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Johnston

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(54) **WORKFLOW DISCOVERY THROUGH USER ACTION MONITORING**

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(73) Assignee: **Amazon Technologies, Inc.**, Seattle, WA (US)

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This patent is subject to a terminal disclaimer.

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G06Q 10/10 (2012.01)

(52) **U.S. Cl.**
CPC ***G06Q 10/0633*** (2013.01); *G06Q 10/06* (2013.01); *G06Q 10/0631* (2013.01)

(58) **Field of Classification Search**
CPC G06Q 10/0633
USPC 705/7.27
See application file for complete search history.

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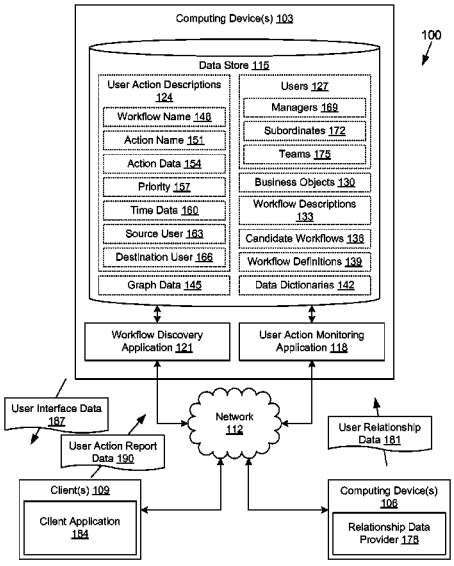
(74) *Attorney, Agent, or Firm* — Thomas Horstemeyer, LLP

(57) **ABSTRACT**

Disclosed are various embodiments for discovering workflows through analysis of user actions. Workflow descriptions are entered by multiple users over a period of time as the users perform user actions. Each workflow description includes a sequence of user action descriptions. The workflow descriptions are modeled as directed graphs, and one or more candidate workflows are determined by identifying a set of isomorphic directed graphs from the directed graphs.

20 Claims, 8 Drawing Sheets



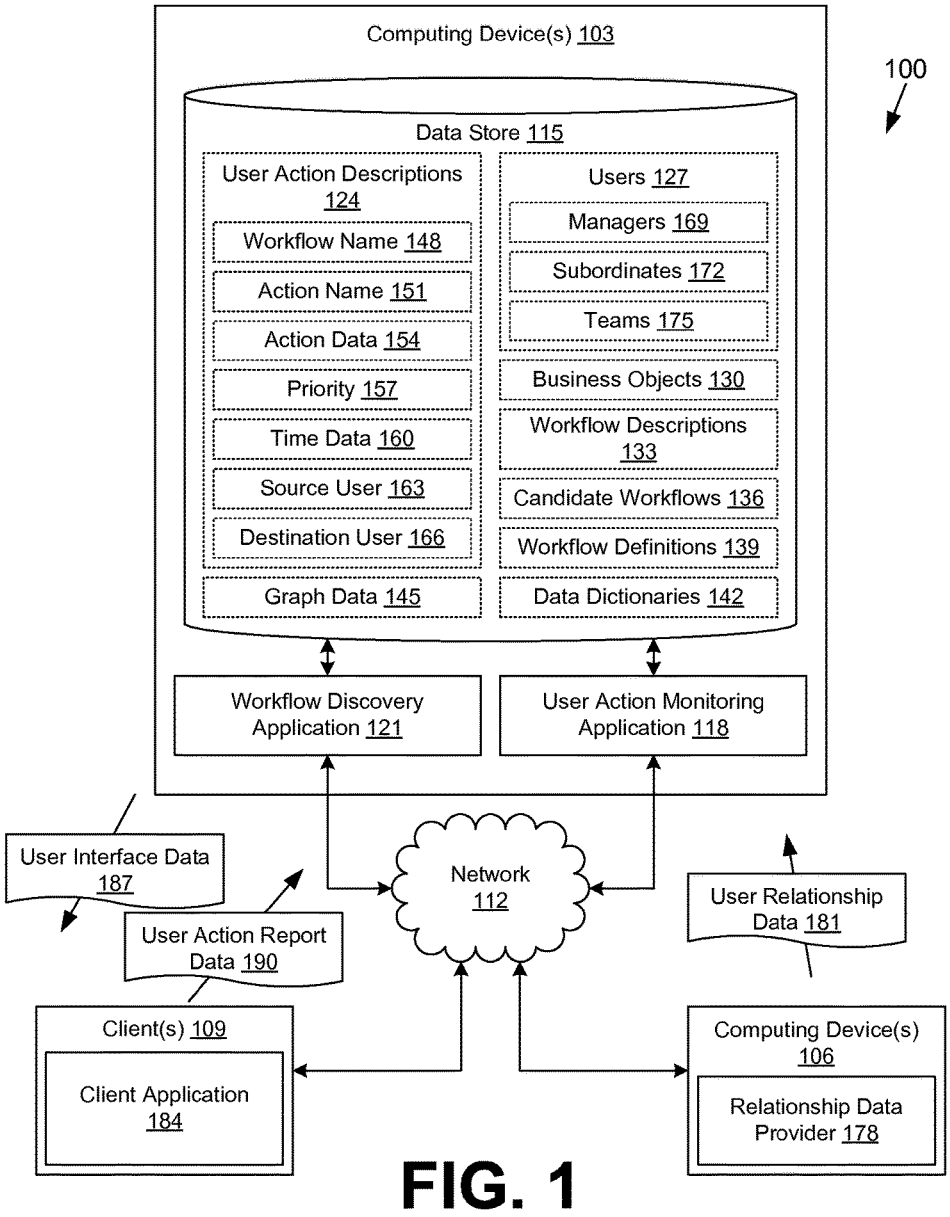

Computing Device(s) 103
100
Data Store 115
User Action Descriptions 124
Workflow Name 148
Action Name 151
Action Data 154
Priority 157
Time Data 160
Source User 163
Destination User 166
Graph Data 145
Users 127
Managers 169
Subordinates 172
Teams 175
Business Objects 130
Workflow Descriptions 133
Candidate Workflows 136
Workflow Definitions 139
Data Dictionaries 142
Workflow Discovery Application 121
User Action Monitoring Application 118
User Interface Data 187
User Action Report Data 190
Network 112
User Relationship Data 181
Client(s) 109
Client Application 184
Computing Device(s) 106
Relationship Data Provider 178

FIG. 1

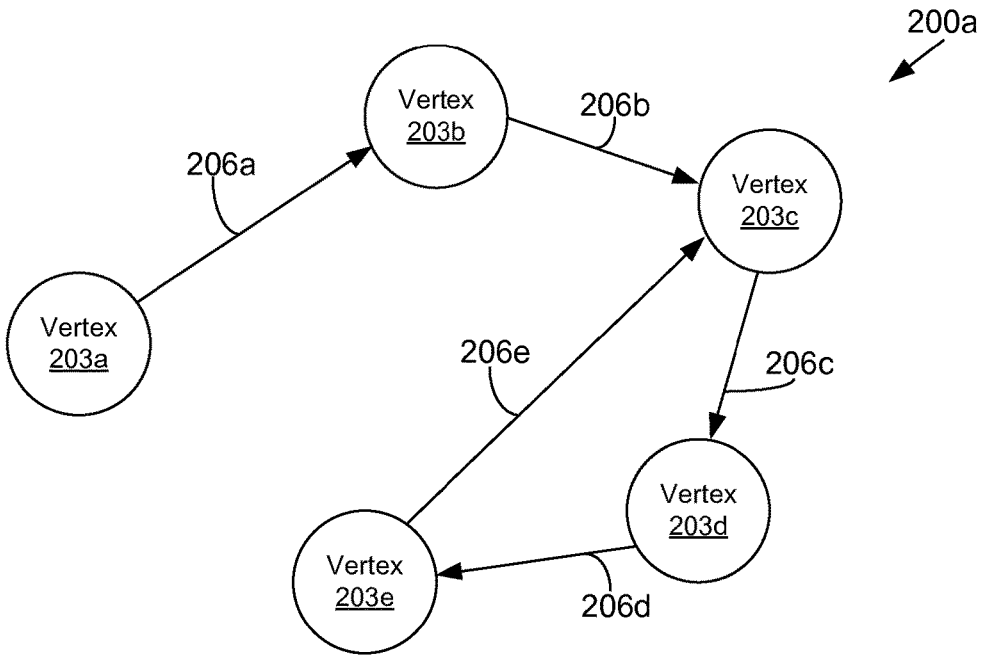

200a
Vertex 203b
206b
206a
Vertex 203c
Vertex 203a
206e
206c
Vertex 203d
Vertex 203e
206d

FIG. 2A

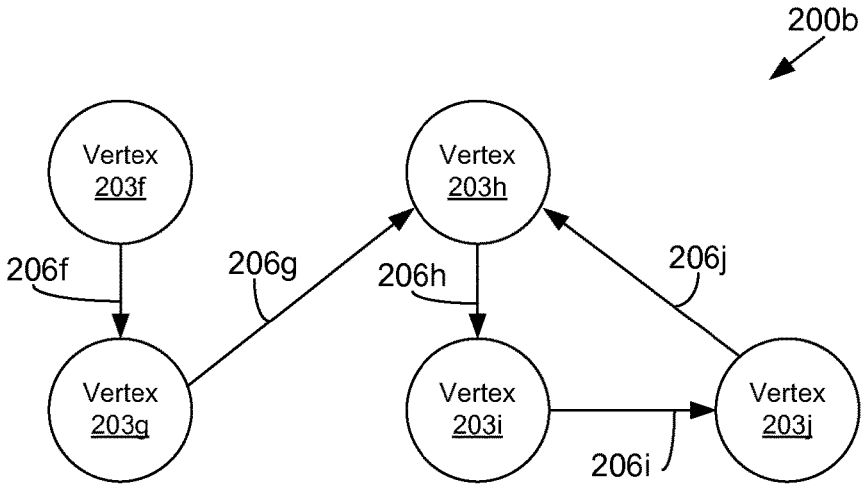

200b
Vertex 203f
Vertex 203h
206f
206g
206h
206j
Vertex 203g
Vertex 203i
Vertex 203j
206i

FIG. 2B

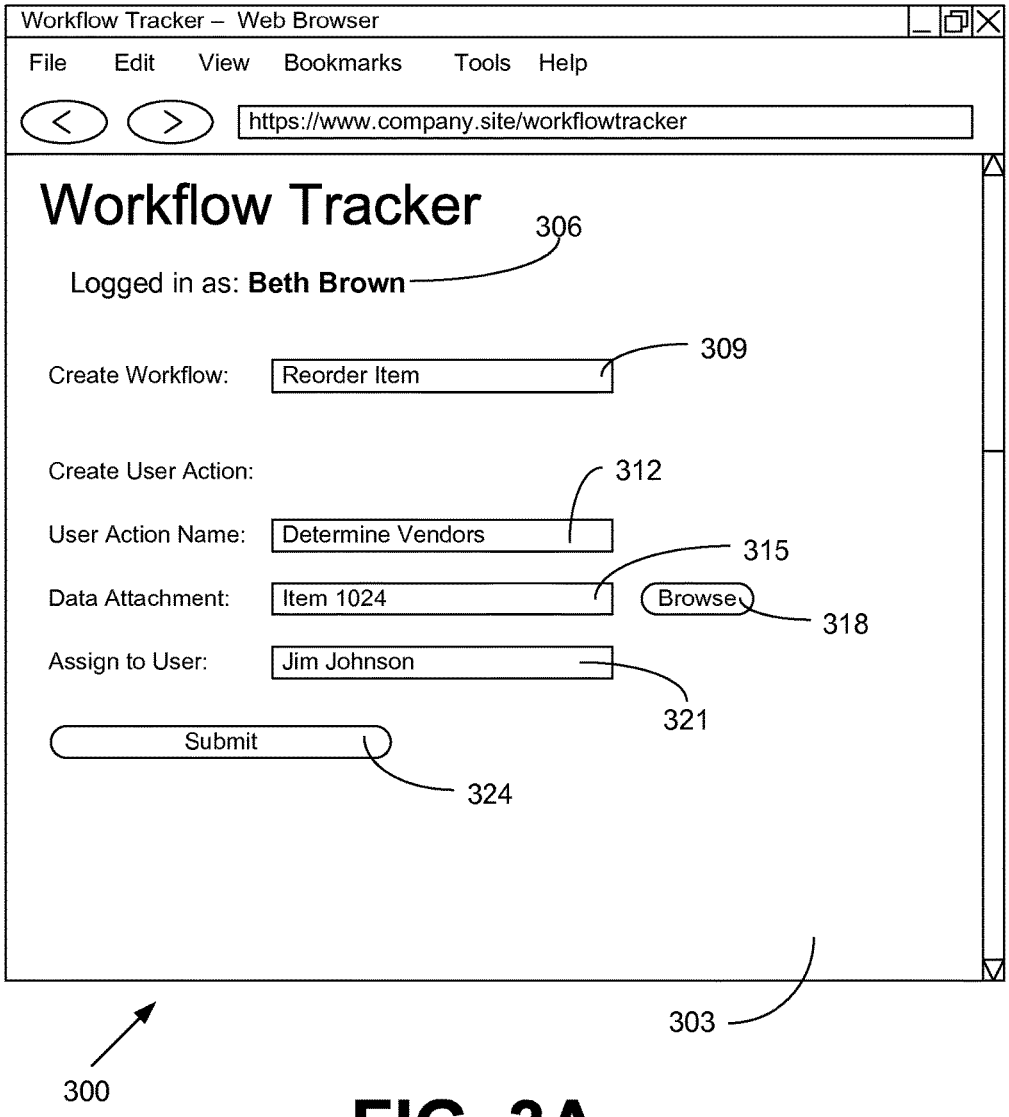

Workflow Tracker – Web Browser
File Edit View Bookmarks Tools Help
https://www.company.site/workflowtracker
Workflow Tracker
306
Logged in as: Beth Brown
309
Create Workflow:
Reorder Item
Create User Action:
312
User Action Name:
Determine Vendors
315
Data Attachment:
Item 1024
Browse
318
Assign to User:
Jim Johnson
321
Submit
324
303
300

FIG. 3A

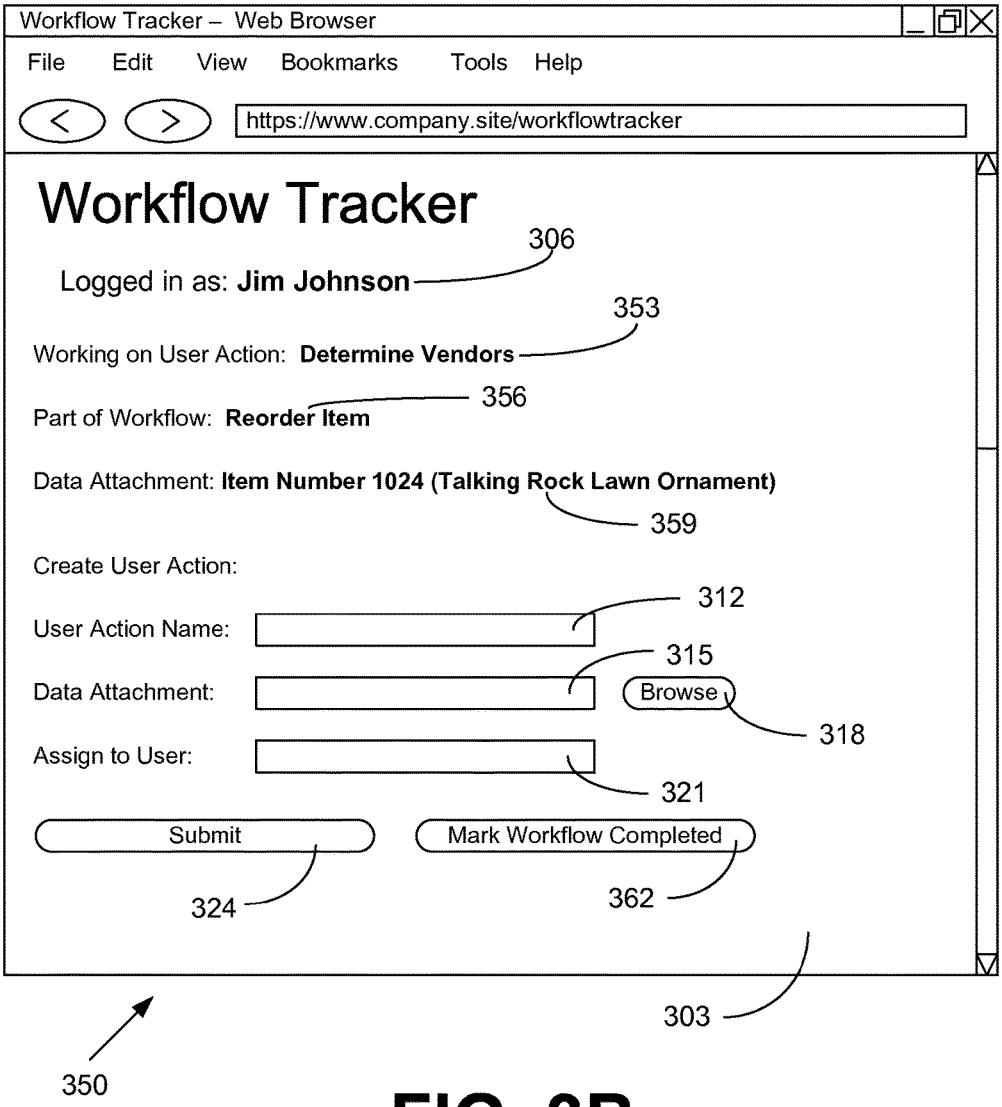

Workflow Tracker – Web Browser
File Edit View Bookmarks Tools Help
https://www.company.site/workflowtracker
Workflow Tracker
306
Logged in as: Jim Johnson
353
Working on User Action: Determine Vendors
356
Part of Workflow: Reorder Item
Data Attachment: Item Number 1024 (Talking Rock Lawn Ornament)
359
Create User Action:
312
User Action Name:
315
Data Attachment:
Browse
318
Assign to User:
321
Submit
Mark Workflow Completed
324
362
303
350

FIG. 3B

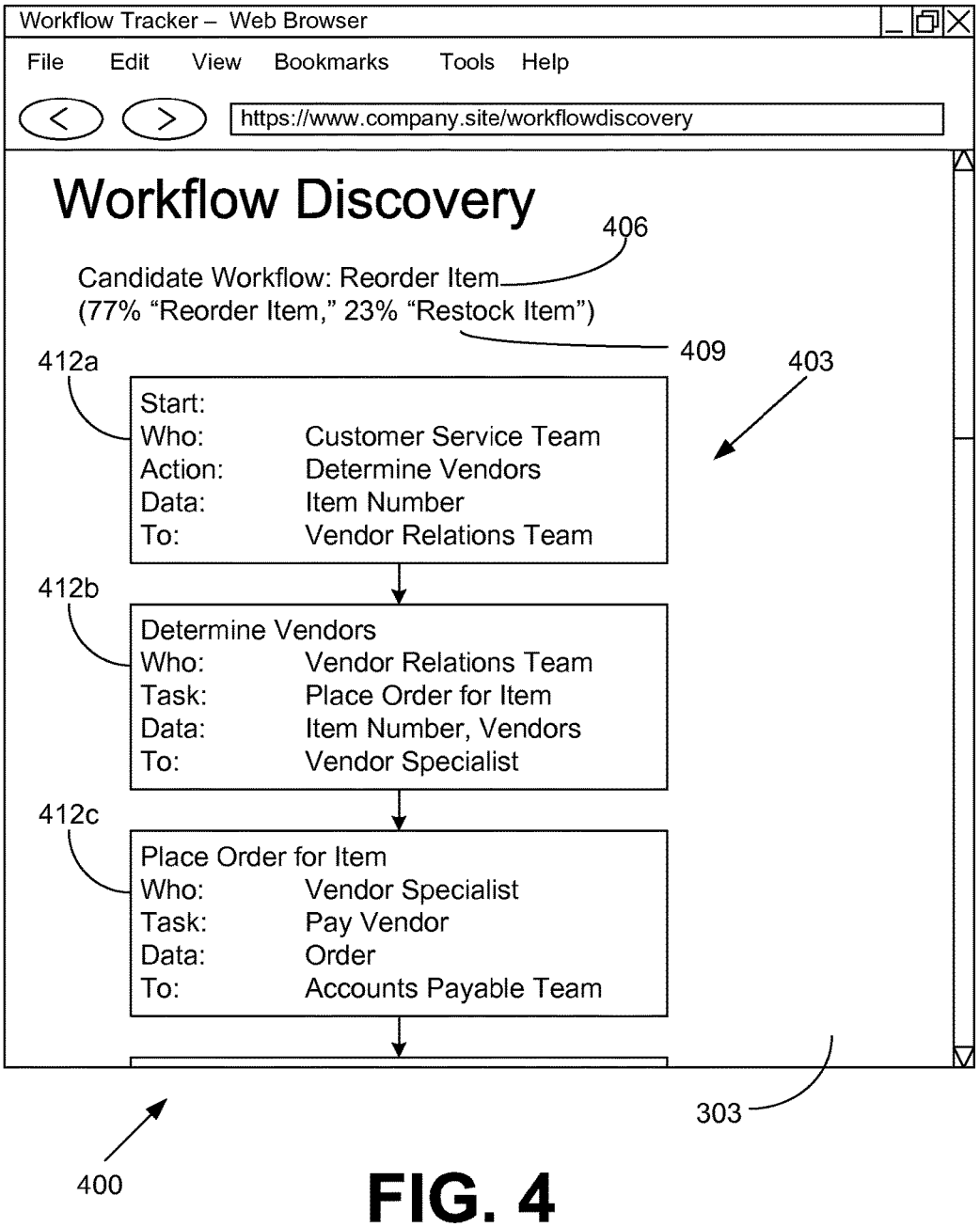

Workflow Tracker – Web Browser
File Edit View Bookmarks Tools Help
https://www.company.site/workflowdiscovery
Workflow Discovery
406
Candidate Workflow: Reorder Item
(77% "Reorder Item," 23% "Restock Item")
409
403
412a
Start:
Who: Customer Service Team
Action: Determine Vendors
Data: Item Number
To: Vendor Relations Team
412b
Determine Vendors
Who: Vendor Relations Team
Task: Place Order for Item
Data: Item Number, Vendors
To: Vendor Specialist
412c
Place Order for Item
Who: Vendor Specialist
Task: Pay Vendor
Data: Order
To: Accounts Payable Team
303
400

FIG. 4

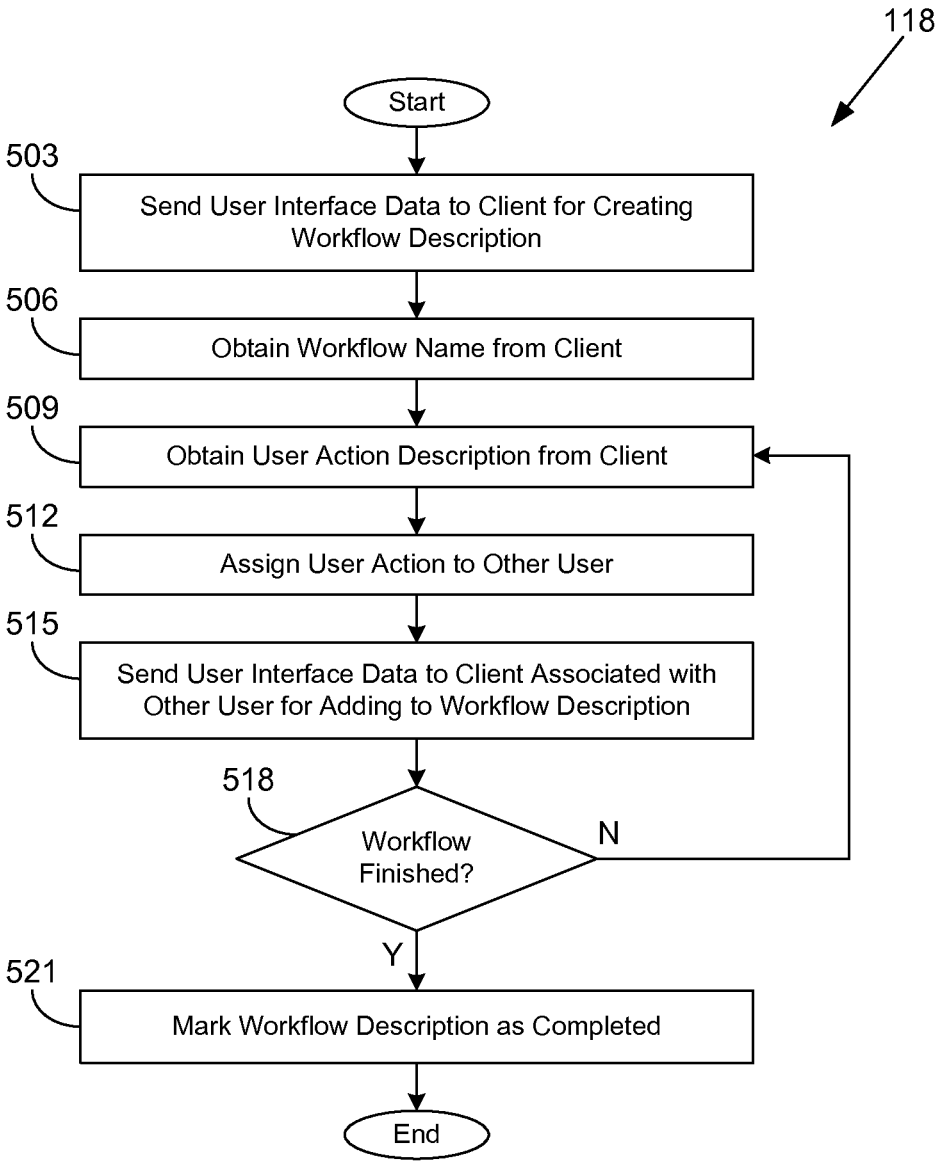

118
Start
503
Send User Interface Data to Client for Creating Workflow Description
506
Obtain Workflow Name from Client
509
Obtain User Action Description from Client
512
Assign User Action to Other User
515
Send User Interface Data to Client Associated with Other User for Adding to Workflow Description
518
Workflow Finished?
N
Y
521
Mark Workflow Description as Completed
End

FIG. 5

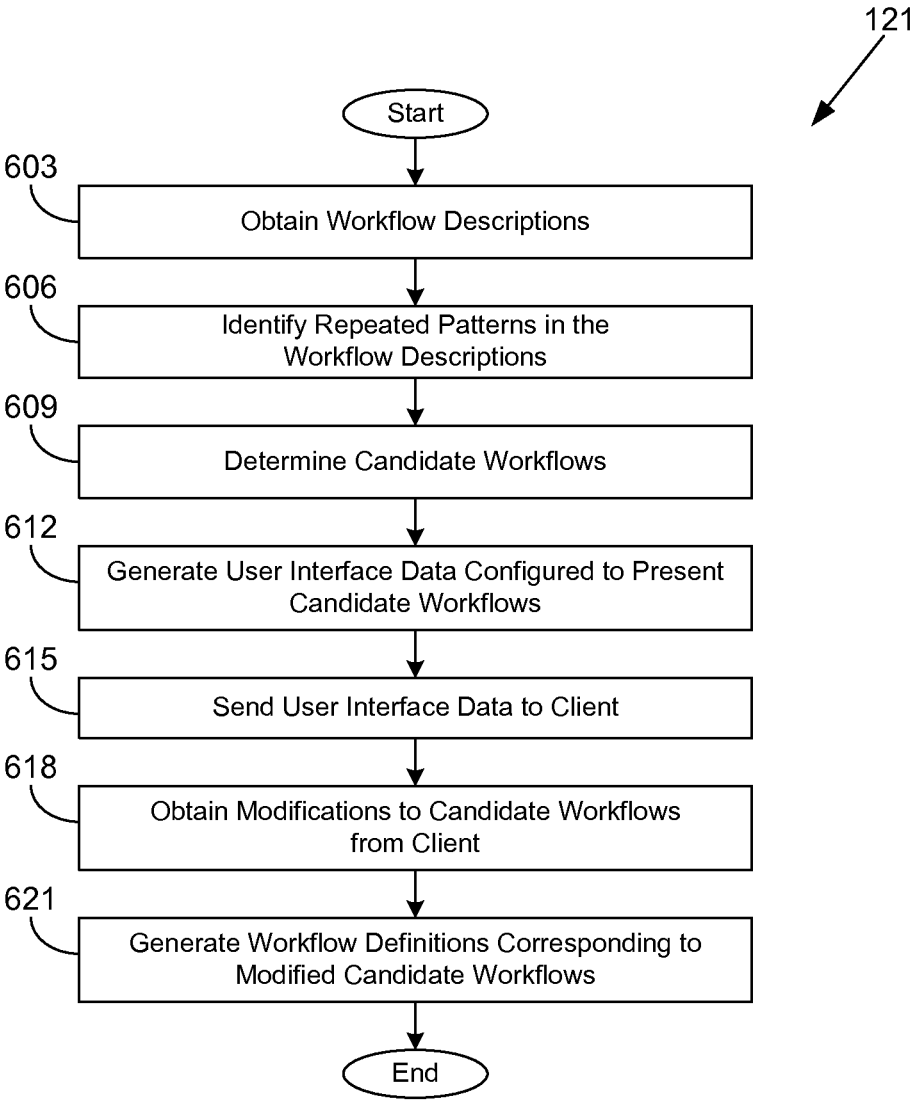

121
Start
603
Obtain Workflow Descriptions
606
Identify Repeated Patterns in the Workflow Descriptions
609
Determine Candidate Workflows
612
Generate User Interface Data Configured to Present Candidate Workflows
615
Send User Interface Data to Client
618
Obtain Modifications to Candidate Workflows from Client
621
Generate Workflow Definitions Corresponding to Modified Candidate Workflows
End

FIG. 6

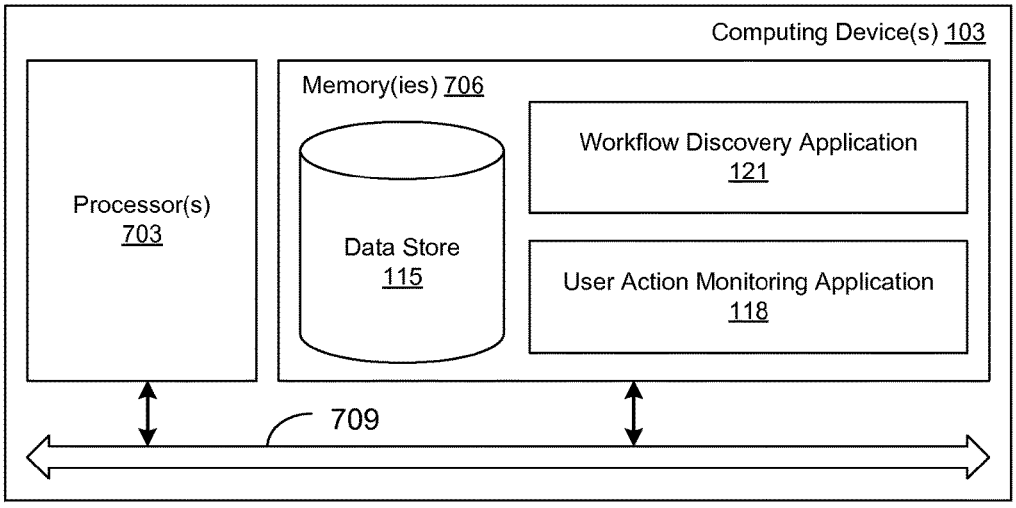

Computing Device(s) 103
Memory(ies) 706
Processor(s)
703
Data Store
115
Workflow Discovery Application
121
User Action Monitoring Application
118
709

FIG. 7

WORKFLOW DISCOVERY THROUGH USER ACTION MONITORING

CROSS-REFERENCE TO RELATED APPLICATIONS

This application is a continuation of, and claims priority to, co-pending U.S. patent application entitled "WORKFLOW DISCOVERY THROUGH USER ACTION MONITORING," filed on Oct. 12, 2011, and assigned application Ser. No. 13/271,840, which is incorporated herein by reference in its entirety.

BACKGROUND

A workflow corresponds to a sequence of tasks to achieve a desired result. In workflow management systems, workflows are defined statically, for example, in workflow definition languages such as business process execution language (BPEL), Xlang, extensible markup language (XML) process definition language (XPDL), and others. A workflow may include various business processes and operate on data such as business objects and other data.

BRIEF DESCRIPTION OF THE DRAWINGS

Many aspects of the present disclosure can be better understood with reference to the following drawings. The components in the drawings are not necessarily to scale, emphasis instead being placed upon clearly illustrating the principles of the disclosure. Moreover, in the drawings, like reference numerals designate corresponding parts throughout the several views.

FIG. **1** is a drawing of a networked environment according to various embodiments of the present disclosure.

FIGS. **2**A and **2**B are drawings of examples of data models employed by a workflow discovery application executed in a computing device in the networked environment of FIG. **1** according to various embodiments of the present disclosure.

FIGS. **3**A, **3**B, and **4** are drawings of examples of user interfaces rendered by a client in the networked environment of FIG. **1** according to various embodiments of the present disclosure.

FIG. **5** is a flowchart illustrating one example of functionality implemented as portions of a user action monitoring application executed in a computing device in the networked environment of FIG. **1** according to various embodiments of the present disclosure.

FIG. **6** is a flowchart illustrating one example of functionality implemented as portions of a workflow discovery application executed in a computing device in the networked environment of FIG. **1** according to various embodiments of the present disclosure.

FIG. **7** is a schematic block diagram that provides one example illustration of a computing device employed in the networked environment of FIG. **1** according to various embodiments of the present disclosure.

DETAILED DESCRIPTION

The present disclosure relates to discovery of workflows from the monitoring of user actions. Workflows are typically statically defined in a workflow definition language such as business process execution language (BPEL), Xlang, extensible markup language (XML) process definition language (XPDL), and others. Statically defined workflows are advantageous in that supporting software or hardware systems may be designed to assist in processing particular steps of the static workflow. However, certain classes of workflows are difficult to express statically. For example, one workflow might involve giving users a choice about where the workflow proceeds at a certain point. Additionally, it may be difficult to obtain information about how a workflow should be defined. Users may not be able to articulate how they perform their work, and there may be a high degree of variability relating to how individuals in a group perform their work.

Various embodiments of the present disclosure enable monitoring of user actions in workflows as they are performed by users over a period of time. From these user actions, repeated patterns may be identified by a workflow discovery application. Candidate workflows may be proposed and may be modified by users. In some cases, multiple candidate workflows may be merged to form a conditional workflow. Workflow definitions in a suitable workflow definition language may be generated from the potentially modified candidate workflows. In the following discussion, a general description of the system and its components is provided, followed by a discussion of the operation of the same.

With reference to FIG. **1**, shown is a networked environment **100** according to various embodiments. The networked environment **100** includes one or more computing devices **103** in data communication with one or more computing devices **106** and one or more clients **109** by way of a network **112**. The network **112** includes, for example, the Internet, intranets, extranets, wide area networks (WANs), local area networks (LANs), wired networks, wireless networks, or other suitable networks, etc., or any combination of two or more such networks.

The computing device **103** may comprise, for example, a server computer or any other system providing computing capability. Alternatively, a plurality of computing devices **103** may be employed that are arranged, for example, in one or more server banks or other arrangements. For example, a plurality of computing devices **103** together may comprise a cloud computing resource, a grid computing resource, and/or any other distributed computing arrangement. Such computing devices **103** may be located in a single installation or may be distributed among many different geographical locations. For purposes of convenience, the computing device **103** is referred to herein in the singular. Even though the computing device **103** is referred to in the singular, it is understood that a plurality of computing devices **103** may be employed in the various arrangements as described above.

Various applications and/or other functionality may be executed in the computing device **103** according to various embodiments. Also, various data is stored in a data store **115** that is accessible to the computing device **103**. The data store **115** may be representative of a plurality of data stores **115** as can be appreciated. The data stored in the data store **115**, for example, is associated with the operation of the various applications and/or functional entities described below.

The components executed on the computing device **103**, for example, include a user action monitoring application **118**, a workflow discovery application **121**, and other applications, services, processes, systems, engines, or functionality not discussed in detail herein. The user action monitoring application **118** is executed to facilitate monitoring of user actions with respect to a workflow. The user action monitoring application **118** observes the users performing actions in connection with their work and then assigning actions to other users along with associated data. In various

embodiments, the user action monitoring application **118** may correspond to an ad hoc workflow management system, with task-tracking features, follow-up features for uncompleted tasks, notification features, etc.

The workflow discovery application **121** processes the data obtained by the user action monitoring application **118** to identify repeated patterns among the observed workflows. The workflow discovery application **121** then generates one or more proposed workflows based at least in part on the repeated patterns. The proposed workflows are presented for manual review via a user interface, which also facilitates modification of the proposed workflows. The workflow discovery application **121** may also generate workflow definitions in workflow definition languages for the proposed, and potentially modified, workflows.

The data stored in the data store **115** includes, for example, user action descriptions **124**, users **127**, business objects **130**, workflow descriptions **133**, candidate workflows **136**, workflow definitions **139**, one or more data dictionaries **142**, graph data **145**, and potentially other data. The user action descriptions **124** describe user actions created by one user **127** and assigned to another user **127**. To this end, each user action description **124** may include a workflow name **148**, an action name **151**, action data **154**, a priority **157**, time data **160**, a source user **163**, a destination user **166**, and/or other data.

The workflow name **148** corresponds to a name and/or unique identifier for a workflow to which the user action description **124** belongs. For example, the workflow name **148** may correspond to an overall task that is performed by multiple subtasks in the workflow. The action name **151** describes or identifies the specific subtask, or user action, embodied by the particular user action description **124**. The action data **154** corresponds to one or more instances of business objects **130**, text data, freeform data, files, attachments, etc. that are associated with the particular user action and are employed by the destination user **166** in performing the user action.

The priority **157** field may indicate a particular level of priority or importance that is to be given to the particular user action. The time data **160** may include time-related information pertaining to the user action. Such time data **160** may include, for example, a time at which the user action description **124** was created, a time at which the user action was assigned from the source user **163** to the destination user **166**, a time at which the user action was completed by the destination user **166**, and/or other data.

The source user **163** corresponds to a user **127** who created the user action description **124** and who assigned a user action identified by the action name **151** to the destination user **166**. In some situations, the source user **163** may be creating a workflow identified by the workflow name **148**, while in other situations, the source user **163** may be completing another user action of the workflow that was assigned to him or her. The destination user **166** is the user **127** to whom the user action is assigned. In some cases, the destination user **166** may be specified by role or as any one of a group of users **127**. When a workflow is completed, there may be no destination user **166** and the user action description **124** may be marked as completed. In some embodiments, a source user **163** may be able to generate multiple user action descriptions **124** from the same workflow so as to create multiple user actions that are respectively assigned to multiple destination users **166**.

The users **127** correspond to employees or other workers who perform business-oriented tasks as part of workflows. The users **127** may have specific jobs or responsibilities within a business entity. Each of the users **127** may be associated with one or more managers **169**, one or more subordinates **172**, one or more teams **175**, and/or other business relationships. The business objects **130** are standardized objects of data that may each correspond to business concepts such as, for example, items, products, vendors, customer orders, purchase orders, customers, and so on, depending on the particular business.

The workflow descriptions **133** provide an entry point to a sequence of user action descriptions **124** which correspond to an observed workflow. The workflow descriptions **133** may each be associated with a respective workflow name **148** from the sequence of user action descriptions **124**. The candidate workflows **136** correspond to proposed classes of workflows identified by the workflow discovery application **121** from the workflow descriptions **133** and the user action descriptions **124**. In various embodiments, the user action descriptions **124**, the workflow descriptions **133**, the candidate workflows **136**, and/or portions thereof may be expressed in XML. The workflow definitions **139** correspond to definitions of workflows for the candidate workflows **136** in workflow definition languages such as BPEL, Xlang, XPDL, and others. The workflow definitions **139** may be suitable for execution by a commercially available workflow management system.

The data dictionaries **142** may correspond to standardized listings of workflow names **148**, action names **151**, names of teams **175**, names of roles of users **127**, and so on. The data dictionaries **142** are employed by the user action monitoring application **118** to facilitate creation of user action descriptions **124** and workflow descriptions **133** by users **127**. By using a data dictionary **142**, the likelihood of duplicate terms being used to name the same task or workflow is reduced. The data dictionaries **142** may be user-modifiable to add names in some embodiments.

The graph data **145** includes various graph-based data models employed by the workflow discovery application **121** to identify candidate workflows **136** from the user action descriptions **124** and workflow descriptions **133**. In one embodiment, a workflow description **133** may be modeled as a directed graph as will be described further in connection with FIGS. **2**A and **2**B.

The computing device **106** may comprise, for example, a server computer or any other system providing computing capability. Alternatively, a plurality of computing devices **106** may be employed that are arranged, for example, in one or more server banks or other arrangements. For example, a plurality of computing devices **106** together may comprise a cloud computing resource, a grid computing resource, and/or any other distributed computing arrangement. Such computing devices **106** may be located in a single installation or may be distributed among many different geographical locations. For purposes of convenience, the computing device **106** is referred to herein in the singular. Even though the computing device **106** is referred to in the singular, it is understood that a plurality of computing devices **106** may be employed in the various arrangements as described above.

Various applications and/or other functionality may be executed in the computing device **106** according to various embodiments. Also, various data is stored in a data store that is accessible to the computing device **106**. The components executed on the computing device **106**, for example, include a relationship data provider **178** and other applications, services, processes, systems, engines, or functionality not discussed in detail herein. The relationship data provider **178** is executed to provide user relationship data **181** to the workflow discovery application **121** and/or the user action

monitoring application **118**. The user relationship data **181** may define various relationships among the users **127**, such as subordinate-manager relationships, team memberships, different team relationships, same team relationships, roles and responsibilities, and so on. In various embodiments, the relationship data provider **178** may correspond to an Active Directory server, a lightweight directory access protocol (LDAP) server, and/or other types of servers.

The client **109** is representative of a plurality of client devices that may be coupled to the network **112**. The client **109** may comprise, for example, a processor-based system such as a computer system. Such a computer system may be embodied in the form of a desktop computer, a laptop computer, personal digital assistants, cellular telephones, smartphones, set-top boxes, music players, web pads, tablet computer systems, game consoles, electronic book readers, or other devices with like capability. The client **109** may include a display comprising, for example, one or more devices such as cathode ray tubes (CRTs), liquid crystal display (LCD) screens, gas plasma-based flat panel displays, LCD projectors, or other types of display devices, etc.

The client **109** may be configured to execute various applications such as a client application **184** and/or other applications. The client application **184** is executed to obtain user interface data **187** from the computing device **103** and render various user interfaces to facilitate user action entry and submission of user action report data **190**. The client application **184** may also render user interfaces for viewing and manipulating candidate workflows **136**. In one embodiment, the client application **184** corresponds to a browser application that is configured, for example, to access and render network pages, such as web pages, or other network content served up by the computing device **103** and/or other servers. The client **109** may be configured to execute applications beyond the client application **184** such as, for example, browser applications, mobile applications, email applications, instant message applications, and/or other applications.

Next, a general description of the operation of the various components of the networked environment **100** is provided. To begin, users **127** access various user interfaces generated by the user action monitoring application **118**. The user interfaces facilitate creation of workflow descriptions **133** and user action descriptions **124**. The users **127** perform various user actions in connection with their respective occupational responsibilities and then transfer data to other users **127** so that other users **127** may perform their respective occupational responsibilities with respect to the workflow. Ultimately, the workflow is completed, and the overarching task associated with the workflow is completed.

User actions and workflows are monitored in this way over a period of time, thereby populating the user action descriptions **124**, the workflow descriptions **133**, the data dictionaries **142**, etc. The workflow discovery application **121** is then executed to analyze the collected data to identify patterns in these observed workflows. For example, the workflows may have the same or similar workflow names **148**. Also, the workflows may include a similar sequence of user action descriptions **124**. Similarity of the user action descriptions **124** may be assessed according to a comparison of the action names **151**, action data **154**, priorities **157**, time data **160**, the source users **163**, the destination users **166**, and so on.

The similarity may also be assessed by determining types of source users **163**, types of destination users **166**, and relationships between the source users **163** and the destination users **166**. The relationships may be determined according to managers **169**, subordinates **172**, teams **175**, and/or other user relationship data **181**. Moreover, the action data **154** may be classified according to the structure of business objects **130** and/or relationships between business objects **130**.

After repeated patterns are identified, the workflow discovery application **121** generates candidate workflows **136** that represent generic workflows that correspond to the similar observed workflows. The candidate workflows **136** may be presented through a user interface for a manual review and manual modification. Statistical outliers may be highlighted and used to determine whether users **127** did not understand the task at hand or whether there are legitimate exceptions to the workflow. The potentially modified candidate workflows **136** may be used to generate workflow definitions **139** which are suitable for execution and further optimization in a workflow management system.

Referring next to FIGS. **2**A and **2**B, shown are drawings of examples of data models employed by the workflow discovery application **121** (FIG. **1**) executed in a computing device **103** (FIG. **1**) in the networked environment **100** (FIG. **1**). In particular, FIG. **2**A shows a directed graph **200***a* comprising a set of vertices **203***a*, **203***b*, **203***c*, **203***d*, and **203***e* and a set of arcs **206***a*, **206***b*, **206***c*, **206***d*, and **206***e*. The workflow descriptions **133** (FIG. **1**) and the corresponding sequence of user action descriptions **124** (FIG. **1**) may be modeled as the directed graph **200***a* in the following way. Each of the vertices **203** corresponds to a tuple including a user action of a user action description **124** (FIG. **1**) and the destination user **166** (FIG. **1**) who is assigned to perform the user action. Each arc **206** corresponds to a tuple including a source vertex **203** and a destination vertex **203**. In some cases, the tuple of the arc **206** may include a condition under which the arc **206** is active or inactive.

FIG. **2**B shows another directed graph **200***b* comprising a set of vertices **203***f*, **203***g*, **203***h*, **203***i*, and **203***j* and a set of arcs **206***f*, **206***g*, **206***h*, **206***i*, and **206***j*. Although directed graphs **200***a* and **200***b* have a different appearance, the directed graphs **200***a* and **200***b* may be identified as isomorphic because each vertex **203** of the directed graph **200***a* maps to a corresponding vertex **203** of the directed graph **200***b*, and each arc **206** of the directed graph **200***a* maps to a corresponding arc **206** of the directed graph **200***b*. In this example, vertex **203***a* maps to vertex **203***f*, vertex **203***b* maps to vertex **203***g*, vertex **203***c* maps to vertex **203***h*, vertex **203***d* maps to vertex **203***i*, and vertex **203***e* maps to vertex **203***j*. Further, arc **206***a* maps to arc **206***f*, arc **206***b* maps to arc **206***g*, arc **206***c* maps to arc **206***h*, arc **206***d* maps to arc **206***i*, and arc **206***e* maps to arc **206***j*.

In various embodiments, the workflow discovery application **121** may identify repeated patterns in the workflow descriptions **133** by modeling each workflow description **133** as a directed graph **200** and identifying directed graphs **200** that are isomorphic. The workflow discovery application **121** may also be configured to identify portions of directed graphs **200** which are isomorphic, thereby potentially identifying workflows that represent different conditions of the same workflow.

Additionally, context data may be available to aid determination of whether directed graphs **200** are isomorphic. For example, vertex **203** coloring schemes may be employed using attributes in the context data. A set of context data may be associated with each directed graph **200**. In one embodiment, such context data may comprise multiple key-value pairs or other data structures. As a non-limiting example, the context data may be based at least in part on a respective action name **151** (FIG. **1**) associated with each of the user

actions, the action data **154** (FIG. **1**) associated with the user actions, and a relationship between the source user **163** (FIG. **1**) and the destination user **166** for each of the user actions.

In another embodiment, the vertices **203** may correspond to the user actions, while additional vertices **203** may be added which represent the users **127** (FIG. **1**). The relationships between users **127** may be modeled with additional arcs **206**.

Turning now to FIG. **3**A, shown is one example of a user interface **300** rendered by a client application **184** (FIG. **1**) executed in a client **109** (FIG. **1**) in the networked environment **100** (FIG. **1**). In particular, the user interface **300** is configured to obtain input from a user **127** (FIG. **1**) to create a workflow description **133** (FIG. **1**) and a user action description **124** (FIG. **1**). In the example of FIG. **3**A, the user interface **300** comprises a rendered network page **303**. The user interface **300** is rendered based at least in part on user interface data **187** (FIG. **1**) obtained from the computing device **103** (FIG. **1**) over the network **112** (FIG. **1**).

The rendered network page **303** includes a user indication **306**, which shows that the user **127** named "Beth Brown" is currently logged in. A create workflow component **309** allows the user **127** to specify a workflow name **148** (FIG. **1**). In this example, the user **127** has specified "Reorder Item" to be the workflow name **148**. It is noted that the create workflow component **309** may be configured to employ a data dictionary **142** (FIG. **1**) of acceptable or previously used workflow names **148**. To this end, the create workflow component **309** may comprise a drop-down box or auto-searching text field. The create workflow component **309** may also be configured to facilitate specification of a workflow name **148** which is not currently in the data dictionary **142**.

The rendered network page **303** also includes a create user action component **312**. The create user action component **312** allows the user **127** to specify an action name **151** (FIG. **1**). In this example, the user **127** has specified "Determine Vendors" to be the action name **151**. It is noted that the create user action component **312** may be configured to employ a data dictionary **142** of acceptable or previously used action names **141**. To this end, the create user action component **312** may comprise a drop-down box or auto-searching text field. The create user action component **312** may also be configured to facilitate specification of an action name **151** which is not currently in the data dictionary **142**.

A data attachment component **315** facilitates entry of free form data, uploading of files, specification of particular business objects **130** (FIG. **1**), and/or other data pertaining to the user action, which will be stored as action data **154** (FIG. **1**). A browse component **318** may be present to facilitate the location of files to be uploaded through the data attachment component **315**. In this example, the user **127** has attached a business object **130** named "Item **1024**."

A user assignment component **321** facilitates the assignment of the user action from the user **127** as a source user **163** (FIG. **1**) to a destination user **166** (FIG. **1**). In this example, the user assignment component **321** indicates that the user action is to be assigned to "Jim Johnson." The user assignment component **321** may be linked to a company directory or other source of user **127** information to ease and/or validate user **127** entry. For example, the destination user **166** may be identified in the user assignment component **321** by a unique identifier, a name, a position, a role, a team, etc. If the destination user **166** is not uniquely identified, the user action monitoring application **118** (FIG. **1**) may be configured to assign the user action to a specific user **127** using criteria specified through the user assignment component **321**.

It is noted that multiple user actions may be created through the user interface **300**, and some user actions may be assigned to multiple destination users **166**. A submit component **324** is provided to submit the user action report data **190** (FIG. **1**) to the computing device **103**. The components included in the user interface **300** may differ in other embodiments.

Moving on to FIG. **3**B, shown is one example of a user interface **350** rendered by a client application **184** (FIG. **1**) executed in a client **109** (FIG. **1**) in the networked environment **100** (FIG. **1**). In particular, the user interface **350** is configured to obtain input from a user **127** (FIG. **1**) to create a user action description **124** (FIG. **1**). In the example of FIG. **3**B, the user interface **350** comprises a rendered network page **303**. The user interface **350** is rendered based at least in part on user interface data **187** (FIG. **1**) obtained from the computing device **103** (FIG. **1**) over the network **112** (FIG. **1**).

The rendered network page **303** includes a user indication **306**, which shows that the user **127** named "Jim Johnson" is currently logged in. The rendered network page **303** includes a user action indication **353**, a workflow indication **356**, and an action data indication **359**. The user action indication **353** indicates an action name **151** (FIG. **1**) of "Determine Vendors" for the user action being worked on by the user **127**.

The workflow indication **356** indicates a workflow name **148** (FIG. **1**) of "Reorder Item" for the workflow with which the user action is associated. The action data indication **359** indicates action data **154** (FIG. **1**) that has been specified for the current user action. In this example, the action data **154** refers to a business object **130** (FIG. **1**) named "Item Number **1024**" which has an associated title of "Talking Rock Lawn Ornament." Because the action data **154** refers to a business object **130**, the user action monitoring application **118** (FIG. **1**) is able to obtain associated data such as the title. In some cases, the user interface **350** may facilitate downloading of files and/or viewing of network pages relating to the action data **154**.

The rendered network page **303** also includes a create user action component **312**. The create user action component **312** allows the user **127** to specify an action name **151**. It is noted that the create user action component **312** may be configured to employ a data dictionary **142** (FIG. **1**) of acceptable or previously used action names **141** (FIG. **1**). To this end, the create user action component **312** may comprise a drop-down box or auto-searching text field. The create user action component **312** may also be configured to facilitate specification of an action name **151** which is not currently in the data dictionary **142**.

A data attachment component **315** facilitates entry of free form data, uploading of files, specification of particular business objects **130**, and/or other data pertaining to the user action, which will be stored as action data **154**. A browse component **318** may be present to facilitate the location of files to be uploaded through the data attachment component **315**.

A user assignment component **321** facilitates the assignment of the user action from the user **127** as a source user **163** to a destination user **166** (FIG. **1**). The user assignment component **321** may be linked to a company directory or other source of user **127** information to ease and/or validate user **127** entry. For example, the destination user **166** may be identified in the user assignment component **321** by a unique identifier, a name, a position, a role, a team, etc. If the

destination user **166** is not uniquely identified, the user action monitoring application **118** may be configured to assign the user action to a specific user **127** using criteria specified through the user assignment component **321**.

It is noted that multiple user actions may be created through the user interface **350**, and some user actions may be assigned to multiple destination users **166**. A submit component **324** is provided to submit the user action report data **190** (FIG. **1**) to the computing device **103**. A mark completed component **362** is provided for the user **127** to mark the current workflow as completed. The components included in the user interface **350** may differ in other embodiments.

With reference to FIG. **4**, shown is another user interface **400** rendered by a client application **184** (FIG. **1**) executed in a client **109** (FIG. **1**) in the networked environment **100** (FIG. **1**). In particular, the user interface **400** is rendered based on user interface data **187** (FIG. **1**) generated by the workflow discovery application **121** (FIG. **1**). In this non-limiting example, the user interface **400** corresponds to a rendered network page **303**.

The user interface **400** presents a representation **403** of a candidate workflow **136** (FIG. **1**) identified by the workflow discovery application **121**. The user interface **400** facilitates manual review of the candidate workflow **136**. The example of FIG. **4** continues the examples of FIGS. **3**A and **3**B. A workflow name indication **406** indicates an identified workflow name **148** (FIG. **1**) of "Reorder Item." However, other information **409** that is provided indicates that the candidate workflow **136** was identified according to a set of workflow descriptions **133** (FIG. **1**) of which 77% had the workflow name **148** of "Reorder Item" and 23% had the workflow name **148** of "Restock Item." Various forms of other information **409** may be provided in conjunction with any pattern identified by the workflow discovery application **121**. Other information **409** may facilitate verification of automatic determinations made by the workflow discovery application **121**.

The representation **403** in this case is a graphical representation but could be a purely textual representation in other embodiments. Further, in other embodiments, simpler or more complex graphical representations may be employed. The representation **403** illustrates various states **412***a*, **412***b*, and **412***c* of the candidate workflow **136**, each of the states **412** corresponding to user action descriptions **124** (FIG. **1**).

The state **412***a* is the first user action of the candidate workflow **136**. The state **412***a* indicates that the user action is created by some member of the "Customer Service Team," the action is named "Determine Vendors," the action includes an "Item Number," and the action is assigned to some member of the "Vendor Relations Team." To determine this state **412***a*, the workflow discovery application **121** may examine many such user action descriptions **124**, such as the one created as the result of the example of the user interface **300** (FIG. **3**A), wherein repeated patterns are identified.

The state **412***b* is the second user action of the candidate workflow **136**. The state **412***b* indicates that the user action is created by some member of the "Vendor Relations Team," the action is named "Place Order for Item," the action includes an "Item Number" and listing of "Vendors," and the action is assigned to someone who fulfills the "Vendor Specialist" role. To determine this state **412***b*, the workflow discovery application **121** may examine many such user action descriptions **124**, such as the one created as the result of the example of the user interface **350** (FIG. **3**B), wherein repeated patterns are identified.

The state **412***c* is the third user action of the candidate workflow **136**. The state **412***c* indicates that the user action is created by a "Vendor Specialist," the action is named "Pay Vendor," the action includes an "Order," and the action is assigned to someone who is in the "Accounts Payable Team." Additional states **412** may be included in the representation **403**, though not shown in FIG. **4**. In particular, the representation **403** may terminate with a completed state **412** indicating a final user action of the workflow.

Although not pictured in FIG. **4**, the user interface **400** may also include tools for merging portions of multiple candidate workflows **136**. For example, two candidate workflows **136** might actually be conditional branches of a single workflow. To this end, the workflow discovery application **121** may be configured to automatically propose a conditional candidate workflow **136** according to the similarities and differences between two or more candidate workflows **136**. Also, the user interface **400** may include a tool for generating a workflow definition **139** (FIG. **1**) from a candidate workflow **136**.

Referring next to FIG. **5**, shown is a flowchart that provides one example of the operation of a portion of the user action monitoring application **118** according to various embodiments. It is understood that the flowchart of FIG. **5** provides merely an example of the many different types of functional arrangements that may be employed to implement the operation of the portion of the user action monitoring application **118** as described herein. As an alternative, the flowchart of FIG. **5** may be viewed as depicting an example of steps of a method implemented in the computing device **103** (FIG. **1**) according to one or more embodiments.

Beginning with box **503**, the user action monitoring application **118** sends user interface data **187** (FIG. **1**) to the client **109** (FIG. **1**). The user interface data **187** encodes for rendering in the client **109** a user interface for creating a workflow description **133** (FIG. **1**). The client **109** is associated with a user **127** (FIG. **1**). In box **506**, the user action monitoring application **118** obtains a workflow name **148** (FIG. **1**) and potentially other data relating to the creation of a workflow description **133** from the client **109**. In box **509**, the user action monitoring application **118** obtains data relating to a user action description **124** (FIG. **1**) from the client **109**.

In box **512**, the user action monitoring application **118** assigns the user action described by the user action description **124** to another user **127** as indicated by the destination user **166** (FIG. **1**) field of the user action description **124**. In box **515**, the user action monitoring application **118** sends user interface data **187** to a client **109** associated with the other user **127**. The user interface data **187** encodes for rendering in the client **109** a user interface for adding to the workflow description **133**.

In box **518**, the user action monitoring application **118** determines whether the other user **127** indicates that the workflow associated with the workflow description **133** is finished according to input supplied by the other user **127**. If the workflow is not finished, the user action monitoring application **118** moves from box **518** to box **509** and obtains another user action description **124**. It is noted that a user **127** may provide multiple user action descriptions **124** for a workflow. Also, in some cases, a user action may be assigned to multiple users **127**. If the user action monitoring application **118** instead determines in box **518** that the workflow is finished, the user action monitoring application **118** moves to box **521** and marks the workflow description

133 as completed. Thereafter, the portion of the user action monitoring application **118** ends.

Continuing now to FIG. **6**, shown is a flowchart that provides one example of the operation of a portion of the workflow discovery application **121** according to various embodiments. It is understood that the flowchart of FIG. **6** provides merely an example of the many different types of functional arrangements that may be employed to implement the operation of the portion of the workflow discovery application **121** as described herein. As an alternative, the flowchart of FIG. **6** may be viewed as depicting an example of steps of a method implemented in the computing device **103** (FIG. **1**) according to one or more embodiments.

Beginning with box **603**, the workflow discovery application **121** obtains the workflow descriptions **133** (FIG. **1**) as observed over a period of time by the user action monitoring application **118** (FIG. **1**). In box **606**, the workflow discovery application **121** identifies repeated patterns in the workflow descriptions **133**. In box **609**, the workflow discovery application **121** determines one or more candidate workflows **136** (FIG. **1**) from the identified repeated patterns.

In box **612**, the workflow discovery application **121** generates user interface data **187** (FIG. **1**) that is configured to render a user interface that presents a representation of the candidate workflows **136**. Such a representation may include a graphical representation and/or a textual representation. The representation may include explanations as to the identified repeated pattern(s) prompting the determination of a candidate workflow **136**. The user interface may include functionality for modifying various aspects of the automatically determined candidate workflow **136**. For example, the user interface may include functionality to merge multiple candidate workflows **136** if the reviewer determines that the candidate workflows **136** are conditional branches of one logical workflow. In box **615**, the workflow discovery application **121** sends the user interface data **187** to the client **109**.

In box **618**, the workflow discovery application **121** obtains modifications to candidate workflows **136** from the client **109**. In box **621**, the workflow discovery application **121** generates workflow definitions **139** (FIG. **1**) that correspond to the potentially modified candidate workflows **136**. Thereafter, the portion of the workflow discovery application **121** ends.

With reference to FIG. **7**, shown is a schematic block diagram of the computing device **103** according to an embodiment of the present disclosure. The computing device **103** includes at least one processor circuit, for example, having a processor **703** and a memory **706**, both of which are coupled to a local interface **709**. To this end, the computing device **103** may comprise, for example, at least one server computer or like device. The local interface **709** may comprise, for example, a data bus with an accompanying address/control bus or other bus structure as can be appreciated.

Stored in the memory **706** are both data and several components that are executable by the processor **703**. In particular, stored in the memory **706** and executable by the processor **703** are the workflow discovery application **121**, the user action monitoring application **118**, and potentially other applications. Also stored in the memory **706** may be a data store **115** and other data. In addition, an operating system may be stored in the memory **706** and executable by the processor **703**.

It is understood that there may be other applications that are stored in the memory **706** and are executable by the processor **703** as can be appreciated. Where any component discussed herein is implemented in the form of software, any one of a number of programming languages may be employed such as, for example, C, C++, C#, Objective C, Java®, JavaScript®, Perl, PHP, Visual Basic®, Python®, Ruby, Delphi®, Flash®, or other programming languages.

A number of software components are stored in the memory **706** and are executable by the processor **703**. In this respect, the term "executable" means a program file that is in a form that can ultimately be run by the processor **703**. Examples of executable programs may be, for example, a compiled program that can be translated into machine code in a format that can be loaded into a random access portion of the memory **706** and run by the processor **703**, source code that may be expressed in proper format such as object code that is capable of being loaded into a random access portion of the memory **706** and executed by the processor **703**, or source code that may be interpreted by another executable program to generate instructions in a random access portion of the memory **706** to be executed by the processor **703**, etc. An executable program may be stored in any portion or component of the memory **706** including, for example, random access memory (RAM), read-only memory (ROM), hard drive, solid-state drive, USB flash drive, memory card, optical disc such as compact disc (CD) or digital versatile disc (DVD), floppy disk, magnetic tape, or other memory components.

The memory **706** is defined herein as including both volatile and nonvolatile memory and data storage components. Volatile components are those that do not retain data values upon loss of power. Nonvolatile components are those that retain data upon a loss of power. Thus, the memory **706** may comprise, for example, random access memory (RAM), read-only memory (ROM), hard disk drives, solid-state drives, USB flash drives, memory cards accessed via a memory card reader, floppy disks accessed via an associated floppy disk drive, optical discs accessed via an optical disc drive, magnetic tapes accessed via an appropriate tape drive, and/or other memory components, or a combination of any two or more of these memory components. In addition, the RAM may comprise, for example, static random access memory (SRAM), dynamic random access memory (DRAM), or magnetic random access memory (MRAM) and other such devices. The ROM may comprise, for example, a programmable read-only memory (PROM), an erasable programmable read-only memory (EPROM), an electrically erasable programmable read-only memory (EEPROM), or other like memory device.

Also, the processor **703** may represent multiple processors **703** and the memory **706** may represent multiple memories **706** that operate in parallel processing circuits, respectively. In such a case, the local interface **709** may be an appropriate network **112** that facilitates communication between any two of the multiple processors **703**, between any processor **703** and any of the memories **706**, or between any two of the memories **706**, etc. The local interface **709** may comprise additional systems designed to coordinate this communication, including, for example, performing load balancing. The processor **703** may be of electrical or of some other available construction.

Although the workflow discovery application **121**, the user action monitoring application **118**, the client application **184** (FIG. **1**), the relationship data provider **178** (FIG. **1**), and other various systems described herein may be embodied in software or code executed by general purpose hardware as discussed above, as an alternative the same may also be embodied in dedicated hardware or a combination of software/general purpose hardware and dedicated hardware. If embodied in dedicated hardware, each can be implemented

as a circuit or state machine that employs any one of or a combination of a number of technologies. These technologies may include, but are not limited to, discrete logic circuits having logic gates for implementing various logic functions upon an application of one or more data signals, application specific integrated circuits having appropriate logic gates, or other components, etc. Such technologies are generally well known by those skilled in the art and, consequently, are not described in detail herein.

The flowcharts of FIGS. **5** and **6** show the functionality and operation of an implementation of portions of the user action monitoring application **118** and the workflow discovery application **121**. If embodied in software, each block may represent a module, segment, or portion of code that comprises program instructions to implement the specified logical function(s). The program instructions may be embodied in the form of source code that comprises human-readable statements written in a programming language or machine code that comprises numerical instructions recognizable by a suitable execution system such as a processor **703** in a computer system or other system. The machine code may be converted from the source code, etc. If embodied in hardware, each block may represent a circuit or a number of interconnected circuits to implement the specified logical function(s).

Although the flowcharts of FIGS. **5** and **6** show a specific order of execution, it is understood that the order of execution may differ from that which is depicted. For example, the order of execution of two or more blocks may be scrambled relative to the order shown. Also, two or more blocks shown in succession in FIGS. **5** and **6** may be executed concurrently or with partial concurrence. Further, in some embodiments, one or more of the blocks shown in FIGS. **5** and **6** may be skipped or omitted. In addition, any number of counters, state variables, warning semaphores, or messages might be added to the logical flow described herein, for purposes of enhanced utility, accounting, performance measurement, or providing troubleshooting aids, etc. It is understood that all such variations are within the scope of the present disclosure.

Also, any logic or application described herein, including the workflow discovery application **121**, the user action monitoring application **118**, the client application **184**, and the relationship data provider **178**, that comprises software or code can be embodied in any non-transitory computer-readable medium for use by or in connection with an instruction execution system such as, for example, a processor **703** in a computer system or other system. In this sense, the logic may comprise, for example, statements including instructions and declarations that can be fetched from the computer-readable medium and executed by the instruction execution system. In the context of the present disclosure, a "computer-readable medium" can be any medium that can contain, store, or maintain the logic or application described herein for use by or in connection with the instruction execution system.

The computer-readable medium can comprise any one of many physical media such as, for example, magnetic, optical, or semiconductor media. More specific examples of a suitable computer-readable medium would include, but are not limited to, magnetic tapes, magnetic floppy diskettes, magnetic hard drives, memory cards, solid-state drives, USB flash drives, or optical discs. Also, the computer-readable medium may be a random access memory (RAM) including, for example, static random access memory (SRAM) and dynamic random access memory (DRAM), or magnetic random access memory (MRAM). In addition, the computer-readable medium may be a read-only memory (ROM), a programmable read-only memory (PROM), an erasable programmable read-only memory (EPROM), an electrically erasable programmable read-only memory (EEPROM), or other type of memory device.

It should be emphasized that the above-described embodiments of the present disclosure are merely possible examples of implementations set forth for a clear understanding of the principles of the disclosure. Many variations and modifications may be made to the above-described embodiment(s) without departing substantially from the spirit and principles of the disclosure. All such modifications and variations are intended to be included herein within the scope of this disclosure and protected by the following claims.

Therefore, the following is claimed:

1. A method, comprising:

detecting, via at least one of one or more computing device, a plurality of user actions occurring with respect to a plurality of user interfaces rendered individually on a plurality of client devices, the plurality of user actions being performed for individual ones of a plurality of workflow descriptions, wherein at least one of the plurality of workflow descriptions are entered by a first user;

identifying, via at least one of the one or more computing devices, a repeated pattern in at least one of the plurality of workflow descriptions by modeling individual ones of the plurality of workflow descriptions as corresponding directed graphs including a set of vertices and a set of arcs, individual ones of the vertices corresponding to a particular user action and a second user assigned to perform the particular user action, individual ones of the arcs corresponding to a source vertex and a destination vertex, individual ones of the corresponding directed graphs including a corresponding set of context data based at least in part on a respective action name associated with the plurality of user actions, the corresponding set of context data being associated with the plurality of user actions, and a relationship between the first user and the second user for individual ones of the plurality of user actions;

determining, via at least one of the one or more computing devices, at least one candidate workflow base at least in part on identifying a set of isomorphic directed graphs from the corresponding directed graphs and the repeated pattern in the at least one of the plurality of workflow descriptions;

merging, via at least one of the one or more computing devices, a first candidate workflow and a second candidate workflow into the at least one candidate workflow, wherein the first candidate workflow and the second candidate workflow are merged to be conditional branches of the at least one candidate workflow; and

generating, via at least one of the one or more computing devices, a respective user interface configured to render a representation of the at least one candidate workflow.

2. The method of claim **1**, wherein the at least one candidate workflow is identified based at least in part on the corresponding set of context data associated with the set of isomorphic directed graphs.

3. The method of claim **1**, further comprising receiving, via at least one of the one or more computing devices, data describing the relationship between the first user and the second user for the individual ones of the plurality of user actions from another computing device.

4. A non-transitory computer-readable medium embodying at least one program executable in a computing device, wherein the at least one program, when executed, causes the computing device to at least:

encode a user interface for receiving a plurality of workflow descriptions, wherein at least one of the plurality of workflow descriptions are entered by a first user;

detect a plurality of user actions occurring with respect to a plurality of client devices over a network for a period of time, wherein individual ones of the plurality of workflow descriptions are populated with at least some of the plurality of user actions;

identify a repeated pattern in at least some of the plurality of workflow descriptions by modeling individual ones of the plurality of workflow descriptions as corresponding directed graphs; and

determine at least one candidate workflow by identifying a set of isomorphic directed graphs based at least in part on the corresponding directed graphs and the repeated pattern in the at least some of the plurality of workflow descriptions, wherein individual ones of the corresponding directed graphs include a set of vertices and a set of arcs, individual ones of the vertices corresponding to a particular user action and a second user assigned to perform the particular user action, individual ones of the arcs corresponding to a source vertex and a destination vertex.

5. The non-transitory computer-readable medium of claim 4, wherein the at least one program further causes the computing device to generate the user interface configured to receive the individual ones of a plurality of user action descriptions.

6. The non-transitory computer-readable medium of claim 4, wherein the at least one program further causes the computing device to:

generate one of the plurality of workflow descriptions based at least in part on a workflow name received from the first user; and

add a particular user action description to a sequence of user action descriptions included in the one of the plurality of workflow descriptions based at least in part on an action name received from the first user.

7. The non-transitory computer-readable medium of claim 4, wherein individual ones of the corresponding directed graphs include a corresponding set of context data based at least in part on a respective action name associated with the plurality of user actions, data associated with the plurality of user actions, and a relationship between a respective first user and a respective second user for individual ones of the plurality of user actions.

8. The non-transitory computer-readable medium of claim 7, wherein the at least one candidate workflow is identified based at least in part on the corresponding set of context data associated with the set of isomorphic directed graphs.

9. The non-transitory computer-readable medium of claim 4, wherein the at least one program further causes the computing device to merge a first candidate workflow and a second candidate workflow into the at least one candidate workflow, wherein the first candidate workflow and the second candidate workflow are merged to be conditional branches of the at least one candidate workflow.

10. The non-transitory computer-readable medium of claim 9, wherein the at least one program further causes the computing device to generate the user interface that renders a graphical representation of the at least one candidate workflow.

11. A system, comprising:

at least one computing device; and

at least one application executable by the at least one computing device, wherein, when executed, the at least one application causes the at least one computing device to:

generate a first user interface configured to receive a workflow description entered by a first user;

detect a plurality of user actions occurring with respect to a plurality of client devices over a network for a period of time, wherein the workflow description is populated with at least one of the plurality of user actions;

identify a repeated pattern in the workflow description by modeling the workflow description as a directed graph;

determine at least one candidate workflow by identifying a set of isomorphic directed graphs based at least in part on the directed graph and the repeated pattern in the workflow description, wherein the set of isomorphic directed graphs are identified further based at least in part on at least one other directed graph corresponding to at least one other workflow description; and

generate a second user interface configured to render a representation of the at least one candidate workflow.

12. The system of claim 11, wherein the at least one candidate workflow is determined based at least in part on relationship data indicating a relationship between the first user and a second user within an organization.

13. The system of claim 11, wherein the directed graph includes a set of vertices and a set of arcs, individual ones of the vertices corresponding to a particular user action and the second user assigned to perform the particular user action, individual ones of the arcs corresponding to a source vertex and a destination vertex.

14. The system of claim 11, wherein the at least one application further causes the at least one computing device to generate another user interface configured to render the representation of the at least one candidate workflow.

15. The system of claim 11, wherein the at least one application further causes the at least one computing device to generate another user interface configured to render the representation of the at least one candidate workflow.

16. The system of claim 15, wherein the other user interface includes one or more tools configured to map at least a portion of a first candidate workflow to be a conditional branch of a second candidate workflow.

17. The system of claim 15, wherein the other user interface includes one or more tools configured to edit the at least one candidate workflow.

18. The system of claim 15, wherein the other user interface includes one or more tools configured to generate a workflow definition for the at least one candidate workflow in a workflow definition language.

19. The system of claim 11, wherein the at least one application further causes the at least one computing device to merge a first candidate workflow and a second candidate workflow into the at least one candidate workflow, wherein the first candidate workflow and the second candidate workflow are merged to be conditional branches of the at least one candidate workflow.

20. The system of claim 11, wherein the workflow description describes a sequence of at least some of the plurality of user actions occurring on at least one of the plurality of client devices.

* * * * *