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Inventor(s)	Marquie; Bruno et al.

Facilitating access to API integrations

Abstract

One disclosed method involves receiving, at a first application programming interface (API) endpoint of a computing system, a first API call requesting performance of a first type of operation; invoking, by the computing system and based on the first API call, a first process to send at least a second API call to a second API endpoint of a first system of record; receiving, by the computing system and from the first system of record, a first response to the second API call; and sending, from the computing system to a source of the first API call, a second response that is based at least in part on the first response.

Inventors: **Marquie; Bruno (Fort Collins, CO), Gupta; Harshavardhan (Kishanganj, IN), Raveendar; Madhumitha (Cary, NC), Saraf; Gaurav (Apex, NC), Bonageri; Venkatesh (Raleigh, NC), Kalagond; Sangamesh Vishweshwar (Vijayapura, IN), Kumar; Rakesh (Cary, NC)**

Applicant: **Citrix Systems, Inc.** (Fort Lauderdale, FL)

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Background/Summary

BACKGROUND

(1) Various systems have been developed that allow client devices to access applications and/or data files over a network. Certain products offered by CITRIX Systems, Inc., of Fort Lauderdale, FL, including the CITRIX WORKSPACE™ family of products, provide such capabilities.

SUMMARY

(2) This Summary is provided to introduce a selection of concepts in a simplified form that are further described below in the Detailed Description. This Summary is not intended to identify key features or essential features, nor is it intended to limit the scope of the claims included herewith.

(3) In some of the disclosed embodiments, a method comprises receiving, by a computing system from a first device, a request to identify application programming interface (API) endpoints that are configured to perform a search operation; determining, by the computing system, that first and second API endpoints of the computing system are both configured to perform search operation operations; sending, from the computing system to the first device and based at least in part on the first and second API endpoints both being configured to perform search operations, indications of the first API endpoint and the second API endpoint; receiving, at the first API endpoint and from the first device, a first API call requesting performance of a first search operation; executing, by the computing system and based on the first API call, a first script to send at least a second API call to a third API endpoint of a first system of record, the second API call representing a request to perform the first search operation; receiving, by the computing system and from the first system of record, first search results in response to the second API call; generating, by the computing system and based at least in part on the first search results, a first response to the first API call, the first response representing the first search results; sending, from the computing system to the first device, the first response; receiving, at the second API endpoint and from the first device, a third API call requesting performance of a second search operation; executing, by the computing system and based on the third API call, a second script to generate at least a fourth API call to a fourth API endpoint of a second system of record, the fourth API call representing a request to perform the second search operation; receiving, by the computing system and from the second system of record,

second search results in response to the fourth API call; generating, by the computing system and based at least in part on the second search results, a second response to the third API call, the second response representing the second search results; and sending, from the computing system to the first device, the second response.
(4) In some of the disclosed embodiments, a method comprises receiving, at a first application programming interface (API) endpoint of a computing system, a first API call requesting performance of a first type of operation; invoking, by the computing system and based on the first API call, a first process to send at least a second API call to a second API endpoint of a first system of record; receiving, by the computing system and from the first system of record, a first response to the second API call; and sending, from the computing system to a source of the first API call, a second response that is based at least in part on the first response.
(5) In some embodiments, a system comprises at least one processor, and at least one computer-readable medium encoded with instructions which, when executed by the at least one processor, cause the system to receive, at a first application programming interface (API) endpoint of the system, a first API call requesting performance of a first type of operation; invoke, based on the first API call, a first process to send at least a second API call to a second API endpoint of a first system of record; receive, from the first system of record, a first response to the second API call; and send, to a source of the first API call, a second response that is based at least in part on the first response.
(6) In some embodiments, at least one non-transitory computer-readable medium is encoded with instructions which, when executed by at least one processor of a computing system, cause the computing system to receive, at a first application programming interface (API) endpoint of the system, a first API call requesting performance of a first type of operation; invoke, based on the first API call, a first process to send at least a second API call to a second API endpoint of a first system of record; receive, from the first system of record, a first response to the second API call; and send, to a source of the first API call, a second response that is based at least in part on the first response.

Description

BRIEF DESCRIPTION OF THE DRAWINGS
(1) Objects, aspects, features, and advantages of embodiments disclosed herein will become more fully apparent from the following detailed description, the appended claims, and the accompanying figures in which like reference numerals identify similar or identical elements. Reference numerals that are introduced in the specification in association with a figure may be repeated in one or more subsequent figures without additional description in the specification in order to provide context for other features, and not every element may be labeled in every figure. The drawings are not necessarily to scale, emphasis instead being placed upon illustrating embodiments, principles and concepts. The drawings are not intended to limit the scope of the claims included herewith.
(2) FIG. **1**A is a diagram illustrating example operations of a system for facilitating access to application programming interface (API) integrations in accordance with the present disclosure;
(3) FIG. **1**B is a diagram illustrating example operations of the system determining endpoints (EPs) configured to perform certain operations, in accordance with the present disclosure;
(4) FIG. **2** is a diagram of a network environment in which some embodiments of the context-based microapp action recommendation system disclosed herein may deployed;
(5) FIG. **3** is a block diagram of a computing system that may be used to implement one or more of the components of the computing environment shown in FIG. **2** in accordance with some embodiments;
(6) FIG. **4** is a schematic block diagram of a cloud computing environment in which various

aspects of the disclosure may be implemented;
(7) FIG. **5**A is a block diagram of an example system in which resource management services may manage and streamline access by clients to resource feeds (via one or more gateway services) and/or software-as-a-service (SaaS) applications;
(8) FIG. **5**B is a block diagram showing an example implementation of the system shown in FIG. **5**A in which various resource management services as well as a gateway service are located within a cloud computing environment;
(9) FIG. **5**C is a block diagram similar to that shown in FIG. **5**B but in which the available resources are represented by a single box labeled "systems of record," and further in which several different services are included among the resource management services;
(10) FIG. **5**D shows how a display screen may appear when an intelligent activity feed feature of a multi-resource management system, such as that shown in FIG. **5**C, is employed;
(11) FIG. **6** is a block diagram of an example system in which a data integration provider service hosts integrations for providing a client with access to systems of record; and
(12) FIG. **7** shows a sequence diagram illustrating messages that may be exchanged amongst various components of a system for facilitating access to API integrations to enable certain aspects of the functionality disclosed herein.
DETAILED DESCRIPTION
(13) For purposes of reading the description of the various embodiments below, the following descriptions of the sections of the specification and their respective contents may be helpful: Section A provides an introduction to example embodiments of a system for facilitating access to API integrations in accordance with some aspects of the present disclosure; Section B describes a network environment which may be useful for practicing embodiments described herein; Section C describes a computing system which may be useful for practicing embodiments described herein; Section D describes embodiments of systems and methods for accessing computing resources using a cloud computing environment; Section E describes embodiments of systems and methods for managing and streamlining access by clients to a variety of resources; Section F provides a more detailed description of example embodiments of the system for facilitating access to API integrations introduced in Section A; and Section G describes example implementations of methods, systems/devices, and computer-readable media in accordance with the present disclosure.
A. Introduction to Illustrative Embodiments of a System for Facilitating Access to API Integrations
(14) Service providers may develop integrations to interact with systems of record for various purposes. For example, as described below in Section E, a multi-resource access system **500** may include a microapp service **528** (shown in FIG. **5**C) that allows microapps to take actions or access resources of systems of record **526** on behalf of clients **202**. In such a system, interaction between clients **202** and systems of record **526** is indirect, with clients **202** interacting with microapps of the microapp service **528**, and the microapps of the microapp service **528** interacting with the systems of record **526** via the data integration provider service **530**. The microapps and corresponding integrations (e.g., included in the data integration provider service **530**) are typically developed in tandem, with respective integrations being specially configured and dedicated to servicing the unique needs of corresponding microapps. Moreover, such integrations may operate on behalf of a company or other entity for which the multi-resource access system **500** is deployed (e.g., using an administrator account) rather than using credentials corresponding to a particular user **524**. Without receiving user-specific credentials, a system of record may be limited from providing functionality that is personalized, for example, based on a user profile.
(15) The inventors have recognized and appreciated that improvements can be made in the manner in which the functionality of systems of record is made accessible to clients. In particular, in some implementations, an API integration provider service may be configured to not only host API integrations for various systems of record, but also make those API integrations directly accessible to clients via integration API endpoints (EPs) (which may be independent of microapps). For

example, a client may send an API call to one of the integration API EPs and, in response to that API call, the API integration provider service may invoke one or more API integrations to interact with one or more systems of record **526** in a manner defined by such integration(s). Such API integration(s) may, for example, include respective scripts or other executable files that may execute processes to generate and send one or more API calls to one or more system of record (SOR) API EPs based on the API call received from the client. Such API integration(s) may also receive one or more responses from the SOR API EP(s). In some cases, an API integration may translate data in the API call received from the client to match an input schema of a particular SOR API EP, and may translate data in system of record response(s) to conform to a standard output schema. The API integration provider service may thus provide one or more integration API EP(s) that the client may use to access functionality of various systems of record using API calls having a consistent format. In some cases, the API integration provider service may send the API call(s) to the SOR API EP(s) via an HTTP proxy service, which may retrieve client credentials to authenticate the API call(s) on behalf of the client before forwarding the API call(s) to the SOR API EP(s), thus allowing a system of record to provide a response based on information associated with a client profile or account.

(16) FIG. **1**A is a diagram illustrating example operations of a system **100** for facilitating access to application programming interface (API) integrations in accordance with some aspects of the present disclosure. As shown, the system **100** may include an API integration provider service **130** that hosts at least a first API integration **120***a* and a second API integration **120***b* (collectively, API integrations **120**), and that exposes those API integrations **120** to a client **202** via one or more integration API EPs **115**. The API integration provider service **130** may be provided by a server or other computer system providing access to one or more client devices and/or client applications; for example, and without limitation, a server **204**, a cloud computing environment **400**, and/or a cloud computing environment **512**, etc. Although illustrated as a computer operated by a user **524**, it should be appreciated that the client **202** may take on any of numerous other forms and need not be user-operated. Several example of clients **202** that may interact with the API integration provider service **130** via the integration API EP(s) **115** are described further below. The client **202** may interact with the respective integration API EPs **115** directly; for example, by sending an API call to an integration API EP **115** and receiving a response. The respective API integrations **120***a*, **120***b* may include scripts or other executable code that may be invoked when an API call is received from the client **202**. An invoked script may initiate a process to send one or more API calls to one or more SOR API EPs **125** on behalf of the client **202**, and to return a response to the client **202** that is based on one or more responses received from such SOR API EP(s) **125**. Thus, an API integration **120** may be configured to interact with a system of record **526** to perform one or more particular operations and/or obtain one or more particular results, and that API integration **120** may describe an integration API EP **115** that the API integration provider service **130** may expose to one or more clients **202** to provide the clients seamless access to such functionality.

(17) The API integration provider service **130** may be local to the client **202** (e.g., on the same local area network) or may be implemented by one or more remove servers **204** (examples of which are described below). The client **202** may communicate with the API integration provider service **130** over one or more computer networks **206** (examples of which are described below). The API integration provider service **130** may communicate with the systems of record **526** over the same or other computer networks. As noted above, the client **202** may access the API integration provider service **130** via the integration API EP(s) **115**, and the API integration provider service **130** may access the systems of record **526** via the SOR API EP(s) **125**.

(18) The API integration provider service **130** may receive one or more general API calls **104** from the client **202** at one or more integration API EPs **115**. The integration API EP **115** may have standardized input/output schemas; for example, that may be independent of input/output schemas used by the SOR API EPs **125**. Thus, a client **202** may make API calls in the standardized format

independent of which system of record is ultimately accessed. In response to such general API call(s) **104**, the first API integration **120***a* may execute the first process and/or the second API integration **120***b* may execute the second process. The API integrations **120** may execute processes to translate or otherwise reformat data from the general API call **104** into a format used by the SOR API EPs **125**. Thus, the first API integration **120***a* may execute a first process during which it makes one or more system of record-specific API calls **105** to one or more SOR API EPs **125***a* hosted by the first system of record **526***a*. The second API integration **120***b* may execute a second process during which it makes one or more system of record-specific API calls **106** to one or more SOR API EPs **125***b* hosted by the second system of record **526***b*. As part of the first and/or second processes, the API integration(s) **120** may receive and process response(s) **108**, **109** from the system(s) of record **526**, and may send a response **107** to the client **202** via the integration API EP **115** that received the general API call **104** from the client **202**. In some implementations, the first and/or second processes may translate data in the general API call **104** to match API EP input schema(s) of the SOR API EP(s) **125**. The first and/or second processes employed by the API integrations **120** may additionally translate data in the system of record response(s) **108**, **109** to match an API EP output schema of the integration API EP **115** to which the client **202** sent the general API call **104**.
(19) FIG. **1**A shows an example routine **150** that may be performed by the API integration provider service **130**. At a step **152** of the routine **150**, the API integration provider service **130** may receive, at an integration API EP **115**, a first API (general) call **104**. The first API call **104** may represent a request to perform a first type of operation (e.g., a search, browse, recent, compare, etc.). In response to receiving the first API call **104**, at a step **154** of the routine **150**, the API integration provider service **130** may invoke or otherwise initiate the first process of the first API integration **120***a* to send at least a second (system of record-specific) API call **105** to the first system of record API EP **125***a*. At a step **156** of the routine **150**, the API integration provider service **130** may receive at least a first response **108** to the second API call **105** from the first system of record **526***a*. At a step **158** of the routine **150**, the API integration provider service **130** may send a second response **107** to a source of the first API call **104** (e.g., the client **202**). The second response **107** may be based at least in part on the first response **108**.
(20) In some implementations, in response to receiving the first API call **104** (per the step **152**), the second process of the second API integration **120***b* may additionally be invoked or initiated in a similar fashion. Additionally or alternatively, in some implementations, the second process of the second API integration **120***b* may be invoked in response to a different general API call to a different integration API EP **115**. In any event, invoking the second process of the second API integration **120***b* may result in one or more system of record-specific API calls **106** to the second system of record API EP(s) **125***b* of the second system of record **526***b*. The second system of record **526***b* may return at least a third response **109**. The second response **107** sent to the client **202** may be further based at least in part on the third response. Alternatively, a separate response **107** that is based at least in part on the third response **109** may be sent to the client **202**.
(21) In some implementations, the client **202** may send separate general API calls **104** for respective system of records **526** that are to be accessed via API integrations **120**. Alternatively, in some implementations, the client **202** may send a single general API call **104** that may indicate multiple systems of record **526** that are to be accessed via API integrations **120**, and the API integration provider service **130** can invoke or execute multiple API integrations **120** in response to receipt of that single general API call **104**.
(22) The system **100** may provide responses to different types of general API calls **104**. The API EP **115** (or set of API EPs **115**) exposed by an API integration **120** may include an on-demand-based API EP **115** or a subscription-based API EP **115**. An on-demand-based API EP **115** may implement actions at the time the API is invoked by a user and/or service using the integration platform. For example, a search query is a type of on-demand API call that may receive a direct response in the

form of search results. A subscription-based API EP **115** may involve events and/or notifications that a system of record **526** pushes to the API integration provider service **130** after receiving a request (e.g., made via a system of record-specific API call **105**) to subscribe to the events/notifications, and that API integration provider service **130**, in turn, pushes to the client **202** (e.g., via a second response **107**). For example, a user may request notifications when new files are shared with the user. The system of record **526** may not provide a response at the time of receiving the request (or may only acknowledge the request), but may send a notification at a later time if it determines that a new file has been shared.

(23) Integrations hosted in the API integration provider service **130** may be recorded in an API registry. Integrations identified in the API registry may be categorized by API type and/or function (i.e., by a type of operation they can facilitate). Category types may include broadly applicable functionalities such as searching content recent content (e.g., recently accessed applications and/or files), browse content, etc., as well as those that may particular to certain business domains, such as compare files, organize a meeting, electronically sign a document, task management (e.g., schedule a task, begin a task, set or send a reminder, check status of a task), etc. Thus, a client **202** may submit a request to the API integration provider service **130** and/or the API registry to identify resources in the category "search," and the API registry may return a list of one or more integration API EPs **115** categorized accordingly. This categorization of integration API EPs **115** by type, using category tags or otherwise, may thus allow API integrations **120** to be readily discovered by clients **202** once added.

(24) FIG. **1**B is a diagram illustrating example operations that may be performed by the system **100** to determine integration API EPs **115** configured to perform certain operations, in accordance with some aspects of the present disclosure. In some implementations, a client **202** may send a request **111** to the API integration provider service **130** for indications of available integration API EPs **115** for performing certain types of operations (e.g., search, browse, recent, compare, etc.). As discussed in more detail below in Section F, after API integrations **120** and corresponding integration API EPs **115** have been created, identifiers of the newly-available integration API EPs **115** may be stored in the API registry **670** together with tags or other data indicative of the operations(s) that will be performed with respect to one or more systems of record **526** when general API calls **104** are made to such integration API EPs **115**. When the API integration provider service **130** receives a request **111** for integration API EPs **115** available for performing a certain type of operation, the API integration provider service **130** can query the API registry **670** by operation type, and receive an indication, or a list of indications, of integration API EPs **115** available for that type of operation.

(25) FIG. **1**B shows an example routine **160** that may be performed by the API integration provider service **130** to provide a client **202** with a list of one or more integration API EPs **115** for performing a certain type of operation. As shown, the client **202** may send a request **111** to the API integration provider service **130** for a list of integration API EPs **115** available for performing a type of operation; for example, a search operation for identifying/locating certain resources by name and/or keyword. The API integration provider service **130** may receive (**162**) the request **111**, and determine (**164**) one or more integration API EPs **115** for API integrations **120** that are hosted by the API integration provider service **130** and configured to perform the first type of operation. For example, the API integration provider service **130** may send a query **112** to the API registry **670** with an indication of the desired operation type. The API registry **670** may return a list **113** indications of one or more integration API EPs **115** configured to perform the operation type. The API integration provider service **130** may send (**166**) the list **114** to the client **202**. The list of integration API EPs **115** sent to the client **202** may indicate one or more integration API EPs **115** for API integrations **120** that are hosted by the API integration provider service **130**; that is, EPs that are available to be called directly by clients **202**, such as the integration API EP **115** shown in FIG. **1**A. The client **202** may use the list **114** of integration API EPs **115** to determine one or more

EPs to which the client **202** may send one or more general API calls **104** corresponding to the operation type.

(26) The API registry **670** may be able to return responses to various types of queries concerning API integrations **120** and/or integration API endpoints **115**. For example, the API registry **670** may provide information such as which systems of record **526** are associated with integrations **120** that support a particular operation, e.g., a "search" operation, what API integrations **120** are available for a particular system or record **526**, what events (e.g., related to subscription API calls) may be supported by an API integration for a system of record **526**, what capabilities of systems of record **526** are exposed via integration API EPs **115** by the API integration provider service **130**, etc. The API registry **670** may itself be exposed via one or more standardized APIs, allowing a user **524** and/or client **202** to directly query what API integrations **120** may be available. These API registry **670** API may thus allow clients **202** of the system **100** to discover available API integrations **120** and/or integration API EPs **115**.

(27) API integrations may be composed of several components that are supported by representational state transfer (REST) APIs. The components may include a property describing the API integration **120**, executable code such as scripts for performing processes, and/or definitions of the system of record API EPs **125** (e.g., including a URL, the system of record **526**, HTTP verb(s) available, input schema, output schema, category, etc.). An API integration **120** may be accessed via one or more integration API EPs **115**. An integration API EP **115** of an API integration **120** may be assigned a general API call **104** depending on its type. The integration API endpoints **115** may be made available to any of a number of types of clients **202**, such as user-operated computing devices or systems, applications (e.g., a resource access application, a search or other content service, etc.), and/or microapps such as those discussed in Section E below. B. Network Environment

(28) Referring to FIG. **2**, an illustrative network environment **200** is depicted. As shown, the network environment **200** may include one or more clients **202**(**1**)-**202**(*n*) (also generally referred to as local machine(s) **202** or client(s) **202**) in communication with one or more servers **204**(**1**)-**204**(*n*) (also generally referred to as remote machine(s) **204** or server(s) **204**) via one or more networks **206**(**1**)-**206**(*n*) (generally referred to as network(s) **206**). In some embodiments, a client **202** may communicate with a server **204** via one or more appliances **208**(**1**)-**208**(*n*) (generally referred to as appliance(s) **208** or gateway(s) **208**). In some embodiments, a client **202** may have the capacity to function as both a client node seeking access to resources provided by a server **204** and as a server **204** providing access to hosted resources for other clients **202**.

(29) Although the embodiment shown in FIG. **2** shows one or more networks **206** between the clients **202** and the servers **204**, in other embodiments, the clients **202** and the servers **204** may be on the same network **206**. When multiple networks **206** are employed, the various networks **206** may be the same type of network or different types of networks. For example, in some embodiments, the networks **206**(**1**) and **206**(*n*) may be private networks such as local area network (LANs) or company Intranets, while the network **206**(**2**) may be a public network, such as a metropolitan area network (MAN), wide area network (WAN), or the Internet. In other embodiments, one or both of the network **206**(**1**) and the network **206**(*n*), as well as the network **206**(**2**), may be public networks. In yet other embodiments, all three of the network **206**(**1**), the network **206**(**2**) and the network **206**(*n*) may be private networks. The networks **206** may employ one or more types of physical networks and/or network topologies, such as wired and/or wireless networks, and may employ one or more communication transport protocols, such as transmission control protocol (TCP), internet protocol (IP), user datagram protocol (UDP) or other similar protocols. In some embodiments, the network(s) **206** may include one or more mobile telephone networks that use various protocols to communicate among mobile devices. In some embodiments, the network(s) **206** may include one or more wireless local-area networks (WLANs). For short range communications within a WLAN, clients **202** may communicate using 802.11,

BLUETOOTH protocol, and/or Near Field Communication (NFC).
(30) As shown in FIG. **2**, one or more appliances **208** may be located at various points or in various communication paths of the network environment **200**. For example, the appliance **208**(**1**) may be deployed between the network **206**(**1**) and the network **206**(**2**), and the appliance **208**(*n*) may be deployed between the network **206**(**2**) and the network **206**(*n*). In some embodiments, the appliances **208** may communicate with one another and work in conjunction to, for example, accelerate network traffic between the clients **202** and the servers **204**. In some embodiments, appliances **208** may act as a gateway between two or more networks. In other embodiments, one or more of the appliances **208** may instead be implemented in conjunction with or as part of a single one of the clients **202** or servers **204** to allow such device to connect directly to one of the networks **206**. In some embodiments, one of more appliances **208** may operate as an application delivery controller (ADC) to provide one or more of the clients **202** with access to business applications and other data deployed in a datacenter, the cloud, or delivered as Software as a Service (SaaS) across a range of client devices, and/or provide other functionality such as load balancing, etc. In some embodiments, one or more of the appliances **208** may be implemented as network devices sold by CITRIX Systems, Inc., of Fort Lauderdale, FL, such as CITRIX GATEWAY™ services or CITRIX ADC™ application delivery controller.
(31) A server **204** may be any server type such as, for example: a file server; an application server; a web server; a proxy server; an appliance; a network appliance; a gateway; an application gateway; a gateway server; a virtualization server; a deployment server; a Secure Sockets Layer Virtual Private Network (SSL VPN) server; a firewall; a web server; a server executing an active directory; a cloud server; or a server executing an application acceleration program that provides firewall functionality, application functionality, or load balancing functionality.
(32) A server **204** may execute, operate or otherwise provide an application that may be any one of the following: software; a program; executable instructions; a virtual machine; a hypervisor; a web browser; a web-based client; a client-server application; a thin-client computing client; an ACTIVEX control; a JAVA applet; software related to voice over internet protocol (VoIP) communications like a soft IP telephone; an application for streaming video and/or audio; an application for facilitating real-time-data communications; a HTTP client; a FTP client; an OSCAR client; a TELNET client; or any other set of executable instructions.
(33) In some embodiments, a server **204** may execute a remote presentation services program or other program that uses a thin-client or a remote-display protocol to capture display output generated by an application executing on a server **204** and transmit the application display output to a client device **202**.
(34) In yet other embodiments, a server **204** may execute a virtual machine providing, to a user of a client **202**, access to a computing environment. The client **202** may be a virtual machine. The virtual machine may be managed by, for example, a hypervisor, a virtual machine manager (VMM), or any other hardware virtualization technique within the server **204**.
(35) As shown in FIG. **2**, in some embodiments, groups of the servers **204** may operate as one or more server farms **210**. The servers **204** of such server farms **210** may be logically grouped, and may either be geographically co-located (e.g., on premises) or geographically dispersed (e.g., cloud based) from the clients **202** and/or other servers **204**. In some embodiments, two or more server farms **210** may communicate with one another, e.g., via respective appliances **208** connected to the network **206**(**2**), to allow multiple server-based processes to interact with one another.
(36) As also shown in FIG. **2**, in some embodiments, one or more of the appliances **208** may include, be replaced by, or be in communication with, one or more additional appliances, such as WAN optimization appliances **212**(**1**)-**212**(*n*), referred to generally as WAN optimization appliance(s) **212**. For example, WAN optimization appliances **212** may accelerate, cache, compress or otherwise optimize or improve performance, operation, flow control, or quality of service of network traffic, such as traffic to and/or from a WAN connection, such as optimizing Wide Area

File Services (WAFS), accelerating Server Message Block (SMB) or Common Internet File System (CIFS). In some embodiments, one or more of the appliances **212** may be a performance enhancing proxy or a WAN optimization controller.

(37) In some embodiments, one or more of the appliances **208**, **212** may be implemented as products sold by CITRIX Systems, Inc., of Fort Lauderdale, FL, such as CITRIX SD-WAN or CITRIX Cloud systems and services. For example, in some implementations, one or more of the appliances **208**, **212** may be cloud connectors that enable communications to be exchanged between resources within a cloud computing environment and resources outside such an environment, e.g., resources hosted within a data center of+ an organization. C. Computing Environment

(38) FIG. **3** illustrates an example of a computing system **300** that may be used to implement one or more of the respective components (e.g., the clients **202**, the servers **204**, the appliances **208**, **212**) within the network environment **200** shown in FIG. **2**. As shown in FIG. **3**, the computing system **300** may include one or more processors **302**, volatile memory **304** (e.g., RAM), non-volatile memory **306** (e.g., one or more hard disk drives (HDDs) or other magnetic or optical storage media, one or more solid state drives (SSDs) such as a flash drive or other solid state storage media, one or more hybrid magnetic and solid state drives, and/or one or more virtual storage volumes, such as a cloud storage, or a combination of such physical storage volumes and virtual storage volumes or arrays thereof), a user interface (UI) **308**, one or more communications interfaces **310**, and a communication bus **312**. The user interface **308** may include a graphical user interface (GUI) **314** (e.g., a touchscreen, a display, etc.) and one or more input/output (I/O) devices **316** (e.g., a mouse, a keyboard, etc.). The non-volatile memory **306** may store an operating system **318**, one or more applications **320**, and data **322** such that, for example, computer instructions of the operating system **318** and/or applications **320** are executed by the processor(s) **302** out of the volatile memory **304**. Data may be entered using an input device of the GUI **314** or received from I/O device(s) **316**. Various elements of the computing system **300** may communicate via communication the bus **312**. The computing system **300** as shown in FIG. **3** is shown merely as an example, as the clients **202**, servers **204** and/or appliances **208** and **212** may be implemented by any computing or processing environment and with any type of machine or set of machines that may have suitable hardware and/or software capable of operating as described herein.

(39) The processor(s) **302** may be implemented by one or more programmable processors executing one or more computer programs to perform the functions of the system. As used herein, the term “processor” describes an electronic circuit that performs a function, an operation, or a sequence of operations. The function, operation, or sequence of operations may be hard coded into the electronic circuit or soft coded by way of instructions held in a memory device. A “processor” may perform the function, operation, or sequence of operations using digital values or using analog signals. In some embodiments, the “processor” can be embodied in one or more application specific integrated circuits (ASICs), microprocessors, digital signal processors, microcontrollers, field programmable gate arrays (FPGAs), programmable logic arrays (PLAs), multi-core processors, or general-purpose computers with associated memory. The “processor” may be analog, digital or mixed-signal. In some embodiments, the “processor” may be one or more physical processors or one or more “virtual” (e.g., remotely located or “cloud”) processors.

(40) The communications interfaces **310** may include one or more interfaces to enable the computing system **300** to access a computer network such as a Local Area Network (LAN), a Wide Area Network (WAN), a Personal Area Network (PAN), or the Internet through a variety of wired and/or wireless connections, including cellular connections.

(41) As noted above, in some embodiments, one or more computing systems **300** may execute an application on behalf of a user of a client computing device (e.g., a client **202** shown in FIG. **2**), may execute a virtual machine, which provides an execution session within which applications execute on behalf of a user or a client computing device (e.g., a client **202** shown in FIG. **2**), such

as a hosted desktop session, may execute a terminal services session to provide a hosted desktop environment, or may provide access to a computing environment including one or more of. one or more applications, one or more desktop applications, and one or more desktop sessions in which one or more applications may execute. D. Systems and Methods for Delivering Shared Resources Using a Cloud Computing Environment

(42) Referring to FIG. **4**, a cloud computing environment **400** is depicted, which may also be referred to as a cloud environment, cloud computing or cloud network. The cloud computing environment **400** can provide the delivery of shared computing services and/or resources to multiple users or tenants. For example, the shared resources and services can include, but are not limited to, networks, network bandwidth, servers, processing, memory, storage, applications, virtual machines, databases, software, hardware, analytics, and intelligence.

(43) In the cloud computing environment **400**, one or more clients **202** (such as those described in connection with FIG. **2**) are in communication with a cloud network **404**. The cloud network **404** may include back-end platforms, e.g., servers, storage, server farms and/or data centers. The clients **202** may correspond to a single organization/tenant or multiple organizations/tenants. More particularly, in one example implementation, the cloud computing environment **400** may provide a private cloud serving a single organization (e.g., enterprise cloud). In another example, the cloud computing environment **400** may provide a community or public cloud serving multiple organizations/tenants.

(44) In some embodiments, a gateway appliance(s) or service may be utilized to provide access to cloud computing resources and virtual sessions. By way of example, CITRIX Gateway, provided by CITRIX Systems, Inc., may be deployed on-premises or on public clouds to provide users with secure access and single sign-on to virtual, SaaS and web applications. Furthermore, to protect users from web threats, a gateway such as CITRIX Secure Web Gateway may be used. CITRIX Secure Web Gateway uses a cloud-based service and a local cache to check for URL reputation and category.

(45) In still further embodiments, the cloud computing environment **400** may provide a hybrid cloud that is a combination of a public cloud and one or more resources located outside such a cloud, such as resources hosted within one or more data centers of an organization. Public clouds may include public servers that are maintained by third parties to the clients **202** or the enterprise/tenant. The servers may be located off-site in remote geographical locations or otherwise. In some implementations, one or more cloud connectors may be used to facilitate the exchange of communications between one more resources within the cloud computing environment **400** and one or more resources outside of such an environment.

(46) The cloud computing environment **400** can provide resource pooling to serve multiple users via clients **202** through a multi-tenant environment or multi-tenant model with different physical and virtual resources dynamically assigned and reassigned responsive to different demands within the respective environment. The multi-tenant environment can include a system or architecture that can provide a single instance of software, an application or a software application to serve multiple users. In some embodiments, the cloud computing environment **400** can provide on-demand self-service to unilaterally provision computing capabilities (e.g., server time, network storage) across a network for multiple clients **202**. By way of example, provisioning services may be provided through a system such as CITRIX Provisioning Services (CITRIX PVS). CITRIX PVS is a software-streaming technology that delivers patches, updates, and other configuration information to multiple virtual desktop endpoints through a shared desktop image. The cloud computing environment **400** can provide an elasticity to dynamically scale out or scale in response to different demands from one or more clients **202**. In some embodiments, the cloud computing environment **400** may include or provide monitoring services to monitor, control and/or generate reports corresponding to the provided shared services and resources.

(47) In some embodiments, the cloud computing environment **400** may provide cloud-based

delivery of different types of cloud computing services, such as Software as a service (SaaS) **402**, Platform as a Service (PaaS) **404**, Infrastructure as a Service (laaS) **406**, and Desktop as a Service (DaaS) **408**, for example. laaS may refer to a user renting the use of infrastructure resources that are needed during a specified time period. laaS providers may offer storage, networking, servers or virtualization resources from large pools, allowing the users to quickly scale up by accessing more resources as needed. Examples of laaS platforms include AMAZON WEB SERVICES provided by AMAZON.COM, Inc., of Seattle, Washington, AZURE laaS services provided by MICROSOFT Corporation or Redmond, Washington, RACKSPACE CLOUD systems and services provided by RACKSPACE US, Inc., of San Antonio, Texas, GOOGLE Compute Engine provided by GOOGLE Inc. of Mountain View, California, and RIGHTSCALE systems and services provided by RIGHTSCALE, Inc., of Santa Barbara, California.

(48) PaaS providers may offer functionality provided by laaS, including, e.g., storage, networking, servers or virtualization, as well as additional resources such as, e.g., the operating system, middleware, or runtime resources. Examples of PaaS include WINDOWS AZURE services provided by MICROSOFT Corporation of Redmond, Washington, GOOGLE App Engine provided by GOOGLE Inc., and HEROKU provided by Heroku, Inc. of San Francisco, California.

(49) SaaS providers may offer the resources that PaaS provides, including storage, networking, servers, virtualization, operating system, middleware, or runtime resources. In some embodiments, SaaS providers may offer additional resources including, e.g., data and application resources. Examples of SaaS include GOOGLE APPS provided by GOOGLE Inc., SALESFORCE systems and services provided by SALESFORCE.COM Inc. of San Francisco, California, or OFFICE 365 provided by MICROSOFT Corporation. Examples of SaaS may also include data storage providers, e.g. CITRIX ShareFile 8′ from CITRIX Systems, DROPBOX provided by Dropbox, Inc. of San Francisco, California, MICROSOFT SKYDRIVE provided by MICROSOFT Corporation, GOOGLE Drive provided by GOOGLE Inc., or APPLE ICLOUD services provided by APPLE Inc. of Cupertino, California.

(50) Similar to SaaS, DaaS (which is also known as hosted desktop services) is a form of virtual desktop infrastructure (VDI) in which virtual desktop sessions are typically delivered as a cloud service along with the apps used on the virtual desktop. CITRIX Cloud from CITRIX Systems is one example of a DaaS delivery platform. DaaS delivery platforms may be hosted on a public cloud computing infrastructure, such as AZURE CLOUD services from MICROSOFT Corporation of Redmond, Washington, or AMAZON WEB SERVICES provided by AMAZON.COM, Inc., of Seattle, Washington, for example. In the case of CITRIX Cloud, CITRIXCITRIX WORKSPACE app may be used as a single-entry point for bringing apps, files and desktops together (whether on-premises or in the cloud) to deliver a unified experience. E. Systems and Methods for Managing and Streamlining Access by Client Devices to a Variety of Resources.

(51) FIG. **5**A is a block diagram of an example multi-resource access system **500** in which one or more resource management services **502** may manage and streamline access by one or more clients **202** to one or more resource feeds **504** (via one or more gateway services **506**) and/or one or more software-as-a-service (SaaS) applications **508**. In particular, the resource management service(s) **502** may employ an identity provider **510** to authenticate the identity of a user of a client **202** and, following authentication, identify one or more resources the user is authorized to access. In response to the user selecting one of the identified resources, the resource management service(s) **502** may send appropriate access credentials to the requesting client **202**, and the client **202** may then use those credentials to access the selected resource. For the resource feed(s) **504**, the client **202** may use the supplied credentials to access the selected resource via a gateway service **506**. For the SaaS application(s) **508**, the client **202** may use the credentials to access the selected application directly.

(52) The client(s) **202** may be any type of computing devices capable of accessing the resource feed(s) **504** and/or the SaaS application(s) **508**, and may, for example, include a variety of desktop

or laptop computers, smartphones, tablets, etc. The resource feed(s) **504** may include any of numerous resource types and may be provided from any of numerous locations. In some embodiments, for example, the resource feed(s) **504** may include one or more systems or services for providing virtual applications and/or desktops to the client(s) **202**, one or more file repositories and/or file sharing systems, one or more secure browser services, one or more access control services for the SaaS applications **508**, one or more management services for local applications on the client(s) **202**, one or more internet enabled devices or sensors, etc. The resource management service(s) **502**, the resource feed(s) **504**, the gateway service(s) **506**, the SaaS application(s) **508**, and the identity provider **510** may be located within an on-premises data center of an organization for which the multi-resource access system **500** is deployed, within one or more cloud computing environments, or elsewhere.

(53) FIG. **5**B is a block diagram showing an example implementation of the multi-resource access system **500** shown in FIG. **5**A in which various resource management services **502** as well as a gateway service **506** are located within a cloud computing environment **512**. The cloud computing environment may, for example, include MICROSOFT AZURE Cloud services, AMAZON WEB SERVICES, GOOGLE Cloud service, or IBM Cloud services. It should be appreciated, however, that in other implementations, one or more (or all) of the components of the resource management services **502** and/or the gateway service **506** may alternatively be located outside the cloud computing environment **512**, such as within a data center hosted by an organization.

(54) For any of the illustrated components (other than the client **202**) that are not based within the cloud computing environment **512**, cloud connectors (not shown in FIG. **5**B) may be used to interface those components with the cloud computing environment **512**. Such cloud connectors may, for example, run on Windows Server instances and/or Linux Server instances hosted in resource locations and may create a reverse proxy to route traffic between those resource locations and the cloud computing environment **512**. In the illustrated example, the cloud-based resource management services **502** include a client interface service **514**, an identity service **516**, a resource feed service **518**, and a single sign-on service **520**. As shown, in some embodiments, the client **202** may use a resource access application **522** to communicate with the client interface service **514** as well as to present a user interface on the client **202** that a user **524** can operate to access the resource feed(s) **504** and/or the SaaS application(s) **508**. The resource access application **522** may either be installed on the client **202**, or may be executed by the client interface service **514** (or elsewhere in the multi-resource access system **500**) and accessed using a web browser (not shown in FIG. **5**B) on the client **202**.

(55) As explained in more detail below, in some embodiments, the resource access application **522** and associated components may provide the user **524** with a personalized, all-in-one interface enabling instant and seamless access to all the user's SaaS and web applications, files, virtual Windows applications, virtual Linux applications, desktops, mobile applications, CITRIX Virtual Apps and Desktops™, local applications, and other data.

(56) When the resource access application **522** is launched or otherwise accessed by the user **524**, the client interface service **514** may send a sign-on request to the identity service **516**. In some embodiments, the identity provider **510** may be located on the premises of the organization for which the multi-resource access system **500** is deployed. The identity provider **510** may, for example, correspond to an on-premises Windows Active Directory. In such embodiments, the identity provider **510** may be connected to the cloud-based identity service **516** using a cloud connector (not shown in FIG. **5**B), as described above. Upon receiving a sign-on request, the identity service **516** may cause the resource access application **522** (via the client interface service **514**) to prompt the user **524** for the user's authentication credentials (e.g., username and password). Upon receiving the user's authentication credentials, the client interface service **514** may pass the credentials along to the identity service **516**, and the identity service **516** may, in turn, forward them to the identity provider **510** for authentication, for example, by comparing them against an

Active Directory domain. Once the identity service **516** receives confirmation from the identity provider **510** that the user's identity has been properly authenticated, the client interface service **514** may send a request to the resource feed service **518** for a list of subscribed resources for the user **524**.
(57) In other embodiments (not illustrated in FIG. 5B), the identity provider **510** may be a cloud-based identity service, such as a MICROSOFT AZURE Active Directory. In such embodiments, upon receiving a sign-on request from the client interface service **514**, the identity service **516** may, via the client interface service **514**, cause the client **202** to be redirected to the cloud-based identity service to complete an authentication process. The cloud-based identity service may then cause the client **202** to prompt the user **524** to enter the user's authentication credentials. Upon determining the user's identity has been properly authenticated, the cloud-based identity service may send a message to the resource access application **522** indicating the authentication attempt was successful, and the resource access application **522** may then inform the client interface service **514** of the successfully authentication. Once the identity service **516** receives confirmation from the client interface service **514** that the user's identity has been properly authenticated, the client interface service **514** may send a request to the resource feed service **518** for a list of subscribed resources for the user **524**.
(58) The resource feed service **518** may request identity tokens for configured resources from the single sign-on service **520**. The resource feed service **518** may then pass the feed-specific identity tokens it receives to the points of authentication for the respective resource feeds **504**. The resource feeds **504** may then respond with lists of resources configured for the respective identities. The resource feed service **518** may then aggregate all items from the different feeds and forward them to the client interface service **514**, which may cause the resource access application **522** to present a list of available resources on a user interface of the client **202**. The list of available resources may, for example, be presented on the user interface of the client **202** as a set of selectable icons or other elements corresponding to accessible resources. The resources so identified may, for example, include one or more virtual applications and/or desktops (e.g., CITRIX Virtual Apps and Desktops™, VMware Horizon, MICROSOFT RDS, etc.), one or more file repositories and/or file sharing systems (e.g., ShareFile 8′, one or more secure browsers, one or more internet enabled devices or sensors, one or more local applications installed on the client **202**, and/or one or more SaaS applications **508** to which the user **524** has subscribed. The lists of local applications and the SaaS applications **508** may, for example, be supplied by resource feeds **504** for respective services that manage which such applications are to be made available to the user **524** via the resource access application **522**. Examples of SaaS applications **508** that may be managed and accessed as described herein include MICROSOFT Office **365** applications, SAP SaaS applications, Workday applications, etc.
(59) For resources other than local applications and the SaaS application(s) **508**, upon the user **524** selecting one of the listed available resources, the resource access application **522** may cause the client interface service **514** to forward a request for the specified resource to the resource feed service **518**. In response to receiving such a request, the resource feed service **518** may request an identity token for the corresponding feed from the single sign-on service **520**.
(60) The resource feed service **518** may then pass the identity token received from the single sign-on service **520** to the client interface service **514** where a launch ticket for the resource may be generated and sent to the resource access application **522**. Upon receiving the launch ticket, the resource access application **522** may initiate a secure session to the gateway service **506** and present the launch ticket. When the gateway service **506** is presented with the launch ticket, it may initiate a secure session to the appropriate resource feed and present the identity token to that feed to seamlessly authenticate the user **524**. Once the session initializes, the client **202** may proceed to access the selected resource.
(61) When the user **524** selects a local application, the resource access application **522** may cause

the selected local application to launch on the client **202**. When the user **524** selects a SaaS application **508**, the resource access application **522** may cause the client interface service **514** to request a one-time uniform resource locator (URL) from the gateway service **506** as well a preferred browser for use in accessing the SaaS application **508**. After the gateway service **506** returns the one-time URL and identifies the preferred browser, the client interface service **514** may pass that information along to the resource access application **522**. The client **202** may then launch the identified browser and initiate a connection to the gateway service **506**. The gateway service **506** may then request an assertion from the single sign-on service **520**. Upon receiving the assertion, the gateway service **506** may cause the identified browser on the client **202** to be redirected to the logon page for identified SaaS application **508** and present the assertion. The SaaS may then contact the gateway service **506** to validate the assertion and authenticate the user **524**. Once the user has been authenticated, communication may occur directly between the identified browser and the selected SaaS application **508**, thus allowing the user **524** to use the client **202** to access the selected SaaS application **508**.

(62) In some embodiments, the preferred browser identified by the gateway service **506** may be a specialized browser embedded in the resource access application **522** (when the resource access application **522** is installed on the client **202**) or provided by one of the resource feeds **504** (when the resource access application **522** is located remotely), e.g., via a secure browser service. In such embodiments, the SaaS applications **508** may incorporate enhanced security policies to enforce one or more restrictions on the embedded browser. Examples of such policies include (1) requiring use of the specialized browser and disabling use of other local browsers, (2) restricting clipboard access, e.g., by disabling cut/copy/paste operations between the application and the clipboard, (3) restricting printing, e.g., by disabling the ability to print from within the browser, (3) restricting navigation, e.g., by disabling the next and/or back browser buttons, (4) restricting downloads, e.g., by disabling the ability to download from within the SaaS application, and (5) displaying watermarks, e.g., by overlaying a screen-based watermark showing the username and IP address associated with the client **202** such that the watermark will appear as displayed on the screen if the user tries to print or take a screenshot. Further, in some embodiments, when a user selects a hyperlink within a SaaS application, the specialized browser may send the URL for the link to an access control service (e.g., implemented as one of the resource feed(s) **504**) for assessment of its security risk by a web filtering service. For approved URLs, the specialized browser may be permitted to access the link. For suspicious links, however, the web filtering service may have the client interface service **514** send the link to a secure browser service, which may start a new virtual browser session with the client **202**, and thus allow the user to access the potentially harmful linked content in a safe environment.

(63) In some embodiments, in addition to or in lieu of providing the user **524** with a list of resources that are available to be accessed individually, as described above, the user **524** may instead be permitted to choose to access a streamlined feed of event notifications and/or available actions that may be taken with respect to events that are automatically detected with respect to one or more of the resources. This streamlined resource activity feed, which may be customized for individual users, may allow users to monitor important activity involving all of their resources-SaaS applications, web applications, Windows applications, Linux applications, desktops, file repositories and/or file sharing systems, and other data through a single interface, without needing to switch context from one resource to another. Further, event notifications in a resource activity feed may be accompanied by a discrete set of user interface elements, e.g., “approve,” “deny,” and “see more detail” buttons, allowing a user to take one or more simple actions with respect to events right within the user's feed. In some embodiments, such a streamlined, intelligent resource activity feed may be enabled by one or more micro-applications, or “microapps,” that can interface with underlying associated resources using APIs or the like. The responsive actions may be user-initiated activities that are taken within the microapps and that provide inputs to the underlying

applications through the API or other interface. The actions a user performs within the microapp may, for example, be designed to address specific common problems and use cases quickly and easily, adding to increased user productivity (e.g., request personal time off, submit a help desk ticket, etc.). In some embodiments, notifications from such event-driven microapps may additionally or alternatively be pushed to clients **202** to notify a user **524** of something that requires the user's attention (e.g., approval of an expense report, new course available for registration, etc.).

(64) FIG. **5**C is a block diagram similar to that shown in FIG. **5**B but in which the available resources (e.g., SaaS applications, web applications, Windows applications, Linux applications, desktops, file repositories and/or file sharing systems, and other data) are represented by a single box **526** labeled "systems of record," and further in which several different services are included within the resource management services block **502**. As explained below, the services shown in FIG. **5**C may enable the provision of a streamlined resource activity feed and/or notification process for a client **202**. In the example shown, in addition to the client interface service **514** discussed above, the illustrated services include a microapp service **528**, a data integration provider service **530**, a credential wallet service **532**, an active data cache service **534**, an analytics service **536**, and a notification service **538**. In various embodiments, the services shown in FIG. **5**C may be employed either in addition to or instead of the different services shown in FIG. **5**B. Further, as noted above in connection with FIG. **5**B, it should be appreciated that, in other implementations, one or more (or all) of the components of the resource management services **502** shown in FIG. **5**C may alternatively be located outside the cloud computing environment **512**, such as within a data center hosted by an organization.

(65) In some embodiments, a microapp may be a single use case made available to users to streamline functionality from complex enterprise applications. Microapps may, for example, utilize APIs available within SaaS, web, or home-grown applications allowing users to see content without needing a full launch of the application or the need to switch context. Absent such microapps, users would need to launch an application, navigate to the action they need to perform, and then perform the action. Microapps may streamline routine tasks for frequently performed actions and provide users the ability to perform actions within the resource access application **522** without having to launch the native application. The system shown in FIG. **5**C may, for example, aggregate relevant notifications, tasks, and insights, and thereby give the user **524** a dynamic productivity tool. In some embodiments, the resource activity feed may be intelligently populated by utilizing machine learning and artificial intelligence (AI) algorithms. Further, in some implementations, microapps may be configured within the cloud computing environment **512**, thus giving administrators a powerful tool to create more productive workflows, without the need for additional infrastructure. Whether pushed to a user or initiated by a user, microapps may provide short cuts that simplify and streamline key tasks that would otherwise require opening full enterprise applications. In some embodiments, out-of-the-box templates may allow administrators with API account permissions to build microapp solutions targeted for their needs. Administrators may also, in some embodiments, be provided with the tools they need to build custom microapps.

(66) Referring to FIG. **5**C, the systems of record **526** may represent the applications and/or other resources the resource management services **502** may interact with to create microapps. These resources may be SaaS applications, legacy applications, or homegrown applications, and can be hosted on-premises or within a cloud computing environment. Connectors with out-of-the-box templates for several applications may be provided and integration with other applications may additionally or alternatively be configured through a microapp page builder. Such a microapp page builder may, for example, connect to legacy, on-premises, and SaaS systems by creating streamlined user workflows via microapp actions. The resource management services **502**, and in particular the data integration provider service **530**, may, for example, support REST API, JSON, OData-JSON, and XML. As explained in more detail below, the data integration provider service **530** may also write back to the systems of record, for example, using OAuth2 or a service account.

(67) In some embodiments, the microapp service **528** may be a single-tenant service responsible for creating the microapps. The microapp service **528** may send raw events, pulled from the systems of record **526**, to the analytics service **536** for processing. The microapp service may, for example, periodically pull active data from the systems of record **526**.
(68) In some embodiments, the active data cache service **534** may be single-tenant and may store all configuration information and microapp data. It may, for example, utilize a per-tenant database encryption key and per-tenant database credentials.
(69) In some embodiments, the credential wallet service **532** may store encrypted service credentials for the systems of record **526** and user OAuth2 tokens.
(70) In some embodiments, the data integration provider service **530** may interact with the systems of record **526** to decrypt end-user credentials and write back actions to the systems of record **526** under the identity of the end-user. The write-back actions may, for example, utilize a user's actual account to ensure all actions performed are compliant with data policies of the application or other resource being interacted with.
(71) In some embodiments, the analytics service **536** may process the raw events received from the microapp service **528** to create targeted scored notifications and send such notifications to the notification service **538**.
(72) Finally, in some embodiments, the notification service **538** may process any notifications it receives from the analytics service **536**. In some implementations, the notification service **538** may store the notifications in a database to be later served in an activity feed. In other embodiments, the notification service **538** may additionally or alternatively send the notifications out immediately to the client **202** as a push notification to the user **524**.
(73) In some embodiments, a process for synchronizing with the systems of record **526** and generating notifications may operate as follows. The microapp service **528** may retrieve encrypted service account credentials for the systems of record **526** from the credential wallet service **532** and request a sync with the data integration provider service **530**. The data integration provider service **530** may then decrypt the service account credentials and use those credentials to retrieve data from the systems of record **526**. The data integration provider service **530** may then stream the retrieved data to the microapp service **528**. The microapp service **528** may store the received systems of record data in the active data cache service **534** and also send raw events to the analytics service **536**. The analytics service **536** may create targeted scored notifications and send such notifications to the notification service **538**. The notification service **538** may store the notifications in a database to be later served in an activity feed and/or may send the notifications out immediately to the client **202** as a push notification to the user **524**.
(74) In some embodiments, a process for processing a user-initiated action via a microapp may operate as follows. The client **202** may receive data from the microapp service **528** (via the client interface service **514**) to render information corresponding to the microapp. The microapp service **528** may receive data from the active data cache service **534** to support that rendering. The user **524** may invoke an action from the microapp, causing the resource access application **522** to send an action request to the microapp service **528** (via the client interface service **514**). The microapp service **528** may then retrieve from the credential wallet service **532** an encrypted Oauth2 token for the system of record for which the action is to be invoked, and may send the action to the data integration provider service **530** together with the encrypted OAuth2 token. The data integration provider service **530** may then decrypt the OAuth2 token and write the action to the appropriate system of record under the identity of the user **524**. The data integration provider service **530** may then read back changed data from the written-to system of record and send that changed data to the microapp service **528**. The microapp service **528** may then update the active data cache service **534** with the updated data and cause a message to be sent to the resource access application **522** (via the client interface service **514**) notifying the user **524** that the action was successfully completed.
(75) In some embodiments, in addition to or in lieu of the functionality described above, the

resource management services **502** may provide users the ability to search for relevant information across all files and applications. A simple keyword search may, for example, be used to find application resources, SaaS applications, desktops, files, etc. This functionality may enhance user productivity and efficiency as application and data sprawl is prevalent across all organizations.

(76) In other embodiments, in addition to or in lieu of the functionality described above, the resource management services **502** may enable virtual assistance functionality that allows users to remain productive and take quick actions. Users may, for example, interact with the "Virtual Assistant" and ask questions such as "What is Bob Smith's phone number?" or "What absences are pending my approval?" The resource management services **502** may, for example, parse these requests and respond because they are integrated with multiple systems on the back-end. In some embodiments, users may be able to interact with the virtual assistant through either the resource access application **522** or directly from another resource, such as MICROSOFT Teams. This feature may allow employees to work efficiently, stay organized, and deliver only the specific information they're looking for.

(77) FIG. **5**D shows how a display screen **540** presented by a resource access application **522** (shown in FIG. **5**C) may appear when an intelligent activity feed feature is employed and a user is logged on to the system. Such a screen may be provided, for example, when the user clicks on or otherwise selects a "home" user interface element **542**. As shown, an activity feed **544** may be presented on the screen **540** that includes a plurality of notifications **546** about respective events that occurred within various applications to which the user has access rights. An example implementation of a system capable of providing an activity feed **544** like that shown is described above in connection with FIG. **5**C. As explained above, a user's authentication credentials may be used to gain access to various systems of record (e.g., SalesForce, Ariba, Concur, Rightsignature, etc.) with which the user has accounts, and events that occur within such systems of record may be evaluated to generate notifications **546** to the user concerning actions that the user can take relating to such events. As shown in FIG. **5**D, in some implementations, the notifications **546** may include a title **560** and a body **562**, and may also include a logo **564** and/or a name **566** of the system of record to which the notification **546** corresponds, thus helping the user understand the proper context with which to decide how best to respond to the notification **546**. In some implementations, one or more filters may be used to control the types, date ranges, etc., of the notifications **546** that are presented in the activity feed **544**. The filters that can be used for this purpose may be revealed, for example, by clicking on or otherwise selecting the "show filters" user interface element **568**. Further, in some embodiments, a user interface element **570** may additionally or alternatively be employed to select a manner in which the notifications **546** are sorted within the activity feed. In some implementations, for example, the notifications **546** may be sorted in accordance with the "date and time" they were created (as shown for the element **570** in FIG. **5**D), a "relevancy" mode (not illustrated) may be selected (e g., using the element **570**) in which the notifications may be sorted based on relevancy scores assigned to them by the analytics service **536**, and/or an "application" mode (not illustrated) may be selected (e.g., using the element **570**) in which the notifications **546** may be sorted by application type.

(78) When presented with such an activity feed **544**, the user may respond to the notifications **546** by clicking on or otherwise selecting a corresponding action element **548** (e.g., "Approve," "Reject," "Open," "Like," "Submit," etc.), or else by dismissing the notification, e.g., by clicking on or otherwise selecting a "close" element **550**. As explained in connection with FIG. **5**C below, the notifications **546** and corresponding action elements **548** may be implemented, for example, using "microapps" that can read and/or write data to systems of record using application programming interface (API) functions or the like, rather than by performing full launches of the applications for such systems of record. In some implementations, a user may additionally or alternatively view additional details concerning the event that triggered the notification and/or may access additional functionality enabled by the microapp corresponding to the notification **546** (e.g.,

in a separate, pop-up window corresponding to the microapp) by clicking on or otherwise selecting a portion of the notification **546** other than one of the user interface elements **548**, **550**. In some embodiments, the user may additionally or alternatively be able to select a user interface element either within the notification **546** or within a separate window corresponding to the microapp that allows the user to launch the native application to which the notification relates and respond to the event that prompted the notification via that native application rather than via the microapp.

(79) In addition to the event-driven actions accessible via the action elements **548** in the notifications **546**, a user may alternatively initiate microapp actions by selecting a desired action, e.g., via a drop-down menu accessible using the “action” user interface element **552** or by selecting a desired action from a list **554** of available microapp actions. In some implementations, the various microapp actions available to the user **524** logged onto the multi-resource access system **500** may be enumerated to the resource access application **522**, e.g., when the user **524** initially accesses the system **500**, and the list **554** may include a subset of those available microapp actions. The available microapp actions may, for example, be organized alphabetically based on the names assigned to the actions, and the list **554** may simply include the first several (e.g., the first four) microapp actions in the alphabetical order. In other implementations, the list **554** may alternatively include a subset of the available microapp actions that were most recently or most commonly accessed by the user **524**, or that are preassigned by a system administrator or based on some other criteria. The user **524** may also access a complete set of available microapp actions, in a similar manner as the “action” user interface element **552**, by clicking on the “view all actions” user interface element **574**.

(80) As shown, additional resources may also be accessed through the screen **540** by clicking on or otherwise selecting one or more other user interface elements that may be presented on the screen. For example, in some embodiments, the user may also access files (e.g., via a CITRIX ShareFile 8′ platform) by selecting a desired file, e.g., via a drop-down menu accessible using the “files” user interface element **556** or by selecting a desired file from a list **558** of recently and/or commonly used files. Further, in some embodiments, one or more applications may additionally or alternatively be accessible (e.g., via a CITRIX Virtual Apps and Desktops™ service) by clicking on or otherwise selecting an “apps” user interface element **572** to reveal a list of accessible applications or by selecting a desired application from a list (not shown in FIG. **5**D but similar to the list **558**) of recently and/or commonly used applications. And still further, in some implementations, one or more desktops may additionally or alternatively be accessed (e.g., via a CITRIX Virtual Apps and Desktops™ service) by clicking on or otherwise selecting a “desktops” user interface element **574** to reveal a list of accessible desktops or by or by selecting a desired desktop from a list (not shown in FIG. **5**D but similar to the list **558**) of recently and/or commonly used desktops.

(81) The activity feed shown in FIG. **5**D provides significant benefits, as it allows a user to respond to application-specific events generated by disparate systems of record without needing to navigate to, launch, and interface with multiple different native applications. F. Detailed Description of Example Embodiments of the System for Facilitating Access to API Integrations Introduced in Section A.

(82) FIG. **6** is a block diagram of an example system in which an API integration provider service **130** hosts API integrations for providing a client **202** with access to particular functionalities or data of systems of record **526**. As shown, a client **202** (which may or may not be operated by a user **524**) may access the API integration provider service **130**. The API integration provider service **130** may provide the client **202** with seamless access to various functionalities or data of one or more systems of record **526***a*, **526***b*, and/or **526***c* (collectively “systems of record **526**”). The client **202** may execute one or more applications and/or other services that may communicate with the integration API EPs **115** (shown in FIG. **1**A) provided by the API integration provider service **130**. As illustrated, examples of such applications/services may include a resource access application

522 (e.g., as shown in FIG. 5B), a search service **624**, and one or more additional content services **626***a*, **626***b*, and/or **626***c* (collectively "content services **626**").
(83) An application and/or service may send one or more general API calls **104** to the API integration provider service **130** (e.g., to an integration API EP **115**). For example, and without limitation, the resource access application **522** and/or the search service **624** may send general API calls **104** representing search queries **606** and/or **608**, and/or one of the content services **626** may send an API call **610** for a different purpose, etc. The API integration provider service **130** may receive such API call(s) and, based on an indication therein, determine an API integration **120** to invoke to, among other things, send one or more requests (e.g., to SOR API EP(s) **125**) to the appropriate system of record **526**. The API integration provider service **130** may include a script service **660** that may execute one or more scripts or other executable code to carry out an API integration process. The script service **660** may retrieve a script corresponding to the API integration **120** from a script storage **665**. The script service **660** may execute the script to generate and send one or more HTTP calls, such as a request **616**, to the system of record **526** (e.g., to one or more SOR API EP(s) **125** of the system of record **526**).
(84) In some implementations, such a request **616** may not include a credential (or other authorization) corresponding to the client **202** (and/or the user **524**). Thus, the request **616** may not include a personal authorization for accessing the system of record **526**, but rather may include credentials for an administrator account of the organization or other custodian of the API integration provider service **130**. This may, however, result in losing accountability over the request such that the system of record **526** may be unable to provide a response that is based on a user or client's profile information. To provide such accountability, the system **100** may use an HTTP proxy service **680** to add user- and/or client-specific credentials to the HTTP request. In some implementations, for example, the HTTP proxy service **680** may retrieve user/client credentials from a credential storage **690**. In some implementations, the credential storage **690** may be, for example, the wallet service **532** or similar service. The HTTP proxy service **680** may forward the request **618**, now authenticated, to the system of record **526**.
(85) The systems of record **526** may handle different types of API calls. For example, a first system of record **526***a* may process on-demand API calls in which a single response is returned directly in response to the request **618**. A second system of record **526***b* may process subscription API calls in which one or multiple responses are returned at some time following the request **618** and upon some other trigger. For example, the user **524** may subscribe to notifications for an event or type of event. In some implementations, a same system of record **526** may process both on-demand and subscription API calls.
(86) In the case of an on-demand API call (e.g., a search query **606** or **608**), the system of record **526** may return a response **636**, which the HTTP proxy service **680** may forward to the API integration provider service **130** as a response **638**. The API integration provider service **130** may return a response **640** to the on-demand API call from the client device **202**.
(87) In the case of a subscription API call, the system of record **526** may return a response **646** that may bypass the HTTP proxy service **680** en route to the API integration provider service **130**. The API integration provider service **130** may return the subscription response **648** to the client **202**. The system of record **526** may continue to send responses following individual triggers/events until and/or unless the subscription is canceled (e.g., by the user **524**).
(88) FIG. **7** shows a sequence diagram illustrating messages that may be exchanged amongst various components of the system **100** to enable certain aspects of the functionality disclosed herein. Section A introduced systems for facilitating access to API integrations **120** hosted by an integration provider service **130**. As explained in Section A, an API integration provider service **130** may host API integrations **120** corresponding to various systems of record **526**. The API integration provider service **130** may provide one or more integration API EPs **115** to which clients **202** may send general API requests **104**. Clients **202** may access the integration API EPs **115** to

invoke one or more processes of the API integration(s) **120** provided by the API integration provider service **130**. In accordance with such process(es), the API integration **120** may make one or more system of record-specific API calls **105**, **106** to one or more systems of record **526** (e.g., to one or more SOR API EP(s) **125**) on behalf of the client **202**. The sequence diagram shown in FIG. **7** illustrates messages that may be exchanged among the client **202**, the API integration provider service **130**, the API registry **670**, the HTTP proxy service **680**, and a system of record **526**, to enable certain aspects of the functionality described in Section A.

(89) As shown in FIG. **7**, a client may send (**702**) a request for a list of integration API EPs **115** made available by the API integration provider service **130** for performing a certain type of operation related to resources accessible by the API integration provider service **130** (e.g., search, recent, browse, compare, etc.). The system **100** may maintain a list of API integrations and/or integration API EPs **115** in the API registry **670**. The API integration provider service **130** may query (**704**) the API registry **670** for a list of API integrations **120** and/or integration API EPs **115** corresponding to the type of operation indicated in the request. The API registry **670** may return (**706**) a list of API integrations **120** and/or integration API EPs **115** associated with that type of operation. The API integration provider service **130** may return (**708**) the list of API integrations **120** and/or integration API EPs to the client **202**. In some implementations, the client **202** may additionally or alternatively query the API registry **670** directly.

(90) The client **202** (in response to user input or otherwise) may select one or more integration API EPs **115** to call to perform a certain type of operation. The client **202** may send (**710**) one or more requests to perform the operation to the API integration provider service **130**. The API integration provider service **130** may, based on the request(s), determine one or more API integrations **120** indicated in the request(s). The API integration provider service **130** may retrieve (**712**) a script or other executable code (e.g., from the script storage **665**). The script service **660** may invoke (**714**) a process for handing the client's API call by executing the retrieved script. The script may generate one or more requests to be sent to the SOR API EP **125**. The API integration provider service **130** may send (**716**) such request(s) to the system of record **526** indicated in the API integration **120**.

(91) In some implementations, the API integration provider service **130** may send the request(s) via an HTTP proxy service **680**. The HTTP proxy service **680** may authenticate the request(s) such that the system of record **526** can process the request(s) on behalf of a particular user (e.g., the user **524**, rather than on behalf of an administrator account). The HTTP proxy service **680** may receive the request(s) and retrieve (**718**) credentials associated with a user indicated in the request(s). The HTTP proxy service **680** may retrieve the credentials from, for example, the credential storage **690**. The HTTP proxy service **680** may generate the authenticated request(s) using the credentials, and send (**720**) the authenticated request(s) to the system of record **526**.

(92) The system of record **526** may receive and process (**722**) the request(s) to generate one or more results to be returned to the API integration provider service **130**. The system of record **526** may process different types of API calls such as on-demand API calls and subscription API calls. An on-demand API call may result in a direct response; for example, the system of record **526** may process the API call, generate a response, and provide the response without delay. Such an on-demand API call may be a search query, changing a setting related to an application, retrieving a document, etc. In the case of an on-demand API call (**721**), the system of record **526** may process (**722**) the request(s), return (**724**) the response(s) via (**726**) the HTTP proxy service **680** to the API integration provider service **130**, which may return (**728**) a response to the requesting client **202**.

(93) A subscription API call may result in one or more future responses; for example, the system of record **526** may send notifications upon the occurrence of a triggering event, such as when a file or file folder is created, modified, and/or accessed. In the case of subscription API call (**731**), the system of record **526** may store data related to the request and, upon detection (**732**) of a subscription event, generate (**734**) a notification. The system of record **526** may send (**736**) the notification (e.g., bypassing the HTTP proxy service **680**) to the API integration provider service

130, which may send (**738**) the notification to the requesting client **202**. G. Example Implementations of Methods, Systems, and Computer-Readable Media in Accordance with the present disclosure.

(94) The following paragraphs (M1) through (M12) describe examples of methods that may be implemented in accordance with the present disclosure. (M1) A method may be performed that involves receiving, by a computing system from a first device, a request to identify application programming interface (API) endpoints that are configured to perform a search operation; determining, by the computing system, that first and second API endpoints of the computing system are both configured to perform search operation operations; sending, from the computing system to the first device and based at least in part on the first and second API endpoints both being configured to perform search operations, indications of the first API endpoint and the second API endpoint; receiving, at the first API endpoint and from the first device, a first API call requesting performance of a first search operation; executing, by the computing system and based on the first API call, a first script to send at least a second API call to a third API endpoint of a first system of record, the second API call representing a request to perform the first search operation; receiving, by the computing system and from the first system of record, first search results in response to the second API call; generating, by the computing system and based at least in part on the first search results, a first response to the first API call, the first response representing the first search results; sending, from the computing system to the first device, the first response; receiving, at the second API endpoint and from the first device, a third API call requesting performance of a second search operation; executing, by the computing system and based on the third API call, a second script to generate at least a fourth API call to a fourth API endpoint of a second system of record, the fourth API call representing a request to perform the second search operation; receiving, by the computing system and from the second system of record, second search results in response to the fourth API call; generating, by the computing system and based at least in part on the second search results, a second response to the third API call, the second response representing the second search results; and sending, from the computing system to the first device, the second response. (M2) A method may be performed that involves receiving, at a first application programming interface (API) endpoint of a computing system, a first API call requesting performance of a first type of operation; invoking, by the computing system and based on the first API call, a first process to send at least a second API call to a second API endpoint of a first system of record; receiving, by the computing system and from the first system of record, a first response to the second API call; and sending, from the computing system to a source of the first API call, a second response that is based at least in part on the first response. (M3) A method may be performed as described in paragraph (M2), and may further involve receiving, by the computing system and from the first device, a request to identify API endpoints configured to perform the first type of operation; determining, by the computing system, that the first API endpoint is configured to perform the first type of operation; and sending, from the computing system to the first device and based at least in part on the first API endpoint being configured to perform the first type of operation, an indication of the first API endpoint. (M4) A method may be performed as described in paragraph (M3), wherein determining that the first API endpoint is configured to perform the first type of operation may further involve determining that the request includes a first indicator of the first type of operation; determining that the first API endpoint is associated with the first indicator; and determining, based at least in part on the request including the first indicator and the first API endpoint being associated with the first indicator, that the first API endpoint is configured to perform the first type of operation. (M5) A method may be performed as described in paragraph (M4), and may further involve, prior to receiving the request, receiving, from a second device, an indication that first API endpoint is configured to perform the first type of operation; and storing, by the computing system and based at least in part on the first API endpoint being configured to perform the first type of operation, a second indicator in association with the first API endpoint; wherein determining that the first API

endpoint is associated with the first indicator further comprises determining that the second indicator corresponds to the first indicator. (M6) A method may be performed as described in any of paragraphs (M2) through (M5), and may further involve determining, by the computing system, access credentials associated with a user of the source of the first API call; and using the access credentials to make the second API call. (M7) A method may be performed as described in any of paragraphs (M2) through (M6), wherein the first API endpoint has a first input schema, the second API endpoint has a second input schema that is different than the first input schema, and invoking the first process may further involve generating, by the computing system, the second API call according to the second input schema. (M8) A method may be performed as described in any of paragraphs (M2) through (M7), wherein the first API endpoint has a first output schema, the second API endpoint has a second output schema that is different than the first output schema, and generating the second response may further involve generating, by the computing system, the second response in accordance with the first output schema. (M9) A method may be performed as described in any of paragraphs (M2) through (M8), and may further involve receiving, at a third API endpoint of the computing system, a third API call requesting performance of the first type of operation; invoking, by the computing system and based on the third API call, a second process to generate at least a fourth API call to a fourth API endpoint of a second system of record; receiving, by the computing system and from the second system of record, a third response to the fourth API call; generating, by the computing system and based at least in part on the third response, a fourth response to the third API call; and sending, from the computing system to a source of the third API call, the fourth response. (M10) A method may be performed as described in (M9), wherein the first API call and the third API call originate from a first device, and the method may further involve receiving, by the computing system and from the first device, a request to identify API endpoints configured to perform the first type of operation; determining, by the computing system, that the first API endpoint and the third API endpoint are both configured to perform the first type of operation; and sending, from the computing system to the first device and based at least in part on the first API endpoint and the third API endpoint both being configured to perform the first type of operation, indications of the first API endpoint and the third API endpoint. (M11) A method may be performed as described in (M10), wherein determining that the first API endpoint and the third API endpoint are both configured to perform the first type of operation may further involve determining that the request includes a first indicator of the first type of operation; determining that the first API endpoint is associated with the first indicator; determining that the third API endpoint is associated with the first indicator; and determining, based at least in part on the request including the first indicator and the first API endpoint and the third API endpoint both being associated with the first indicator, that the first API endpoint and the third API endpoint are both configured to perform the first type of operation. (M12) A method may be performed as described in (M11), and may further involve prior to receiving the request, receiving a first indication that first API endpoint is configured to perform the first type of operation; storing, by the computing system and based at least in part on the first API endpoint being configured to perform the first type of operation, a second indicator in association with the first API endpoint; prior to receiving the request, receiving a second indication that third API endpoint is configured to perform the first type of operation; and storing, by the computing system and based at least in part on the third API endpoint being configured to perform the first type of operation, a third indicator in association with the third API endpoint; wherein determining that the first API endpoint is associated with the first indicator further comprises determining that the second indicator corresponds to the first indicator, and determining that the third API endpoint is associated with the first indicator further comprises determining that the third indicator corresponds to the first indicator.

(95) The following paragraphs (S1) through (S11) describe examples of systems and devices that may be implemented in accordance with the present disclosure. (S1) A system may comprise at least one processor, and at least one computer-readable medium encoded with instructions which,

when executed by the at least one processor, cause the system to receive, at a first application programming interface (API) endpoint of the system, a first API call requesting performance of a first type of operation; invoke, based on the first API call, a first process to send at least a second API call to a second API endpoint of a first system of record; receive, from the first system of record, a first response to the second API call; and send, to a source of the first API call, a second response that is based at least in part on the first response. (S2) A system may be configured as described in paragraph (S1), and the at least one computer-readable medium may be further encoded with additional instructions which, when executed by the at least one processor, further cause the system to receive, from the first device, a request to identify API endpoints configured to perform the first type of operation; determine that the first API endpoint is configured to perform the first type of operation; and send, to the first device and based at least in part on the first API endpoint being configured to perform the first type of operation, an indication of the first API endpoint. (S3) A system may be configured as described in paragraph (S2), and the at least one computer-readable medium may be further encoded with additional instructions which, when executed by the at least one processor, further cause the system to determine that the request includes a first indicator of the first type of operation; determining that the first API endpoint is associated with the first indicator; and determine, based at least in part on the request including the first indicator and the first API endpoint being associated with the first indicator, that the first API endpoint is configured to perform the first type of operation. (S4) A system may be configured as described in paragraph (S3), and the at least one computer-readable medium may be further encoded with additional instructions which, when executed by the at least one processor, further cause the system to, prior to receiving the request, receive, from a second device, an indication that first API endpoint is configured to perform the first type of operation; store, based at least in part on the first API endpoint being configured to perform the first type of operation, a second indicator in association with the first API endpoint; and determine that the first API endpoint is associated with the first indicator at least in part by determining that the second indicator corresponds to the first indicator. (S5) A system may be configured as described in any of paragraphs (S1) through (S4), and the at least one computer-readable medium may be further encoded with additional instructions which, when executed by the at least one processor, further cause the system to determine access credentials associated with a user of the source of the first API call; and use the access credentials to make the second API call. (S6) A system may be configured as described in any of paragraphs (S1) through (S5), wherein the first API endpoint has a first input schema, the second API endpoint has a second input schema that is different than the first input schema, and the at least one computer-readable medium is further encoded with additional instructions which, when executed by the at least one processor, further cause the system to generate, by the computing system, the second API call according to the second input schema. (S7) A system may be configured as described in any of paragraphs (S1) through (S6), wherein the first API endpoint has a first output schema, the second API endpoint has a second output schema that is different than the first output schema, and generating the second response may further involve generating, by the computing system, the second response in accordance with the first output schema. (S8) A system may be configured as described in any of paragraphs (S1) through (S7), and the at least one computer-readable medium may be further encoded with additional instructions which, when executed by the at least one processor, further cause the system to receive, at a third API endpoint of the system, a third API call requesting performance of the first type of operation; invoke, based on the third API call, a second process to generate at least a fourth API call to a fourth API endpoint of a second system of record; receive, from the second system of record, a third response to the fourth API call; generate, based at least in part on the third response, a fourth response to the third API call; and send, to a source of the third API call, the fourth response. (S9) A system may be configured as described in paragraph (S8), wherein the first API call and the third API call originate from a first device, and the at least one computer-readable medium may be further encoded with additional instructions which, when executed by the at least one processor, further cause the system to receive, from the first device, a request to identify API endpoints configured to perform the first type of operation; determine that the first API endpoint and the third API endpoint are both configured to perform the first type of operation; and send, to the first device and based at least in part on the first API endpoint and the third API endpoint both being configured to perform the first type of operation, indications of the first API endpoint and the third API endpoint. (S10) A system may be configured as described in paragraph (S9), wherein determining that the first API endpoint and the third API endpoint are both configured to perform the first type of operation may further involve determining that the request includes a first indicator of the first type of operation; determining that the first API endpoint is associated with the first indicator; determining that the third API endpoint is associated with the first indicator; and determining, based at least in part on the request including the first indicator and the first API endpoint and the third API endpoint both being associated with the first indicator, that the first API endpoint and the third API endpoint are both configured to perform the first type of operation. (S11) A system may be configured as described in paragraph (S10), and the at least one computer-readable medium may be further encoded with additional instructions which, when executed by the at least one processor, further cause the system to, prior to receiving the request, receive a first indication that first API endpoint is configured to perform the first type of operation; store, based at least in part on the first API endpoint being configured to perform the first type of operation, a second indicator in association with the first API endpoint; prior to receiving the request, receive a second indication that third API endpoint is configured to perform the first type of operation; and store, based at least in part on the third API endpoint being configured to perform the first type of operation, a third indicator in association with the third API endpoint; wherein determining that the first API endpoint is associated with the first indicator further comprises determining that the second indicator corresponds to the first indicator, and determining that the third API endpoint is associated with the first indicator further comprises determining that the third indicator corresponds to the first indicator.

(96) The following paragraphs (CRM1) through (CRM11) describe examples of computer-readable media that may be implemented in accordance with the present disclosure. (CRM1) At least one non-transitory computer-readable medium may be encoded with instructions which, when executed by at least one processor of a system, cause the system to receive, at a first application programming interface (API) endpoint of the system, a first API call requesting performance of a first type of operation; invoke, based on the first API call, a first process to send at least a second API call to a second API endpoint of a first system of record; receive, from the first system of record, a first response to the second API call; and send, to a source of the first API call, a second response that is based at least in part on the first response. (CRM2) At least one non-transitory computer-readable medium may be configured as described in paragraph (CRM1), and the at least one computer-readable medium may be further encoded with additional instructions which, when executed by the at least one processor, further cause the system to receive, from the first device, a request to identify API endpoints configured to perform the first type of operation; determine that the first API endpoint is configured to perform the first type of operation; and send, to the first device and based at least in part on the first API endpoint being configured to perform the first type of operation, an indication of the first API endpoint. (CRM3) At least one non-transitory computer-readable medium may be configured as described in paragraph (CRM2), and may be further encoded with additional instructions which, when executed by the at least one processor, further cause the system to determine that the request includes a first indicator of the first type of operation; determining that the first API endpoint is associated with the first indicator; and determine, based at least in part on the request including the first indicator and the first API endpoint being associated with the first indicator, that the first API endpoint is configured to perform the first type of operation. (CRM4) At least one non-transitory computer-readable medium

may be configured as described in paragraph (CRM3), and may be further encoded with additional instructions which, when executed by the at least one processor, further cause the system to, prior to receiving the request, receive, from a second device, an indication that first API endpoint is configured to perform the first type of operation; store, based at least in part on the first API endpoint being configured to perform the first type of operation, a second indicator in association with the first API endpoint; and determine that the first API endpoint is associated with the first indicator at least in part by determining that the second indicator corresponds to the first indicator. (CRM5) At least one non-transitory computer-readable medium may be configured as described in any of paragraphs (CRM1) through (CRM4), and may be further encoded with additional instructions which, when executed by the at least one processor, further cause the system to determine access credentials associated with a user of the source of the first API call; and use the access credentials to make the second API call. (CRM6) At least one non-transitory computer-readable medium may be configured as described in any of paragraphs (CRM1) through (CRM5), wherein the first API endpoint has a first input schema, the second API endpoint has a second input schema that is different than the first input schema, and the at least one computer-readable medium is further encoded with additional instructions which, when executed by the at least one processor, further cause the system to generate, by the computing system, the second API call according to the second input schema. (CRM7) At least one non-transitory computer-readable medium may be configured as described in any of paragraphs (CRM1) through (CRM6), wherein the first API endpoint has a first output schema, the second API endpoint has a second output schema that is different than the first output schema, and generating the second response may further involve generating, by the computing system, the second response in accordance with the first output schema. (CRM8) At least one non-transitory computer-readable medium may be configured as described in any of paragraphs (CRM1) through (CRM7), and may be further encoded with additional instructions which, when executed by the at least one processor, further cause the system to receive, at a third API endpoint of the system, a third API call requesting performance of the first type of operation; invoke, based on the third API call, a second process to generate at least a fourth API call to a fourth API endpoint of a second system of record; receive, from the second system of record, a third response to the fourth API call; generate, based at least in part on the third response, a fourth response to the third API call; and send, to a source of the third API call, the fourth response. (CRM9) At least one non-transitory computer-readable medium may be configured as described paragraph (CRM8), wherein the first API call and the third API call originate from a first device, and may be further encoded with additional instructions which, when executed by the at least one processor, further cause the system to receive, from the first device, a request to identify API endpoints configured to perform the first type of operation; determine that the first API endpoint and the third API endpoint are both configured to perform the first type of operation; and send, to the first device and based at least in part on the first API endpoint and the third API endpoint both being configured to perform the first type of operation, indications of the first API endpoint and the third API endpoint. (CRM10) At least one non-transitory computer-readable medium may be configured as described paragraph (CRM9), wherein determining that the first API endpoint and the third API endpoint are both configured to perform the first type of operation may further involve determining that the request includes a first indicator of the first type of operation; determining that the first API endpoint is associated with the first indicator; determining that the third API endpoint is associated with the first indicator; and determining, based at least in part on the request including the first indicator and the first API endpoint and the third API endpoint both being associated with the first indicator, that the first API endpoint and the third API endpoint are both configured to perform the first type of operation. (CRM11) At least one non-transitory computer-readable medium may be configured as described in paragraph (CRM10), and may be further encoded with additional instructions which, when executed by the at least one processor, further cause the system to, prior to receiving the request, receive a first indication that first API endpoint is configured to perform the first type of operation; store, based at least in part on the first API endpoint being configured to perform the first type of operation, a second indicator in association with the first API endpoint; prior to receiving the request, receive a second indication that third API endpoint is configured to perform the first type of operation; and store, based at least in part on the third API endpoint being configured to perform the first type of operation, a third indicator in association with the third API endpoint; wherein determining that the first API endpoint is associated with the first indicator further comprises determining that the second indicator corresponds to the first indicator, and determining that the third API endpoint is associated with the first indicator further comprises determining that the third indicator corresponds to the first indicator.

(97) Having thus described several aspects of at least one embodiment, it is to be appreciated that various alterations, modifications, and improvements will readily occur to those skilled in the art. Such alterations, modifications, and improvements are intended to be part of this disclosure, and are intended to be within the spirit and scope of the disclosure. Accordingly, the foregoing description and drawings are by way of example only.

(98) Various aspects of the present disclosure may be used alone, in combination, or in a variety of arrangements not specifically discussed in the embodiments described in the foregoing and is therefore not limited in this application to the details and arrangement of components set forth in the foregoing description or illustrated in the drawings. For example, aspects described in one embodiment may be combined in any manner with aspects described in other embodiments.

(99) Also, the disclosed aspects may be embodied as a method, of which an example has been provided. The acts performed as part of the method may be ordered in any suitable way. Accordingly, embodiments may be constructed in which acts are performed in an order different than illustrated, which may include performing some acts simultaneously, even though shown as sequential acts in illustrative embodiments.

(100) Use of ordinal terms such as “first,” “second,” “third,” etc. in the claims to modify a claim element does not by itself connote any priority, precedence or order of one claim element over another or the temporal order in which acts of a method are performed, but are used merely as labels to distinguish one claimed element having a certain name from another element having a same name (but for use of the ordinal term) to distinguish the claim elements.

(101) Also, the phraseology and terminology used herein is used for the purpose of description and should not be regarded as limiting. The use of “including,” “comprising,” or “having,” “containing,” “involving,” and variations thereof herein, is meant to encompass the items listed thereafter and equivalents thereof as well as additional items.

Claims

1. A method, comprising: receiving, by a computing system from a first device, a request to identify application programming interface (API) endpoints that are configured to perform a search operation; determining, by the computing system, that first and second API endpoints of the computing system are both configured to perform search operation operations; sending, from the computing system to the first device and based at least in part on the first and second API endpoints both being configured to perform search operations, indications of the first API endpoint and the second API endpoint; receiving, at the first API endpoint and from the first device, a first API call requesting performance of a first search operation; executing, by the computing system and based on the first API call, a first script to send at least a second API call to a third API endpoint of a first system of record, the second API call representing a request to perform the first search operation; receiving, by the computing system and from the first system of record, first search results in response to the second API call; generating, by the computing system and based at least in part on the first search results, a first response to the first API call, the first response representing the first

search results; sending, from the computing system to the first device, the first response; receiving, at the second API endpoint and from the first device, a third API call requesting performance of a second search operation; executing, by the computing system and based on the third API call, a second script to generate at least a fourth API call to a fourth API endpoint of a second system of record, the fourth API call representing a request to perform the second search operation; receiving, by the computing system and from the second system of record, second search results in response to the fourth API call; generating, by the computing system and based at least in part on the second search results, a second response to the third API call, the second response representing the second search results; and sending, from the computing system to the first device, the second response.

2. The method of claim 1, wherein determining that the first API endpoint is configured to perform the search operation further comprises: determining that the request to identify the API endpoints includes a first indicator of the search operation; determining that the first API endpoint is associated with the first indicator; and determining, based at least in part on the request to identify the API endpoints including the first indicator and the first API endpoint being associated with the first indicator, that the first API endpoint is configured to perform the search operation.

3. The method of claim 2 further comprising: prior to receiving the request to identify the API endpoints, receiving, from a second device, an indication that the first API endpoint is configured to perform the search operation; and storing, by the computing system and based at least in part on the first API endpoint being configured to perform the search operation, a second indicator in association with the first API endpoint; wherein determining that the first API endpoint is associated with the first indicator further comprises determining that the second indicator corresponds to the first indicator.

4. The method of claim 1, further comprising: determining, by the computing system, access credentials associated with a user of the first API call; and using the access credentials to make the second API call.

5. The method of claim 1, wherein the first API endpoint has a first input schema, the second API endpoint has a second input schema that is different than the first input schema, and executing the first script further comprises: generating, by the computing system, the second API call according to the second input schema.

6. The method of claim 1, wherein the first API endpoint has a first output schema, the second API endpoint has a second output schema that is different than the first output schema, and generating the second response further comprises: generating, by the computing system, the second response in accordance with the first output schema.

7. The method of claim 1, wherein the first API call and the third API call originate from the first device, and the method further comprises: receiving, by the computing system and from the first device, a request to identify API endpoints configured to perform a first type of operation; determining, by the computing system, that the first API endpoint and the third API endpoint are both configured to perform the first type of operation; and sending, from the computing system to the first device and based at least in part on the first API endpoint and the third API endpoint both being configured to perform the first type of operation, indications of the first API endpoint and the third API endpoint.

8. The method of claim 7, wherein determining that the first API endpoint and the third API endpoint are both configured to perform the first type of operation further comprises: determining that the request to identify the API endpoints includes a first indicator of the first type of operation; determining that the first API endpoint is associated with the first indicator; determining that the third API endpoint is associated with the first indicator; and determining, based at least in part on the request to identify the API endpoints including the first indicator and the first API endpoint and the third API endpoint both being associated with the first indicator, that the first API endpoint and the third API endpoint are both configured to perform the first type of operation.

9. The method of claim 8, further comprising: prior to receiving the request to identify the API

endpoints, receiving a first indication that first API endpoint is configured to perform the first type of operation; storing, by the computing system and based at least in part on the first API endpoint being configured to perform the first type of operation, a second indicator in association with the first API endpoint; prior to receiving the request, receiving a second indication that third API endpoint is configured to perform the first type of operation; and storing, by the computing system and based at least in part on the third API endpoint being configured to perform the first type of operation, a third indicator in association with the third API endpoint; wherein determining that the first API endpoint is associated with the first indicator further comprises determining that the second indicator corresponds to the first indicator, and determining that the third API endpoint is associated with the first indicator further comprises determining that the third indicator corresponds to the first indicator.