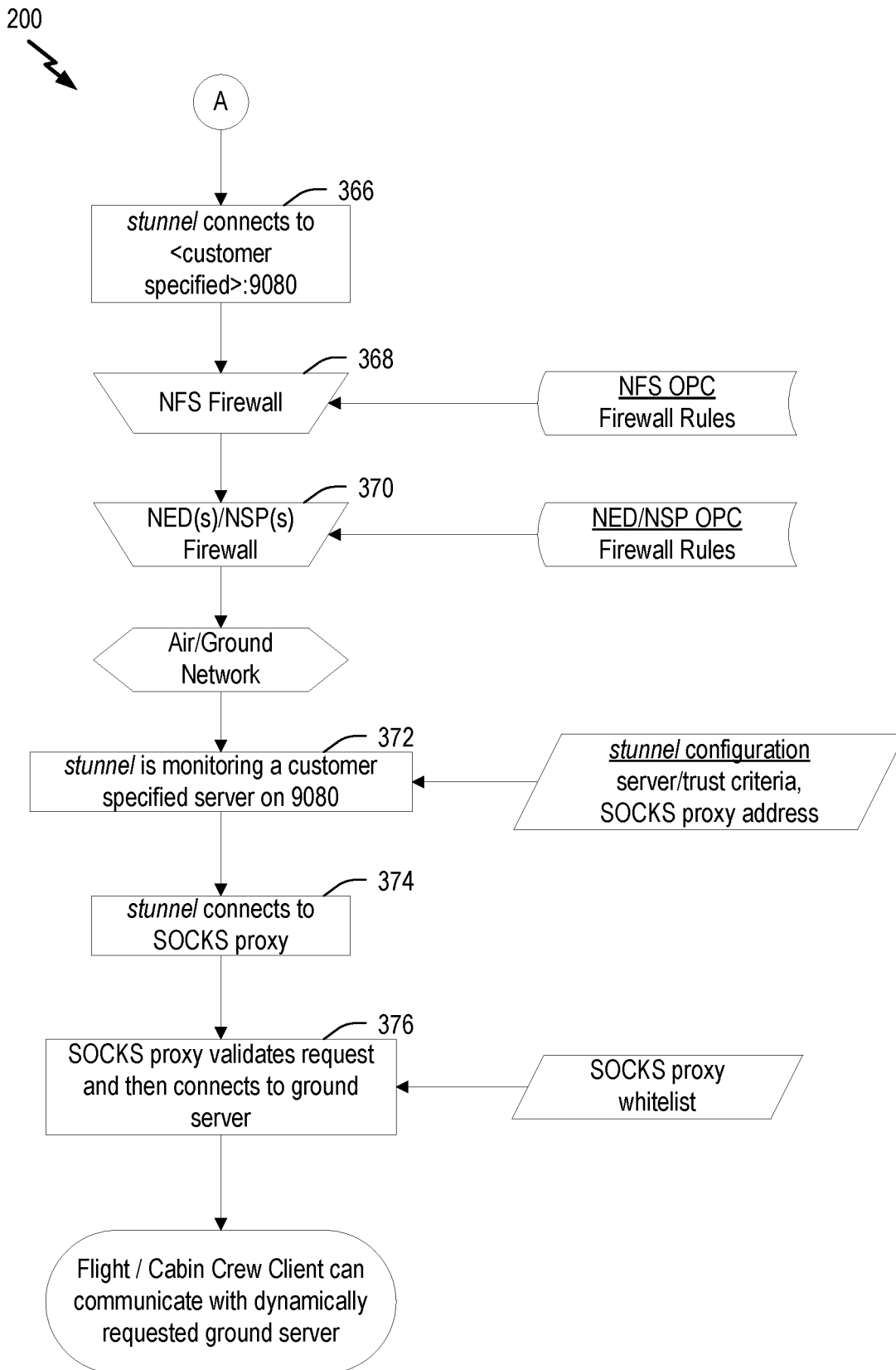
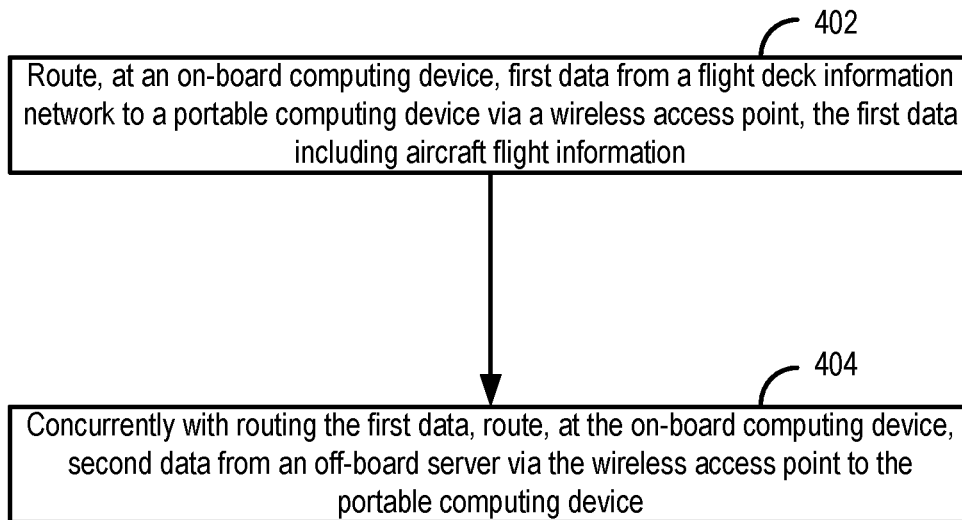


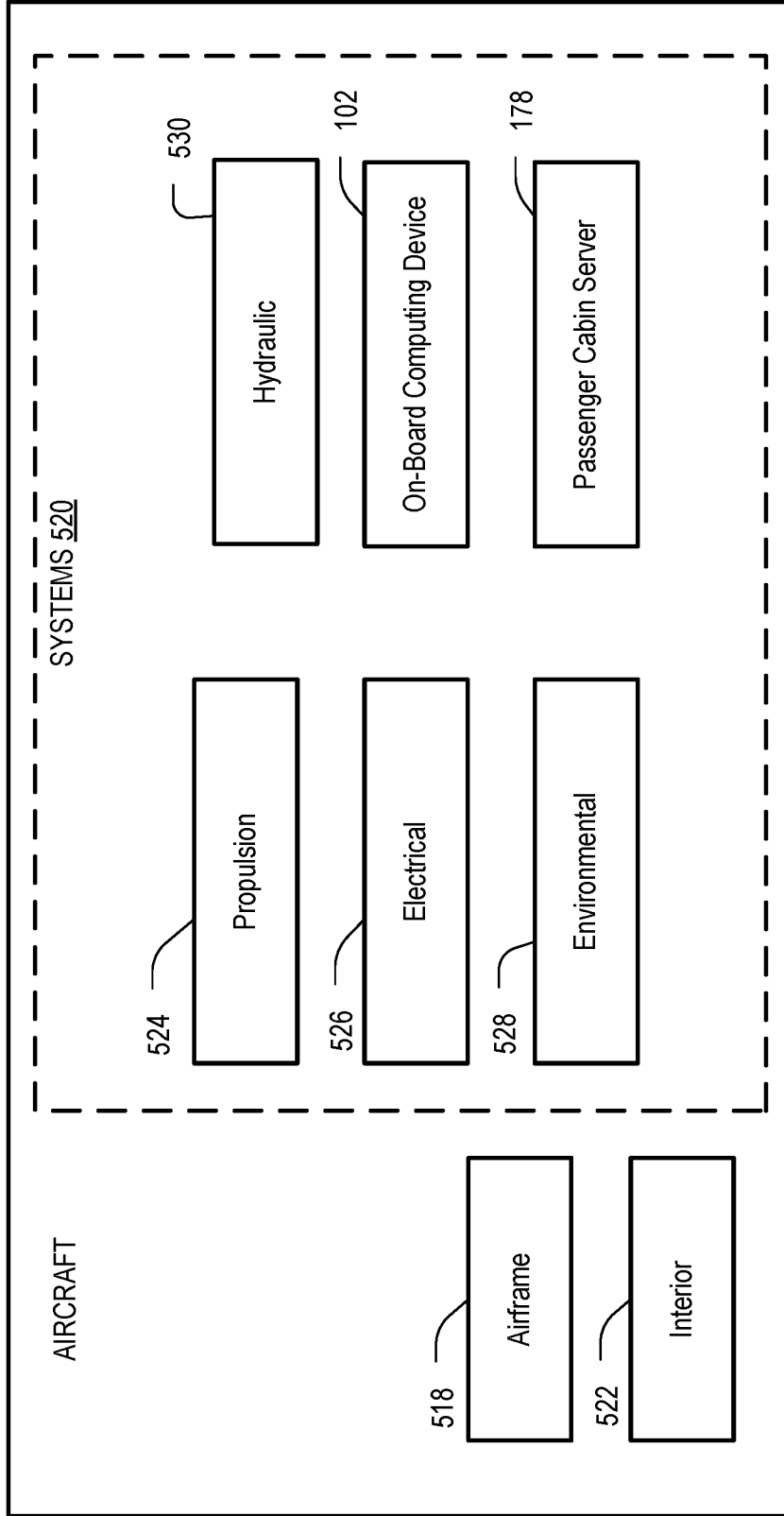
FIG. 3

400  
↘



**FIG. 4**

500 ↗



**FIG. 5**

## SYSTEMS AND METHODS FOR AIRCRAFT COMMUNICATION WITH OFF-BOARD SYSTEMS

### FIELD OF THE DISCLOSURE

[0001] The present disclosure is generally related to systems and methods for aircraft communication with off-board systems.

### BACKGROUND

[0002] Aircraft typically have multiple separate communication domains. For example, flight deck information data could be critical to the operation of the aircraft and is communicated via a first communication link to an off-board network. Other non-critical data, such as passenger data, is communicated via a second communication link that is separate from the first communication link to the off-board network. As more flight tasks move to portable devices, it would improve user experience for a pilot to be able to access the flight deck information data and other non-critical data using the same portable device. However, unrestricted access to data from off-board servers at the portable computing device while the portable computing device has access to the flight deck information data could be against security policies for the aircraft operator.

### SUMMARY

[0003] In a particular implementation, a system for aircraft communication includes an on-board computing device. The on-board computing device includes a first network interface, a second network interface, a third network interface, and a processor. The first network interface is configured to communicate via a wireless access point with a portable computing device. The second network interface is configured to communicate with a flight deck information network. The third network interface is configured to communicate via an off-board network with an off-board server. The processor is configured to route first data from the second network interface to the portable computing device via the first network interface. The first data includes aircraft flight information. The processor is also configured to, concurrently with routing the first data, route second data from the off-board server via the third network interface to the portable computing device via the first network interface.

[0004] In another particular implementation, an aircraft includes a wireless access point and a network file server (NFS) coupled to the wireless access point. The wireless access point is configured to communicate with a portable computing device. The NFS is configured to route first data from a flight deck information network to the portable computing device via the wireless access point. The first data includes aircraft flight information. The NFS is also configured to, concurrently with routing the first data, route second data from an off-board server via the wireless access point to the portable computing device.

[0005] In another particular implementation, a method of aircraft communication includes routing, at an on-board computing device, first data from a flight deck information network to a portable computing device via a wireless access point. The first data includes aircraft flight information. The method also includes, concurrently with routing the first

data, routing, at the on-board computing device, second data from an off-board server via the wireless access point to the portable computing device.

[0006] In another particular implementation, a computer-readable storage device stores instructions that, when executed by a processor, cause the processor to perform operations including routing first data from a flight deck information network to a portable computing device via a wireless access point. The first data includes aircraft flight information. The operations also include, concurrently with routing the first data, routing second data from an off-board server via the wireless access point to the portable computing device.

[0007] The features, functions, and advantages described herein can be achieved independently in various implementations or may be combined in yet other implementations, further details of which can be found with reference to the following description and drawings.

### BRIEF DESCRIPTION OF THE DRAWINGS

[0008] FIG. 1 is a block diagram that illustrates a system for aircraft communication with off-board systems;

[0009] FIG. 2 is a diagram that illustrates aspects of an example of aircraft communication performed by the system of FIG. 1;

[0010] FIG. 3 is a diagram that illustrates further aspects of an example of aircraft communication performed by the system of FIG. 1;

[0011] FIG. 4 is a flow chart of an example of a method of aircraft communication with off-board systems; and

[0012] FIG. 5 is a block diagram of an aircraft configured to support aspects of computer-implemented methods and computer-executable program instructions (or code) according to the present disclosure.

### DETAILED DESCRIPTION

[0013] Implementations described herein are directed to systems and methods for aircraft communication with off-board systems. An aircraft includes an on-board computing device that is configured to communicate with a portable computing device. The portable computing device could be used by a pilot of the aircraft (e.g., as an electronic flight bag device). The on-board computing device is also configured to receive flight information data from a flight information computing device. The on-board computing device is configured to communicate, via an off-board network, with a ground-based proxy device. The ground-based proxy device has access to security policies (e.g., a white list or a black list) that indicate whether communication with particular ground servers is authorized while the portable computing device has access to aircraft flight information. To illustrate, the security policies indicate that communication with a first ground server is authorized, communication with a second ground server is not authorized, or both.

[0014] A flight deck service of the on-board computing device receives first data from the flight information computing device and forwards the first data to the portable computing device. For example, the first data indicates aircraft flight information that the pilot is monitoring.

[0015] The portable computing device sends a request to a communication service of the on-board computing device. For example, the request is sent responsive to a user input indicating that the pilot requests data from a ground server,

such as a third-party server, an e-mail server, a weather application server, a webserver, a publicly accessible server, or a combination thereof. To illustrate, the pilot activates an aviation application on the portable computing device and the aviation application sends the request to the communication service for data from a ground server associated with the aviation application. The communication service establishes a secured network connection with the ground-based proxy device and uses the secured network connection to send the request, via the off-board network, to the ground-based proxy device.

**[0016]** The ground-based proxy device forwards the request to the ground server in response to determining that the security policies indicate that communication with the ground server is authorized. The ground-based proxy device receives second data from the ground server. In a particular example, the ground-based proxy device determines, based on the security policies, whether the second data is to be routed to the aircraft. To illustrate, the ground-based proxy device determines that the second data is to be routed to the aircraft in response to determining that the second data satisfies an anti-virus check. The ground-based proxy device uses the secured network connection to send the second data to the communication service of the aircraft. The communication service provides the second data to the portable computing device.

**[0017]** The on-board computing device thus, concurrently with routing the first data to the portable computing device, routes the second data to the portable computing device. The second data is routed to the portable computing device if the security policies of the ground-based proxy device indicate that communication with the off-board server is authorized. Having the ground-based proxy device determine whether the security policies are satisfied keeps intensive data processing tasks off the aircraft and at the ground-based proxy device. Determining whether the second data satisfies the security policies at the ground-based proxy device, as compared to on the aircraft, also ensures that the data that does not satisfy the security policies is kept off the aircraft. Refraining from sending data to the aircraft that fails to satisfy the security policies conserves communication resources (e.g., bandwidth and time). Data from off-board servers can thus be selectively provided to the portable computing device while the portable computing device has access to the aircraft flight information.

**[0018]** As used herein, various terminology is used for the purpose of describing particular implementations only and is not intended to be limiting. For example, the singular forms “a,” “an,” and “the” are intended to include the plural forms as well, unless the context clearly indicates otherwise. Further, the terms “comprise,” “comprises,” and “comprising” are used interchangeably with “include,” “includes,” or “including.” Additionally, the term “wherein” is used interchangeably with the term “where.” As used herein, “exemplary” indicates an example, an implementation, and/or an aspect, and should not be construed as limiting or as indicating a preference or a preferred implementation. As used herein, an ordinal term (e.g., “first,” “second,” “third,” etc.) used to modify an element, such as a structure, a component, an operation, etc., does not by itself indicate any priority or order of the element with respect to another element, but rather merely distinguishes the element from another element having a same name (but for use of the

ordinal term). As used herein, the term “set” refers to a grouping of one or more elements, and the term “plurality” refers to multiple elements.

**[0019]** Referring to FIG. 1, a system **100** for aircraft communication with off-board systems is shown. The system **100** includes an on-board computing device **102**, a passenger cabin server **178**, or both. The on-board computing device **102** includes a processor **170**, a memory **122**, a network interface **130**, a network interface **132**, a network interface **134**, or a combination thereof. In a particular aspect, the on-board computing device **102** includes or corresponds to a network file server (NFS).

**[0020]** The network interface **130** is configured to be coupled to a wireless access point **140**. The wireless access point **140** is configured to communicate, via a network **142**, with a portable computing device **104**. The portable computing device **104** includes, for example, a mobile device, a communication device, a computing device, a personal digital assistant, or any combination thereof. The network **142** includes a wired network, a wireless network, or both. In a particular aspect, an aircraft includes the on-board computing device **102**, a coverage area of the network **142** includes a cockpit of the aircraft, and the portable computing device **104** is configured to be used by a pilot of the aircraft. For example, the portable computing device **104** can include an electronic flight bag application.

**[0021]** The network interface **132** is configured to communicate, via a flight deck information network **150**, with a flight information computing device **166**. A flight information computing device **166** can be connected to an aircraft sensor, for example, a temperature sensor, an inertial measurement unit (IMU), a gyroscope, an accelerometer, a magnetometer, a fuel gauge, a pressure sensor, a force sensor, a torque sensor, a speed sensor, a global positioning system (GPS) receiver, a flow sensor, a proximity sensor, a radar sensor, an angle-of-attack sensor, a smoke detection sensor, an altimeter sensor, or any combination thereof. Additionally, or in the alternative, the flight information computing device **166** can be connected to a flight control computer or line replaceable unit (LRU) to access flight information.

**[0022]** The network interface **134** is configured to communicate, via an off-board network **160**, with a ground-based proxy device **162**, an off-board server **164**, or a combination thereof. The ground-based proxy device **162** has access to security policies. For example, the ground-based proxy device **162** is located at a flight operations center associated with an airline or other operator of the aircraft, and the security policies are based on configuration data, operator policies, default data, user input, or a combination thereof. The security policies (e.g., a white list or a black list) indicate whether communication with particular servers is authorized for the portable computing device **104** while the portable computing device **104** has access to the flight information.

**[0023]** The passenger cabin server **178** includes a network interface **136**, a network interface **138**, or both. The passenger cabin server **178** includes or is coupled to a wireless access point **144**. The wireless access point **144** is configured to communicate, via a network **146**, with a portable computing device **106**. The network interface **138** is configured to communicate, via the off-board network **160**, with the off-board server **164**. The network **146** includes a wired network, a wireless network, or both. In a particular aspect,



an aircraft includes the on-board computing device 102, a coverage area of the network 146 includes a passenger cabin of the aircraft, and the portable computing device 104 is configured to be used by a passenger of the aircraft. For example, the portable computing device 106 includes a personal computer of the passenger and does not have access to the flight information computing device 166. In a particular aspect, the passenger cabin server 178 is configured to enable communication between the portable computing device 106 and the off-board server 164 independently of the ground-based proxy device 162 because the portable computing device 106 does not have access to the flight information computing device 166.

[0024] In a particular aspect, an aircraft includes the on-board computing device 102, the wireless access point 140, the network 142, the portable computing device 104, the flight deck information network 150, the flight information computing device 166, the passenger cabin server 178, the wireless access point 144, the network 146, the portable computing device 106, or any combination thereof. In a particular aspect, the off-board server 164, the ground-based proxy device 162, the off-board network 160, or any combination thereof, are external to the aircraft.

[0025] It should be noted that in the following description, various functions performed by the system 100 of FIG. 1 are described as being performed by certain components or modules. However, this division of components and modules is for illustration only. In an alternate aspect, a function described herein as performed by a particular component or module is divided amongst multiple components or modules. Moreover, in an alternate aspect, two or more components or modules of FIG. 1 are integrated into a single component or module. In a particular aspect, one or more functions described herein as performed by the on-board computing device 102 are divided amongst multiple devices (e.g., the on-board computing device 102, a central server, a distributed system, or any combination thereof). Each component or module illustrated in FIG. 1 may be implemented using hardware (e.g., a field-programmable gate array (FPGA) device, an application-specific integrated circuit (ASIC), a digital signal processor (DSP), a controller, etc.), software (e.g., instructions executable by a processor), or any combination thereof.

[0026] The memory 122 includes volatile memory devices (e.g., random access memory (RAM) devices), nonvolatile memory devices (e.g., read-only memory (ROM) devices, programmable read-only memory, and flash memory), or both. In a particular aspect, the memory 122 includes one or more applications (e.g., instructions) executable by the processor 170 to initiate, control, or perform one or more operations described herein. In an illustrative example, a computer-readable storage device (e.g., the memory 122) includes instructions that, when executed by the processor 170, cause the processor 170 to initiate, perform, or control operations described herein. In a particular aspect, the memory 122 is configured to store instructions 187 that are executable by the processor 170 to perform one or more operations described herein.

[0027] The memory 122 is configured to store routing information 183. The routing information 183 (e.g., a white list or a black list) indicates whether communication with a destination address 181 is authorized while the portable computing device 104 has access to aircraft flight information. For example, the routing information 183 indicates that

communication with one or more destination addresses is authorized and communication with any destination address that is not included in the one or more destination addresses is unauthorized. As another example, the routing information 183 indicates that communication with one or more destination addresses is unauthorized and communication with any destination address that is not included in the one or more destination addresses is authorized.

[0028] The processor 170 includes an address server 172, a communication service 174, a flight deck service 176, or a combination thereof. The address server 172 (e.g., a hypertext transfer protocol (HTTP) server) is configured to receive a routing request 105 from the portable computing device 104. For example, the portable computing device 104, in response to determining that a first request 111 is to be sent to the off-board server 164, sends the routing request 105 to the address server 172 to determine where to send the first request 111 for routing to the off-board server 164. The address server 172 is configured to, based on determining whether communication with the off-board server 164 (e.g., the destination address 181) is authorized, provide a non-routable address 109 or a routing address 107 of the communication service 174 to the portable computing device 104. The portable computing device 104 sends the first request 111 to the address (e.g., the non-routable address 109 or the routing address 107) provided by the address server 172. The flight deck service 176 is configured to route first data 151 from the flight information computing device 166 via the network interface 132 to the portable computing device 104 via the network interface 130.

[0029] The communication service 174 is configured to receive the first request 111 from the portable computing device 104 to communicate with the off-board server 164. The first request 111 indicates the destination address 181 of the off-board server 164. The communication service 174 is configured to establish secure communication with the ground-based proxy device 162 and forward the first request 111 to the ground-based proxy device 162. The communication service 174 is configured to receive second data 161 from the ground-based proxy device 162 and forward the second data 161 to the portable computing device 104.

[0030] During operation, a user (e.g., a pilot) uses an electronic flight bag application of the portable computing device 104 to request aircraft flight information from the flight deck service 176. For example, the portable computing device 104 sends a flight information request 117 to the flight deck service 176. The flight deck service 176 forwards the flight information request 117 to the flight information computing device 166. The flight information computing device 166 generates the first data 151. The first data 151 indicates aircraft flight information (e.g., sensor data or flight data). The flight information computing device 166, in response to receiving the flight information request 117, provides the first data 151 to the flight deck service 176. For example, the network interface 132 of the on-board computing device 102 receives the first data 151 via the flight deck information network 150 from the flight information computing device 166. The flight deck service 176 forwards the first data 151 to the portable computing device 104. For example, the flight deck service 176 sends the first data 151, via the network interface 130, to the wireless access point 140. The wireless access point 140 sends the first data 151, via the network 142, to the portable computing device 104.

[0031] The pilot uses another application (e.g., a weather application or an e-mail application) that generates the first request 111 for the off-board server 164. The portable computing device 104 generates the routing request 105 indicating the destination address 181 of the off-board server 164. The portable computing device 104 sends the routing request 105 to the address server 172 to determine where to send the first request 111 for routing to the off-board server 164. For example, the portable computing device 104 sends the routing request 105 to the address server 172 in response to determining that configuration data of the portable computing device 104 indicates that routing requests are to be sent to the address server 172. The portable computing device 104 sends the routing request 105, via the network 142, to the wireless access point 140.

[0032] The address server 172 receives the routing request 105 via the network interface 130 from the portable computing device 104. For example, the address server 172 receives the routing request 105 from the wireless access point 140. The address server 172 determines, based on the routing information 183, whether the destination address 181 satisfies a routing criterion 185. For example, the address server 172 determines that the destination address 181 fails to satisfy the routing criterion 185 in response to determining that the routing information 183 indicates that communication with the destination address 181 is unauthorized while the portable computing device 104 has access to the flight deck information network 150. The address server 172, in response to determining that the destination address 181 fails to satisfy the routing criterion 185, sends the non-routable address 109 via the first network interface 130 to the portable computing device 104. In a particular aspect, the non-routable address 109 includes an internet protocol (IP) address (e.g., 192.168.0.0, 10.0.0.0, or 172.16.0.0) that is excluded from the public address space.

[0033] The portable computing device 104, in response to receiving the non-routable address 109 from the address server 172, determines that the first request 111 is to be sent to the non-routable address 109 and sends the first request 111 for the off-board server 164 to the non-routable address 109. The portable computing device 104 receives an error message (e.g., a host not reachable message) responsive to the first request 111. For example, the wireless access point 140, in response to receiving a packet including the first request 111 and determining that a destination address field of the packet indicates the non-routable address 109, sends the error message (e.g., the host not reachable message) to the portable computing device 104. When communication with the off-board server 164 is unauthorized while the portable computing device 104 has access to the flight deck information network 150, providing the non-routable address 109 to the portable computing device 104 prevents the first request 111 from leaving the aircraft, being routed by the off-board network 160, reaching the off-board server 164, or a combination thereof, thereby conserving bandwidth.

[0034] In a particular example, the address server 172 determines that the destination address 181 satisfies the routing criterion 185 in response to determining that the routing information 183 indicates that communication with the destination address 181 is authorized (or is not unauthorized) while the portable computing device 104 has access to the flight deck information network 150. The address server 172, in response to determining that the

destination address 181 satisfies the routing criterion 185, selects the routing address 107 of the communication service 174. The address server 172 sends the routing address 107 to the portable computing device 104. For example, the address server 172 sends the routing address 107 via the network interface 130 to the wireless access point 140. The wireless access point 140 sends the routing address 107 via the network 142 to the portable computing device 104.

[0035] The portable computing device 104, in response to receiving the routing address 107 from the address server 172, determines that the first request 111 is to be sent via the routing address 107 and sends the first request 111 for the off-board server 164 to the routing address 107 of the communication service 174. The communication service 174 forwards the first request 111 to the ground-based proxy device 162. For example, the communication service 174, in response to receiving the first request 111, establishes a secured network connection with the ground-based proxy device 162. To illustrate, the communication service 174 sends credentials of the on-board computing device 102 to the ground-based proxy device 162, exchanges encryption keys with the ground-based proxy device 162, or a combination thereof. The communication service 174, in response to determining that the ground-based proxy device 162 has authorized the on-board computing device 102 and that the secured network connection has been successfully established, forwards the first request 111 via the secured network connection to the ground-based proxy device 162. For example, the communication service 174 uses an encryption key associated with the network connection to encrypt the first request 111 and sends an encrypted version of the first request 111 via the off-board network 160 to the ground-based proxy device 162.

[0036] The ground-based proxy device 162, in response to receiving the first request 111, determines whether security policies indicate that communication with the off-board server 164 is authorized while the portable computing device 104 is communicating with the second network interface 132 to access the aircraft flight information. The ground-based proxy device 162, in response to determining that the security policies indicate that communication with the off-board server 164 is unauthorized, discards the first request 111, sends a first error message (e.g., an unauthorized access message) via the secured network connection to the communication service 174, or both. The communication service 174, in response to receiving the first error message from the ground-based proxy device 162, sends a second error message (e.g., a host not reachable message) to the portable computing device 104. In a particular implementation, determining whether the destination address 181 satisfies the routing criterion 185 is less computationally expensive than determining whether the first request 111 satisfies the security policies. Performing the less computationally expensive determination at the aircraft and the more computationally expensive determination at the ground-based proxy device 162 balances saving network resources of the off-board network 160 (by not refraining from routing requests that fail to satisfy the routing criterion 185) and conserving computational resources of the aircraft (by performing the more computationally expensive determining off the aircraft). In a particular aspect, having the ground-based proxy device 162 determine whether the first request 111 satisfies the security policies includes determining whether the destination address 181 satisfies the routing

criterion **185**. In this aspect, if the portable computing device **104** sends the first request **111** to the routing address **107** independently of whether the destination address **181** satisfies the routing criterion **185**, the ground-based proxy device **162** prevents the first request **111** from being forwarded to the off-board server **164** in response to determining that the first request **111** fails to satisfy the security policies.

[0037] In a particular aspect, the ground-based proxy device **162**, based on determining that the communication with the off-board server **164** is authorized, retrieves the second data **161** from the off-board server **164**. For example, the ground-based proxy device **162** sends the first request **111** to the off-board server **164** in response to determining that the security policies indicate that communication with the off-board server **164** is authorized. The off-board server **164**, in response to receiving the first request **111** from the ground-based proxy device **162**, sends the second data **161** to the ground-based proxy device **162**.

[0038] The ground-based proxy device **162**, in response to receiving the second data **161**, forwards the second data **161** via the secured network connection to the communication service **174**. For example, the ground-based proxy device **162** generates encrypted data by encrypting the second data **161** using an encryption key associated with the secured network connection.

[0039] The communication service **174** receives the encrypted data via the secured network connection, extracts the second data **161** from the encrypted data, and routes the second data **161** to the portable computing device **104**. For example, the communication service **174** forwards the second data **161** received from the ground-based proxy device **162** via the network interface **134** to the portable computing device **104** via the network interface **130**. The portable computing device **104** thus, concurrently with routing the first data **151** (e.g., aircraft flight information) received from flight information computing device **166** via the network interface **132** to the portable computing device **104** via the network interface **130**, routes the second data **161** received from the off-board server **164** via the network interface **134** to the portable computing device **104** via the network interface **130**.

[0040] In some aspect, the portable computing device **104** is unaware of the use of the network connection and the ground-based proxy device **162** to enable communication with the off-board server **164**. For example, there may be few, if any, changes to an application on the portable computing device **104** to enable communication via the ground-based proxy device **162** (as compared to directly) with the off-board server **164**.

[0041] In a particular aspect, the passenger cabin server **178** receives a second request **121** via the network interface **136** from the portable computing device **106**. For example, the portable computing device **106** generates the second request **121** in response to activation of an application (e.g., a weather application or an e-mail application) at the portable computing device **106**, receiving user input from a user (e.g., a passenger), or both. The portable computing device **106** determines that the second request **121** is to be sent to the off-board server **164**. In a particular aspect, the off-board server **164** is associated with the application, indicated by the user input, or both. The portable computing device **106** can send the second request **121** via the network **146** to the wireless access point **144**. The passenger cabin server **178** receives the second request **121** from the wireless access

point **144** via the network interface **136** and forwards the second request **121** to the off-board server **164** via the network interface **138**.

[0042] The off-board server **164**, in response to receiving the second request **121**, sends third data **163**, via the off-board network **160**, to the passenger cabin server **178**. The passenger cabin server **178** is configured to route the third data **163** from the off-board server **164** via the wireless access point **144** to the portable computing device **106**. For example, the passenger cabin server **178** receives the third data **163** from the off-board server **164** via the network interface **138** and forwards the third data **163** to the portable computing device **106** via the network interface **136**. The third data **163** received from the off-board server **164** is routed to the portable computing device **106** via the wireless access point **144** that is distinct from the wireless access point **140** that is used to route the first data **151** (e.g., aircraft flight information) to the portable computing device **104**.

[0043] The system **100** thus enables routing the second data **161** (received from the off-board server **164** via the network connection established by the communication service **174**) to the portable computing device **104** via the wireless access point **140** that is used to concurrently route the first data **151** (received from the flight information computing device **166** via the flight deck information network **150**) to the portable computing device **104**. A user (e.g., the pilot) can thus use the same portable computing device **104** to access the aircraft flight information received from the flight information computing device **166** and the second data **161** received from the off-board server **164**.

[0044] Referring to FIGS. 2-3, an example **200** of aircraft communication performed by the system **100** of FIG. 1 is shown. One or more operations described with reference to the example **200** are performed by the address server **172**, the communication service **174**, the flight deck service **176**, the processor **170**, the on-board computing device **102**, or a combination thereof.

[0045] In the example **200**, flight/cabin crew client initiates a web request to access a ground server, at **250**. For example, a flight/cabin crew application (e.g., an e-mail client or a web client) of the portable computing device **104** of FIG. 1 receives a user input from a user (e.g., a pilot or a cabin crew member) indicating a request to communicate with the off-board server **164**. The flight/cabin crew application, in response to receiving the user input, initiates a web request to access the off-board server **164**.

[0046] Flight/cabin crew client accesses proxy auto-config (PAC) file to determine a routing address for communicating with the ground server, at **254**. In a particular example, an operating system (OS) of the portable computing device **104** supports auto-configured proxy setting via a configuration file (e.g., a PAC file) assigned per wireless network. For example, a particular configuration file (e.g., "proxy.pac") is assigned to a particular service set identifier (SSID) that uniquely identifies a wireless local-area network (LAN). The portable computing device **104** is pre-configured to access the particular configuration file (e.g., "proxy.pac"). In a particular aspect, the particular configuration file is stored in a memory of the portable computing device **104**, the memory **122** of the on-board computing device **102**, or both. The portable computing device **104** determines that the particular configuration file (e.g., "proxy.pac") indicates that the destination address **181** of the off-board server **164** maps

to the routing address **107** (e.g., “osslop\commserv.ons.pnet:1080”) of the communication service **174**.

[0047] Alternatively, or in addition, a SOCKS-enabled flight/cabin crew client initiates a request to communicate with the ground server via a SOCKS proxy, at **252**. For example, the flight/cabin crew application (e.g., an e-mail client or a web client) of the portable computing device **104** is SOCKS-enabled. SOCKS refers to an internet protocol for exchanging network packets between a client and a server through a proxy server. The flight/cabin crew application (e.g., an e-mail client or a web client) of the portable computing device **104** sends the routing request **105** to the address server **172** to request communication with the off-board server **164** via a proxy (e.g., the ground-based proxy device **162**). In a particular aspect, the ground-based proxy device **162** includes a SOCKS proxy server. The address server **172**, in response to receiving the routing request **105**, sends the routing address **107** (e.g., “osslop\commserv.ons.pnet:1080”) of the communication service **174** to the portable computing device **104**, as described with reference to FIG. 1.

[0048] The flight/cabin crew client connects to the routing address, at **256**. The particular configuration file (e.g., “proxy.pac”) includes the routing information **183** of FIG. 1 indicating a mapping between sites and addresses. For example, the routing information **183** indicates a first set of addresses (e.g., one or more of an IP address, a universal resource locator (URL), or a universal resource identifier (URI)) that map to the ground-based proxy device **162**, a second set of addresses (e.g., one or more of an IP address, a URL, or a URI) that are not routable, or both. Communication with devices associated with the first set of addresses is authorized while having access to aircraft flight information. Communication with devices associated with the second set of addresses is unauthorized while having access to the aircraft flight information. The routing information **183** indicates that the off-board server **164** is reachable via the communication service **174**. The routing information **183** indicates the routing address **107** (e.g., “osslop\commserv.ons.pnet:1080”) of the communication service **174**. The portable computing device **104** sends the first request **111** for the off-board server **164** to the routing address **107** (e.g., “osslop\commserv.ons.pnet:1080”).

[0049] The communication service **174** determines whether network extension device (NED)/NED subsystem processor (NSP) firewall rules are satisfied, at **258**. For example, the communication service **174** determines whether the first request **111** satisfies first firewall rules. The communication service **174**, in response to determining that the first request **111** fails to satisfy first firewall rules, discards the first request **111**, sends an error message (e.g., a host unreachable message) to the portable computing device **104**, or both. The first firewall rules include one or more NED firewall rules, one or more NSP firewall rules, or a combination thereof. In a particular aspect, a NED includes an on-board router, a collector of aircraft data, or both. For example, the NED includes an Ethernet switch, a router, or both. In a particular aspect, the NED complies with the aeronautical radio inc. (ARINC®), a registered trademark of ARINC Inc., Annapolis, Md.) 429 technical standard. For example, the NED has ARINC 429 input/output capability. In a particular aspect, the NSP includes an on-board router, a collector of aircraft data, or both. For example, the NSP includes an Ethernet switch, a router, or both. In a particular

aspect, the NSP complies with the ARINC® 429 technical standard. In a particular aspect, the NSP is built into the same hardware components as the NFS.

[0050] The communication service **174**, in response to determining that the first request **111** satisfies the NED/NSP firewall rules, at **258**, determines whether NFS firewall rules are satisfied, at **260**. For example, the communication service **174** determines whether the first request **111** satisfies NFS firewall rules. The communication service **174**, in response to determining that the first request **111** fails to satisfy NFS firewall rules, discards the first request **111**, sends an error message (e.g., a host unreachable message) to the portable computing device **104**, or both.

[0051] The communication service **174** has a stunnel listening on port 1080. For example, the communication service **174**, at startup of the communication service **174**, the portable computing device **104**, or both, retrieves credentials of the portable computing device **104**, configuration data, or both, from the memory **122** of FIG. 1. The configuration data indicates a security server address, a SOCKS server address, or both. The configuration data includes user-specified identifiers of ground servers for which communication is authorized while having access to aircraft flight information. For example, the user-specified identifiers include a name of the off-board server **164**, the destination address **181** of the off-board server **164**, or both. In a particular aspect, the configuration data indicates a particular port (e.g., a listening port). The communication service **174** monitors the particular port (e.g., 1080).

[0052] Continuing at FIG. 3, stunnel connects to <customer specified>:9080, at **366**. For example, the communication service **174**, in response to receiving the first request **111** from the portable computing device **104**, establishes a session with a port (e.g., 9080) of the ground-based proxy device **162**.

[0053] The communication service **174** determines whether NFS firewall rules are satisfied, at **368**. For example, the communication service **174** generates a forwarding request including the first request **111** and determines whether the forwarding request satisfies the NFS firewall rules. The communication service **174**, in response to determining that the forwarding request fails to satisfy the NFS firewall rules, discards the forwarding request, discards the first request **111**, sends an error message (e.g., a host unreachable message) to the portable computing device **104**, or a combination thereof.

[0054] The communication service **174**, in response to determining that the forwarding request satisfies the NFS firewall rules, at **368**, determines whether the forwarding request satisfies one or more NED firewall rules, one or more NSP firewall rules, or a combination thereof. The communication service **174**, in response to determining that the forwarding request fails to satisfy at least one of the NED firewall rules or the NSP firewall rules, discards the forwarding request, discards the first request **111**, sends an error message (e.g., a host unreachable message) to the portable computing device **104**, or a combination thereof.

[0055] The communication service **174**, in response to determining that the forwarding request satisfies the NED firewall rules, the NSP firewall rules, or a combination thereof, at **368**, monitors a customer specified server on port 9080, at **372**. For example, the communication service **174** monitors the session established with the ground-based proxy device **162**.

[0056] The communication service 174 connects to a SOCKS proxy, at 374. For example, the communication service 174 establishes a secured network connection with the SOCKS proxy server of the ground-based proxy device 162.

[0057] The SOCKS proxy validates the request and then connects to the ground server, at 376. The communication service 174 sends the forwarding request via the secured network connection to the ground-based proxy device 162. The forwarding request indicates that the first request 111 is to be forwarded to the off-board server 164. The ground-based proxy device 162 validates the forwarding request based on security policies (e.g., a SOCKS proxy whitelist). For example, the ground-based proxy device 162, in response to determining that the security policies (e.g., a SOCKS proxy whitelist) indicate that communication with the off-board server 164 is authorized, sends the first request 111 to the off-board server 164.

[0058] The portable computing device 104 communicates via the ground-based proxy device 162 with the off-board server 164. For example, the off-board server 164 sends the second data 161 via the ground-based proxy device 162 to the portable computing device 104, as described with reference to FIG. 1.

[0059] The communication service 174 thus enables routing the second data 161 received from the off-board server 164 via the network connection established by the communication service 174 to the portable computing device 104. The second data 161 is routed to the portable computing device 104 in response to determining that communication with the off-board server 164 is authorized.

[0060] FIG. 4 is a flowchart of a method 400 for aircraft communication with off-board systems. The method 400 may be performed by the processor 170, the address server 172, the communication service 174, the flight deck service 176, the on-board computing device 102, the system 100 of FIG. 1, or any combination thereof.

[0061] The method 400 includes routing, at an on-board computing device, first data from a flight deck information network to a portable computing device via a wireless access point, at 402. For example, the on-board computing device 102 of FIG. 1 routes the first data 151 from the flight deck information network 150 to the portable computing device 104 via the wireless access point 140, as described with reference to FIG. 1. The first data 151 includes aircraft flight information.

[0062] The method 400 also includes concurrently with routing the first data, routing, at the on-board computing device, second data from an off-board server via the wireless access point to the portable computing device, at 404. For example, the on-board computing device 102, concurrently with routing the first data 151, routes the second data 161 from the off-board server 164 via the wireless access point 140 to the portable computing device 104, as described with reference to FIG. 1.

[0063] The method 400 thus enables routing the second data 161 (received from the off-board server 164) to the portable computing device 104 via the wireless access point 140 that is used to concurrently route the first data 151 (received via the flight deck information network 150) to the portable computing device 104. A user (e.g., the pilot) can thus use the same portable computing device 104 to access the aircraft flight information received via the flight deck

information network 150 and the second data 161 received from the off-board server 164.

[0064] Aspects of the disclosure may be described in the context of an aircraft 500 as shown in FIG. 5. The aircraft 500 includes an airframe 518 with a plurality of systems 520 (e.g., high-level systems) and an interior 522. Examples of the systems 520 include one or more of a propulsion system 524, an electrical system 526, an environmental system 528, an hydraulic system 530, the on-board computing device 102, and the passenger cabin server 178. Other systems can also be included.

[0065] The on-board computing device 102, the passenger cabin server 178, or both, are configured to support aspects of computer-implemented methods and computer-executable program instructions (or code) according to the present disclosure. For example, the on-board computing device 102, the passenger cabin server 178, or portions thereof, are configured to execute instructions to initiate, perform, or control one or more operations described with reference to FIGS. 1-4. Although an aerospace example is shown, the present disclosure can be applied to other industries. For example, the on-board computing device 102, the passenger cabin server 178, or both, can be used onboard a manned or unmanned vehicle (such as a satellite, a watercraft, or a land-based vehicle), in a building or other structure.

[0066] Although one or more of FIGS. 1-5 illustrate systems, apparatuses, and/or methods according to the teachings of the disclosure, the disclosure is not limited to these illustrated systems, apparatuses, and/or methods. One or more functions or components of any of FIGS. 1-5 as illustrated or described herein may be combined with one or more other portions of another of FIGS. 1-5. For example, one or more elements of the method 400 of FIG. 4 may be performed in combination with other operations described herein. Accordingly, no single implementation described herein should be construed as limiting and implementations of the disclosure may be suitably combined without departing from the teachings of the disclosure. As an example, one or more operations described with reference to FIGS. 1-4 may be optional, may be performed at least partially concurrently, and/or may be performed in a different order than shown or described.

[0067] Examples described above are illustrative and do not limit the disclosure. It is to be understood that numerous modifications and variations are possible in accordance with the principles of the present disclosure.

[0068] The illustrations of the examples described herein are intended to provide a general understanding of the structure of the various implementations. The illustrations are not intended to serve as a complete description of all of the elements and features of apparatus and systems that utilize the structures or methods described herein. Many other implementations may be apparent to those of skill in the art upon reviewing the disclosure. Other implementations may be utilized and derived from the disclosure, such that structural and logical substitutions and changes may be made without departing from the scope of the disclosure. For example, method operations may be performed in a different order than shown in the figures or one or more method operations may be omitted. Accordingly, the disclosure and the figures are to be regarded as illustrative rather than restrictive.

[0069] Moreover, although specific examples have been illustrated and described herein, it should be appreciated that

any subsequent arrangement designed to achieve the same or similar results may be substituted for the specific implementations shown. This disclosure is intended to cover any and all subsequent adaptations or variations of various implementations. Combinations of the above implementations, and other implementations not specifically described herein, will be apparent to those of skill in the art upon reviewing the description.

**[0070]** The Abstract of the Disclosure is submitted with the understanding that it will not be used to interpret or limit the scope or meaning of the claims. In addition, in the foregoing Detailed Description, various features may be grouped together or described in a single implementation for the purpose of streamlining the disclosure. Examples described above illustrate but do not limit the disclosure. It should also be understood that numerous modifications and variations are possible in accordance with the principles of the present disclosure. As the following claims reflect, the claimed subject matter may be directed to less than all of the features of any of the disclosed examples. Accordingly, the scope of the disclosure is defined by the following claims and their equivalents.

What is claimed is:

1. A system for aircraft communication comprising:
  - an on-board computing device including:
    - a first network interface configured to communicate via a wireless access point with a portable computing device;
    - a second network interface configured to communicate with a flight deck information network;
    - a third network interface configured to communicate via an off-board network with an off-board server; and
    - a processor configured to:
      - route first data from the second network interface to the portable computing device via the first network interface, the first data including aircraft flight information; and
      - concurrently with routing the first data, route second data from the off-board server via the third network interface to the portable computing device via the first network interface.
  2. The system of claim 1, further comprising a memory configured to store routing information, wherein the processor is configured to:
    - receive, via the first network interface from the portable computing device, a routing request indicating a destination address; and
    - determine, based on the routing information, whether the destination address satisfies a routing criterion.
  3. The system of claim 2, wherein the processor is further configured to:
    - select a routing address based on determining that the destination address satisfies the routing criterion; and
    - send the routing address via the first network interface to the portable computing device.
  4. The system of claim 2, wherein the processor is further configured to, based on determining that the destination address fails to satisfy the routing criterion, send a non-routable address via the first network interface to the portable computing device.
  5. The system of claim 1, further comprising a ground-based proxy device configured to:

- receive a first request via the on-board computing device from the portable computing device to communicate with the off-board server;
- determine, based on security policies, whether communication with the off-board server is authorized while the portable computing device is communicating with the second network interface to access the aircraft flight information;
- based on determining that the communication with the off-board server is authorized, retrieve the second data from the off-board server; and
- send the second data to the on-board computing device.
6. The system of claim 5, wherein the on-board computing device is configured to:
  - establish a secured network connection via the third network interface with the ground-based proxy device;
  - receive encrypted data via the secured network connection; and
  - prior to routing the second data to the portable computing device, extract the second data from the encrypted data.
7. An aircraft comprising:
  - a wireless access point configured to communicate with a portable computing device; and
  - a network file server (NFS) 102 coupled to the wireless access point, the NFS configured to:
    - route first data from a flight deck information network to the portable computing device via the wireless access point, the first data including aircraft flight information; and
    - concurrently with routing the first data, route second data from an off-board server via the wireless access point to the portable computing device.
8. The aircraft of claim 7, wherein the NFS comprises:
  - a first network interface configured to communicate with the wireless access point;
  - a second network interface configured to communicate with the flight deck information network; and
  - a third network interface configured to communicate via an off-board network with the off-board server.
9. The aircraft of claim 7, further comprising a flight information computing device configured to generate the aircraft flight information.
10. The aircraft of claim 7, further comprising:
  - a second wireless access point configured to communicate with a second portable computing device; and
  - a passenger cabin server coupled to the second wireless access point, the passenger cabin server configured to route third data from the off-board server via the second wireless access point to the second portable computing device.
11. A method of aircraft communication comprising:
  - routing, at an on-board computing device, first data from a flight deck information network to a portable computing device via a wireless access point, the first data including aircraft flight information; and
  - concurrently with routing the first data, routing, at the on-board computing device, second data from an off-board server via the wireless access point to the portable computing device.
12. The method of claim 11, further comprising:
  - receiving, at the on-board computing device via the wireless access point from the portable computing device, a routing request indicating a destination address; and

determining, based on routing information, whether the destination address satisfies a routing criterion.

**13.** The method of claim **12**, further comprising:  
selecting, at the on-board computing device, a routing address based on determining that the destination address satisfies the routing criterion; and  
sending the routing address from the on-board computing device via the wireless access point to the portable computing device.

**14.** The method of claim **12**, further comprising, based on determining at the on-board computing device that the destination address fails to satisfy the routing criterion, sending a non-routable address via the wireless access point to the portable computing device.

**15.** The method of claim **11**, further comprising:  
receiving, at the on-board computing device, a first request via the wireless access point from the portable computing device to communicate with the off-board server; and  
sending the first request from the on-board computing device to a ground-based proxy device, the second data from the off-board server received via the ground-based proxy device responsive to the ground-based proxy device determining that communication with the off-board server is authorized.

**16.** The method of claim **15**, further comprising:  
establishing a secured network connection between the on-board computing device and the ground-based proxy device;  
receiving encrypted data at the on-board computing device via the secured network connection from the ground-based proxy device; and  
prior to routing the second data to the portable computing device, extracting the second data from the encrypted data.

**17.** A computer-readable storage device storing instructions that, when executed by a processor, cause the processor to perform operations comprising:

routing first data from a flight deck information network to a portable computing device via a wireless access point, the first data including aircraft flight information; and

concurrently with routing the first data, routing second data from an off-board server via the wireless access point to the portable computing device.

**18.** The computer-readable storage device of claim **17**, wherein the operations further comprise:  
receiving, via the wireless access point from the portable computing device, a routing request indicating a destination address; and  
determining, based on routing information, whether the destination address satisfies a routing criterion.

**19.** The computer-readable storage device of claim **18**, wherein the operations further comprise:  
selecting a routing address based on determining that the destination address satisfies the routing criterion; and  
sending the routing address via the wireless access point to the portable computing device.

**20.** The computer-readable storage device of claim **18**, wherein the operations further comprise, based on determining that the destination address fails to satisfy the routing criterion, sending a non-routable address via the wireless access point to the portable computing device.

**21.** The computer-readable storage device of claim **17**, wherein the operations further comprise:  
receiving a first request via the wireless access point from the portable computing device to communicate with the off-board server; and  
sending the first request to a ground-based proxy device, the second data from the off-board server received via the ground-based proxy device responsive to the ground-based proxy device determining that communication with the off-board server is authorized.

**22.** The computer-readable storage device of claim **21**, further comprising:  
establishing a secured network connection with the ground-based proxy device;  
receiving encrypted data via the secured network connection from the ground-based proxy device; and  
prior to routing the second data to the portable computing device, extracting the second data from the encrypted data.

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