

(54) **MACHINE LEARNING AUTOMATION OF NETWORK RESOURCE WORKFLOWS**

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Publication Classification

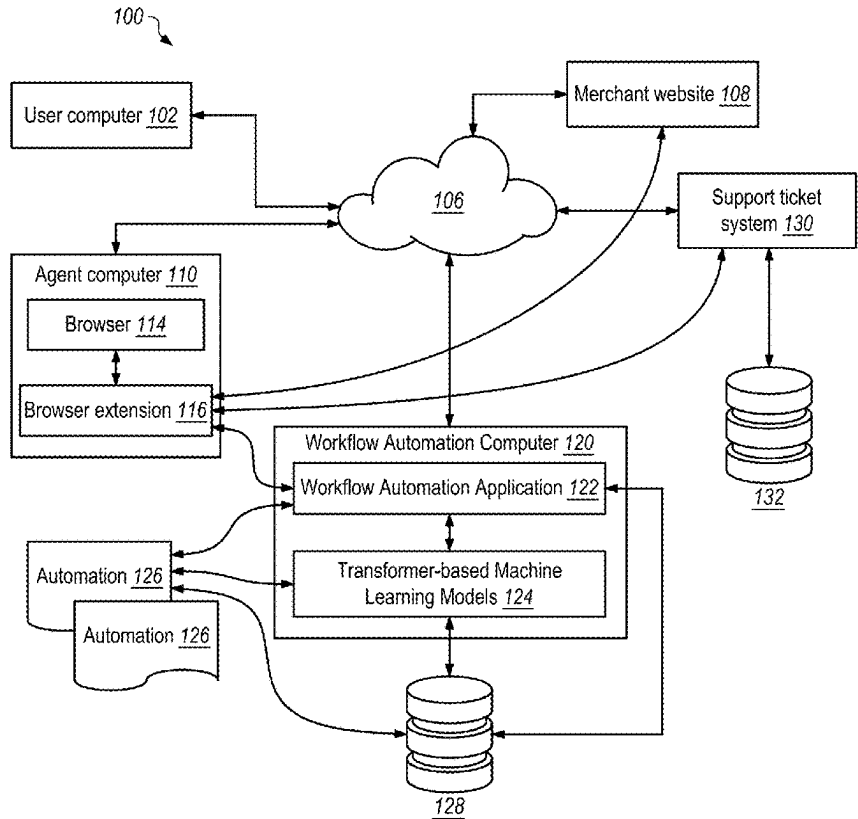
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(52) **U.S. Cl.**
CPC **G06F 16/285** (2019.01); **H04L 67/02** (2013.01)

(57) **ABSTRACT**

In an embodiment, a workflow automation computer system comprises one or more hardware processors; one or more

network interfaces that are communicatively coupled to one or more internetworks and capable of network communication with a browser extension hosted on an agent computer, a relational database system, and a support ticket system; and one or more non-transitory computer-readable storage media coupled to the one or more hardware processors and storing one or more trained machine learning models having been trained to output predictions of actions of web-based applications based on input specifying a plurality of browser events from interactions with the web-based applications; and one or more sequences of instructions which, when executed using one or more processors, cause the one or more processors to execute receiving, from the browser extension, one or more browser event objects corresponding to user input signals arising from interactions of the agent computer with the web-based applications, extracting attribute values from the one or more browser event objects, and storing, in the relational database system, the one or more browser event objects and attribute values as a plurality of events of user action time series records; clustering the plurality of events and performing action analysis on the plurality of events by executing a first inference stage of the one or more trained machine learning models over the one or more events to output suggestions of associations of user actions corresponding to the one or more events; forming one or more training data records based on the associations of user actions corresponding to the one or more events; re-training the one or more trained machine learning models based on the associations of user actions to produce one or more re-trained machine learning models.



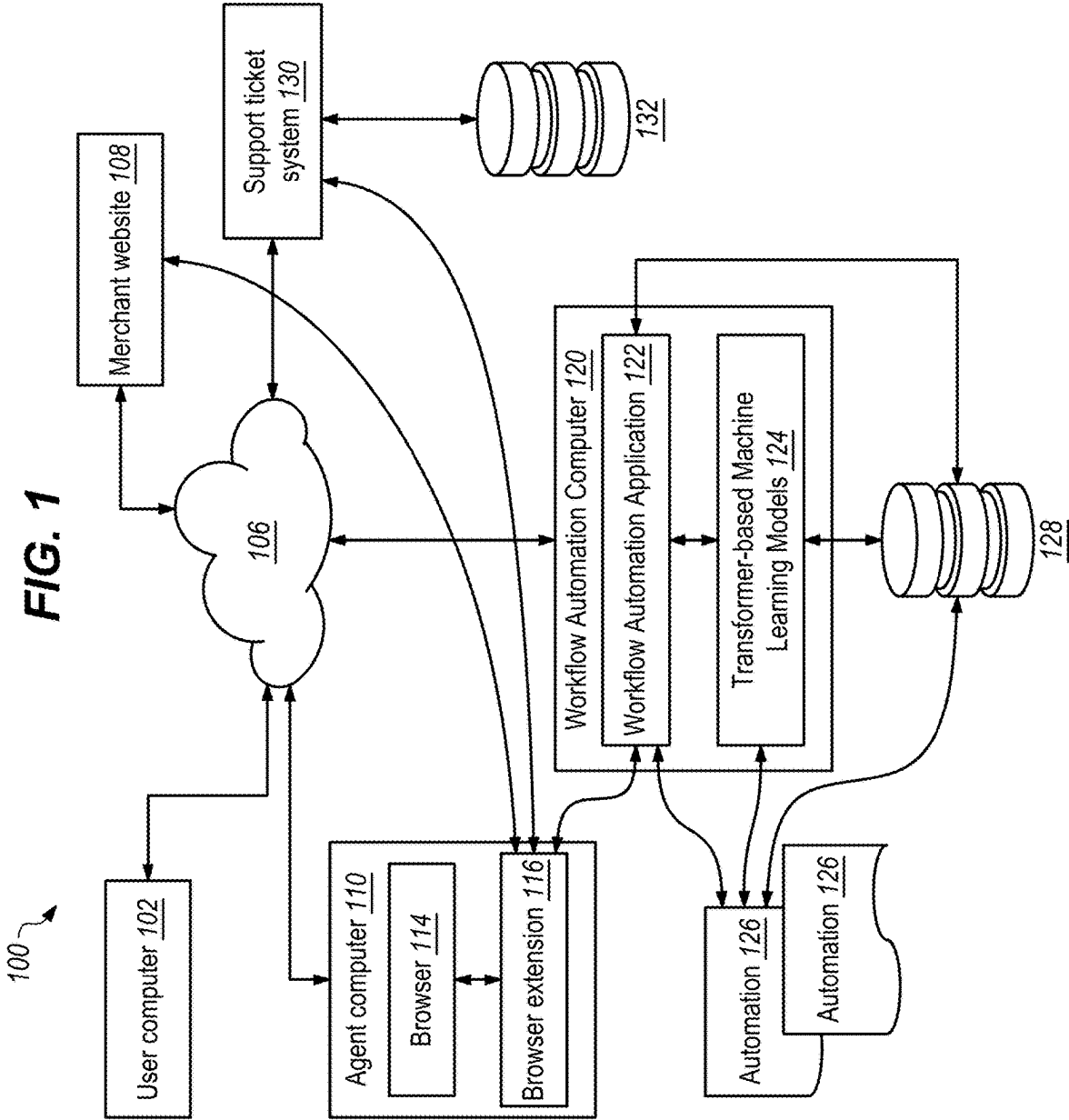


FIG. 2

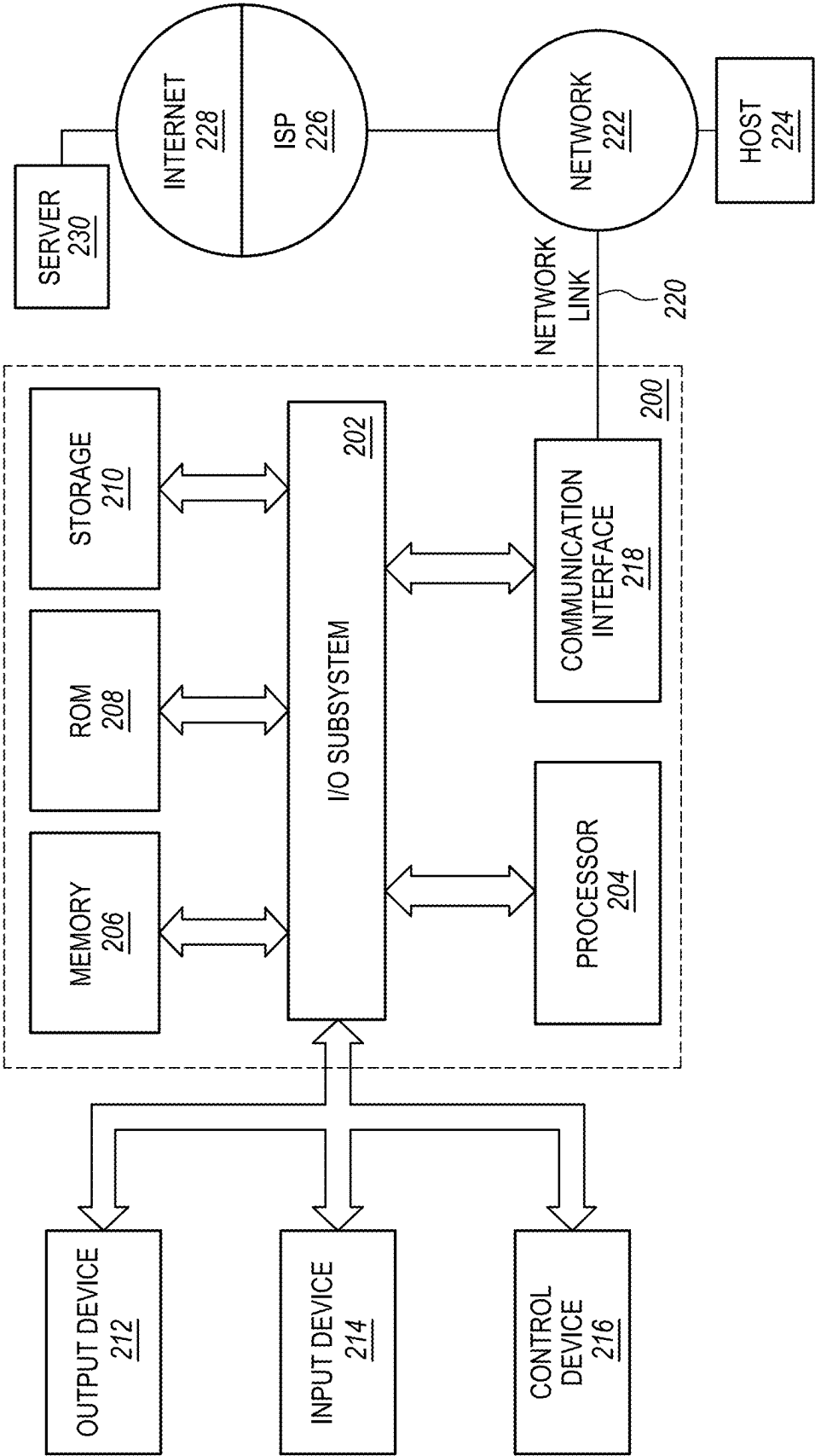


FIG. 3

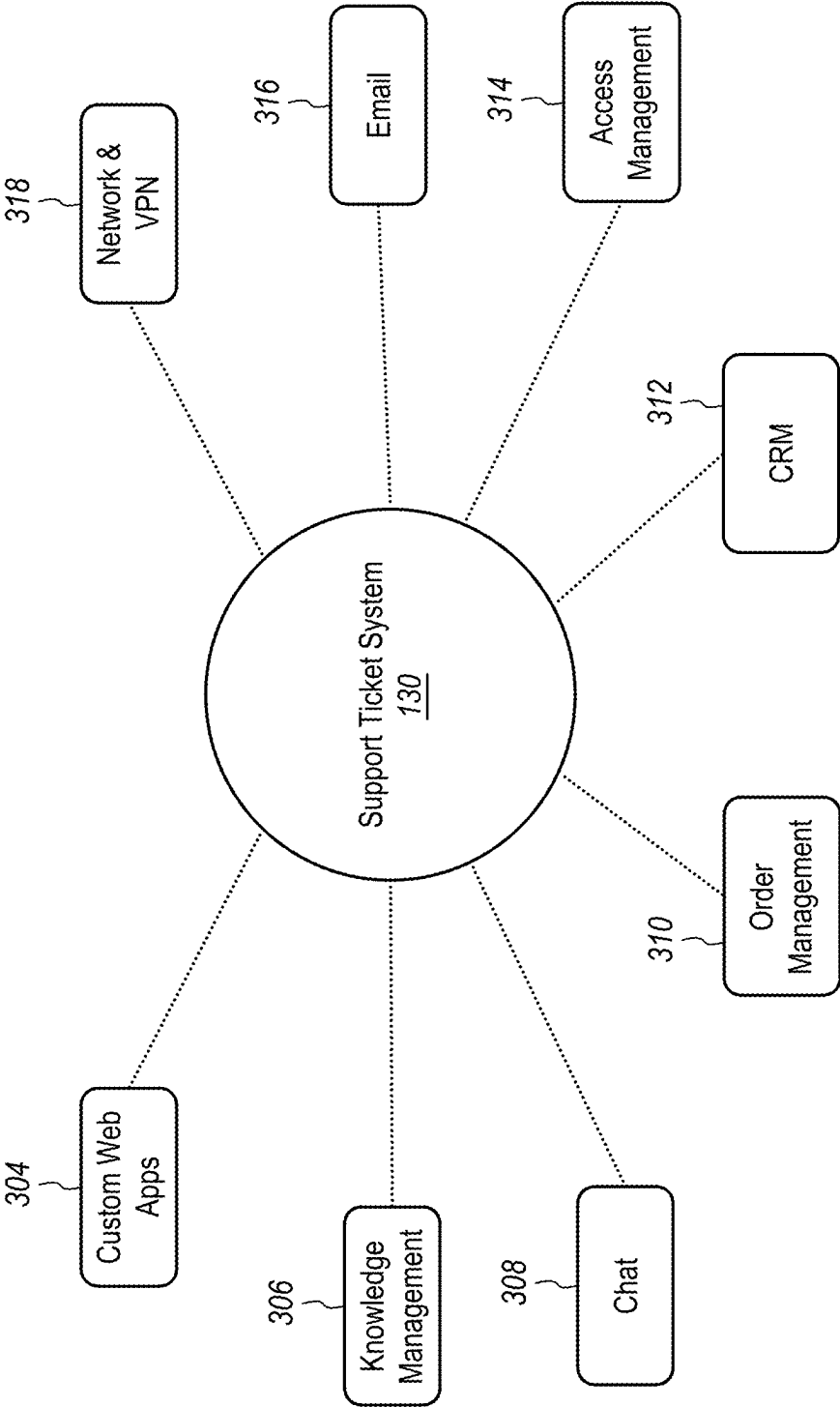


FIG. 4

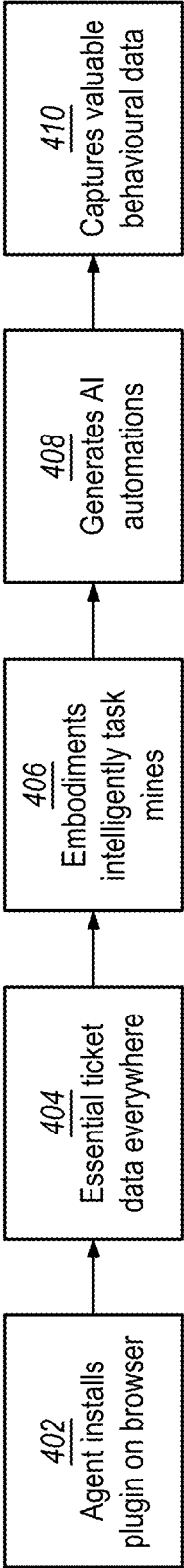


FIG. 5

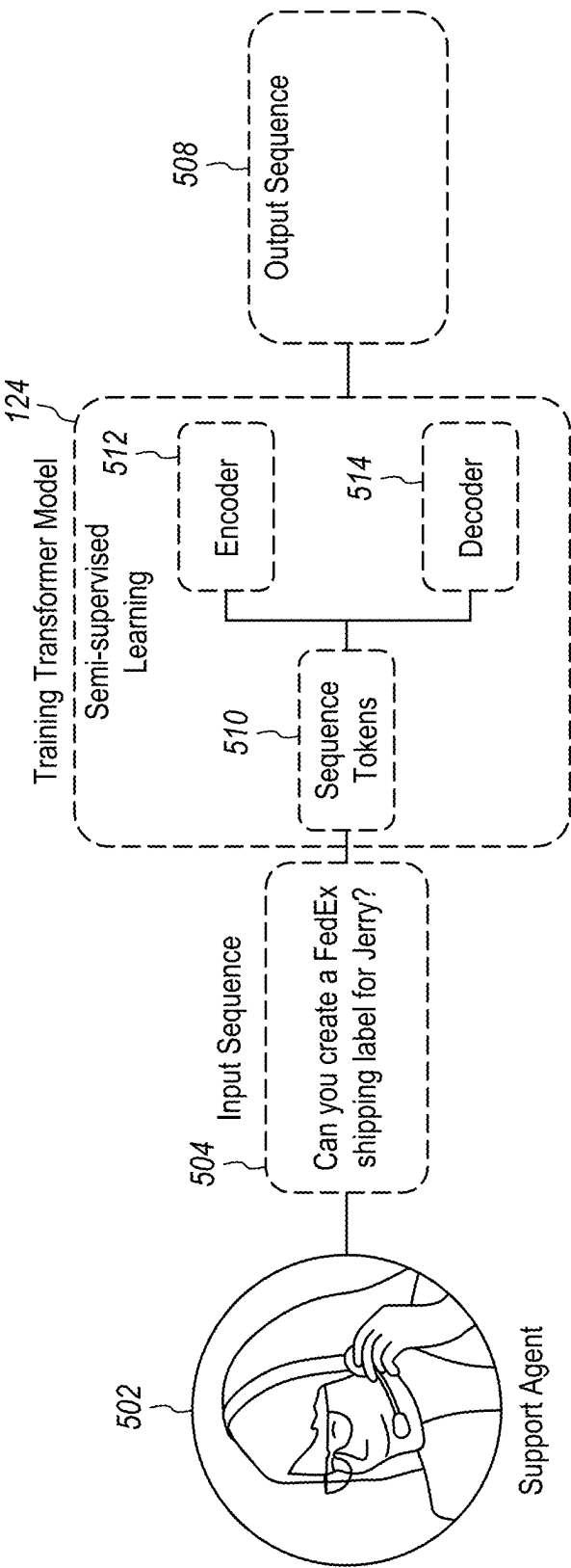


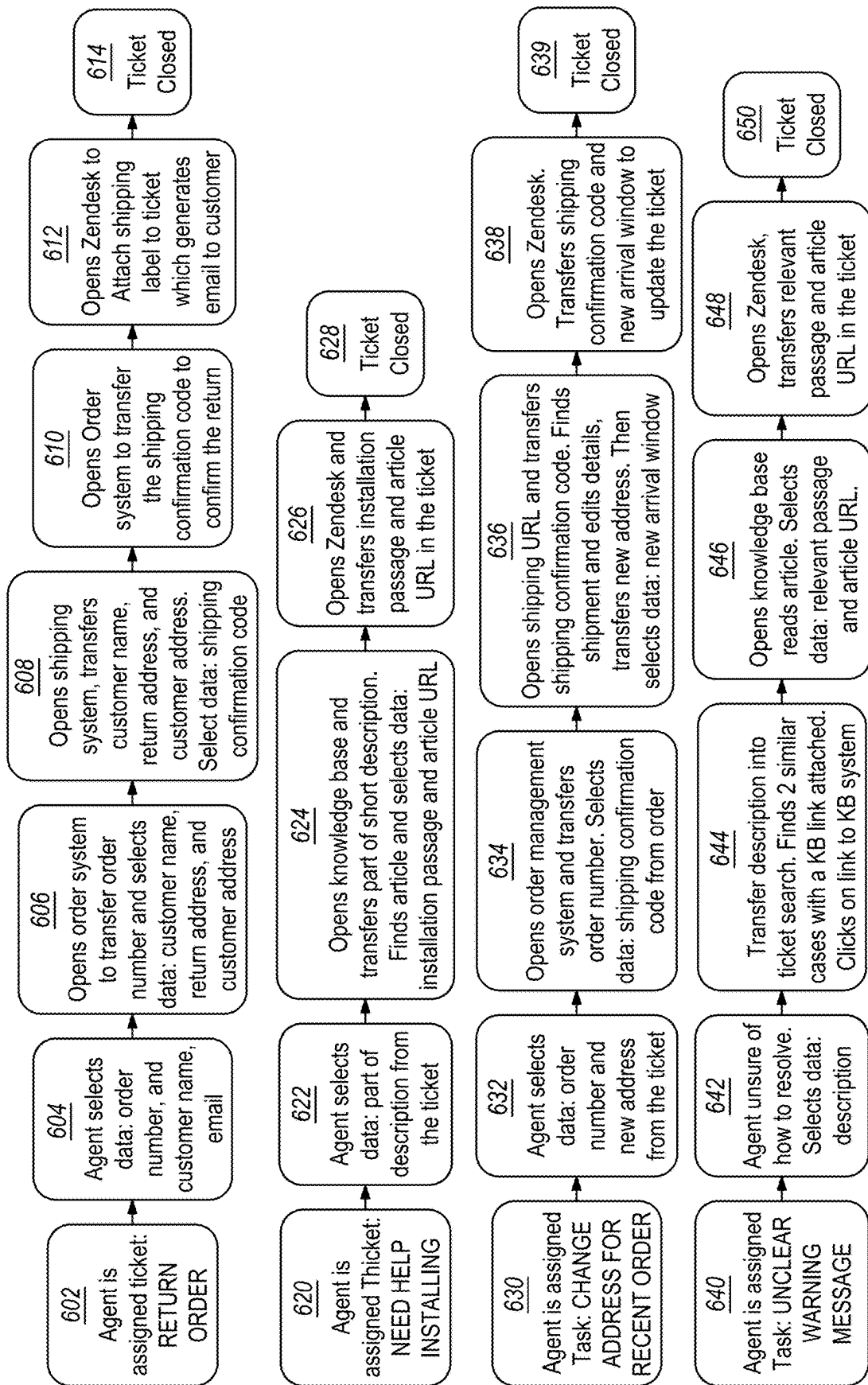
FIG. 6

FIG. 7A

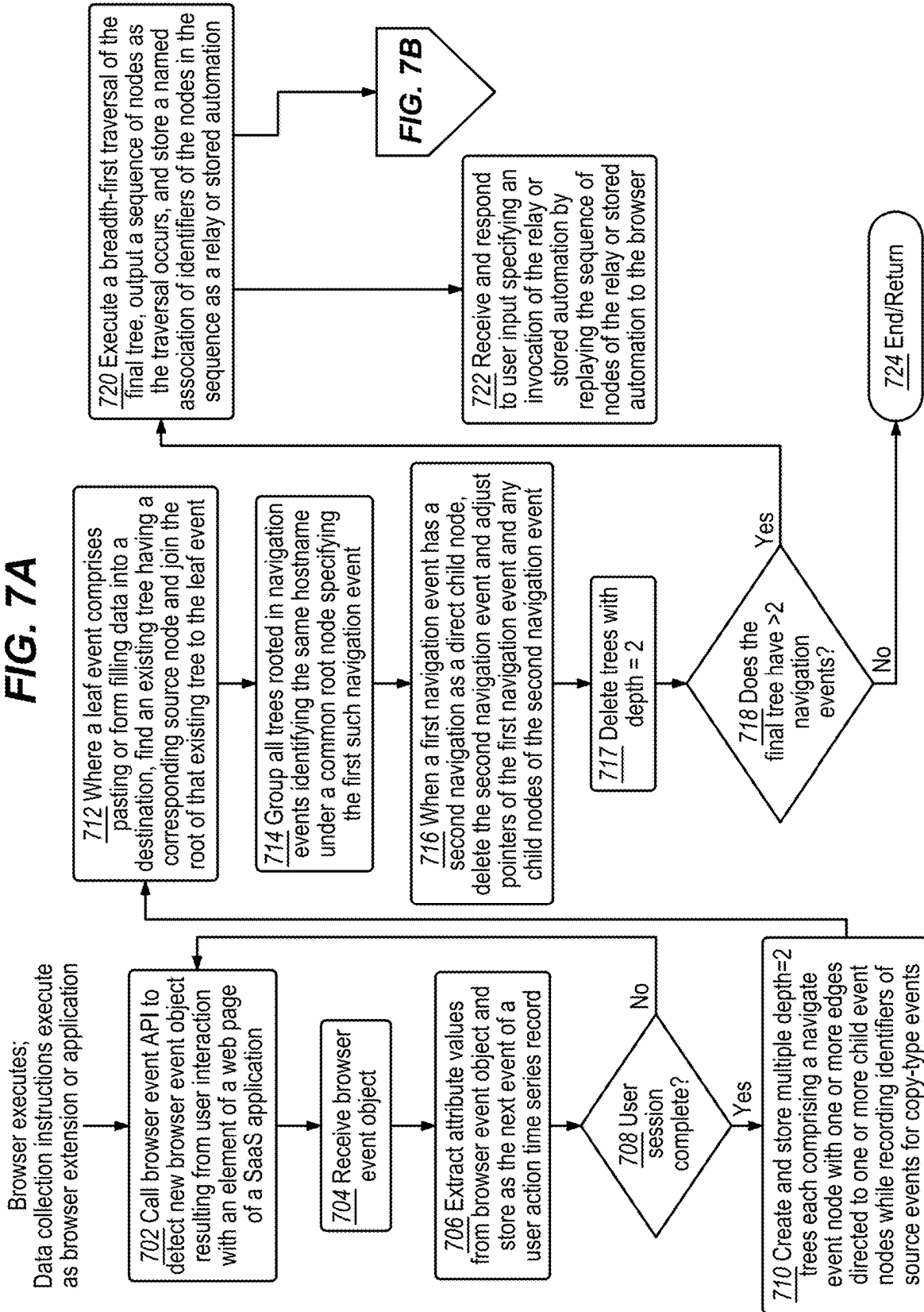


FIG. 7B

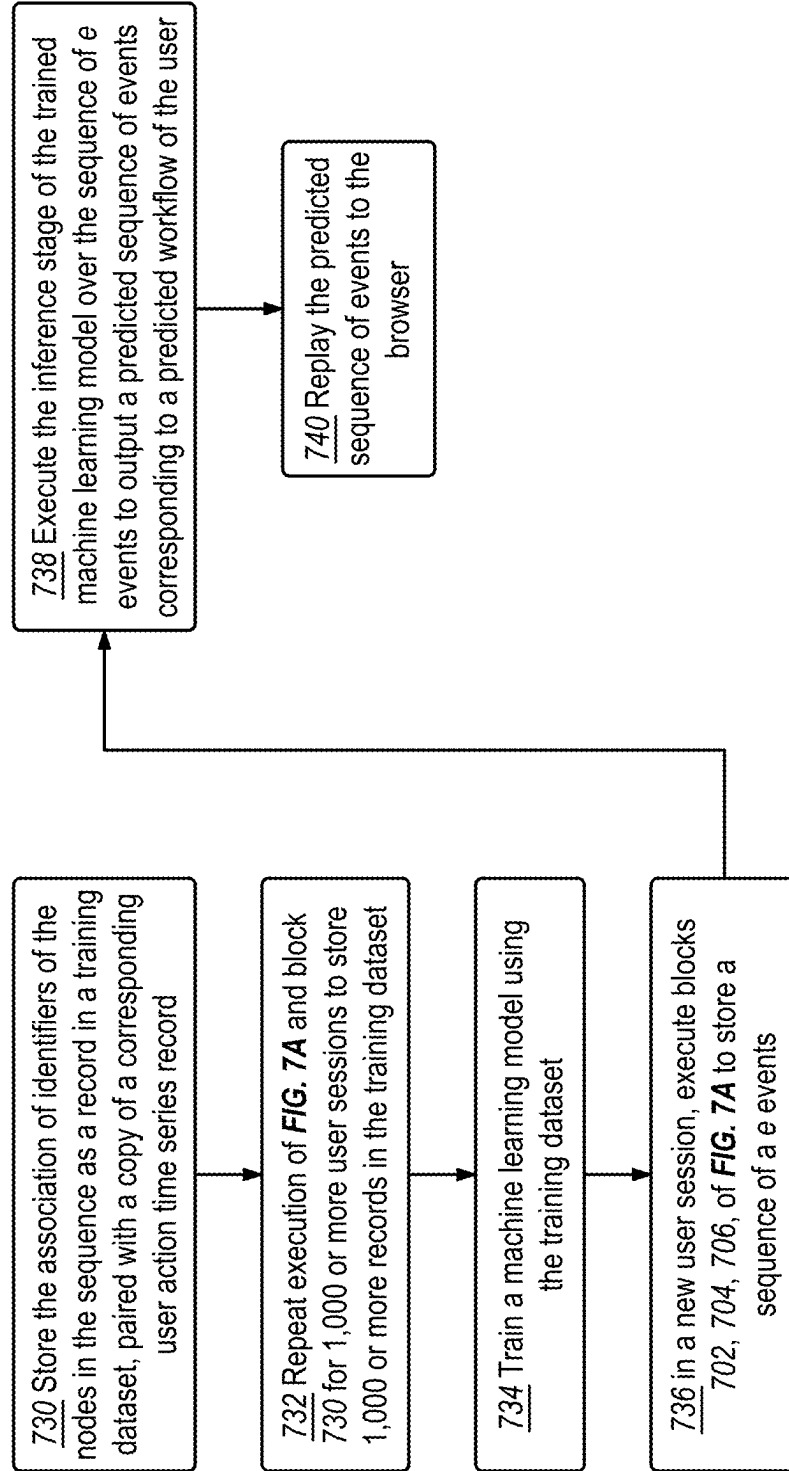


FIG. 7C

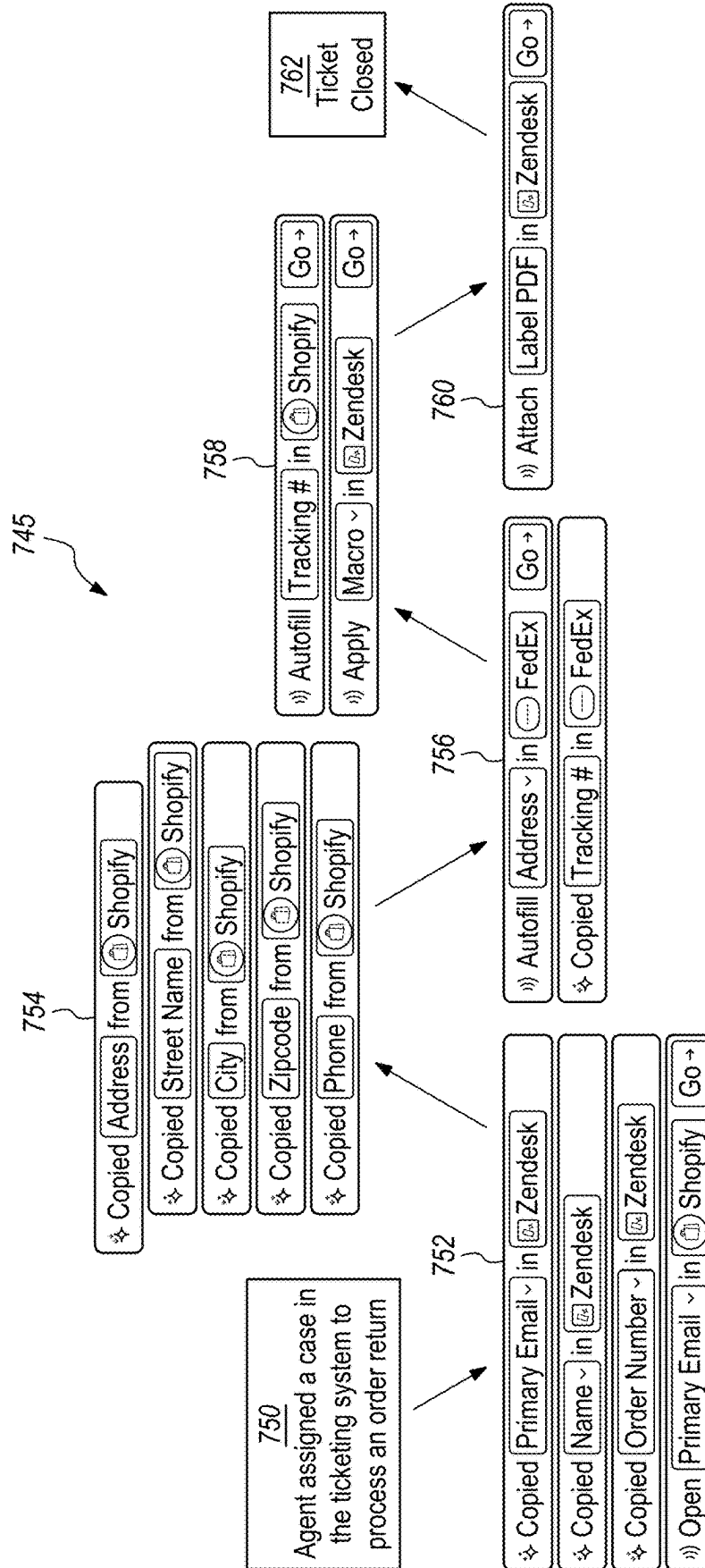


FIG. 8B

FIG. 8B

804

Jane Customer #124 + Add 802 Open Incident #1

Example (create) The Customer

Requester Jane Customer

Assignee* take it

Support/Support Agent... follow

Followers

Tags sample support zendesk

Type Incident Priority Normal

Linked problem -

806

Return Label Via Chat 808 Jane Customer

Oh no! The stuff I ordered is the wrong size. Can you send me a return label?

826

828

830

832

Public reply ~ | To @The Customer CC 809

810

812

Apply macro

Close tab Submit as Open

FIG. 9

804

820

802

806

Jane Customer #124

+ Add

Example (create)

The Customer

Open Incident #1

Requester

Jane Customer

Assignee*

take it

Support/Support Agent...

follow

Followers

Tags

sample* support* zendesk*

Type

Incident

Priority

Normal

Linked problem

-

Return Label

Via Chat

Jane Customer

Oh no! The stuff I ordered is the wrong size.

Can you send me a return label?

Public reply ~

To @The Customer

CC

Back

Ticket #1

8 pins | 3d ago

902

Description

Customer needs to return order.

904

State

In Progress

Pinpad

824

Presets

Customer: Joe Collapses

Requester

Jane Customer

Primary Email

janecustomer@gmail.com

Close tab

Submit as Open

FIG. 10A

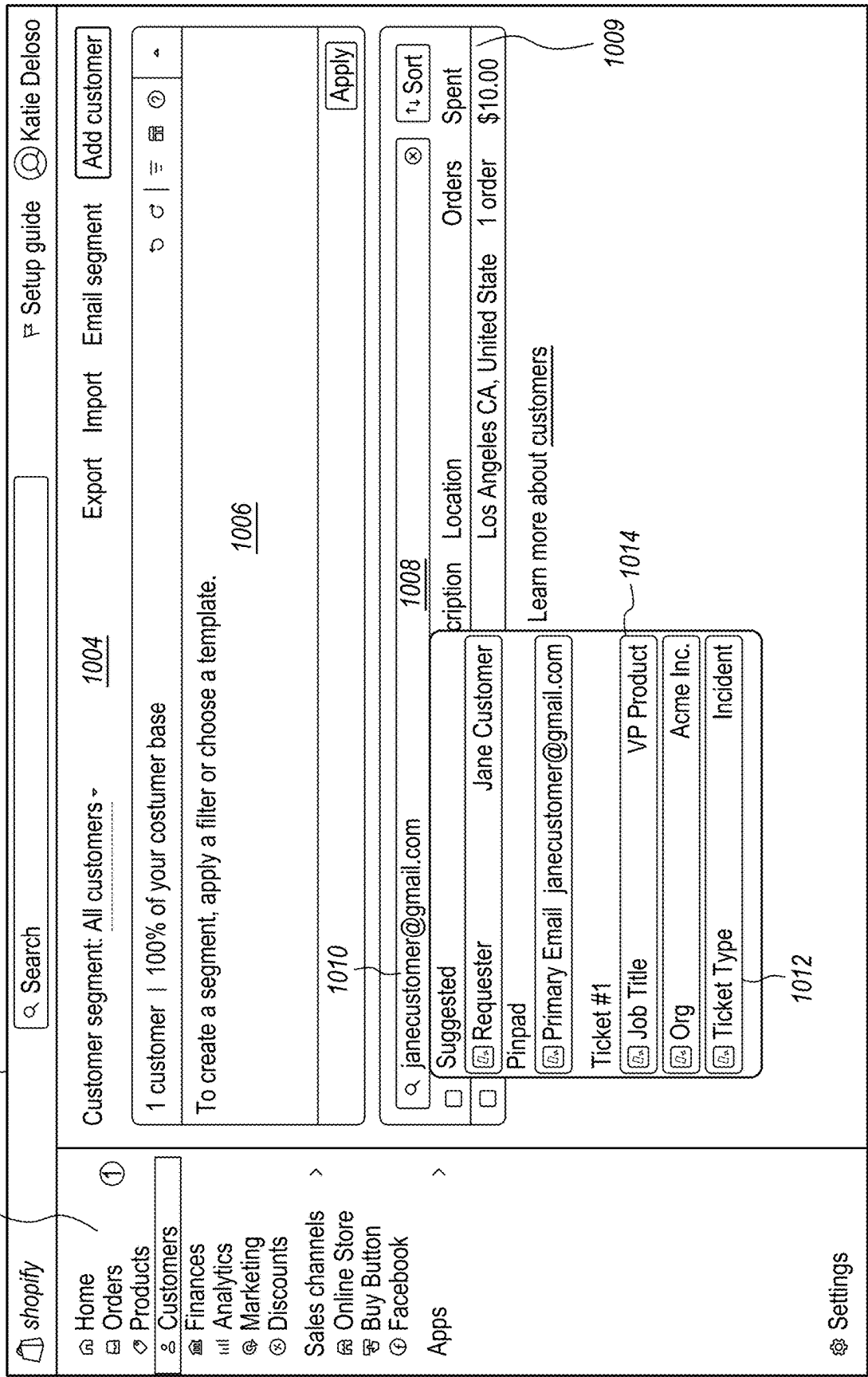


FIG. 10B

1020

FedEx	Shipping	Tracking	Design & Print	Locations	Support	Sign Up or Log in
<p>Record high volumes of e-commerce orders, COVID 19 closures and weather events may cause delivery delays.</p> <p>⌚ Before finalizing your shipment, please confirm that your recipient can receive your package and service alert updates.</p>						
<p>FedEx Ship Manager Lite</p>						
1. Address Information						
Enter your (From) address and the recipient's (To) address.						
From Address			To Address			
1026			1024			
Your name	Jane Customer		Recipient name			
Company	Suggested Requester Jane Customer		Company (optional)			
Country/Location	Pinpad		Country/Location United States			
Address	Primary Email janecustomer@gmail.com		Address Street address			
1012 Zip	Street Address 555 Main Street		Apt, Floor, Suite			
City	City Los Angeles		Zip			
State	State California		City			
1014 Phone	Zip Code 90239		State			
Email Notifications	Ticket #1		Phone			
	Job Title VP Product		Email Notifications (optional)			
	Org Acme Inc.		Perform detailed address check			
	Ticket Type Incident		<input type="checkbox"/> This is a new address			
<p>Ticket #1 7 pins 3d ago 820</p> <p>Description Customer needs to return order. 822</p> <p>State In Progress</p> <p>Pinpad 824 Presets</p> <p>Customer: Joe Collapses 830</p> <p>Requester Jane Customer</p> <p>Primary Email janecustomer@gmail.com</p> <p>Customer: Jane Customer 1022</p> <p>Order Number 1002</p> <p>Street Address 555 Main Street</p> <p>City Los Angeles</p> <p>State California</p> <p>Zip Code 91010</p> <p>Continue</p>						

FIG. 10C

FedEx Tracking

1030

Track Another Shipment Help

DELIVERED

Wednesday

8/3/2022 at 1:40 pm

Signature not required

Left at front door

Obtain Proof of delivery

How was your delivery?

☆☆☆☆☆

Manage Delivery

DELIVERY STATUS

Delivered

Get Status Updates

TRACKING ID

276286873292

1032

From

Fontana, CA US

Label Created

8/2/2022 8:05 AM

Package Received By

Bloomington, CA

8/2/2022 12:00 AM

In Transit

Sun Valley, CA

8/3/2022 5:35 AM

Out For Delivery

Sun Valley, CA

8/3/2022 5:47 AM

DELIVERED

Beverly Hills, CA US

DELIVERED

8/3/2022 at 1:40 PM

View travel history

Shipments facts

Shipments overview

Tracking Number

Ship Date

Standard Transit

Actual Delivery

Services

276286873292

8/2/22

8/3/22

8/3/22 at 1:40 pm

832

1034

Back

Ticket #1

7 pins

3d ago

820

Description

Customer needs to return order.

State

In Progress

Pinpad

Presets

Customer: Joe Collapses

Requester

Jane Customer

Primary Email

janecustomer@gmail.com

Customer: Jane Customer

Order Number

1002

Street Address

555 Main Street

City

Los Angeles

State

California

Zip Code

91010

Ship Manager Lite

Tracking ID

276286873292

Label URL

www.fedex.com/lite-s...

FIG. 11

804

FIG. 11

Jane Customer #1 + Add		Back	
Organization (create) Jane Customer Incident #1		Ticket #1 820 7 pins 3d ago	
Requester Jane Customer		Description Customer needs to return order.	
Assignee* take it		State In Progress	
Support/Support Agent...~		Pinpad Presets	
Followers follow		Customer: Joe Collapses ...	
Tags sample * support * zendesk *		Requester Jane Customer	
Type Incident ~ Priority Low		Primary Email janecustomer@gmail.com	
Linked problem		Customer: Jane Customer ...	
		Order Number 1002	
		Street Address 555 Main Street	
		City Los Angeles	
		State California	
		Zip Code 91010	
		Ship Manager Lite ...	
		Tracking ID 276286873292	
		Label URL www.fedex.com/lite-s...	

Jane Customer #1		802	
Organization (create) Jane Customer Incident #1		Open Incident #1	
1# Return Label Via sample ticket Assign		Received a call from Jane, will update the ticket further.	
Yev Goldin Assign		808	
To: Jane Customer Show more		Hi Jane,	
Thank you for reaching out to support, I've started processing this and will get back to you ASAP.		Thank you, Support	
Public reply ~ To Jane Customer 809		832	
Hi Jane,		I've processed your return and you can access your Shipping label and QR code through this link:	
www.fedex.com/lite-ship/276286873292		1104	
T @ # ?			

Apply macro		Close tab ~ Submit as Open	
-------------	--	----------------------------	--

812

FIG. 12

FIG. 13A

[illegible]

FIG. 13B

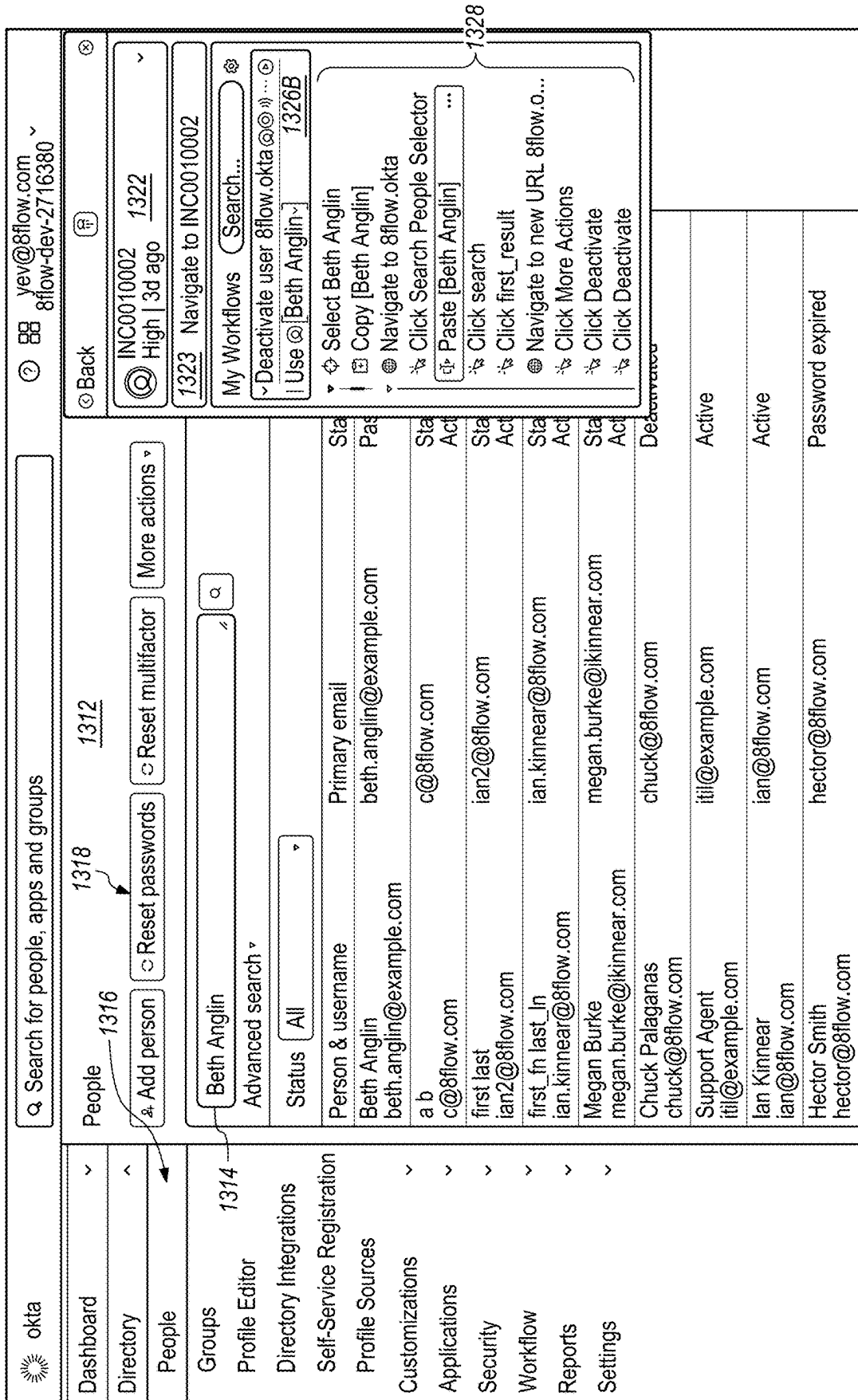


FIG. 13C

okta

Search for people, apps and groups

88 yev@8flow.com yev@8flow.com ~ 8flow-dev-2716380

Dashboard >

Directory <

People

Groups

Profile Editor

Directory Integrations

Self-Service Registration

Profile Sources

Customizations >

Applications >

Security >

Workflow >

Reports >

Settings >

Beth Anglin

beth.anglin@example.com

1332

1330

1336

1334

More actions ▾

Resend Password Email

User → Password reset. U

Applications Groups

Assigned Applications

Assign Applications

Application

8flowsupport. Zendesk

Assignment & App Username

Individual

beth.anglin@example.com

✕

1337

1338

Click [Deactivate]

© 2024 Okta, Inc. Privacy Status site OK12 Cell (US) Version 2024.01.2 C Download Okta Plugin Feedback

FIG. 13D

okta

Search for people, apps and groups

Dashboard

Directory

People

Groups

Profile Editor

Directory Integrations

Self-Service Registration

Profile Sources

Customizations

Applications

Security

Workflow

Reports

Settings

Beth Anglin

beth.anglin@example.com

1316

Activate

1342

Delete

User → Deactivated

View Logs

Applications

Groups

Profile

Assigned Applications

Search...

Application

Assignment & App Username

01101110

01101111

01110100

01100000

01101001

01101110

01100111

No apps assigned to this user.

8FMail

https://mail.google.com/mail/u/1/#inbox

Workflow Complete

©2024 Okta, Inc.

Privacy

Status site

OK12 Cell (US)

Version 2024.01.2 C

Download Okta Plugin

Feedback

FIG. 14A

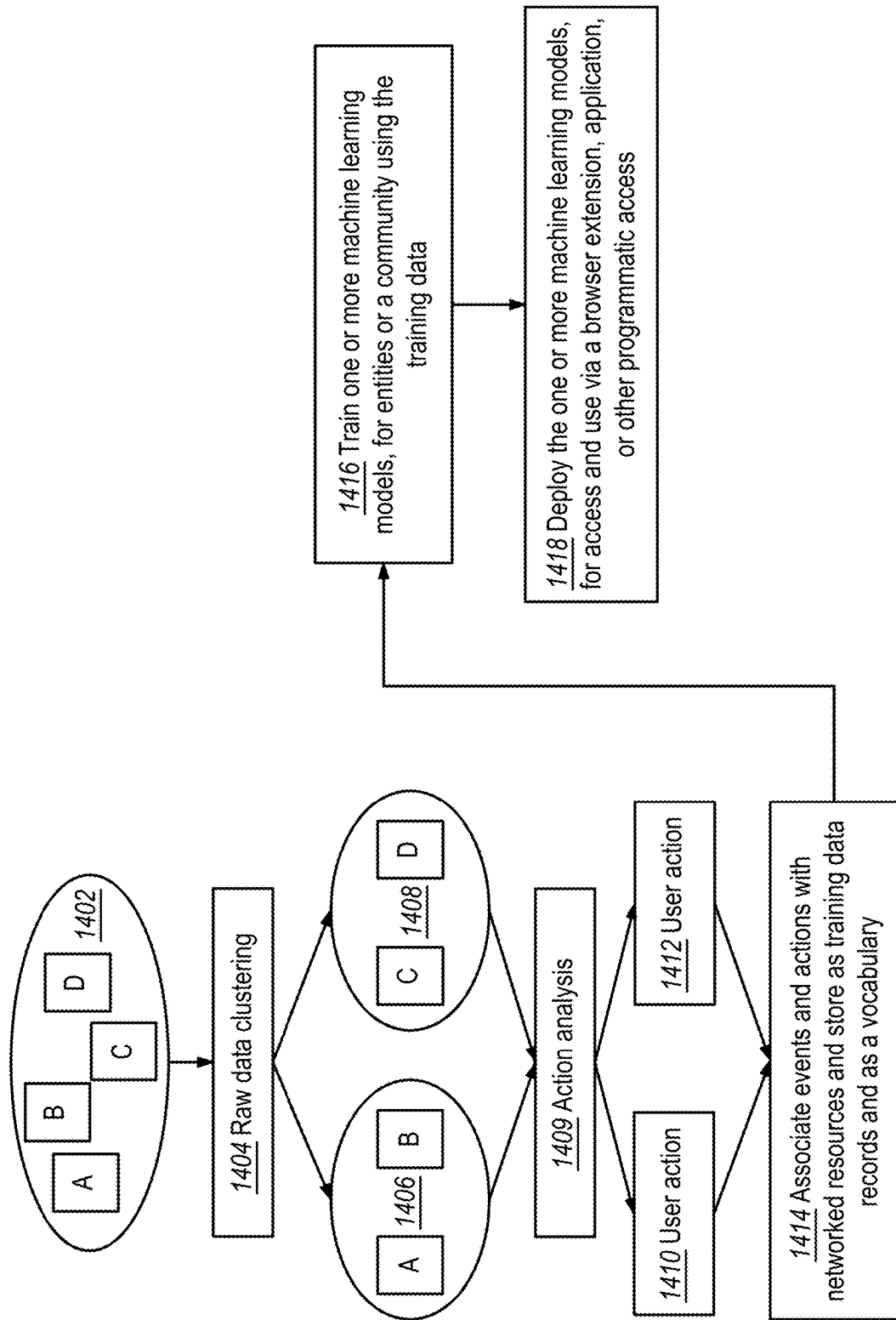


FIG. 14B

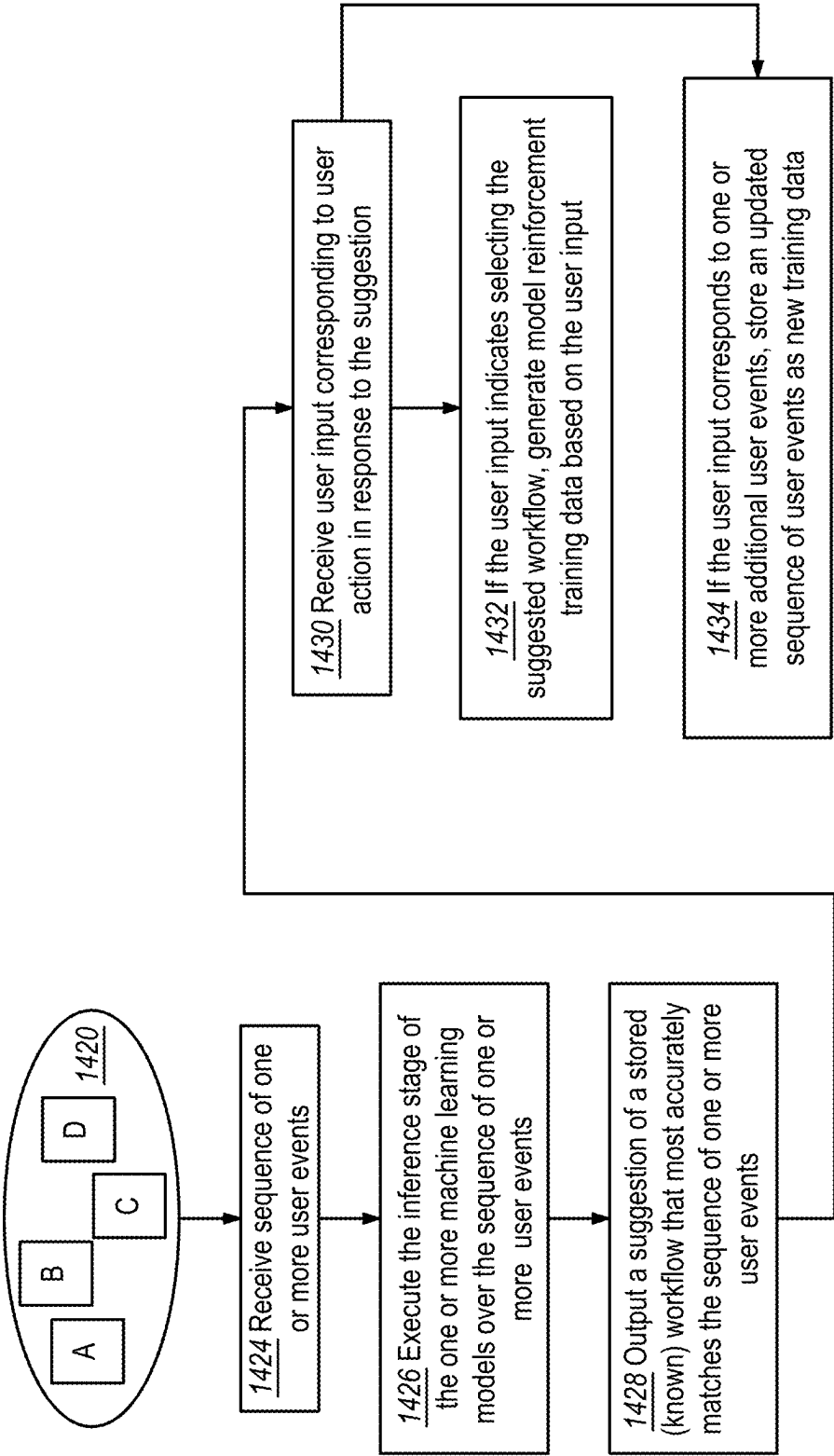
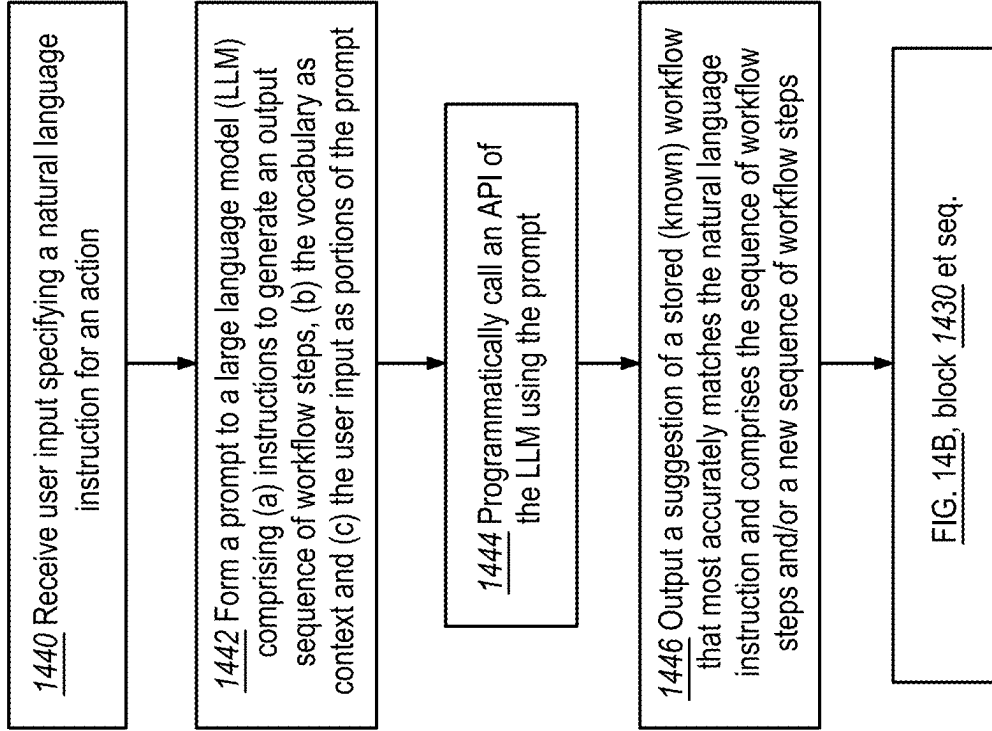


FIG. 14C



MACHINE LEARNING AUTOMATION OF NETWORK RESOURCE WORKFLOWS

BENEFIT CLAIM

[0001] This application claims the benefit under 35 U.S.C. § 120 as a continuation of application Ser. No. 18/679,518, filed May 31, 2024, which claims the benefit under 35 U.S.C. 119(e) of provisional application 63/470,383, filed Jun. 1, 2023, the entire contents of which are hereby incorporated by reference for all purposes as if fully set forth herein.

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TECHNICAL FIELD

[0003] The present disclosure covers artificial intelligence and machine learning models as applied to workflow automation. It also covers software-implemented methods of automating the submission of requests to networked resources.

BACKGROUND

[0004] The approaches described in this section are approaches that could be pursued but not necessarily approaches that have been previously conceived or pursued. Therefore, unless otherwise indicated, it should not be assumed that any of the approaches described in this section qualify as prior art merely by their inclusion in this section. [0005] Knowledge workers such as customer support agents often work across a group of software applications all day, every day, to get work done. For example, in response to a phone call or chat session in which a customer communicates a question or request to an agent, the agent may start working with a request ticketing system, switch to one or more websites or web-based applications to view information, click on functions and thus submit uniform resource locators (URLs) to websites or web-based applications, and return to the ticketing system to close the request. Support is a world of many applications, tabs, workflows, and data transfers. During these actions, to accomplish a sub-task to close a ticket, agents may repeatedly select the same websites, web applications, or types of information. Over time, agents may interact with many customers, callers, or other requesters, each of whom is requesting assistance with transactions having different details concerning products, services, prices, and dates. However, resolving requests for all such customers still requires the repeated use of the same websites or web applications in a routinized manner, while selected transaction details differ.

[0006] For example, handling an order return has been observed to require 50 or more clicks or selections of information across different systems. Assume an agent is assigned a case in a ticketing system to process an order return. The ticketing system could be Zendesk or another. To initiate the return, the agent must copy three fields from the ticket: customer name, email, and order number—seven

clicks. The agent must open the ordering system and find the order by pasting the order number. The agent might verify the customer's name and contact information and initiate a return on the order. The agent then needs to copy the return address, customer name, and customer address—perhaps 18 clicks. The agent then must open a shipping system like FedEx, UPS, or USPS to obtain a shipping label. For this, the agent inputs the return address, customer name, and customer address, receives the shipping label, and must copy the shipping confirmation code—requiring 15 clicks. The agent must return to the ordering system and paste the shipping confirmation code to confirm the return and initiate a backend return workflow—5 clicks. The agent then must return to the ticketing system and attach the shipping label, generating an email with the shipping label to send to the user—7 clicks. These repeated flows of clicks, network accesses, or other web interactions are inefficient, time-consuming, slow, and not a good use of human time.

[0007] Based on the foregoing, the referenced technical fields have developed an acute need for better ways to implement computer learning of online workflows so that the machine knows what to do next and the agents guide the machine learning to improve.

SUMMARY

[0008] The appended claims may serve as a summary of the invention.

BRIEF DESCRIPTION OF THE DRAWINGS

[0009] In the drawings:

[0010] FIG. 1 illustrates a distributed computer system showing the context of use and principal functional elements with which one embodiment could be implemented.

[0011] FIG. 2 illustrates a computer system with which one embodiment could be implemented.

[0012] FIG. 3 illustrates a set of software applications with which an embodiment can interoperate.

[0013] FIG. 4 illustrates a process of installing and executing a workflow automation program.

[0014] FIG. 5 illustrates a process of executing an inference stage of a machine learning model to predict a sequence of operations for execution using web-based applications.

[0015] FIG. 6 illustrates four example user workflows involving interactions with and transfers of data between multiple different web-based applications.

[0016] FIG. 7A illustrates a program flow of one embodiment of creating and storing data useful in workflow automations and training machine learning models.

[0017] FIG. 7B illustrates a program flow of one embodiment of training a machine learning model and executing the inference stage of the machine learning model.

[0018] FIG. 7C illustrates a sequence of user actions corresponding to multiple sub-tasks in multiple web-based applications that can be captured as a single automation in training data to train a machine learning model.

[0019] FIG. 8A illustrates examples of an extension panel, a relay panel, and a suggested flows panel that a browser extension may be programmed to generate and display over a web page of a web-based application.

[0020] FIG. 8B illustrates an example of a graphical user interface of a web-based software application in association with an extension panel that implements aspects of the present disclosure.

[0021] FIG. 9 illustrates an example of initially creating pinned data associated with user action in an application.

[0022] FIG. 10A illustrates an example of a browser extension generating and displaying suggestions of pinned data for entry in fields of a web-based application.

[0023] FIG. 10B illustrates an example of a browser extension generating and displaying suggestions of pinned data for entry in fields of a web-based application different from that of FIG. 10A.

[0024] FIG. 10C illustrates another GUI with the extension panel and an automatic data update in the extension panel.

[0025] FIG. 11 illustrates the GUI of FIG. 8B and FIG. 9 with updates to the extension panel and a reply from the agent.

[0026] FIG. 12 illustrates the GUI of FIG. 11 after the agent has sent the reply message to the customer.

[0027] FIG. 13A, FIG. 13B, FIG. 13C, and FIG. 13D illustrate examples of graphical user interfaces that can be used in another embodiment.

[0028] FIG. 14A, FIG. 14B, and FIG. 14C illustrate examples of programmed processes, of one embodiment, to train and use machine-learning models to automatically learn workflows in web-based applications from user events, and to generate suggestions of workflows in response to sequences of user events or natural language input.

DETAILED DESCRIPTION

[0029] In the following description, for the purposes of explanation, numerous specific details are set forth to provide a thorough understanding of the present invention. It will be apparent, however, that the present invention may be practiced without these specific details. In other instances, well-known structures and devices are shown in block diagram form to avoid unnecessarily obscuring the present invention.

[0030] The text of this disclosure, in combination with the drawing figures, is intended to state in prose the algorithms that are necessary to program the computer to implement the claimed inventions at the same level of detail that is used by people of skill in the arts to which this disclosure pertains to communicate with one another concerning functions to be programmed, inputs, transformations, outputs and other aspects of programming. That is, the level of detail outlined in this disclosure is the same level of detail that persons of skill in the art normally use to communicate with one another to express algorithms to be programmed or the structure and function of programs to implement the inventions claimed herein.

[0031] This disclosure may describe one or more different inventions, with alternative embodiments to illustrate examples. Other embodiments may be utilized, and structural, logical, software, electrical, and other changes may be made without departing from the scope of the particular inventions. Various modifications and alterations are possible and expected. Some features of one or more of the inventions may be described concerning one or more particular embodiments or drawing figures, but such features are not limited to usage in the one or more particular embodiments or figures for which they are described. Thus, the present disclosure is neither a literal description of all embodiments of one or more inventions nor a listing of features of one or more of the inventions that must be present in all embodiments.

[0032] Headings of sections and the title are provided for convenience but are not intended to limit the disclosure in any way or as a basis for interpreting the claims. Devices that are described as in communication with each other need not be in continuous communication with each other unless expressly specified otherwise. In addition, devices that communicate with each other may communicate directly or indirectly through one or more intermediaries, logical or physical.

[0033] A description of an embodiment with several components in communication with one other does not imply that all such components are required. Optional components may be described to illustrate a variety of possible embodiments and to fully illustrate one or more aspects of the inventions. Similarly, although process steps, method steps, algorithms, or the like may be described in sequential order, such processes, methods, and algorithms may generally be configured to work in different orders unless specifically stated to the contrary. Any sequence or order of steps described in this disclosure is not a required sequence or order. The steps of the described processes may be performed in any order practical. Further, some steps may be performed simultaneously. The illustration of a process in a drawing does not exclude variations and modifications, does not imply that the process or any of its steps are necessary to one or more of the invention(s), and does not imply that the illustrated process is preferred. The steps may be described once per embodiment but need not occur only once. Some steps may be omitted in some embodiments or occurrences, or some steps may be executed more than once in a given embodiment or occurrence. When a single device or article is described, more than one device or article may be used in place of a single device or article. Where more than one device or article is described, a single device or article may be used instead of more than one device or article.

[0034] The functionality or features of a device may be alternatively embodied by one or more other devices that are not explicitly described as having such functionality or features. Thus, other embodiments of one or more inventions need not include the device itself. Techniques and mechanisms described or referenced herein will sometimes be described in singular form for clarity. However, it should be noted that particular embodiments include multiple iterations of a technique or multiple manifestations of a mechanism unless noted otherwise. Process descriptions or blocks in figures should be understood as representing modules, segments, or portions of code that include one or more executable instructions for implementing specific logical functions or steps in the process. Alternate implementations are included within the scope of embodiments of the present invention in which, for example, functions may be executed out of order from that shown or discussed, including substantially concurrently or in reverse order, depending on the functionality involved.

1. General Overview

[0035] In one embodiment, one or more machine learning models are trained and programmed to support the automated creation and transmission of network requests to networked resources, such as the automatic submission of uniform resource locators (URLs) to websites or web-based applications, based on observing network traffic between an agent and one or more network resources and predicting

sequences of network requests that represent repetitive workflows that are likely to be reused for different requesters with different transaction details. For example, in a customer service representative application, the disclosed technologies can observe network traffic representing repeated similar workflows of an agent with a ticketing system and one or more networked resources such as websites and use the observed data to train a machine learning model. The trained model then can execute an inference stage to predict workflows that the agent is likely to need or use again for different requesters who are associated with different transaction details. Predicted workflows associated with high confidence values can be digitally stored in a database, as associations of data termed automations, then replayed on demand when a similar request occurs. When an automation is replayed, the system automatically transmits URLs or other networked requests to third-party applications, systems, or services to execute the tasks that had been observed in the training stage for customer- or request-specific transactions or data. In this manner, the disclosed technology can determine, create, and store definitions of repetitive workflows that can be replayed automatically, with or without guidance from the agent, to automate the repetitive workflows using customer- or request-specific transaction details or data. Model training can be based on data collected from thousands of agents working on thousands of instances of web applications, producing millions of operational events in the database. Model training or re-training also can be based on comparing manual actions that agents perform to predicted actions output from the model and determining a degree of accuracy of the output predictions.

[0036] An embodiment can be viewed as managing a digital agent's clipboard supported with AI-based automations. The support agent has access to data for a ticket via an extension panel across all the tabs of their browser, with the extension panel continuously visible and superimposed over web pages of any tab. Thus, the agent never must return to the ticketing system to obtain data or perform basic actions. An embodiment executes to pin data from key fields to a ticket record, visually exposed in the extension panel, enabling the same data to be selected and applied to fields across systems. Embodiments also allow agents to pin fields across systems. The AI model learns the agent's behavior and suggests editable shortcuts. Workflows can be saved for powerful automations that can be used repeatedly.

[0037] Embodiments can be implemented in phases, stages, or multiple federated applications. For example, the first implementation phase can comprise agent automation and data. Agents use software programmed according to embodiments which learns their workflows and offers helpful automations. Managers and executives can access a powerful analytics suite with invaluable data across agent workflows. For example, analytics reports based on the data collected in embodiments can answer questions such as: How often are agents copying and pasting out of each system? How many tabs does each agent have open on average? Why is Agent A closing tickets faster than Agent B? How much time does each agent spend on each application? What are the top fields used in each system? Which agent's workflow is the right one? How do hardware or network speeds affect agent performance?

[0038] In this context, agents may work in dozens of software applications all day to complete work. A manager can call, email, or text team members to complete a task, but

an individual contributor is always X number of clicks away from completing work. Therefore, such individuals should be able to instruct a computing system what to do without needing to click, copy, and paste as frequently as in past approaches.

[0039] The disclosed embodiments can also enhance workflow visibility by making records of one user's relays and automations visible to multiple other users to evaluate efficiency or adherence to policies. In this manner, embodiments can help management identify non-compliant agent actions that may implicate losses or increased costs of a service business. Embodiments also promote the reduced use of computing resources and computing time by enabling the standardization of workflows based on objective data about what operations agents conduct and how they transfer data between systems. Agent training can be improved because managers acquire the right data to support agent improvements and can correct issues about which they were previously unaware, as embodiments can provide more accurate data points for coaching. Agents can find focus difficult when many tabs are open and extensive copy and paste is required to complete a ticket. Slower processes can frustrate customers, and manual data transfers are more prone to error.

[0040] In one embodiment, a browser extension passively observes and collects data representing user events such as mouse clicks, tab selections, or other online activity in web-based applications, which later can be used to extract valuable insights about the agent's use of the application. In this context, for any embodiment described in this disclosure, the term "browser extension" refers broadly to a browser extension program, a browser plug-in, an application program that is hosted on an agent computer or user computer, or a browser that is natively programmed to, or executing browser-executable code programmed to, execute one or more programmatic calls to an application programming interface of a workflow automation application.

[0041] In an embodiment, an AI engine, as further described, can be programmed to combine data representing user behavior with task-mining processes to predict and optimize workflows while giving operational efficiency insights. Workflow analysis enables understanding how agents resolve similar tickets differently, enabling optimization of resolution paths for computing resource efficiency and/or other different outcomes. Analyzing process differences between top and bottom-performing agents enables the constant optimization of team performance. Secure and correct processes can be determined based on granular process mining and data analysis to enhance data loss prevention and provide integration points and insights.

[0042] From the perspective of an agent using an agent computer, as further described, the machine learning models and artificial intelligence support of embodiments appear as a personal assistant that learns continuously from the agent's inputs, signals, use, and behavior interacting with online applications, becoming more effective over time. In an embodiment, the machine learning model is trained based on all data from all agents of an organization to enable different agents of the same organization to benefit from all usage of all agents. Specific programmed AI/ML functions can include:

[0043] Smart data—suggests data based on ticket type and ongoing usage.

[0044] Relays—Creates shortcuts and automations after observation of user behavior.

[0045] Form filling—Auto fills multiple text fields contextually based on URL values.

[0046] Advanced workflows—Stringing together multiple relays for an advanced sequence.

[0047] Text autocomplete—Analyzing all free-text comments of individuals and teams to complete responses.

[0048] Knowledge base suggestions—Cross-system knowledge base suggestions based on ticket type and previously used articles.

[0049] Embodiments of the disclosure encompass the subject matter of the following numbered clauses:

[0050] 1. A workflow automation computer system comprising: one or more hardware processors; one or more network interfaces that are communicatively coupled to one or more internetworks and capable of network communication with a browser extension hosted on an agent computer, a relational database system, and a support ticket system; and one or more non-transitory computer-readable storage media coupled to the one or more hardware processors and storing: one or more trained machine learning models; and one or more sequences of instructions which, when executed using one or more processors, cause the one or more processors to execute: receiving, from the browser extension, one or more browser event objects, extracting attribute values from the one or more browser event objects, and storing, in the relational database system, the one or more browser event objects and attribute values as one or more events of user action time series records; creating and storing in memory multiple trees having a depth=2, each of the trees comprising a plurality of nodes corresponding to browser event objects and a plurality of edges that connect the nodes to one or more child event nodes while recording identifiers of source events for copy-type events; for a particular child event node that represents browser event objects corresponding to pasting or form-filling data, identifying an existing tree among the trees having a corresponding source node, and joining a root node of that existing tree to the particular child event node; grouping all trees rooted in navigation events identifying a particular hostname under a common root node that specifies a first navigation event; for the first navigation event having a second navigation event as a direct child node, deleting the second navigation event; deleting from the memory all the trees having the depth=2; and in response to determining that a final tree has >2 navigation events, creating and storing a relay based on the final tree.

[0051] 2. The workflow automation computer system of clause 1, further comprising sequences of instructions which, when executed using the one or more processors, cause the one or more processors to create and store the relay based on the final tree by executing a breadth-first traversal of the final tree, outputting a sequence of nodes as the traversal occurs, and storing an association of the identifiers of the nodes in the sequence as the relay.

[0052] 3. The workflow automation computer system of clause 2, further comprising sequences of instructions which, when executed using the one or more processors, cause the one or more processors to execute: receiving input from the agent computer specifying an invocation of the relay; and replaying the sequence of nodes of the relay to a browser hosted on the agent computer via the browser extension.

[0053] 4. The workflow automation computer system of clause 2, further comprising sequences of instructions which, when executed using the one or more processors, cause the one or more processors to execute: storing the association of the identifiers of the nodes in the sequence as a record in a training dataset in association with a copy of a corresponding user action time series record; training the machine learning model using the training dataset; during a new user session, storing a sequence of events based on the one or more browser event objects; executing an inference stage of the machine learning model over the sequence of events to output a predicted sequence of events corresponding to a predicted workflow of the user computer; and replaying the predicted sequence of events to a browser hosted on the agent computer via the browser extension.

[0054] 5. The workflow automation computer system of clause 4, further comprising sequences of instructions which, when executed using the one or more processors, cause the one or more processors to repeat the execution of the sequences of instructions corresponding to functions of clause 1 for 1,000 or more user sessions to store 1,000 or more records in the training dataset.

[0055] 6. The workflow automation computer system of clause 5, further comprising sequences of instructions which, when executed using the one or more processors, cause the one or more processors to store the sequence of events based on the one or more browser event objects by repeating the execution of receiving, from the browser extension, the one or more browser event objects.

[0056] 7. The workflow automation computer system of clause 1, further comprising sequences of instructions which, when executed using the one or more processors, cause the one or more processors to execute receiving, from the browser extension, the one or more browser event objects, and extracting the attribute values in part by the browser extension calling a browser event API of a browser hosted on the agent computer.

[0057] 8. The workflow automation computer system of clause 1, further comprising sequences of instructions which, when executed using the one or more processors, cause the one or more processors to execute: receiving input from the agent computer specifying an invocation of the relay; and replaying the relay to a browser hosted on the agent computer via the browser extension.

[0058] 9. The workflow automation computer system of clause 1, each of the trees comprising a navigate event node with one or more edges directed to one or more child event nodes.

[0059] 10. The workflow automation computer system of clause 1, further comprising sequences of instructions which, when executed using the one or more processors, cause the one or more processors to execute adjusting pointers of the first navigation event and any child nodes of the second navigation event.

[0060] 11. One or more non-transitory computer-readable storage media storing one or more trained machine learning models and one or more sequences of instructions which, when executed using one or more processors, the one or more processors being are communicatively coupled to one or more network interfaces that are communicatively coupled to one or more internetworks and capable of network communication with a browser extension hosted on an agent computer, a relational database system, and a support ticket system, cause the one or more processors to execute:

receiving, from the browser extension, one or more browser event objects, extracting attribute values from the one or more browser event objects, and storing, in the relational database system, the one or more browser event objects and attribute values as one or more events of user action time series records; creating and storing in memory multiple trees having a depth=2, each of the trees comprising a plurality of nodes corresponding to browser event objects and a plurality of edges that connect the nodes to one or more child event nodes while recording identifiers of source events for copy-type events; for a particular child event node that represents browser event objects corresponding to pasting or form-filling data, identifying an existing tree among the trees having a corresponding source node, and joining a root node of that existing tree to the particular child event node; grouping all trees rooted in navigation events identifying a particular hostname under a common root node that specifies a first navigation event; for the first navigation event having a second navigation event as a direct child node, deleting the second navigation event; deleting from the memory all the trees having the depth=2; and in response to determining that a final tree has >2 navigation events, creating and storing a relay based on the final tree.

[0061] 12. The one or more non-transitory computer-readable storage media of clause 11, further comprising sequences of instructions which, when executed using the one or more processors, cause the one or more processors to create and store the relay based on the final tree by executing a breadth-first traversal of the final tree, outputting a sequence of nodes as the traversal occurs, and storing an association of the identifiers of the nodes in the sequence as the relay.

[0062] 13. The one or more non-transitory computer-readable storage media of clause 12, further comprising sequences of instructions which, when executed using the one or more processors, cause the one or more processors to execute: receiving input from the agent computer specifying an invocation of the relay; and replaying the sequence of nodes of the relay to a browser hosted on the agent computer via the browser extension.

[0063] 14. The one or more non-transitory computer-readable storage media of clause 12, further comprising sequences of instructions which, when executed using the one or more processors, cause the one or more processors to execute: storing the association of the identifiers of the nodes in the sequence as a record in a training dataset in association with a copy of a corresponding user action time series record; training the machine learning model using the training dataset; during a new user session, storing a sequence of events based on the one or more browser event objects; executing an inference stage of the machine learning model over the sequence of events to output a predicted sequence of events corresponding to a predicted workflow of the user computer; and replaying the predicted sequence of events to a browser hosted on the agent computer via the browser extension.

[0064] 15. The one or more non-transitory computer-readable storage media of clause 14, further comprising sequences of instructions which, when executed using the one or more processors, cause the one or more processors to repeat the execution of the sequences of instructions corresponding to functions of clause 11 for 1,000 or more user sessions to store 1,000 or more records in the training dataset.

[0065] 16. The one or more non-transitory computer-readable storage media of clause 15, further comprising sequences of instructions which, when executed using the one or more processors, cause the one or more processors to store the sequence of events based on the one or more browser event objects by repeating the execution of receiving, from the browser extension, the one or more browser event objects.

[0066] 17. The one or more non-transitory computer-readable storage media of clause 11, further comprising sequences of instructions which, when executed using the one or more processors, cause the one or more processors to execute receiving, from the browser extension, the one or more browser event objects, and extracting the attribute values in part by the browser extension calling a browser event API of a browser hosted on the agent computer.

[0067] 18. The one or more non-transitory computer-readable storage media of clause 11, further comprising sequences of instructions which, when executed using the one or more processors, cause the one or more processors to execute: receiving input from the agent computer specifying an invocation of the relay; and replaying the relay to a browser hosted on the agent computer via the browser extension.

[0068] 19. The one or more non-transitory computer-readable storage media of clause 11, each of the trees comprising a navigate event node with one or more edges directed to one or more child event nodes.

[0069] 20. The one or more non-transitory computer-readable storage media of clause 11, further comprising sequences of instructions which, when executed using the one or more processors, cause the one or more processors to execute adjusting pointers of the first navigation event and any child nodes of the second navigation event.

1.1 Distributed Computer System Example

[0070] FIG. 1 illustrates a distributed computer system showing the context of use and principal functional elements with which one embodiment could be implemented. In an embodiment, the computer system comprises components that are implemented at least partially by hardware at one or more computing devices, such as one or more hardware processors executing stored program instructions stored in one or more memories for performing the functions that are described herein. In other words, all functions described herein are intended to indicate operations that are performed using programming in a special-purpose computer or general-purpose computer in various embodiments. FIG. 1 illustrates only one of many possible arrangements of components configured to execute the programming described herein. Other arrangements may include fewer or different components, and the division of work between the components may vary depending on the arrangement.

[0071] FIG. 1, and the other drawing figures and all of the description and claims in this disclosure, are intended to present, disclose, and claim a technical system and technical methods in which specially programmed computers, using a special-purpose distributed computer system design, execute functions that have not been available before to provide a practical application of computing technology to the problem of computer-implemented automation of workflows associated with networked resources. In this manner, the disclosure presents a technical solution to a technical problem, and any interpretation of the disclosure or claims

to cover any judicial exception to patent eligibility, such as an abstract idea, mental process, method of organizing human activity, or mathematical algorithm, has no support in this disclosure and is erroneous.

[0072] An embodiment's infrastructure can follow the following general design and operating principles. It interacts with external data, user interactions, and user events and data. Concerning external data, an embodiment can be programmed to connect to one or more external systems to present meaningful data to an agent. These operations can use existing browser tokens, normalize data received from APIs of external systems, and poll the external systems regularly to maintain updated data. Concerning user interactions, an embodiment maintains UI components the user can access across web tabs. An extension panel, autofill menu or suggestion panel, and on-page interactions support automatically tracking and entering data across systems. Smart pins of key data, relays, and other automations support similar operations. Concerning user events and data, an embodiment is programmed to gather data that can yield operational insights as users solve tickets. Embodiments capture copy, paste, and tab changes as events. The event data can be mined to derive relays and automations. The data can be used to generate an executive report.

[0073] Embodiments can also be programmed to support data security principles. Embodiments characterize data in three ways: customer data, metadata, and user behavior data. Customer data comprises content within business applications and stays local to an agent's computer. Metadata comprises structural, operational, and workflow data from websites and systems and feeds into the AI core of the system. User behavior data describes how users interact with systems and optimize individually and collectively for future workflows.

[0074] In the example of FIG. 1, one or more user computers **102** and agent computers **110** are communicatively coupled, directly or indirectly, to a data communication network **106**. Each user computer **102** and agent computer **110** can comprise a desktop computer, laptop computer, tablet computer, or another mobile computing device in various embodiments. For purposes of illustrating a clear example, FIG. 1 shows one user computer **102** and one agent computer **110**, but other embodiments can support any number of such computers by changing the processing power of server-side elements.

[0075] Typically, the user computer **102** is associated with a consumer, customer, or another individual undertaking a transaction with a networked resource, including but not limited to a merchant website **108**. The user computer **102** hosts or executes one or more application programs, including but not limited to a web browser by which the user computer **102** interacts with the merchant website **108** or a web-based application of the merchant website. For purposes of illustrating a clear example, a single merchant website **108** is shown, but other embodiments can comprise any number of networked resources like the merchant website. The merchant website **108** can comprise any system by which the user computer **102** can read information, view products and services, and/or purchase or order products or services. The merchant can offer or supply goods or services in any field, including consumer goods, travel, music and entertainment, industrial products, or other commodities. While the label "merchant" is used to illustrate one clear example, the merchant website **108** could also be a website,

web application, or web server associated with a government agency, educational institution, nonprofit enterprise, or other entity or enterprise.

[0076] Agent computer **110** typically is associated with a customer service representative (CSR), customer service agent, or other agent or representative whose role is to assist users of the user computer **102** in creating, reading, updating, or deleting one or more transactions associated with the merchant website **108**. Each agent computer **110** hosts or executes a web browser **114** and a browser extension **116**, the functions of which are further described in other sections herein. The agent computer **110** can download the browser extension **116** from an app store, from the workflow automation computer **120**, or another networked server.

[0077] A support ticket system **130** is communicatively coupled to network **106** and to ticket database **132**. The support ticket system **130** can comprise any support ticket system or ticketing system that is commercially available at the time of this writing. Examples include ZENDESK and SERVICENOW. The support ticket system **130** comprises a web-based application that the agent computer **110** can access and use via browser **114**. The ticket database **132** stores many database records for issues, customer requests, tickets, and related data.

[0078] In an embodiment, a workflow automation computer **120** is communicatively coupled to network **106** and hosts and executes a workflow automation application **122**, which is programmed to execute the features and functions that are described in the supplemental specification and certain other sections herein. The workflow automation application **122** is compatible with the browser extension **116** and can establish a network connection to the browser extension. In an embodiment, as the agent computer **110** is interacting with the support ticket system **130**, the merchant website **108**, and zero or more other networked resources, the browser extension **116** observes network traffic between the agent computer and other computers, captures signals representing the network traffic, and stores the signals or data derived from or based on the signals in the database **128**. Traffic typically comprises URLs, data entered in fields or forms, form submission actions, selections of functions or options, or any other signal that the agent computer **110** can communicate or submit to the other computers shown in FIG. 1.

[0079] Further, the workflow automation application **122** is programmed to transmit data and presentation instructions to the browser extension **116** to cause the browser extension to create and display one or more windows, panels, or other graphical user interface (GUI) elements near, on, or over a conventional browser window of the browser **114**. For example, as the agent computer **110** browses pages of the support ticket system **130** and/or the merchant website **108**, the browser extension **116** is programmed to receive data from the workflow automation application **122** and present the data in one or more one or more windows, panels, or other GUI elements near, on, or over a window of the browser **114**.

[0080] The workflow automation computer **120** also hosts, trains, and executes the inference stage of one or more machine learning models **124**. In one embodiment, the workflow automation computer **120** and database **128** are programmed using multi-tenant techniques to support multiple independent enterprises or entities with segregated data storage. In such an embodiment, the workflow automation

computer 120 can train and use a different ML model for each entity, with training data collected from all agent computers 110 of all agents associated with that entity. For example, event data is stored in training datasets with attribute values specifying the tenant, entity, or instance active in the web-based application at the time that an event occurred, and used for training machine learning models. Importantly, tracking and using these attributes enables training models that are customized to particular tenants or instances, while still leveraging community-wide data. Thus, as further described in other sections, when workflow automation computer 120 detects a partial or complete sequence of user events, the system can determine a suggestion of a workflow corresponding to those event based on community data for similar events, even if the current user's instance is different than all other instances for which the other similar events were collected. Therefore, even if the system has not learned a user action corresponding to a sequence of events for the current particular instance of the user, the system can suggest an action or workflow corresponding to the user's events based on knowledge derived from other event sequences of other instances.

[0081] In an embodiment, the workflow automation application 122 is programmed to create and store workflow training data in a workflow automation database 128 coupled with the workflow automation computer 120. The training data comprises records of interactions of the agent computer 110 with the merchant website 108 and/or the support ticket system 130, which, taken together, represent a workflow of the agent computer to access a support ticket, act on the support ticket, and close the support ticket.

[0082] In an embodiment, the workflow automation application 122 is programmed to create and store a plurality of automations 126 in the workflow automation database 128. Each of the automations 126 comprises a set of data and instructions describing or representing an observed workflow that can be replayed or repeated automatically. Each of the automations 126 can be created, in one embodiment, by accumulating a large quantity of the training data and then executing the inference stage of the machine learning model 124 to output predictions of a sequence of operations that are likely to represent a workflow, with a confidence value. If the confidence value is greater than a threshold value specified in a programmed constant or variable or a configuration file, then the sequence of operations can be stored in the workflow automation database 128 as a named or otherwise identified automation. The terms “flow” and “automation” are equivalent in this disclosure.

1.2 Primary Ticketing System

[0083] FIG. 3 illustrates a set of software applications with which an embodiment can interoperate. In one embodiment, the support ticket system 130 is communicatively coupled via one or more internetworks to multiple different networked servers, SaaS systems, and/or web application endpoints or APIs. Different embodiments can include one or more of the systems shown, as examples, in FIG. 3, including but not limited to one or more custom web apps 304, a knowledge management system 306, a chat system 308, an order management system 310, a customer relationship management (CRM) system 312, an access management system 314, an email system 316, and network and VPN servers or system 318. Each of the foregoing elements can be implemented in a different server computer, server pro-

cess, virtual computing instance, or networked endpoint. In an embodiment, the agent computer 110 may periodically visit any of the systems in FIG. 3 using browser 114 as part of processing a ticket originated in the support ticket system 130, gathering information, or distributing information.

1.3 Example Installation and Execution Process

[0084] FIG. 4 illustrates a process of installing and executing a workflow automation program. At block 402, an agent installs a plugin on a browser. In an embodiment, agent computer 110 uses browser 114 to access a copy of the browser extension 116 at a website or server computer and installs the browser extension 116 in association with browser 114. For example, the browser 114 can open a network connection to workflow automation computer 120 and access web pages served from the workflow automation application that enable accessing a download link for the browser extension 116. The workflow automation computer 120 can be programmed as a networked file server to serve copies of the browser extension 116 on demand in response to user input at agent computer 110 to select the link via the browser 114.

[0085] Block 404 represents the capability of workflow automation computer 120 to provide essential ticket data, sourced from the support ticket system 130, everywhere that an agent computer 110 executes with a compatible browser extension 116. Block 406 represents the capability of workflow automation computer 120 to intelligently task mine data in the support ticket system 130 to determine what tasks in other systems, such as the systems of FIG. 3, must occur to resolve or close tickets.

[0086] At block 408, in response to input from block 406 specifying one or more particular tasks, the workflow automation computer 120 is programmed to generate AI-based automations that can be replayed to execute the particular tasks in the systems of FIG. 3, merchant website 108 (FIG. 1), or other networked systems.

[0087] At block 410, during the execution of block 408, the workflow automation computer 120 is programmed to capture behavioral data representing mouse clicks, DOM element selections, copy or paste operations, and other machine interactions of the agent computer 110 with the merchant website 108 or the systems of FIG. 3. The behavioral data can be evaluated using an inference stage of a trained machine learning model to derive new automations.

[0088] FIG. 5 illustrates a process of executing an inference stage of a machine learning model to predict a sequence of operations for execution using web-based applications. In an embodiment, a support agent 502 uses agent computer 110, with browser 114 and browser extension 116 interacting with the workflow automation application 122, to form an input sequence of operations 504 with merchant website 108 or one or more of the systems of FIG. 3 that implements a task, such as “Can you create a FedEx shipping label for Jerry?” The workflow automation application 122 programmatically calls one of the machine learning models 124 to execute the inference stage over the input sequence. Sequence tokens 510 are routed to an encoder 512 and decoder 514, resulting in an output sequence 508 of tokens that express other operations to perform with merchant website 108 or one or more of the systems of FIG. 3. Output sequence 508 can be persistently stored in database 128 as one of the automations 126.

[0089] In this manner, system 100 can be used to persistently store in networked digital storage the automations 126 of many kinds, all capable of replaying using multiple different networked systems to automatically execute tasks in the systems.

[0090] FIG. 6 illustrates four example user workflows involving interactions with and data transfers between multiple web-based applications. To illustrate clear examples, FIG. 6 illustrates four examples of sequences of operations with merchant website 108 or one or more of the systems of FIG. 3 that implement different tasks. In an embodiment, most sequences begin when the support agent 502 or agent computer 110 interoperates with the support ticket system 130 to view a previously created ticket or task.

[0091] 1.3.1. For example, in the first sequence, at block 602, the agent is assigned a ticket specifying RETURN ORDER associated with a consumer's request to return an order of a tangible product or service. The commercially available ZENDESK system could be used at block 602, but other embodiments can interoperate with ticketing systems of other kinds, and using ZENDESK is not required.

[0092] At block 604, with the browser 114 communicatively coupled to ZENDESK as the support ticket system 130, the agent selects a set of data elements such as an order number, customer name, and customer email address. At block 606, the agent enters input to direct the browser 114 to connect to and open an order system, such as SHOPIFY. The agent signals the order system to transfer an order number and selects data such as a customer name, return address of a merchant, and customer address.

[0093] At block 608, the agent enters input to direct the browser 114 to connect to and open a shipping system, such as FEDEX and transfers the customer's name, return address, and customer address. The agent selects data such as a shipping confirmation code. At block 610, the agent opens the order system to transfer the shipping confirmation code to confirm the return. At block 612, the agent directs the browser 114 to return to the support ticket system 130 to attach a shipping label to the open ticket, which causes the support ticket system to automatically generate and dispatch an email message to the customer. At block 614, the ticket is closed.

[0094] 1.3.2. In a second sequence, at block 620, the agent computer 110 is assigned a ticket of the type NEED HELP INSTALLING. At block 622, browser 114 uses support ticket system 130 to select a part of a description from the ticket. At block 624, browser 114 opens a knowledge base and transfers part of the short description from the ticket, using it to find an article, and selects data from the article, such as a passage describing how to install an item and a URL of the article. At block 626, browser 114 opens the support ticket system 130 and transfers the installation passage and article URL to the ticket. At block 628, the ticket is closed.

[0095] 1.3.3. In a third sequence, at block 630, the agent computer 110 is assigned a ticket of the type CHANGE ADDRESS FOR RECENT ORDER. At block 632, the agent uses the browser 114 to select data such as an order number and new address from the ticket in the support ticket system 130. At block 634, browser 114 opens the order management system and transfers the order number. Input to browser 114 selects a shipping confirmation code from the order. At block 636, input to browser 114 causes the browser to connect to the shipping system, and agent 502 uses agent computer 110

to enter signals to transfer the shipping confirmation code. The agent finds the shipment and edits the details to transfer the new address. The agent selects a new arrival window, which the shipping system reports. At block 638, the agent directs browser 114 to the support ticket system 130 and transfers the shipping confirmation code and new arrival window to update the ticket. At block 639, the ticket is closed.

[0096] 1.3.4. In a fourth sequence, at block 640, the agent computer 110 is assigned a ticket of the type UNCLEAR WARNING MESSAGE. At block 642, the agent is unsure how to resolve the ticket, so the agent selects a ticket description in the support ticket system 130. At block 644, the browser 114 transfers the description into a ticket search field and provides input to select a search function. In response, the support ticket system 130 finds two similar cases with a knowledge base link attached to each of them. The browser 114 receives input to select one of the links. In response, browser 114 redirects to the knowledge base at block 646 and displays an article. Input via browser 114 selects data consisting of the text of a relevant passage and the article's URL. At block 648, browser 114 opens the support ticket system 130 and transfers the relevant passage and article URL to the ticket. At block 650, the ticket is closed.

2. Implementation Example—Forming Training Data for Machine Learning Models to Support Creating Automations

2.1 Process Flow

[0097] FIG. 7A illustrates a program flow of one embodiment of creating and storing data useful in workflow automations and training machine learning models. FIG. 7A presumes that a browser executes and that data collection instructions execute as a browser extension or application.

[0098] In an embodiment, the process of FIG. 7A is programmed at block 702 to call a browser event API to detect a new browser event object. The browser event object is associated with or results from a user interaction with an element of a web page of a SaaS application. Section 2.2 below identifies examples of browser events that can be captured by programming the browser extension 116 in one embodiment and the property values or attributes ("properties") that the browser extension detects and stores for specified types of events.

[0099] At block 704, the process is programmed to receive the browser event object. At block 706, the process is programmed to extract attribute values from the browser event object and store the attribute values as the next event of a user action time series record.

[0100] At block 708, the process is programmed to test whether the user session is complete. If the test of block 708 is FALSE or negative or the equivalent, then control transfers back to block 702 to repeat the subprocess of block 702, 704, 706, or other events of the user session. If the test of block 708 is TRUE or positive or the equivalent, control transfers to block 710. At block 710, the process is programmed to create and store multiple trees having a depth of two, each of the trees comprising a navigate event node with one or more edges directed to one or more child event nodes while recording identifiers of source events for copy-type events.

[0101] At block 712, the process is programmed, where a leaf event comprises pasting or form-filling data into a destination, finding an existing tree having a corresponding source node, and joining the root of that existing tree to the leaf event.

[0102] At block 714, the process is programmed to group all the trees rooted in navigation events that identify the same hostname under a common root node specifying the first such navigation event. At block 716, the process is programmed to execute when a first navigation event has a second navigation as a direct child node, deleting the second navigation event, adjusting pointers of the first navigation event, and adjusting pointers of the first navigation event and any child nodes of the second navigation event. At block 717, the process is programmed to delete trees with depth=2.

[0103] At block 718, the process is programmed to test whether the final tree has more than two navigation events. If the result of block 718 is NO, FALSE, negative, or the equivalent, then control transfers to block 724, at which point the process returns control to a calling process or terminates normally. Under the conditions that cause control to arrive at block 724, creating a stored automation sequence is not possible or useful. If the result of block 718 is YES, TRUE, positive, or the equivalent, then at block 720, the process is programmed to execute a breadth-first traversal of the final tree, output a sequence of nodes as the traversal occurs, and store a named association of identifiers of the nodes in the sequence as a relay or stored automation. In this context, a “relay” may refer to an association of digitally stored data specifying an action, a field, an application, and the next action or application. Examples of relays can include: Open Employee ID in Okta; Autofill from Pin Pad in FedEx; Attach Label PDF in Zendesk; Create Jira ticket from ServiceNow; Post Knowledge URL to Slack. A stored automation can combine relays as a named or specified set. An example of an automation is: Name: “Create a FedEx shipping label.” Relays: Access Zendesk ticket; access Shopify to find an address and copy the address; access FedEx to auto-fill the address and get a shipping label; access Zendesk to attach the shipping label and generate a response to the customer.

[0104] Thus, block 720 enables automatically creating and storing an automation sequence based on an observed, repeated sequence of user operations. Control then transfers to block 722, where the process is programmed to receive and respond to user input specifying an invocation of the relay or stored automation by replaying the sequence of nodes of the relay or stored automation to the browser. Block 722 can be executed at any time after block 720 and a separation in time from seconds to weeks is possible in different use cases.

[0105] Asynchronously, with or without executing block 722, the process is programmed to continue from block 720 at FIG. 7B. FIG. 7B illustrates a program flow of one embodiment of training a machine learning model and executing the inference stage of the machine learning model. In an embodiment, the process is programmed at block 730 to store the association of identifiers of the nodes in the sequence as a record in a training dataset, paired with a copy of a corresponding user action time series record.

[0106] At block 732, the process is programmed to repeat the execution of FIG. 7A and block 730 for 1,000 or more user sessions to store 1,000 or more records in the training dataset. The number 1,000 is provided as a lower bound to

indicate the model training contemplated by FIG. 7B is not practical to execute manually, in the human mind, or another non-automated manner. Other embodiments could execute training based on many more records of user sessions. At block 734, the process is programmed to train a machine-learning model using the training dataset.

[0107] At block 736, in a new session, the process is programmed to execute blocks 702, 704, and 706 of FIG. 7A, to store a sequence of events, denoted *e* for convenience or as shorthand. At block 738, the process is programmed to execute the inference stage of the trained machine-learning model over the sequence of *e* events to output a predicted sequence of events corresponding to a predicted workflow of the user. At block 740, the process is programmed to replace the predicted sequence of events in the browser.

[0108] In this manner, machine-learning techniques can be used to observe user action, store a large set of database records representing a training set, and train an ML model on the training data. Later, at runtime during another user session, the user execution of a set of operations can be used to infer other events or sequences that should occur next and to replay those events or sequences automatically. Consequently, a user of a software application can initiate only a few manual operations and then allow the machine to complete a workflow automatically, interacting via the browser with the same software application.

[0109] FIG. 7C illustrates a sequence of user actions corresponding to multiple sub-tasks in multiple web-based applications that can be captured as a single automation in training data to train a machine learning model. An example workflow 745 begins at block 750 at which an agent is assigned a case in a ticketing system to process an order return. To act on this case, the agent interacts with browser 114 of agent computer 110 (FIG. 1) to conduct a first set of operations 752, comprising copying a primary email address in a ZENDESK ticket, copying a name in Zendesk, copying an order number in Zendesk, and opening a page in a SHOPIFY application based on the primary email.

[0110] The agent then switches applications using the browser 114 and conducts a second set of operations 754, comprising copying an address from Shopify, which could include individual copy operations for street name, city, ZIP code, and phone number. The agent next directs the browser 114 to a FEDEX application and conducts a third set of operations 756, comprising auto filling an address and copying a tracking number that the FedEx application generates. The agent returns browser 114 to Shopify and Zendesk to conduct a fourth set of operations 758, including auto-filling the FedEx tracking number in Shopify and applying a macro in Zendesk. Finally, at operation 760, the agent attaches a shipping label PDF to the ticket in Zendesk and closes the ticket at operation 762.

[0111] The complete sequences of operations of workflow 745 require numerous mouse clicks and context switching between different applications. Embodiments of the present disclosure can capture all the operations that have been described for this example as a single automation, enabling it to be replayed via the browser 114 with all the different applications to move data more rapidly between the applications to complete a task or ticket. Furthermore, the techniques of the present disclosure can capture variations in the foregoing workflow. Thus, at different times, depending on

the nature of a ticket, an agent who is assigned a case in a ticketing system to process an order return could complete the task using a variation of the steps shown above. The techniques of the present disclosure can capture and automate each variation of the same general task by observing differences in web page navigation, UI element selection,

copy operations, paste operations, auto-fill operations, and so forth.

2.2 Example Event Objects

[0112] TABLE 1 illustrates examples of events that the system can be programmed to detect and act on.

TABLE 1		
illustrates examples of events that the system can be programmed to detect and act on.		
Event Name	Event Type	Objects and Properties
Click Event	Browser	Event Type, Common Properties, Current Tab Object properties, Element Metadata Object properties, Event Metadata Object properties, Button (a number that corresponds to buttons on a mouse or other pointing device), Coordinates including X, Y values for offsets, client, page, and screen, and Workstream Selectors
Copy Event. A copy is defined when a user uses command-C, right-click copy, or edit-copy. Copy from Collection URL. An event for when a URL is copied from a collection title.	Browser	Event Type, Common Properties, Current Tab Object properties, Element Metadata Object properties, Event Metadata Object properties, and Workstream Selectors
	Custom	Event Type, Common Properties including Collection ID, Collection Title, Collection URL, Current Tab Object properties, Element Metadata Object properties, Event Metadata Object properties
Copy From Pinpad Event	Custom	Event Type, Common Properties including Field Label and Field Source, Current Tab Object properties, Element Metadata Object properties, Event Metadata Object properties, and Workstream Selectors
Dropdown Event	Custom	Event Type, Common Properties Current Tab Object properties, Element Metadata Object properties, Event Metadata Object properties, Value (the value chosen in a dropdown menu)
Hotkey Event	Custom	Event Type, Common Properties including Collection ID, Collection Title, Collection URL, Current Tab Object properties, Element Metadata Object properties, Event Metadata Object properties, Source (“keystroke”), Meta values for key, keycode, shiftKey, ctrlKey, altKey, metaKey, shiftKey, and Workstream Selectors
Idle Event	Custom	
Keypress Event		
Paste Event. A paste is defined when a user uses command-V, right-click paste, menu-edit-paste.	Browser	Event Type, Common Properties, Current Tab Object properties, Element Metadata Object properties, Event Metadata Object properties, Workstream Selectors, Copy Source Object (details for the copy element source), Recorded Events (tracked events that immediately precede the paste), Source URL (URL of source of copy for this paste)
Radio Button Event	Custom	Event Type, Common Properties, Current Tab Object properties, Element Metadata Object properties, Event Metadata Object properties, Value (the value chosen via a radio button selection)
Relay Clicked	Custom	Event Type, Common Properties including Relay Type (suggested or side panel) and Order (visual order of relay on screen), Current Tab Object properties, Element Metadata Object properties, Event Metadata Object properties, Workstream Selectors
Scroll End Event	Browser	Event Type, Common Properties, Current Tab Object properties, Element Metadata Object properties, Event Metadata Object properties

TABLE 1-continued

illustrates examples of events that the system can be programmed to detect and act on.		
Event Name	Event Type	Objects and Properties
Select Double Dash	Custom	Event Type, Common Properties including Copy Source and Source URL, Current Tab Object properties, Element Metadata Object properties, Event Metadata Object properties
Switch App. An event for when the user switches to a non-browser app	Browser	Event Type, Common Properties, Current Tab Object
Tab Event. The event is captured when the user opens a new tab or clicks on an existing tab, or when the URL in a tab changes	Browser	Event Type, Common Properties, Current Tab Object
URL Navigation	Browser	Event Type, Common Properties including total number of tabs and total number of windows, Current Tab Object properties, Element Metadata Object properties, Event Metadata Object properties

2.3 Example Properties

[0113] In an embodiment, the default properties included on every event are: Active Ticket Id, Browser, Browser Version, Current Pinpad Id, Distinct Id, Domain, Event Type, Extension Version, Favicon URL, Field Id (Id of related pin), Instance, Nth-Child Selector, OS, Placeholder, Timestamp, UID, URL, and URL Host.

[0114] In an embodiment, the default event metadata properties, which are included when available from browser or DOM events, are: Meta Event Name, Source, Timestamp, Workstream Variables. One or more of the foregoing can be captured optionally.

[0115] In an embodiment, the properties obtained for a current tab object are: Active, Audible, Auto Discardable,

Discarded, Favicon URL, Group Id, Height, Highlighted, Id, Incognito, Index, Muted Info, Muted, Pinned, Selected, Status, Title, URL, Width, and Window Id.

[0116] In an embodiment, the default element metadata properties, which are included when available, are: auto-complete (“on” or “off”), class, label, id, placeholder, name, data-* properties, and any other attribute of the target element. Optionally, these properties can include fieldID (ID of a related pin), innerText, and label.

[0117] Workstream selectors can be captured as an array of selectors in priority or specificity order. These are available on events that have a “target” element.

[0118] TABLE 2 illustrates example event attributes, values, and descriptions of the attributes, for one embodiment; other embodiments can define different attributes of events.

TABLE 2

EXAMPLE EVENT ATTRIBUTES		
Attribute	Example Value	Description
active	true	Flag specifying whether this event is actively associated with one or more actions
activeTicketid	165	Ticket number of an issue tracking system with which this event is associated
audible	false	Flag specifying whether the event was audible
autoDiscardable	true	
currentPinpadID	165	Identifier of a pin pad of the system
currentTab: {attributes of a tab}		
distinctID	19ea9b7b-dfdf-4dfd-aa56-0d8a713d9f11	Unique system ID for the event

TABLE 2-continued

EXAMPLE EVENT ATTRIBUTES		
Attribute	Example Value	Description
eventType	click_event	Type of event
faviconUrl	https://ssl.gstatic.com/translate/favicon.ico	URL of an icon
groupID	-1	
height	1294	
highlighted	true	
id	1336308316	Page identifier of a web page of the application in which the event occurred
incognito	false	Flag specifying whether the event occurred in a private browsing session
index	1	
instance	dev-8flow	Instance of a system server that was running when the event occurred.
isPreplayEvent	false	
nthChildSelector	nth-child(2)>:nth-child(2)	
OS	Mac OS	User operating system
parsedURL	{URL, variables broken out}	JSON block specifying sub-attributes of a URL to enable associating events with tenants or instances of a multi-tenant web application, for example. Importantly, tracking and using these attributes enables training models that are customized to particular tenants or instances, while still leveraging community-wide data.
pinned	false	
selected	true	
source	mouse	Type of user action that produced the event
status	complete	
timestamp	2024-02-07T19:55:32.276Z	Date and time of the event
title	Ticket: need to return order 00000157	Title of a page in which the event occurred
uid	oCnBs9gkuXcrrUfBqBHK3Fyjef2	De-identified but unique identifier of a user machine or account
url	https://translate.google.com	URL at which the event occurred
urlHost	translate.google.com . . .	Host service associated with the event
version	1.11.74	Version of the processing system in use when the event occurred
width	1280	
windowID	1336308036	

3. Execution Example Using Graphical User Interface

[0119] FIG. 8A illustrates examples of an extension panel, a relay panel, and a suggested flows panel that the browser extension may be programmed to generate and display over a web page of a web-based application. In an embodiment, the browser extension 116 is programmed to generate and display one or more of the extension panels, relay panels, and suggested flows panels superimposed over a GUI or web page of a web-based application.

[0120] In an embodiment, an extension panel 820 comprises a ticket identifier 821, a description panel 822, and a dynamic, extensible pin pad 824 comprising a plurality of data panels 826, 828, 830, and 832. In an embodiment, description panel 822 displays metadata associated with a particular stored automation, such as a description, state, and task type. In the example, the description is “Can I please exchange this item?I received the wrong size.” The state is “Open,” and the task type is “Incident.” Other embodiments can use other specific data values. Embodiments can streamline how an agent moves between tabs; the browser extension 116 is programmed to always display the extension panel, allowing users to access key ticket information regardless of the web application they are viewing. Consequently, users do not need to reopen a ticketing application to obtain the information or perform standard actions to resolve a ticket.

[0121] As further described, the browser extension 116 is programmed to automatically pin key fields and field values to the extension panel 820 without user action. Embodiments can be programmed to update a machine learning model based on user action over time to effectively learn what the user pins and uses more often. Pinned fields and values can be collected and reused across systems or web applications without specific integration with those systems or applications. In an embodiment, each field shown in the extension panel 820 is an active hyperlink so that a browser tab from which the field came can be accessed just by clicking the field in the extension panel. In response, the browser extension 116 is programmed to cause the browser to change focus to the correct tab of the application associated with the field.

[0122] In an embodiment, a relay panel 840 comprises a title bar 842 having a search box 844, and a relay subpanel 848 that displays one or more previously defined relays 846. Each of the relays 846 comprises an automation that the browser extension 116 has learned, alone or in conjunction with the workflow automation application 122 and machine learning model 124 (FIG. 1). Each relay 846 comprises a stored association of actions, fields, and applications that can be selected to run a repetitive operation on behalf of the user. Consequently, user selection of a relay 846 can execute an action in a web application using a single click rather than the many to dozens of clicks of prior approaches, as noted in the Background section.

[0123] Over time, execution of the workflow automation application 122 and machine learning model 124 can instruct the browser extension 116 to create and store one or more flows based on the relays 846. Thus, each automation represented in a relay can become more advanced over time under programmatic control of an advanced, user-driven, AI-powered robotic process automation engine consisting of the workflow automation application 122 and machine learning model 124. By selecting a flow in the suggested

flow panel, the agent can allow the browser extension 116 to execute fully automated, complete workflows.

[0124] In an embodiment, a suggested flow panel 850 comprises a search box 852 and one or more flow rows 854 that identify flows. Each row 854 comprises a selection widget 856, a name 858, and a configuration widget 860. The selection widget 856 is programmed to receive input from the agent computer 110 specifying whether to use or activate a flow corresponding to the name 858. When a row is not selected, the selection widget 856 can be clicked to expand and show a flow description. The configuration widget 860 is programmed to receive input from the agent computer 110 to change the applications, fields, and/or actions of a flow. In an embodiment, the suggested flow panel 850 also comprises a CREATE FLOW or similarly named widget 859, which, when selected, initiates a dialog, wizard flow, or series of menus and panels to enable the agent computer 110 to manually define a flow.

[0125] In an embodiment, all the data visualized in the extension panel 820, relay panel 840, and suggested flow panel 850 corresponds to data digitally stored in rows of tables of a relational table schema of the database 128. For example, for the extension panel 820, the data shown in ticket identifier 821 can correspond to a row in a master ticket table, the description panel 822 can comprise attribute values of that row, and the pin pad 824 can correspond to a plurality of pointers in the same row to other rows in a data panel table that store the data for the plurality of data panels 826, 828, 830, and 832, where each of the data panels corresponds to a different row of the data panel table. Similarly, the relay panel 840 can be backed by a relay table in the database 128, where the relay table has a plurality of rows, each corresponding to one of the relays 846, and where those rows store attribute values identifying the actions, fields, and applications that comprise a relay. Further, a flow table in the database 128 can back the suggested flow panel 850, where each row in the flow table stores attribute values for row 854, such as a plurality of pointers to rows in the relay table. Thus, a flow corresponds to a stored association of a plurality of the relays 846 as previously described.

[0126] FIG. 8B illustrates an example of a graphical user interface of a web-based software application in association with an extension panel that implements aspects of the present disclosure. For purposes of illustrating a clear example, FIG. 8B shows a GUI 802 that has been generated via browser interaction with the commercially available ZENDESK application, but other embodiments can interoperate with other web-based or SaaS-based online applications that browsers can use. GUI 802 comprises a toolbar 804, a task panel 806, a chat panel 808, an interaction panel 810, and a SUBMIT button 812. Other applications may offer different visual or graphical panels, tools, or widgets.

[0127] In the example, the toolbar 804 comprises a plurality of vertically aligned buttons, links, or other widgets which, when selected using a pointing device, access main functions of the platform such as ticket management, user management, statistical data, and configuration functions. In an embodiment, task panel 806 identifies a particular request or ticket that has been assigned to a customer service representative or another user for action, with basic details about the requester, user accounts that are assigned to or following the ticket, tags specifying the nature of the ticket, ticket type, priority, and linked issues. In an embodiment,

chat panel **808** provides a workspace for conducting a live electronic chat dialog with a customer or other party that submitted a request or needs assistance. The chat panel **808** can be associated with a reply panel **809** that is programmed to receive a written reply from the agent or user who is interacting with the customer or requester. In an embodiment, interaction panel **810** comprises widgets, data, and selectable elements that are programmed for interacting with other representatives concerning the customer issue. The SUBMIT button **812** can be programmed to persistently save a record of the state of the ticket in a digital database.

[0128] In an embodiment, an extension panel **820** is visually displayed superimposed over and floating on the GUI **802**. Browser extension **116** (FIG. 1) generates and displays the extension panel **820** using browser functions or services. In an embodiment, browser extension **116** is programmed to display the extension panel **820** with a description panel **822** and a dynamic, extensible pin pad **824** comprising a plurality of data panels **826**, **828**, **830**, and **832**. In an embodiment, description panel **822** displays metadata associated with a particular stored automation, such as a description, state, and task type. In the example, the description is “Can I please exchange this item?I received the wrong size.” The state is “Open,” and the task type is “Incident.” Other embodiments can use other specific data values.

[0129] In an embodiment, the pin pad **824** is programmed to show, associate, and store together a plurality of data items that have been captured, copied, or pasted from different parts of a form or workflow that the GUI **802** or its underlying application exposes or provides. Each data panel **826**, **828**, **830**, **832** can have a different size or number of attributes and values and a different title. For example, data panel **826** is titled “Ticket #3” and specifies a requester, data panel **828** is titled “Jame Smith” and specifies an email address, data panel **830** is titled “Customer: Jane Smith” and contains address details for the customer, and data panel **832** is titled “Detailed Tracking” and contains a tracking number associated with a shipper application such as the online FEDEX application. Each data item in a data panel can represent a user interaction with a task or workflow within the GUI **802** that could be related, reused, or part of a sequence of events or actions associated with completing the task or workflow.

[0130] Thus, embodiments are programmed to streamline how an agent moves between tabs. The extension panel **820** is automatically displayed superimposed over web pages that the agent browses with a web browser, so the extension panel is omnipresent during the processing of a request or ticket. In an embodiment, key information associated with a ticket in an issue tracking or ticket management system is associated together and digitally stored in a ticket record in the database **128**. The extension panel **820** graphically displays or visualizes a ticket record and/or the key information associated with a ticket. Consequently, after browsing from the ticketing system to another application, the user never needs to reopen the ticketing system to copy information or perform the standard actions to resolve a ticket. Instead, the key information is associated with the ticket record and shown in the extension panel **820** as one or more pinned fields, values, attributes, or panels, and data can be selected from the extension panel and filled automatically into a field of another application.

[0131] In an embodiment, key fields are automatically visually pinned in the extension panel on behalf of the user

as the user interacts with the ticketing system. Embodiments are programmed to learn from agent interactions with the GUI of a SaaS application over time so that the fields adjust based on what the user pins and uses more often. Further, embodiments are programmed to suggest editable shortcuts driven by an AI-powered RPA engine. This automates steps in the workflow, such as “open Tracking ID in FedEx.” An automation can execute repetitive operations on behalf of the user to turn a multi-click process into one click. Workflows can be saved for powerful automations for reuse. The ticket can be resolved without returning to the ticketing system. Pins can be collected and reused across systems with no integrations needed. Also, fields and systems are hyperlinked, so tab navigation becomes seamless directly from the panel.

[0132] FIG. 9 illustrates an example of initially creating pinned data associated with user action in an application. GUI **802** has the same elements as shown in FIG. 9, and the extension panel **820** is displayed superimposed over the GUI. In this example, the assigned agent has recently begun processing a ticket in Zendesk. When the agent accesses the ticket in Zendesk by browsing a web page, the browser **114** automatically creates and stores a document object model (DOM) in the memory of agent computer **110** after downloading HTML for the web page and rendering the web page with GUI **802**. The browser extension **116** is programmed to detect data displayed on the screen by programmatically reading and traversing the DOM and to automatically instantiate and display the extension panel **820** based on data obtained from the DOM. For example, the browser extension **116** is programmed to automatically assign the name “Ticket #1” to data panel **902** of the extension panel **820** based on finding “Incident #1” in the DOM. In an embodiment, the attributes of the top-most data panel **902** of extension panel **820** correspond to a record of a ticket or automation in database **128** (FIG. 1). The browser extension **116** is also programmed to create and store a second data panel **904** with a description of the ticket, and to create and store a pin pad **824** in association with the ticket represented in data panel **902**. The extension panel **820** can also show one or more other data panels **906** that are automatically populated with attributes and values based on traversing the DOM.

[0133] FIG. 10A illustrates an example of a browser extension generating and displaying suggestions of pinned data for entry in fields of a web-based application. In an embodiment, the browser extension **116** is programmed to determine, for each web-based application that the browser **114** accesses, based on the DOM of each web page, one or more form fields or UI widgets of the web page that may correspond to data items in pinned data panels of the extension panel **820**. If a match is found, the browser extension **116** is programmed to generate and display a suggestion panel that identifies values that could be automatically entered in the form field or UI widget.

[0134] In the example of FIG. 10A, browser **114** has navigated to a web page of the Shopify online application, which has returned dynamic HTML that the browser has rendered as the web page **1000**. In an embodiment, the web page **1000** comprises a menu bar **1004**, a segment panel **1004**, a customer panel **1006**, and a search box **1008**. In an embodiment, the menu bar **1004** comprises a vertically arranged set of links, buttons, or other UI widgets that, when selected, cause the application to provide access to a respec-

tive plurality of different named functions or actions. The segment panel **1004** comprises a GUI widget for selecting a segment of customers for inspection and processing. Attributes of the selected segment can be displayed in the customer panel **1006**, and the search box **1008** can be displayed near table **1009**, showing one or more records of customers that are in the selection specified via the widget of the segment panel.

[0135] In the example, an email address **1010** can be entered in the search box **1008**. The browser extension **116** is programmed to determine from the DOM that the search box **1008** can receive an email address. In response, based on data panels of the extension panel **820** or other data in the database **128**, the browser extension **116** is programmed to generate and display a suggestion panel **1012** having one or more data panels **1014** corresponding to data panels of the extension panel. The effect of the suggestion panel **1012** is to display data available to the browser extension **116** that could be filled automatically into the search box **1008**. In an embodiment, the browser extension **116** chooses the value representing the best match of the available data to the DOM element corresponding to the search box **1008** and automatically fills in a value like the email address **1010**. In an embodiment, the suggestion panel **1012** is displayed just below or otherwise near the field corresponding to search box **1008**; screen position data can also be obtained programmatically from the DOM. With this arrangement, the agent can rapidly view values in the data panels **1014** of the suggestion panel **1012** and then click on one of the values to select that value. In response, the browser extension **116** is programmed to automatically fill the selected value in the field for search box **1008**.

[0136] FIG. 10B illustrates an example of a browser extension generating and displaying suggestions of pinned data for entry in fields of a web-based application different from that of FIG. 10A. In FIG. 10B, the browser **114** of agent computer **110** has navigated to and accessed the FedEx online application, which has returned dynamic HTML that has been rendered as a GUI **1020**. In the example, the GUI **1020** has a shipping address panel **1014** programmed with form fields to enter a name, company, address, and related data, which the FedEx application can use to generate a shipping label. The browser extension **116** is programmed to display the extension panel **820** superimposed over the web page with GUI **1020**, and the extension panel has data similar to the previous examples.

[0137] In the example of FIG. 10B, under program control, the browser extension **116** has identified, from the DOM of the web page, a field **1026** titled “Your name” that should receive a data value from one of the data panels pinned to the extension panel **820**. The browser extension **116** is programmed to generate and display, superimposed over the GUI **1002**, the suggestion panel **1012** with one or more data panels **1014** of values that could fit the field **1026**. In an embodiment, the suggestion panel **1012** is displayed just below or otherwise near field **1026**; screen position data can also be obtained programmatically from the DOM. With this arrangement, the agent can rapidly view values in the data panels **1014** of the suggestion panel **1012** and then click on one of the values to select that value. In response, the browser extension **116** is programmed to automatically fill the selected value in the field **1026**.

[0138] In this manner, the browser extension **116** can dramatically reduce the work of an agent who must move

between different applications to conduct the work associated with a single issue, ticket, or request originating in a different first system, like Zendesk. Rather than constantly re-entering the same data values in multiple different systems necessary to resolve a request or ticket or repeatedly copying and pasting values, the browser extension **116** automatically manages and executes the process of determining which values should be pinned to a ticket record represented in the extension panel **820** and which values should be suggested for automatic filling into fields of a new web page.

[0139] FIG. 10C illustrates another GUI with the extension panel and an automatic data update in the extension panel. As with prior examples, the extension panel **820** is displayed superimposed over a web page **1030** of the FedEx system. In a previous step of the shipping process, the FedEx system generated a shipping label confirmation page with a tracking identifier. In the example of FIG. 10C, the tracking identifier **1034** has been automatically pinned to the extension panel **820**. Assume that the customer received a shipping label and returned goods to a merchant as an extension of the previously discussed examples. The agent could investigate the status of a ticket and direct the browser **114** to the web page **1030** of FIG. 10C and receive a suggestion to enter the tracking identifier **1034** in a search field. In response, the FedEx system would respond with the tracking history and delivery status of a completed delivery from the customer, as seen on web page **1030**. In this manner, the extension panel **820** provides a visualization of persistently stored ticket data that can be recalled and reused in different applications or web pages without manual data re-entry.

[0140] FIG. 11 illustrates the GUI of FIG. 8B and FIG. 9 with updates to the extension panel and a reply from the agent. FIG. 11 represents a state in processing the request or ticket at which the agent has created a return address label for the customer. In response to creating a return label via the FedEx online application, the browser extension **116** has automatically detected the tracking ID and URL of a return label and updated the extension panel **820** in data panel **832** by pinning the URL **1104** of the return label. Therefore, in reply panel **809**, the agent has composed, but not sent, a reply message to the customer specifying the URL for the return label. The URL can be placed in the reply message of reply panel **809** automatically by selecting the pinned value of the URL **1104**.

[0141] FIG. 12 illustrates the GUI of FIG. 11 after the agent has sent the reply message to the customer. In this example, reply panel **809** shows the reply message **1102** as sent and not in the composing state. At this stage, the underlying ticket in the Zendesk system has transitioned to a Closed state. In response, the browser extension **116** is programmed to close the extension panel **820** and display a user-specific panel **1202** comprising a pin pad **1204**. “User-specific” means that panel **1202** shows data customized for the user account of the then-current agent or other user who is interacting with the application represented in GUI **802**. In an embodiment, the pin pad **1204** comprises a plurality of pinned data panels **1206**, **1208** that can show one or more URLs linked to knowledge base data or support information. In this manner, the user retains visual context and awareness that the browser extension **116** is running rather than seeing nothing. In an embodiment, the knowledge base data comprise one or more cross-system knowledge base suggestions

based on the current ticket type and articles that the agent assigned to the current ticket previously used.

[0142] The content of pin pad 1204 can be specified via configuration data of the workflow automation application 122, records in database 128, or other sources. It can vary based on the agent, user account, agent computer 110, or enterprise in which the agent or user works.

[0143] FIG. 13A, FIG. 13B, FIG. 13C, and FIG. 13D illustrate examples of graphical user interfaces that can be used in another embodiment. Referring first to FIG. 13A, in an embodiment, a web page 1302 corresponding to a new record of an incident has been generated by the Servicenow application and rendered in a browser. The terms incident, ticket, case, and record can be interchangeable for purposes of the present description and the implementation of an embodiment. The web page 1302 comprises a plurality of widgets 1304 that are programmed to receive basic metadata details for an incident and description widgets 1306. A search panel 1310 displays results of related incidents based on the description 1306. The specific form of the web page 1302 can vary in different embodiments and as the Servicenow application is updated or changed by its provider. Thus, the specific elements of web page 1302 are not critical.

[0144] Under the control of the workflow automation application 122, an extension panel 1320 is displayed superimposed over the web page 1302. The extension panel 1320 comprises an incident identifier panel 1322, a link 1323, and a workflow panel having a plurality of rows 1324. The incident identifier panel 1322 comprises an incident identifier value that has been automatically populated from the widgets 1304. The link 1323 comprises a hyperlink identifying the same incident and, when selected via user input, causes redirecting the browser 114 to the web page 1302, if a different web page was being displayed in the browser. Each row of the plurality of rows 1324 corresponds to a different workflow that has been previously identified, based on user events, and stored. Thus, each of the rows 1324 corresponds to a workflow that the workflow automation application 122 has automatically learned based on receiving and analyzing events that the extension panel 1320 has detected and relayed. Examples of processes for automatic, programmed learning of workflows are described herein in other sections.

[0145] Workflow 1326A is labeled “Deactivate user” and corresponds to a stored series of steps or actions in one or more web-based applications that collectively result in deactivating a user. Assume, for purposes of clearly explaining one operational example, and not as a limitation, that the workflow automation application 122 detects user input to select the workflow 1326A of the extension panel 1320. In response, the extension panel 1320 is programmed to update automatically to the form of the extension panel 1322 seen in FIG. 13B and to initiate replaying the stored actions and events of the workflow 1326A by programmatically instructing the browser 114 to access one or more web pages, enter data in widgets, select buttons or controls, or execute other functions of a web page that the browser is capable of executing.

[0146] A first step of the workflow 1326A is to execute an action in the Okta web-based application. Therefore, as an example, FIG. 13B shows a web page 1312 that the Okta application has generated and the browser 114 has rendered in response to a redirection instruction from the extension panel 1322 under the control of the workflow 1326A. The

web page 1312 can comprise any combination of widgets corresponding to the functions of the web page, such as a list 1316 of links to functions, buttons 1318, and a text entry box 1314. In an embodiment, the extension panel 1322 comprises the same incident identifier as in extension panel 1320, the same link 1323 as in the prior extension panel, and an expanded workflow 1326B comprising a list of actions 1328 corresponding to the workflow 1326A. In this manner, the extension panel 1322 enables a user to see the forthcoming actions that the workflow will execute automatically. Further, in an embodiment, as the actions of the list of actions 1328 execute, the specific action that is currently executing is highlighted in the list.

[0147] The automatic execution of actions of a workflow can include instructing the browser 114 to access and render different web pages of the same application or a different application. Referring now to FIG. 13C, in an embodiment, the actions 1328 of the expanded workflow 1326B or extension panel 1322 have caused the browser to access and display a second web page 1330 of the Okta application. In an embodiment, the second web page 1330 comprises the list 1316 of links to functions, data 1332 identifying a user for which a deactivation operation is proceeding, and a pull-down menu widget 1334. In the example of FIG. 13C, the actions 1328 of the expanded workflow 1326B or extension panel 1322 have caused the browser to automatically, programmatically select the pull-down menu widget 1334, thereby rendering a list 1336 of selectable functions, and to automatically, programmatically select a Deactivate function 1337. In response, the extension panel 1322 causes generating and displaying a step message 1338 in the second web page 1330; the step message specifies the step of the workflow 1326B that the system is then-currently executing.

[0148] Referring now to FIG. 13D, in an embodiment, the actions 1328 of the expanded workflow 1326B or extension panel 1322, specifically selecting the Deactivate function 1337, have caused the browser to access and display a third web page 1340 of the Okta application. In an embodiment, the third web page 1340 comprises the list 1316 of links to functions and a status value 1342 confirming that the specified user has been deactivated. In an embodiment, the actions 1328 of the expanded workflow 1326B or extension panel 1322 conclude by causing rendering and displaying a second step message 1344 superimposed over the third web page 1340. In this example, the second step message 1344 indicates that the selected workflow is complete and the user can close the corresponding ticket or take other actions.

[0149] FIG. 14A, FIG. 14B, and FIG. 14C illustrate examples of programmed processes, of one embodiment, to train and use machine-learning models to automatically learn workflows in web-based applications from user events, and to generate suggestions of workflows in response to sequences of user events or natural language input. In one embodiment, the workflow automation application 122 is programmed to execute the steps of FIG. 14A, FIG. 14B, and FIG. 14C. Referring first to FIG. 14A, in one embodiment, at block 1402, the workflow automation application 122 is programmed to receive a plurality of user events. For purposes of one clear example, user events are labeled A, B, C, and D. User events are collected automatically via the extension panel 120 as users navigate a website to accomplish a task. Examples have been given previously but can include click event, paste event, navigation event. In the aggregate, the system can analyze the usage of many dif-

ferent users on a specific website. An example of this would be a support agent responding to a ticket and resetting a user's password. All events are captured initially as unstructured data generally consisting of a timestamp, a website or URL, and an event type. Event data can be stored in the database **128**.

[0150] At block **1404**, the workflow automation application **122** is programmed to execute raw data clustering. For example, events A and B are assigned to cluster **1406** and events C and D are assigned to cluster **1408**. Clustering can comprise inspecting all events of all users represented in the database for the same website and determining which sets of events occur repeatedly and therefore appear similar. In an embodiment, each cluster comprises from two to 10 events that have been observed, across multiple users, as repeatedly used in the same sequence and therefore associated.

[0151] At block **1409**, the workflow automation application **122** is programmed to execute action analysis. Using data analysis at block **1409**, the workflow automation application **122** is programmed to determine that certain combinations of user events are equivalent to a specific user action. For example, events A and B are found by analysis to be used to look up a user by user identifier. Those events can be digitally stored in association with a named workflow titled "Lookup user by id," represented in FIG. **14A** as user action **1410**. Or, events C and C are found by analysis to be used to reset a users password and can be stored as a workflow named "Reset user password by id," corresponding to user action **1412**. User actions **1410**, **1412** correspond to higher-level views of sequences of events and are roughly equivalent to API calls. An association of a sequence of otherwise unstructured events to a user action comprises an item of structured data that can be stored separately in the database **128** and used to solve future problems.

[0152] In some embodiments, clustering at block **1404** and action analysis at block **1409** could be implemented by executing the inference stage of a commercial, trained, web application action-based machine-learning model over the events of block **1402**, rather than using a programmed clustering algorithm and analysis steps. In some cases, supervised learning may be needed to label training data for such a model to ensure accurate results in classifying sequences of events as actions; supervised learning can be used to kick-start a model to achieve good results followed by unsupervised learning over time as further described for other blocks of the flow diagram. Or, one or more of the clustering at block **1404** and action analysis at block **1409** could be implemented by submitting data describing the events **1402** to a public LLM API with an engineered prompt that requests the LLM to identify an action to which the events correspond. Any of the foregoing implementations can be supplemented with manual labeling of events to associate the events with clusters or actions.

[0153] For example, a prompt to an LLM could specify three different events that are known to correspond to a particular event, and then ask the LLM to assess thousands of other event records to identify any other events that are similar to the three events. Based on the output from that prompt, another prompt could request identifying sequences of events in the data that correlate to be the same action(s) with which the first three events are associated. Or, the other events that the LLM indicates to be similar to the three events could be added to the training data in association with the same actions. In this manner, prompts to an LLM can be

effectively used to synthesize new training data. An example prompt is: "I am going to share with you unstructured json data of a series of events that describe an optimal way to accomplish an action in the browser. I would like you to analyze these events and explain to me what they are trying to accomplish. Please group them any way you like and explain to me the limits of what you can determine."

[0154] An example partial response of an LLM to the foregoing prompt is:

[0155] "Based on the detailed sequence of browser events you've provided, it appears that the user is engaging in a multi-step process that involves using various applications and services to manage customer service tasks and perhaps communication of translation tasks as well. Here's a high-level analysis of the actions and possible sequences these events suggest: 1. Navigation and Interaction in Customer Service Platform (Zendesk) . . . a. Events: multiple tab activations and navigations in Zendesk, focusing on specific customer support tickets . . . b. Purpose: Managing customer service tickets, possibly viewing or responding to customer inquiries. The frequent activation of specific ticket tabs suggests repeated referencing or updating of information related to a particular customer issue . . . 2. Use of Google Translate . . . Possible Sequence: 1. Review Ticket in Zendesk: The user starts by retrieving details of a ticket in Zendesk; 2. Translation of Communications: Text from the ticket or a proposed response is translated using Google Translate . . ."

[0156] At block **1414**, the workflow automation application **122** is programmed to associate one or more events and actions with networked resources and store the events, actions, and resource identifiers as training data records and as a vocabulary for use in other processing based on natural language. For example, after analysis at block **1409**, the workflow automation application **122** is programmed to build a list of common websites and the specific user actions that are associated with these sites. Therefore, each website or URL can be associated with a plurality of specific user actions. In effect this step defines a structured vocabulary that can be used to train a machine learning model or an API that can be used deterministically. The foregoing process can be used for any number of websites. For any given website, selecting a named user action can retrieve the specific events that can be replayed to execute the user action for that website.

[0157] At block **1418**, the workflow automation application **122** is programmed to use the vocabulary as structured data to train and deploy one or more machine learning models. Various embodiments can use different forms of ML model; in one embodiment, a Transformer-based neural network is used, but in other embodiments a linear classifier or action-based model could be used. After deployment, the trained ML models can be accessed and used via a browser or browser extension.

[0158] FIG. **14B** represents a programmed process of using the trained ML model(s) in response to user action to interact with one or more websites. Thus, FIG. **14B** typically executes after a ML model is trained and deployed as previously described. In an embodiment, at block **1424**, the workflow automation application **122** is programmed to receive a sequence of one or more user events **1420**. For example, events A, B, C, and D could be received sequen-

tially as a user interacts with one or more websites and selects tabs, selects widgets, enters data, copies, pastes, or executes other actions.

[0159] At block 1426, the workflow automation application 122 is programmed to execute the inference stage of the one or more machine learning models over the sequence of one or more user events. For example, one or more of events A, B, C, and D are programmatically transmitted to the ML model that was trained as described for FIG. 13A, as part of a request to execute the inference stage of the model. Such a request will cause the ML model to receive the events as input and output a suggestion of a stored or known workflow that most accurately matches the sequences of one or more user events, as block 1428 indicates. As the phrase “most accurately matches” suggests, the programmed logic of block 1428 can include receiving a plurality of ranked suggestions or predictions, each suggestion identifying a workflow using a workflow identifier and having an associated confidence value, then selecting the suggestion having the highest confidence value. The selected suggestion can be output in the extension panel 120 or another user interface element that is superimposed, via the browser extension, over the web page that the browser 114 is currently presenting. The particular manner of presenting the selected suggestion to the user is not critical.

[0160] The process of FIG. 14B starting at block 1426 can execute repeatedly as each sequential event is received, without waiting for all events of a sequence to occur. For example, FIG. 14B can execute immediately after event A is received via the browser extension or extension panel; if the results of other blocks of the process are inconclusive or a confidence level of a suggestion is too low, then the process of FIG. 14B starting at block 1426 can execute after both event A and B, or all of events A, B, and C, and so forth, until the output generates a suggestion with a confidence level that is sufficiently high.

[0161] At block 1430, the workflow automation application 122 is programmed to receive input corresponding to a user action in response to or after the suggestion. Block 1430 represents detecting any user action after a suggestion is presented, whether or not the user action could be interpreted as a response to the suggestion. For example, the user action could comprise clicking on the suggestion in a workflow panel or extension panel, or any other user action such as selecting a browser tab, selecting a browser widget, pasting data, copying data, etc.

[0162] At block 1432, the workflow automation application 122 is programmed to test whether the user input indicates selecting the suggested workflow. If so, then model reinforcement training data is generated based on the input and added to the training dataset that was used in FIG. 14A. In this case, the workflow automation application 122 has correctly predicted the user task or intent associated with one or more events that were received at block 1420. The user’s selection of the suggested workflow indicates that the suggested workflow was correct, so the machine-learning model should be reinforced with added training data.

[0163] At block 1434, if the user input corresponds to one or more other user events—that is, the suggested workflow was not selected—then the workflow automation application 122 is programmed to capture and store an updated sequence of user events as new training data. In this case, the user’s action to ignore the suggestion and take other actions indicates that the user task or intent does not closely match

the suggestion and the initial events of block 1420, with the events executed after the suggestion, should be considered as new training data for the model. Any new training data created in this manner also can serve as reference data for the clustering operation of block 1404 (FIG. 14A).

[0164] In this manner, in an embodiment, the system is programmed to send its current activity as a raw stream of events to the deployed model. The deployed model uses its training to suggest the actions the user should take to accomplish their goal. Based on accuracy of the suggestion, the system can determine if the user was successful, as indicated by using the suggestion one or more times. This information then reinforces the model. In addition new events are reintroduced back into the training cycle used for clustering, as previously described. Furthermore, the machine-learning model(s) can improve with new training data whether the user elects to execute some of a suggested workflow, all of a suggested workflow, or elects to undertake other actions manually.

[0165] FIG. 14C illustrates an example in which a large language model (LLM) supports certain aspects of workflow automation. In an embodiment, at block 1440, the workflow automation application 122 is programmed to receive user input specifying a natural language instruction for an action. For example, using a chat interface, or a text entry box widget of the extension panel 120, the workflow automation application 122 could receive an input like “Please process ticket 123 in my ticketing system and show your work.” Text of this form expresses a request or goal at a high level without indicating the nature or description of the ticket. However, an LLM is able to analyze the high-level request and then use the specific vocabulary created at FIG. 14A to accomplish the user’s goal.

[0166] In an embodiment, at block 1442, the workflow automation application 122 is programmed to form a prompt to an LLM. In an embodiment, the prompt comprises (a) instructions to generate an output sequence of workflow steps, (b) the vocabulary as context and (c) the user input as portions of the prompt. The instructions are typically static and can comprise text like: “Below I am giving you a vocabulary consisting of actions in web-based applications and the user tasks to which the actions correspond. I am also giving you a text string that specifies a proposed user task. Based on this information, give me a precise description in five words or less of what task the text string specifies, in a form similar to the terms used in the vocabulary. Also give me an ordered list of web-based applications, and actions in those applications, that will complete the proposed user task. Be specific in terms of identifying functions or widgets in the applications, and what actions to take using a browser.” The vocabulary provided as context at (b) can be the specific vocabulary created at FIG. 14A. The user input of (c) can be the same string that the user entered as their task, goal, or instruction.

[0167] At block 1444, the workflow automation application 122 is programmed to programmatically call an API of the LLM using the prompt. For example, the workflow automation application 122 is programmed to generate a parameterized HTTP request directed to an endpoint of an LLM like GPT4, GPT3.5, GEMINI, CLAUDE, etc., in which one parameter is a request type and another parameter is the prompt of block 1442. Block 1444 also can comprise entering a wait state, receiving a response from the API call, and at least transiently storing the response in memory.

[0168] At block 1446, the workflow automation application 122 is programmed to output a suggestion of a stored or known workflow that most accurately matches the natural language instruction and comprises the sequence of workflow steps and/or a new sequence of workflow steps. Block 1446 can comprise applying post-processing to the response that was received from the LLM via block 1444, and then creating and storing a new, named workflow, corresponding to the user task, and identifying the workflow steps that block 1446 identified. Or, block 1446 can comprise identifying an existing, known workflow by name, represented in the output from the LLM that was received via block 1444, and suggesting this workflow to the user in the extension panel or another UI window, panel, or widget. At this point, the process of FIG. 14C can continue as described for FIG. 14B, starting at block 1430.

[0169] As noted earlier, in an embodiment, the event data is stored in training datasets with attribute values specifying the tenant, entity, or instance active in the web-based application at the time that an event occurred, and used for training machine learning models. These attributes enable training ML models that are customized to particular tenants or instances, while still leveraging community-wide data. Thus, when workflow automation computer 120 detects a partial or complete sequence of user events, the system can determine a suggestion of a workflow corresponding to those event based on community data for similar events, even if the current user's instance is different than all other instances for which the other similar events were collected. Therefore, even if the system has not learned a user action corresponding to a sequence of events for the current particular instance of the user, the system can suggest an action or workflow corresponding to the user's events based on knowledge derived from other event sequences of other instances.

4. Implementation Example—Hardware Overview

[0170] According to one embodiment, the techniques described herein are implemented by at least one computing device. The techniques may be implemented in whole or in part using a combination of at least one server computer and/or other computing devices that are coupled using a network, such as a packet data network. The computing devices may be hard-wired to perform the techniques or may include digital electronic devices such as at least one application-specific integrated circuit (ASIC) or field programmable gate array (FPGA) that is persistently programmed to perform the techniques or may include at least one general purpose hardware processor programmed to perform the techniques pursuant to program instructions in firmware, memory, other storage, or a combination. To accomplish the described techniques, such computing devices may also combine custom hard-wired logic, ASICs, or FPGAs with custom programming. The computing devices may be server computers, workstations, personal computers, portable computer systems, handheld devices, mobile computing devices, wearable devices, body-mounted or implantable devices, smartphones, smart appliances, internetworking devices, autonomous or semi-autonomous devices such as robots or unmanned ground or aerial vehicles, any other electronic device that incorporates hard-wired and/or program logic to implement the described techniques, one or more virtual computing machines or instances in a data center, and/or a network of server computers and/or personal computers.

[0171] FIG. 2 is a block diagram that illustrates an example computer system with which an embodiment may be implemented. In the example of FIG. 2, a computer system 200 and instructions for implementing the disclosed technologies in hardware, software, or a combination of hardware and software, are represented schematically, for example, as boxes and circles, at the same level of detail that is commonly used by persons of ordinary skill in the art to which this disclosure pertains for communicating about computer architecture and computer systems implementations.

[0172] Computer system 200 includes an input/output (I/O) subsystem 202, which may include a bus and/or other communication mechanism(s) for communicating information and/or instructions between the components of the computer system 200 over electronic signal paths. The I/O subsystem 202 may include an I/O controller, a memory controller, and at least one I/O port. The electronic signal paths are represented schematically in the drawings, for example, as lines, unidirectional arrows, or bidirectional arrows.

[0173] At least one hardware processor 204 is coupled to I/O subsystem 202 for processing information and instructions. Hardware processor 204 may include, for example, a general-purpose microprocessor or microcontroller and/or a special-purpose microprocessor such as an embedded system or a graphics processing unit (GPU), or a digital signal processor or ARM processor. Processor 204 may comprise an integrated arithmetic logic unit (ALU) or be coupled to a separate ALU.

[0174] Computer system 200 includes one or more units of memory 206, such as a main memory, which is coupled to I/O subsystem 202 for electronically digitally storing data and instructions to be executed by processor 204. Memory 206 may include volatile memory such as various forms of random-access memory (RAM) or other dynamic storage device. Memory 206 may also be used for storing temporary variables or other intermediate information during the execution of instructions to be executed by processor 204. Such instructions, when stored in non-transitory computer-readable storage media accessible to processor 204, can render computer system 200 into a special-purpose machine that is customized to perform the operations specified in the instructions.

[0175] Computer system 200 further includes non-volatile memory such as read-only memory (ROM) 208 or other static storage devices coupled to I/O subsystem 202 for storing information and instructions for processor 204. The ROM 208 may include various forms of programmable ROM (PROM), such as erasable PROM (EPROM) or electrically erasable PROM (EEPROM). A unit of persistent storage 210 may include various forms of non-volatile RAM (NVRAM), such as FLASH memory, solid-state storage, magnetic disk, or optical disks such as CD-ROM or DVD-ROM and may be coupled to I/O subsystem 202 for storing information and instructions. Storage 210 is an example of a non-transitory computer-readable medium that may be used to store instructions and data, which, when executed by the processor 204, cause performing computer-implemented methods to execute the techniques herein.

[0176] The instructions in memory 206, ROM 208, or storage 210 may comprise one or more sets of instructions that are organized as modules, methods, objects, functions, routines, or calls. The instructions may be organized as one

or more computer programs, operating system services, or application programs including mobile apps. The instructions may comprise an operating system and/or system software; one or more libraries to support multimedia, programming, or other functions; data protocol instructions or stacks to implement TCP/IP, HTTP, or other communication protocols; file format processing instructions to parse or render files coded using HTML, XML, JPEG, MPEG or PNG; user interface instructions to render or interpret commands for a graphical user interface (GUI), command-line interface or text user interface; application software such as an office suite, internet access applications, design and manufacturing applications, graphics applications, audio applications, software engineering applications, educational applications, games or miscellaneous applications. The instructions may implement a web server, web application server, or web client. The instructions may be organized as a presentation layer, application layer, and data storage layer, such as a relational database system using structured query language (SQL) or no SQL, an object store, a graph database, a flat file system, or other data storage.

[0177] Computer system 200 may be coupled via I/O subsystem 202 to at least one output device 212. In one embodiment, output device 212 is a digital computer display. Examples of a display that may be used in various embodiments include a touchscreen display, a light-emitting diode (LED) display, a liquid crystal display (LCD), or an e-paper display. Computer system 200 may include other types(s) of output devices 212, alternatively or in addition to a display device. Examples of other output devices 212 include printers, ticket printers, plotters, projectors, sound cards or video cards, speakers, buzzers or piezoelectric devices or other audible devices, lamps or LED or LCD indicators, haptic devices, actuators or servos.

[0178] At least one input device 214 is coupled to I/O subsystem 202 for communicating signals, data, command selections, or gestures to processor 204. Examples of input devices 214 include touch screens, microphones, still and video digital cameras, alphanumeric and other keys, keypads, keyboards, graphics tablets, image scanners, joysticks, clocks, switches, buttons, dials, slides, and/or various types of sensors such as force sensors, motion sensors, heat sensors, accelerometers, gyroscopes, and inertial measurement unit (IMU) sensors and/or various types of transceivers such as wireless, such as cellular or Wi-Fi, radio frequency (RF) or infrared (IR) transceivers and Global Positioning System (GPS) transceivers.

[0179] Another type of input device is a control device 216, which may perform cursor control or other automated control functions such as navigation in a graphical interface on a display screen, alternatively or in addition to input functions. The control device 216 may be a touchpad, a mouse, a trackball, or cursor direction keys for communicating direction information and command selections to processor 204 and controlling cursor movement on an output device 212 such as a display. The input device may have at least two degrees of freedom in two axes, a first axis (e.g., x) and a second axis (e.g., y), that allows the device to specify positions in a plane. Another type of input device is a wired, wireless, or optical control device such as a joystick, wand, console, steering wheel, pedal, gearshift mechanism, or other type of control device. An input device 214 may include a combination of multiple different input devices, such as a video camera and a depth sensor.

[0180] In another embodiment, computer system 200 may comprise an Internet of Things (IoT) device in which one or more of the output device 212, input device 214, and control device 216 are omitted. Or, in such an embodiment, the input device 214 may comprise one or more cameras, motion detectors, thermometers, microphones, seismic detectors, other sensors or detectors, measurement devices or encoders, and the output device 212 may comprise a special-purpose display such as a single-line LED or LCD display, one or more indicators, a display panel, a meter, a valve, a solenoid, an actuator or a servo.

[0181] When computer system 200 is a mobile computing device, input device 214 may comprise a global positioning system (GPS) receiver coupled to a GPS module that is capable of triangulating to a plurality of GPS satellites, determining and generating geo-location or position data such as latitude-longitude values for a geophysical location of the computer system 200. Output device 212 may include hardware, software, firmware, and interfaces for generating position reporting packets, notifications, pulse or heartbeat signals, or other recurring data transmissions that specify a position of the computer system 200, alone or in combination with other application-specific data, directed toward host computer 224 or server computer 230.

[0182] Computer system 200 may implement the techniques described herein using customized hard-wired logic, at least one ASIC or FPGA, firmware, and/or program instructions or logic which, when loaded and used or executed in combination with the computer system, causes or programs the computer system to operate as a special-purpose machine. According to one embodiment, the techniques herein are performed by computer system 200 in response to processor 204 executing at least one sequence of at least one instruction contained in main memory 206. Such instructions may be read into main memory 206 from another storage medium, such as storage 210. Execution of the sequences of instructions contained in main memory 206 causes processor 204 to perform the process steps described herein. In alternative embodiments, hard-wired circuitry may be used in place of or in combination with software instructions.

[0183] The term “storage media,” as used herein, refers to any non-transitory media that store data and/or instructions that cause a machine to operate in a specific fashion. Such storage media may comprise non-volatile media and/or volatile media. Non-volatile media includes, for example, optical or magnetic disks, such as storage 210. Volatile media includes dynamic memory, such as memory 206. Common forms of storage media include, for example, a hard disk, solid state drive, flash drive, magnetic data storage medium, any optical or physical data storage medium, memory chip, or the like.

[0184] Storage media is distinct from but may be used in conjunction with transmission media. Transmission media participates in transferring information between storage media. For example, transmission media includes coaxial cables, copper wire, and fiber optics, including the wires that comprise a bus of I/O subsystem 202. Transmission media can also be acoustic or light waves, such as those generated during radio-wave and infrared data communications.

[0185] Various forms of media may carry at least one sequence of at least one instruction to processor 204 for execution. For example, the instructions may initially be carried on a magnetic disk or solid-state drive of a remote

computer. The remote computer can load the instructions into its dynamic memory and send the instructions over a communication link such as a fiber optic or coaxial cable or telephone line using a modem. A modem or router local to computer system 200 can receive the data on the communication link and convert the data to a format that can be read by computer system 200. For instance, a receiver such as a radio frequency antenna or an infrared detector can receive the data carried in a wireless or optical signal, and appropriate circuitry can provide the data to I/O subsystem 202 such as place the data on a bus. I/O subsystem 202 carries the data to memory 206, from which processor 204 retrieves and executes the instructions. The instructions received by memory 206 may optionally be stored on storage 210 either before or after execution by processor 204.

[0186] Computer system 200 also includes a communication interface 218 coupled to a bus of I/O subsystem 202. Communication interface 218 provides a two-way data communication coupling to a network link(s) 220 that are directly or indirectly connected to at least one communication network, such as network 222 or a public or private cloud on the Internet. For example, communication interface 218 may be an Ethernet networking interface, integrated-services digital network (ISDN) card, cable modem, satellite modem, or a modem to provide a data communication connection to a corresponding type of communications line, for example, an Ethernet cable or a metal cable of any kind or a fiber-optic line or a telephone line. Network 222 broadly represents a local area network (LAN), wide-area network (WAN), campus network, internetwork, or any combination thereof. Communication interface 218 may comprise a LAN card to provide a data communication connection to a compatible LAN, a cellular radiotelephone interface that is wired to send or receive cellular data according to cellular radiotelephone wireless networking standards, or a satellite radio interface that is wired to send or receive digital data according to satellite wireless networking standards. In any such implementation, communication interface 218 sends and receives electrical, electromagnetic, or optical signals over signal paths that carry digital data streams representing various types of information.

[0187] Network link 220 typically provides electrical, electromagnetic, or optical data communication directly or through at least one network to other data devices, using, for example, satellite, cellular, Wi-Fi, or BLUETOOTH technology. For example, network link 220 may connect through network 222 to a host computer 224.

[0188] Furthermore, network link 220 may provide a connection through network 222 or to other computing devices via internetworking devices and/or computers that are operated by an Internet Service Provider (ISP) 226. ISP 226 provides data communication services through a worldwide packet data communication network represented as Internet 228. A server computer 230 may be coupled to Internet 228. Server computer 230 broadly represents any computer, data center, virtual machine, or virtual computing instance with or without a hypervisor or computer executing a containerized program system such as DOCKER or KUBERNETES. Server computer 230 may represent an electronic digital service that is implemented using more than one computer or instance, and that is accessed and used by transmitting web services requests, uniform resource locator (URL) strings with parameters in HTTP payloads, API calls, app services calls, or other service calls. Com-

puter system 200 and server computer 230 may form elements of a distributed computing system that includes other computers, a processing cluster, a server farm, or other organization of computers that cooperate to perform tasks or execute applications or services. Server computer 230 may comprise one or more sets of instructions that are organized as modules, methods, objects, functions, routines, or calls. The instructions may be organized as one or more computer programs, operating system services, or application programs including mobile apps. The instructions may comprise an operating system and/or system software; one or more libraries to support multimedia, programming, or other functions; data protocol instructions or stacks to implement TCP/IP, HTTP, or other communication protocols; file format processing instructions to parse or render files coded using HTML, XML, JPEG, MPEG or PNG; user interface instructions to render or interpret commands for a graphical user interface (GUI), command-line interface or text user interface; application software such as an office suite, internet access applications, design and manufacturing applications, graphics applications, audio applications, software engineering applications, educational applications, games or miscellaneous applications. Server computer 230 may comprise a web application server that hosts a presentation layer, application layer, and data storage layer, such as a relational database system using a structured query language (SQL) or no SQL, an object store, a graph database, a flat file system or other data storage.

[0189] Computer system 200 can send messages and receive data and instructions, including program code, through the network(s), network link 220, and communication interface 218. In the Internet example, server computer 230 might transmit a requested code for an application program through Internet 228, ISP 226, local network 222, and communication interface 218. The received code may be executed by processor 204 as it is received and/or stored in storage 210 or other non-volatile storage for later execution.

[0190] The execution of instructions, as described in this section, may implement a process in the form of an instance of a computer program that is being executed, consisting of program code and its current activity. Depending on the operating system (OS), a process may comprise multiple threads of execution that execute instructions concurrently. In this context, a computer program is a passive collection of instructions, while a process may execute those instructions. Several processes may be associated with the same program; for example, opening up several instances of the same program often means more than one process is being executed. Multitasking may be implemented to allow multiple processes to share processor 204. While each processor 204 or core of the processor executes a single task at a time, computer system 200 may be programmed to implement multitasking to allow each processor to switch between tasks that are being executed without having to wait for each task to finish. In an embodiment, switches may be performed when tasks perform input/output operations when a task indicates that it can be switched or on hardware interrupts. Time-sharing may be implemented to allow fast response for interactive user applications by rapidly performing context switches to provide the appearance of concurrent execution of multiple processes simultaneously. In an embodiment, for security and reliability, an operating system may prevent

direct communication between independent processes, providing strictly mediated and controlled inter-process communication functionality.

[0191] In the foregoing specification, embodiments of the invention have been described with numerous specific details that may vary from implementation to implementation. The specification and drawings are, accordingly, to be regarded in an illustrative rather than a restrictive sense. The sole and exclusive indicator of the scope of the invention, and what is intended by the applicants to be the scope of the invention, is the literal and equivalent scope of the set of claims issued from this application in the specific form in which such claims issue, including any subsequent correction.

What is claimed is:

1. A workflow automation computer system comprising:
 - one or more hardware processors;
 - one or more network interfaces that are communicatively coupled to one or more internetworks and capable of network communication with a browser extension hosted on an agent computer, a relational database system, and a support ticket system; and
 - one or more non-transitory computer-readable storage media coupled to the one or more hardware processors and storing:
 - one or more trained machine learning models having been trained to output predictions of actions of web-based applications based on input specifying a plurality of browser events from interactions with the web-based applications; and
 - one or more sequences of instructions which, when executed using one or more processors, cause the one or more processors to execute:
 - receiving, from the browser extension, one or more browser event objects corresponding to user input signals arising from interactions of the agent computer with the web-based applications, extracting attribute values from the one or more browser event objects, and storing, in the relational database system, the one or more browser event objects and attribute values as a plurality of events of user action time series records;
 - clustering the plurality of events and performing action analysis on the plurality of events by executing a first inference stage of the one or more trained machine learning models over the one or more events to output suggestions of associations of user actions corresponding to the one or more events;
 - forming one or more training data records based on the associations of user actions corresponding to the one or more events;
 - re-training the one or more trained machine learning models based on the associations of user actions to produce one or more re-trained machine learning models.
2. The workflow automation computer system of claim 1, further comprising one or more sequences of instructions which, when executed using one or more processors, cause the one or more processors to deploy the one or more re-trained machine learning models, for access and use via the browser extension.
3. The workflow automation computer system of claim 1, further comprising one or more sequences of instructions which, when executed using one or more processors, cause the one or more processors to execute:

- receiving a sequence of one or more user events;
- executing an inference stage of one or more machine learning models over the sequence of one or more user events;
- outputting a suggestion of a workflow that most accurately matches the sequence of one or more user events;
- receiving user input corresponding to user action in response to the suggestion;
- when the user input indicates selecting the suggested workflow, generating reinforcement training data based on the user input;
- when the user input corresponds to one or more additional user events, storing an updated sequence of user events as new training data.

4. The workflow automation computer system of claim 1, further comprising one or more sequences of instructions which, when executed using one or more processors, cause the one or more processors to execute:

- storing, as a vocabulary, the associations of user actions corresponding to the one or more events in association with identifiers of websites with which the user actions occurred;
- receiving first user input specifying a natural language instruction for an action or goal;
- forming a prompt for a large language model (LLM), the prompt comprising instructions to generate an output sequence of workflow steps, the vocabulary, and the user input;
- programmatically calling an application programming interface (API) of the LLM using the prompt;
- outputting a suggestions of a stored workflow that most accurately matches the natural language instruction and comprises the sequence of workflow steps and/or a new sequence of workflow steps.

5. The workflow automation computer system of claim 4, further comprising one or more sequences of instructions which, when executed using one or more processors, cause the one or more processors to execute:

- receiving second user input corresponding to user action in response to the suggestion;
- when the user input indicates selecting the suggested workflow, generating reinforcement training data based on the user input;
- when the user input corresponds to one or more additional user events, storing an updated sequence of user events as new training data.

6. The workflow automation computer system of claim 1, wherein the browser extension comprises any of a browser extension program, a browser plug-in, an application program that is hosted on an agent computer or user computer, or a browser that is natively programmed to, or executing browser-executable code programmed to, execute one or more programmatic calls to an application programming interface of a workflow automation application.

7. The workflow automation computer system of claim 1, wherein each of the one or more trained machine learning models comprises a Transformer-based neural network.

8. One or more non-transitory computer-readable storage media storing one or more trained machine learning models having been trained to output predictions of actions of web-based applications based on input specifying a plurality of browser events from interactions with the web-based applications and one or more sequences of instructions which, when executed using one or more processors, the one

or more processors being are communicatively coupled to one or more network interfaces that are communicatively coupled to one or more internetworks and capable of network communication with a browser extension hosted on an agent computer, a relational database system, and a support ticket system, cause the one or more processors to execute:

- receiving, from the browser extension, one or more browser event objects corresponding to user input signals arising from interactions of the agent computer with the web-based applications, extracting attribute values from the one or more browser event objects, and storing, in the relational database system, the one or more browser event objects and attribute values as a plurality of events of user action time series records;

- clustering the plurality of events and performing action analysis on the plurality of events by executing a first inference stage of the one or more trained machine learning models over the one or more events to output suggestions of associations of user actions corresponding to the one or more events;

- forming one or more training data records based on the associations of user actions corresponding to the one or more events;

- re-training the one or more trained machine learning models based on the associations of user actions to produce one or more re-trained machine learning models.

9. The one or more non-transitory computer-readable storage media of claim 8, further comprising sequences of instructions which, when executed using the one or more processors, cause the one or more processors to deploy the one or more re-trained machine learning models, for access and use via the browser extension.

10. The one or more non-transitory computer-readable storage media of claim 8, further comprising sequences of instructions which, when executed using the one or more processors, cause the one or more processors to execute:

- receiving a sequence of one or more user events;
- executing an inference stage of one or more machine learning models over the sequence of one or more user events;

- outputting a suggestion of a workflow that most accurately matches the sequence of one or more user events;

- receiving user input corresponding to user action in response to the suggestion;

- when the user input indicates selecting the suggested workflow, generating reinforcement training data based on the user input;

- when the user input corresponds to one or more additional user events, storing an updated sequence of user events as new training data.

11. The one or more non-transitory computer-readable storage media of claim 8, further comprising sequences of instructions which, when executed using the one or more processors, cause the one or more processors to execute:

- storing, as a vocabulary, the associations of user actions corresponding to the one or more events in association with identifiers of websites with which the user actions occurred;

- receiving first user input specifying a natural language instruction for an action or goal;

- forming a prompt for a large language model (LLM), the prompt comprising instructions to generate an output sequence of workflow steps, the vocabulary, and the user input;

- programmatically calling an application programming interface (API) of the LLM using the prompt;

- outputting a suggestions of a stored workflow that most accurately matches the natural language instruction and comprises the sequence of workflow steps and/or a new sequence of workflow steps.

12. The one or more non-transitory computer-readable storage media of claim 8, further comprising sequences of instructions which, when executed using the one or more processors, cause the one or more processors to execute:

- receiving second user input corresponding to user action in response to the suggestion;

- when the user input indicates selecting the suggested workflow, generating reinforcement training data based on the user input;

- when the user input corresponds to one or more additional user events, storing an updated sequence of user events as new training data.

13. The one or more non-transitory computer-readable storage media of claim 8, wherein the browser extension comprises any of a browser extension program, a browser plug-in, an application program that is hosted on an agent computer or user computer, or a browser that is natively programmed to, or executing browser-executable code programmed to, execute one or more programmatic calls to an application programming interface of a workflow automation application.

14. The one or more non-transitory computer-readable storage media of claim 8, wherein each of the one or more trained machine learning models comprises a Transformer-based neural network.

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